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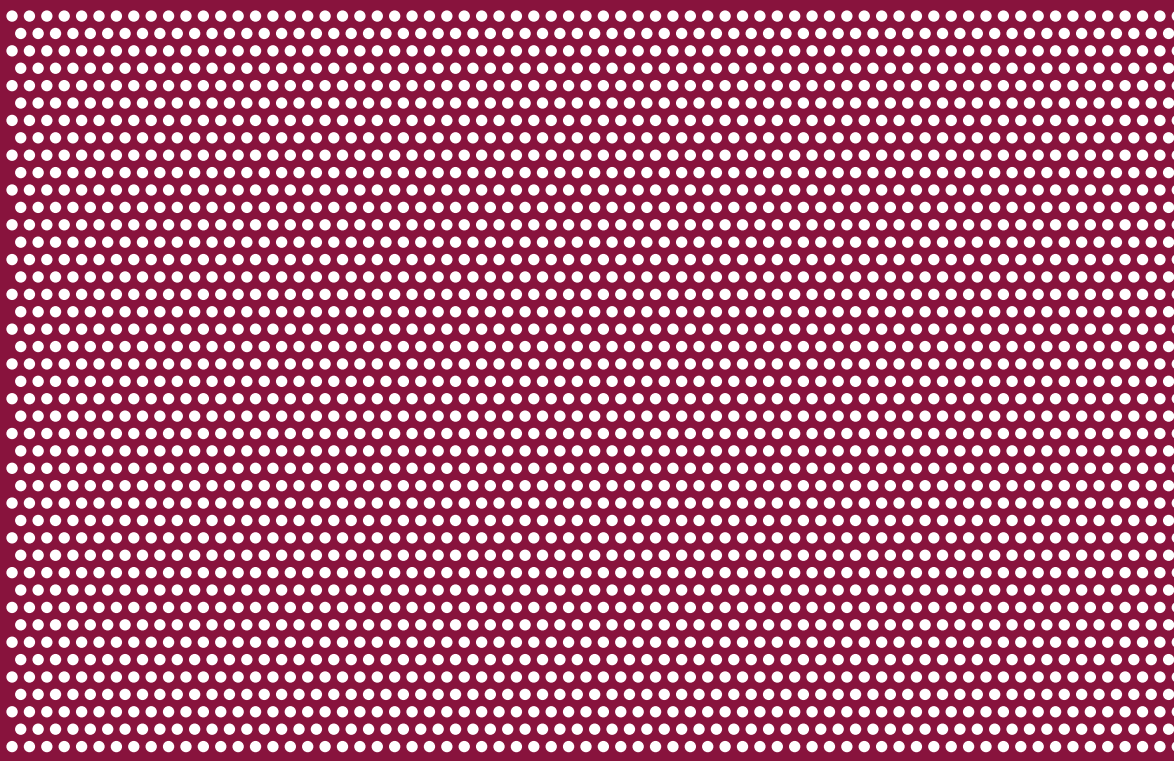
Research Institute for Science and Technology



April, 2024 – March, 2025

TOKYO UNIVERSITY OF SCIENCE

Introduction

This annual report is the activity records of Research Institute for Science and Technology, Organization for Research Advancement, Tokyo University of Science (TUS-RIST) in FY2024 (from April 2024 to March 2025).

Research Institute for Science and Technology has innovated and strengthened its research system in Tokyo University of Science with the aim of opening up new research areas and developing research activities based on an organic collaboration system in line with the new era. In FY2024, Nucleic Acid Drug Discovery Center, Division of Aging Biology, and Division of Co-creative Design Innovation Research were newly installed.

As a result, Research Institute for Science and Technology consisted of five Research Centers, two Research Hubs, eighteen Research Divisions, one Joint Usage / Research Center, and one Open Innovation Project at the end of FY2024.

Purposes of establishment of this research institute are as follows.

– Promotion of substantial collaborative research
– Development of cross-sectional research
– To open up new fields from a comprehensive perspective on basic and applied research
– Promotion of collaborative research that removes both domestic and international barriers within and outside academia
– Strengthening cooperation with society
– Nurturing highly creative and diverse human resources that are responsible for the next generation of society

In order to actively promote collaborative research to achieve these goals, we introduced a domain system in FY2010. At present, the system consists of five domains: “Bio and Pharmacy”, “Fundamentals”, "Functional Materials", "Information and Societal", and "Structural Materials". In addition, since FY2014, the Advisory Committee, consisting of experts inside and outside the university, has been set up in each of the Research Centers, Research Hubs, and Research Divisions, and has been playing a key role in developing R&D activities from a broader perspective.

Among Tokyo University of Science that aim to make progress "From TUS in Japan to TUS in the World", Research Institute for Science and Technology will continue to make further efforts to contribute not only to academia but also to society through the development of ambitious research activities from a global perspective.

We appreciate the cooperation and support of everyone involved.

March, 2025

Hiroshi Nishihara
Director.
Research Institute for Science and Technology (RIST)
Tokyo University of Science

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History and current status of Research Institute for Science and Technology

(1) Objectives and Features of Research Institute for Science and Technology

In order to respond to changes and advances in academia, and to meet the needs of society, Research Institute for Science and Technology (RIST) aims to develop an interdisciplinary and cross-disciplinary comprehensive research system through the cooperation of teachers in several disciplines, and to create and disseminate outstanding research benefits through active collaboration with non-academic experts and industrial and administrative agencies. It also aims to contribute significantly to society through the sustainable development of the academic and educational research system in this academy and the realization of an upgraded environment for human resources development.

RIST is a cross-linking organization that connects Faculty of Science Division I, Faculty of Science Division II, Faculty of Pharmaceutical Sciences, Faculty of Engineering, Faculty of Science and Technology, Faculty of Advanced Engineering, and School of Management. RIST emphasizes not only domestic but also international collaboration, and actively promotes activities as a research base both domestically and internationally.

(2) History of Research Institute for Science and Technology

Research Institute for Science and Technology was originally General Research Institute established in 1981. It later became the Tokyo University of Science General Research Institution in November 2005, In April, 2015, with the establishment of the Organization for Research Advancement with the aim of enhancing the research promotion system, it was reorganized into the Research Institute for Science and Technology. General Research Institute had been active as the university's only cross-disciplinary comprehensive research organization and accumulated many achievements. In the 25 years up to 2005 from 1981, 17 research departments were established, and the university played an important role as a pioneer of cross-disciplinary research groups and a parent body for many research organizations. In 1989, Research Institute for Biological Sciences was established from Biosystems Division, and in 1996, Organization for Information Science Education and Research was established from Computational Mechanics Division.

On March 31, 2004, the “Report on the Ideal Form of Research Institutes, etc., at the Tokyo University of Science” was compiled, and based on this, on April 25, 2005, “Proposal for establishment of Tokyo University of Science General Research Institution (Final Report of the Future Plan for the Tokyo University of Science Institute for General Research) was compiled. On November 10, 2005, the “Report of the Preparatory Committee for the Establishment of the Tokyo University of Science Research Organization” was compiled, and based on it, General Research Institution consisting of 10 centers and 5 research divisions was established.

In the 10 years up to 2015, the Research Equipment Center and Research Administration Center were established, the Research Center for Fire Science and Technology was recognized as a Joint Usage/Research Center, and the Global Fire Science and Technology was newly established through the “Global COE Program”, and Photocatalysis International Research Center.

(3) Organization of the Research Institute for Science and Technology

Research Institute for Science and Technology established under the Organization for Research Advancement in 2015 consists of Research Centers, Joint Usage / Research Center, Research Hubs, Research Divisions, and the Open Innovation Projects.

Research Reports by Research Center/ Research Hub/Research Division

Center for Fire Science and Technology

Center for Fire Science and Technology

1. Overview

The Center for Fire Science and Technology was established in 2003 when its predecessor, the Research Division of Fire Science Research within the Research Institute for Science and Technology, was selected as a core organization for the 21st Century COE Program (program name: the Center of Excellence for Promoting Leading Research on Building Fire Safety Engineering) by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan. In 2008, the MEXT Global COE Program (program name: the East Asia Center of Education and Research for Leading Fire Safety Engineering) was subsequently accepted. Through the ten years of these two COE (Center of Excellence) programs, we have promoted not only cutting-edge research but also activities to contribute to the development of fire science from various perspectives by organizing international symposia/seminars, publishing a peer-reviewed international journal, and making full use of the Laboratory for research projects with industry and government. The journal, International Journal for Fire Science and Technology, was launched in 1981 and now publishes papers on the J-stage platform, which people worldwide can freely access. In particular, we have contributed to developing human resources by promoting foreign education/research institutions. The activities include the analysis of fire risks and safety measures to reduce them in Asian (mainly East Asian) cities, holding intensive lectures, accepting early-career researchers for short-term stays, and joining the Sakura Science Plan promoted by JST. Further, in 2013, MEXT adopted our proposal of a project to support the formation of a strategic research infrastructure for private universities (project name: Formation of an Asian Fire Safety Information Center Based on Sharing Specialized Knowledge—a New Direction of Fire Safety in the Information Society). Asian cities, which are modernizing with the increasing number of high-rise buildings at an unexperienced rate and scale, need scientific analyses and taking appropriate safety measures against the threats posed by emerging fire risks. We aim to reduce fire risks and improve the city's safety levels by utilizing the Internet to identify fire hazards in Asian cities, building a fire-information network to share such information with related parties, and utilizing the results of TUS research. Specifically, we have the following two research themes:

1) Fire risk analysis of Asian cities based on the formation of the fire safety information center

2) Analysis of fire hazards and incidents in Asian cities

The former is to establish a mechanism in the Asian region to collect fire-incident information and to share specialized knowledge of fire engineering. The latter is to discuss how to investigate the causes and safety measures for the emerging fire risks associated with modernization and urbanization. Consequently, the Center aims to function as a research center for sharing expertise in fire safety engineering, analyzing fire incidents in Asian cities, and deploying information in combination with safety measures to reduce fire risk in the region as a whole. The Center has been established as a permanent organization indefinitely since 2018; it was also accredited as a designated performance-evaluation organization by the Ministry of Land, Infrastructure, Transport, and Tourism in 2020, utilizing the facilities and equipment of the Laboratory.

Furthermore, the "Research Center for Fire Safety Science" was accredited by MEXT as a joint usage/research center in 2009, promoting joint research in cooperation with researchers inside and outside TUS. Its primary objective is to contribute to minimizing potential fire risks that increase with available new spaces associated with urbanization and new materials associated with industrialization and energy conservation.

2. Organization and Facilities

As shown in Fig. 1, building fire safety engineering research covers fire phenomena, smoke flow, fire spread, evacuation behavior, and heating properties of structural members. The research scope also includes fire safety in cities as a set of buildings and underground spaces. The Center considers interrelationships among these diverse research subjects, as shown in Fig. 2, and expands research activities. Putting "fire safety engineering corresponding to changing space and material utilization" as the vital theme, the Center develops research activities in the following four areas: (1) physical and chemical phenomena in fires, (2) human behaviors (psychology, physiology, and behavior) during fires, (3) performance-based fire safety design technology, and (4) establishment of fire-safety performance evaluation and design systems corresponding to changing space and material utilization," which aims to integrate each element for practical use. The Fire Research and Test Laboratory, one of the world's largest university-based fire-science research laboratories, plays a crucial role in these research activities. The Laboratory capabilities have been enhanced by installing large-scale facilities and equipment. Figure 3 and Photo 1 show their names and the layout using floor plans.

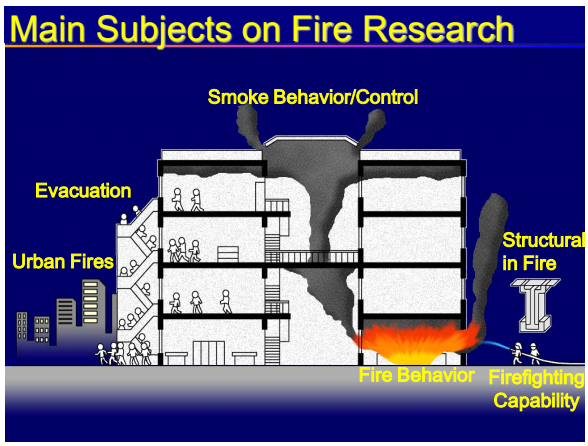

Fig. 1. A schematic of building fire safety engineering research.

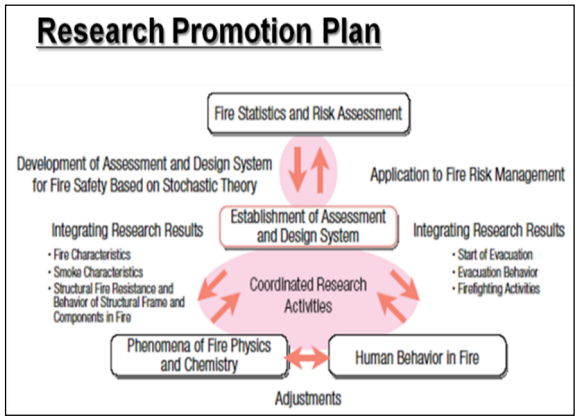

Fig. 2. Interrelationships of research areas and structures.

① Cone calorimeter and FTIR gas analyzer etc.
② Medium-scale structural fire-resistance furnace (inner size: W1.5 x D1.5 x H1.5 m)
③ Radiation panel (ICAL apparatus)
④ Smoke collection hood (fixed, 5m x 5m) (with Room corner testing unit)
⑤ Full-scale fire compartment model with a watering system
⑥ Multi-purpose horizontal loading furnace (inner size: W3 x D4 x H3.5 m, the maximum load: 500 MN)
⑦ Exterior material heating test equipment
⑧ Large-scale wall fire-resistance furnace (inner size: W3.5 x D1.0 x H3.5 m)
⑨ Secondary furnace (exhaust-gas treatment system)

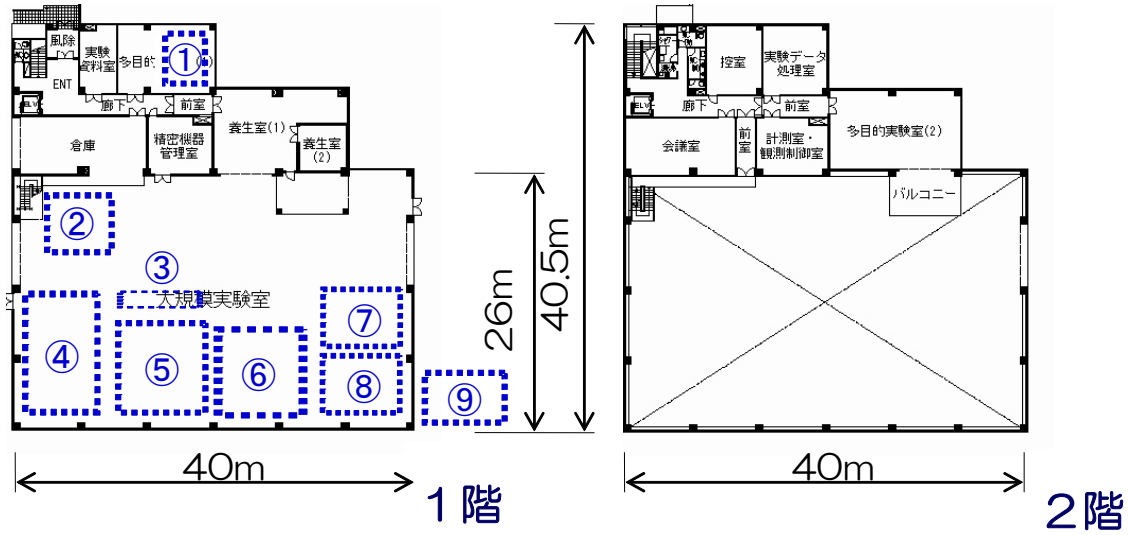

Fig. 3. Floor plans and facilities/equipment of the Fire Research and Test Laboratory.

(i) ⑥ Multi-purpose horizontal loading furnace

(ii) ⑧ Large-scale wall fire-resistance furnace

Photo 1. Fire Research and Test Laboratory.

3. Activity Reports

3. 1. Area of Fire Dynamics

In the Fire Dynamics Research Area, fundamental studies are conducted to elucidate the phenomena related to fire, combustion and explosion. In this issue, results of research on toxicity gas test and the mechanism of smoldering to flaming transition are reported.

In order to replace the toxicity testing of combustion product gases of building interior materials in Japan and to investigate alternative methods for the use of laboratory animals, a Fourier Transmission Infrared Spectrophotometer (FT-IR) was installed in the current gas toxicity test apparatus and the behavior stopping time of mice obtained from the gas toxicity test was compared with that obtained from the FT-IR. The Fractional Effective Dose (FED) was calculated from data obtained by the FT-IR. Using the FED, we analyzed the results focusing on CO_2, which is classified as a simple asphyxiant gas as well as a chemical asphyxiant gas among the toxic gases. The results correlated

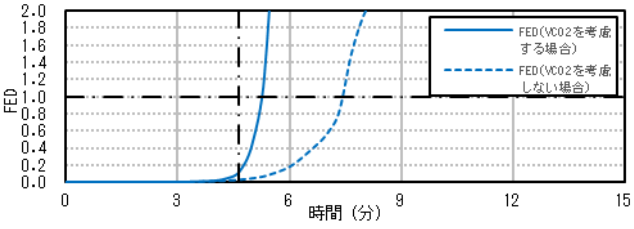

Fig.4. Relationship between FED and time of mouse action cessation.

well with the behavioral time of mice when the CO_2 concentration was taken into account in the study using FED as a method of toxicity evaluation in gas toxicity testing equipment.

The transition from smoldering combustion, which is a low-temperature, slow reaction, to faster, high-temperature flaming combustion can occur under certain conditions. This transition phenomenon is often observed in cigarette-related fires and wildfires, triggering a rapid escalation of fire damage. In 2024, a mathematical model was developed to predict the critical conditions for this transition (Fig. 5). The model reveals that the smoldering mode dominates under low oxygen concentrations, while a coexistence region for both smoldering and flaming combustion emerges as oxygen levels increase. Beyond a critical oxygen threshold, flaming combustion becomes the sole reaction mode. The model also predicts the influence of other external factors, such as airflow velocity, on transition conditions.

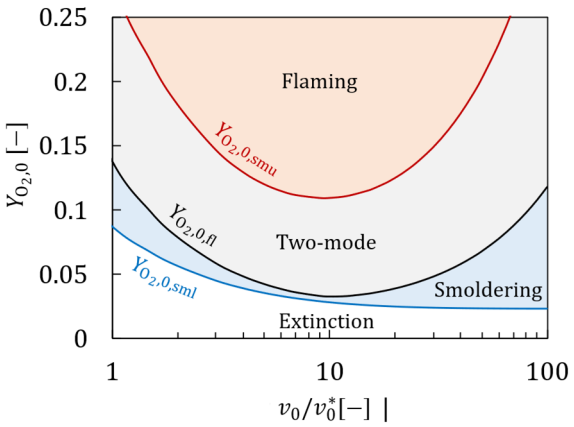

Fig. 5. Combustion-mode map predicted by the newly developed model.

3. 2. Area of Evacuation and Human Behavior

"Security measures for evacuation safety"

Access control devices such as security gates are increasingly being installed in buildings. There is concern that access control devices for crime prevention purposes may hinder evacuation and firefighting activities. In this study, measures to ensure safety in evacuation were examined through a survey of security such as access restrictions on evacuation routes. Experiments were conducted on subjects to operate emergency locks, and data was collected and analyzed, such as the time it took to unlock four types of emergency locks and open the door, and the force required to unlock them. The time required to open varied greatly depending on the type of emergency lock. It ranged from 6.3 seconds to 27.6 seconds on average. In particular, it took nearly 60 seconds to unlock Type-B and Type-C, with six people and three people giving up, respectively. The order of ease of operation was Type-D > A > B ≒ C overall. Except for Type-D, it is difficult to understand how to unlock the lock at first glance, and it can be said that there are issues with operating it in an emergency. The order of ease of operation is roughly as expected, but there is little correlation between ease of operation and the force required to unlock.

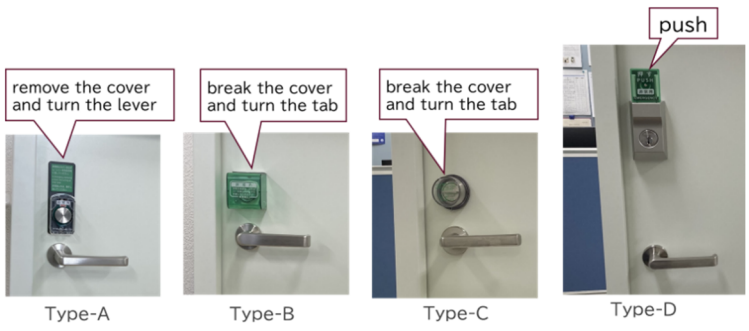

Fig. 6. Four types of emergency locks

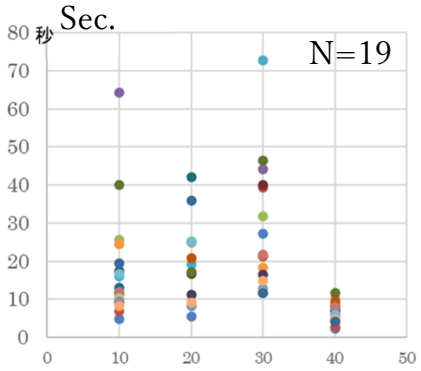

Fig. 7. Time required to open

3. 3. Area of Fire Resistance for Structural Members and Materials for Disaster Prevention

"Experimental study on fire behavior near ceilings surrounded by wooden hanging walls"

This study aimed to collect technical knowledge on fire behavior near ceilings with exposed wooden beams and hanging walls, and conducted experiments assuming a ceiling surrounded by wooden hanging walls (Photo 2). In the experiment, a ceiling with plan dimensions of 0.9m x 0.9m and 0.9m x 1.8m was surrounded by wooden hanging walls, and the effects of the depth of the hanging walls and the fire source conditions on the incident heat and combustion properties to the hanging walls were confirmed under conditions where the entire hanging walls were heated uniformly.

As a result, in a space surrounded by wooden hanging walls, when all four hanging walls were closed, there was a lack of oxygen near the ceiling surface, and although the smoke layer temperature reached 500-600°C, the index of flashover occurrence, there was no rapid fire spread, and flaming combustion was only near the fire source. In addition, if the fire source conditions and the depth of the hanging wall are the same, the smaller the planar size of the ceiling surrounded by the hanging wall, the more likely it is that heat will be trapped, and the more likely it is that the pyrolysis of the wooden hanging wall will be accelerated.

Photo 2. Experimental set-up

3. 4. Area of Firefighting, Fire Prevention, and Industry Fires

Research is conducted from the perspectives of "advancing firefighting activities through the use of science and technology" and "protecting against fires caused by chemicals and industrial activities."

Concerning research on health management and effective training methods for the prevention of occupational accidents among firefighters, we are collaborating with fire departments to continuously conduct studies in which physiological indicators are measured during training sessions with firefighters wearing their actual gear. These studies aim to develop management methods to ensure operational safety and to devise effective training programs. Additionally, we have conducted research analyzing the temporal changes in firefighters' heat acclimatization training on-site to reduce the risk of heatstroke during summer firefighting operations. Other research topics include the utilization of drone technology in fire and disaster prevention, and the evaluation of fire extinguishing agents with consideration for environmental impact.

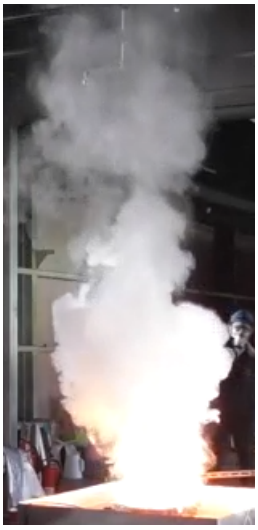

Photo 3. Thermal runaway of a lithium-ion battery

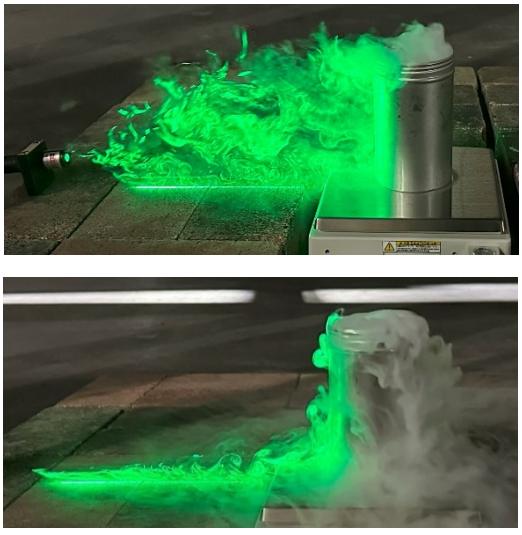

Photo 4. Gas dispersion experiment

We have also investigated energy and environmental issues related to industrial development and fire hazards from the perspective of chemical substances. For example, studies have been conducted on hazardous substances in forestry and wildfires, fires involving renewable, recycled materials and biomass power plants, and the fire risks of inorganic compounds such as nuclear power plant waste.

In addition to the above, we have also conducted experiments on the thermal runaway of lithium-ion batteries (Photo 3) and on the dispersion of leaked gases (Photo 4)

4. Challenges and Prospects

Research activities were initiated in four new areas in 2021, and have achieved many research results in each area. On the other hand, the phenomena of fires that have occurred in recent years are becoming increasingly diversified due to various external factors such as global environmental changes and promotion of energy conservation. In addition, fires following large-scale disasters such as the Nankai Trough and earthquakes directly under the Tokyo metropolitan area, as well as the frequent occurrence of large-scale wildfires in various parts of Japan, require the establishment of a new research framework and the strengthening of cooperation among research fields. In the future, we would like to conduct field surveys and analyses of characteristic phenomena, particularly wildfires, and then proceed with research while identifying and discussing issues in each area. We would like to continue to solve common problems through close collaboration among the disciplines, which will lead to the reduction of fire damage. Furthermore, we would like to strengthen our research system by actively collaborating with other organizations. In addition, since the “Joint Usage/Collaborative Research Center” was able to recover to its previous level of activity from 2024, we would like to carry out active research activities, including joint research with overseas institutions.

5. Conclusion

The Center’s research organization has carried out two COE programs promoted by MEXT for ten years. It has also carried out the Strategic Research Infrastructure Formation Support Program for Private Universities (project name: Formation of Asian Fire Safety Information Center Based on Sharing Expertise—A New Approach to Fire Safety in the Information Society) for five years since 2013. Recognizing these achievements, the Center has been positioned as a research center with no fixed term from 2018. We will continue to analyze information on fire accidents, mainly in Asia, and produce research outcomes that contribute to fire risk reduction while promoting them by sharing information with relevant parties in Asia. Furthermore, in Japan, the Center will actively promote and implement its services as a designated performance evaluation institution by the Minister of Land, Infrastructure, Transport and Tourism.

The “Research Center for Fire Safety Science” operated by the Center has been accredited by the Ministry of Education, Culture, Sports, Science and Technology as a Joint Usage/Collaborative Research Center. Therefore, it has the mission to fulfill further its role as the core of fire science research in Japan. Overseas collaboration has been sluggish over the past few years due to the COVID-19 pandemic but has recovered to the previous activity level. We will conduct joint research with more overseas institutions in the future and continue to expand our global activities as a center for fire science and fire safety engineering in Asia.

As for internationalization efforts, it is worth mentioning that, since 2012, the Center has taken the lead in establishing the Forum on Fire Science Research/Education in Asia (Fire FORUM), organizing a symposium/seminar every year. In the past few years, due to the impact of the coronavirus outbreak, the event has been canceled or held online, but a face-to-face meeting was held in Hanoi, Vietnam, in November

2023. In 2025, planning and preparation for the holding of the FORUM will proceed. So far, discussions have focused on establishing an educational system on fire science, but in the future, the participating institutions of Fire FORUM plan to actively promote international joint research by applying for and being accepted by a research program to strengthen collaboration.

Major Research Achievements (FY2024)

Academic Papers

1. Deep-learning prediction of safety moiety of salen-type complex crystals towards explosive perchlorate salts, T. Akitsu, Y. Takiguchi, S. Suda, and D. Nakane, FirePhysChem, 4, 238-244 (2024) (Peer-reviewed)
2. Fire of Radio-Volatile RuO4 in Atomic Power Generation, H. Nishimura, K. Katsusima, Z. Miyamoto, S. Sato, T. Nakano, T. Akitsu, Fire Science and Technology, 43, 17-24 (2024)
3. Air Pollution Caused by Wildfires and Chemistry of Cr(VI) and Radicals, S. Furumoto, M. Toyokita, T. Kimura, A. Umi, N. Katahira, T. Iida, M. Komura, Y. Yoshida, and T. Akitsu, Fire Science and Technology, 43, 45-57 (2024)
4. Safety Perceptions of Transition Metal Elements and Their Potential Fire Relevance, T. Akitsu, Fire Science and Technology, 43, 59-81 (2024)
5. Large eddy simulations fire modeling of JIS A 1310 façade calibration test with respect to sidewall, Xukun Sun, Hideki Yoshioka, Takafumi Noguchi, Yuhei Nishio, Yoshifumi Ohmiya, Tetsuya Hayakawa, Biao Zhou, Fire & Materials, 2024, 48(4), 411−425 (Peer-reviewed)
6. 火災加熱を受ける高強度コンクリート部材に生じる熱応力に関する解析研究, 加藤正樹, 日本建築学会学術講演梗概集, pp.335-336, 2024.7 (in Japanese)
7. 高温環境下におけるセメントペーストの熱収縮挙動に関する研究, 小山 拓, 小澤満津雄, 兼松 学, セメント・コンクリート論文集, 78 巻, 1 号, pp.128 - 136, 2025.3 (in Japanese) (Peer-reviewed)
8. Resilience assessment of RC buildings focusing on loss of functionality caused by repair work, H. Kinugasa, T. Mukai, H. Choe, Proceedings of 18th World Conference on Earthquake Engineering, EVO Monitor_8, 12 pages, 2024.07 (Peer-reviewed)
9. RC 曲げ破壊部材における修復時間に着目した損傷評価指標の算出法, 衣笠秀行, 向井智久, チェホンボク, コンクリート工学年次論文集 Vol.46, No.2, pp.91-96, 2024.06 (in Japanese) (Peer-reviewed)
10. 業務用ガスコンロにより加熱される鍋の伝熱(第 1 報)鍋側面の対流熱伝達率の測定, 島貫友貴, 倉渕 隆, 金 政一, 有賀瑞稀, 大澤嵩生, 鳥海吉弘, 李 時桓, 大森敏明, 冨永隆一, 空気調和・衛生工学会論文集, No.326, pp.9-15, (2024.5) (in Japanese) (Peer-reviewed)
11. Verification of Response Time of CO_2 Concentration Sensors for Measuring Age of Air Distribution using Dynamic Steady-State Concentration, Jin-Ya Takeuchi, Takashi Kurabuchi, Hajime Yoshino, Yoshihiro Toriumi, Kazuki Ko-Dama, Indoor Air 2024, pp.1262-1263, (July, 2024) (Peer-reviewed)
12. Study on Ventilation Efficiency Measurement Method of Air Purifier Using Artificial Droplets, Jeongil Kim, Takashi Kurabuchi, Sihwan Lee, Indoor Air 2024, pp.1566-1567, (July, 2024) (Peer-reviewed)
13. Ventilation and improvement of thermal environment using buoyancydriven ventilation with a single opening, Akito Kono, Takashi Kurabuchi, Takashi Kurabuchi, Jeongil Kim, Indoor Air 2024, (July, 2024) (Peer-reviewed)
14. Measurement of Age of Air in Air-Recirculating Systems using Dynamic Steady-State Concentration Theory, Tatsuya Murai, Takashi Kurabuchi, Jin-ya Takeuchi, Hajime Yoshino, Yoshihiro Toriumi, Jeongil Kim, Toshihiro Nonaka, Hiko Ri, Indoor Air 2024, pp.1600-1607, (July, 2024) (Peer-reviewed)
15. Development of quad thermistor for wind direction measurement, Norise Tanabe, Takashi Kurabuchi, Toshihiro Nonaka, Jeongil Kim, Indoor Air 2024, pp.1185-1191, (July, 2024) (Peer-reviewed)
16. Comparison of the Eulerian and Lagrangian Approaches for Predicting Fate of Particle by Single-Sided Natural Ventilation, Sihwan Lee, Takashi Kurabuchi, Jeongil Kim, Indoor Air 2024, pp.1396-1398, (July, 2024) (Peer-reviewed)

17. Early warning signals of flashover in compartment fires, N. Thinnakornsutibutr, K. Kuwana, M. Mizuno, T. Ushijima, S. Yazaki, Fire Safety Journal, 150 (Part A), 104264, 2024.12 (Peer-reviewed)
18. Predicting extinction limits of concurrent smoldering spread by a reduced analytical model, P. Viriya-amornkij, K. Kuwana, X. Huang, Combustion and Flame, 269, 113668, 2024.11 (Peer-reviewed)
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1. Chemistry that contributes to bio-derived energy and its fire accidents, Takashiro Akitsu, World Science Congress The 16th international science conference WSC (18-20 October 2024) Bangladesh (Online)
2. 企業の火災・爆発事故の発生防止・被害軽減対策, 土橋 律, 製造業における防災・減災対策セミナー, 中部インダストリアル・エンジニアリング協会, 2024.10.9 (in Japanese)
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4. 松山 賢, 基調講演, 電線総合技術センター研究発表会, 2025.3.19 (in Japanese)
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Public Relations

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2. 松山 賢, 新潟佐渡・春日における大規模火災の再出火に関するコメント, 新潟日報, 2024.11.23 (in Japanese)

Awards

1. 後藤 治, 村田眞志, 石郷岡 将, 松山 賢, 技術賞, 日本火災学会, 2024.5
2. 松山 賢, 特別功労賞, 日本石膏ボード工業会, 2024.5
3. 水野雅之, 日本火災学会賞, 日本火災学会, 25 May 2024
4. Masayuki Mizuno, Best Poster Presentatation Award, 13th Asia-Oceania Association for Fire Science and Technology, 24 Oct. 2024

Individual Research Topics

Takashiro Akitsu

"Chemistry in Wild fire and Air Pollution"

Environmental pollution due to pollutants generated from wildfires has become a serious problem. When one considers the mechanism of ozone layer depletion, we find that it is related to basic chemistry such as radicals, acid bases, and redox. From a chemical point of view, the above-mentioned pollutants are mainly nanomaterials such as PM2.5, NOx, etc., and are mainly in the form of aerosols. When we consider the mechanism of ozone layer depletion, we find that it is related to basic chemistry such as radicals, acid bases, and redox. Therefore, I summarized the related chemistry for related problems such as air pollution and climate change caused by wildfires.

Shiro Ichimura

"Epidemiological survey of heart disease in Japanese firefighters during work time"

On American firefighters, deaths caused heart disease during work time are very high, averaging 43% of all deaths over the past decade (7% for police officers and 11% for emergency medical workers). In particular, the greatest risk is during or immediately after firefighting and the frequency reported to be 10 to 130 times greater than during other fire department operations. However, it is not clear how many Japanese firefighters have heart disease during work time. Therefore, we conduct an epidemiological survey of heart disease during work time in Japanese firefighters.

Yoshifumi Ohmiya

"Study on fire spread prevention system during a building fire"

Assuming a fully-developed fire as fire phase in a building, we will conduct research on the properties of the hot airflow jet emerging from an opening in the compartment where the fire occurred. Focusing on the heat airflow jet emerging from an opening, which is a factor in the spread of fire within the building, experiments will be conducted to quantitatively understand the incident heat flux on the walls above the opening. Furthermore, a quantitative prediction method for the hot airflow jet emerging from the openings will be proposed based on the experimental results.

Masaki Kato

"STADY ON THERMAL STRESS AT OCCURRENCE OF SPALLING BEHAVIOR IN HIGH-STRENGTH CONCRETE UNDER FIRE ENVIRONMENT -Analysis of Thermal Stress Considering Water Vapor Pressure-"

Concerns about spalling of high strength concrete members in fire have been raised. The purpose of this study is to clarify the main factors that cause spalling by focusing on thermal stress. In this year, analytical investigations considering water vapor pressure were conducted on members using high strength concrete.

Manabu Kanematsu

“Study on the Durability Evaluation of Fire-Retardant Treated Wood”

In recent years, wood has been increasingly used as an exterior material for buildings. From a fire safety perspective, fire-retardant treated wood is commonly employed; however, there are concerns that exposure to rainfall may result in the leaching of fire-retardant chemicals, leading to a decline in the required performance over time. This study aims to establish a method for evaluating the fire performance of fire-retardant treated wood used in exterior applications, taking into account aging and deterioration. To achieve this, the degradation mechanisms of fire-retardant treated wood are being investigated through natural weathering tests, and efforts are underway to develop an accelerated degradation test method based on repeated wet-dry cycles.

Hideyuki Kinugasa

“Study on Urban Functional Recovery in the Event of Natural Disasters”

The importance of assessing structural performance from the perspective of seismic resilience (i.e., “loss of functionality” and “recovery time” during an earthquake) has recently increased. Against this backdrop, we obtained the loss of functionality and recovery time changes due to increased deformation of the building to demonstrate that there are certain regularities in the resilience behavior induced by increased damage. We then presented the effects of the building’s collapse mode and the amount of nonstructural members on its resilience behavior.

Takashi Kurabuchi

“Study on CFD prediction of thermal plume from gas stove and capture efficiency by exhaust Hood”

Standard k-ε model tends to overestimate the exhaust capture efficiency of an exhaust hood of a gas stove on which a pot is placed. It is known that there is a problem with the consistency of the turbulence model, and an attempt was made to apply GGDH, which takes into account temperature and velocity gradients in lateral directions to predict the turbulent heat flux. We are aiming at high-precision prediction by CFD simulation of the exhaust capture efficiency when a pot is placed on a gas stove.

Kazunori Kuwana

“Modeling reactions of combustible solids”

Improving the accuracy of fire and explosion simulations is crucial for quantitative risk assessment and developing efficient firefighting strategies. This study aims at developing mathematical models of combustible-particle reactions during dust explosions and smoldering-to-flaming transitions. Further, dynamical markers for the early detection of transition phenomena are being investigated.

Atsushi Shono

“Study on thermophysical properties of thermal insulation materials”

This study investigates the relationship between thermal conductivity and internal structure in a lightweight insulation material composed of glass wool and a small amount of inorganic binder. Key structural parameters include fiber orientation, fiber length, fiber diameter, porosity, pore shape, and pore connectivity. Thermal conductivity is measured using a heat flux method, while internal structure is analyzed via X-ray CT scanning. The goal is to clarify how these structural factors influence thermal performance and to develop a predictive equation for thermal conductivity, contributing to the efficient design of high-performance insulation materials.

Ritsu Dobashi

“Research on Consequence Prediction and Risk Reduction of Fire and Explosion Hazards”

The phenomena of fire, gas explosion hazard, and dust explosion hazard are being elucidated, especially through combustion science approaches. The results of these phenomena are analyzed to evaluate the consequence of these disasters and to reduce the impact of such disasters, i.e., to reduce the risk. Through detailed examination of the experimental results, I aim to clarify the governing mechanism of the phenomenon and to develop an appropriate model.

Ichiro Hagiwara

“Study on criteria for firefighting support performance”

The purpose of this study is to clarify the firefighting support performance that buildings should have, and to organize it as a fire safety standard. In past fire incidents, it is often the case that damage has increased because it is difficult to enter in the fire building. This year, we organized a draft standard for installing direct stairs and external openings for each fire compartment, focusing on direct stairs and emergency elevators as routes to enter the building.

“Security measures for evacuation safety”

A field survey of security measures such as access control on evacuation routes, which have been increasing in recent years, will be conducted, accidents and failures that are expected to occur will be analyzed, and countermeasures will be considered to ensure evacuation safety. This year, we conducted an experiment on subjects operating emergency locks, and analyzed the time it takes to unlock four types of emergency locks, as well as the force required to operate them, and presented the results in a paper at an academic conference.

Ken Matsuyama

“Study on gas toxicity testing using FT-IR.”

In Japan, toxicity testing on combustion product gases of building interior materials has been carried out by qualitative methods using mice. In this study, an experimental study was conducted to establish a quantitative test method using FT-IR. The comparison of the Fractional Effective Dose (FED) was used in the study. The comparative study was considered with respect to CO_2, which is classified as a simple asphyxiating gas, along with gases classified as chemical asphyxiating among toxic gases. As a result, it was found that taking into account the CO_2 concentration correlated with the behavioral time intervals of mice.

Masayuki Mizuno

“Study on Reproduction Methods of Smoke Flow in VR Evacuation Simulators”

Studies on visibility distance in smoke are well-known, including research by Dr. Tadahisa Jin. In this study, we investigated the relationship between the smoke extinction coefficient and the visibility distance of a B-class evacuation guidance light, using a high-luminance type of LED light source that is widely used today. Using this average relationship, we clarified the conditions for smoke flow in VR space, such as the setting values of transparency corresponding to the temperature attenuation of ceiling jet. In the future, we plan to incorporate smoke flow into VR evacuation simulators and utilize it for analyzing evacuation behavior.

“Investigation on Fire Hazards in Large-Scale Warehouses”

With the widespread adoption of e-commerce sites, many logistics warehouses have continued to be constructed in recent years. However, some fires that occurred in large-scale warehouses between 2017 and 2021 burned continuously for several days. These incidents were caused by failures in fire shutter closures, but rapid fire spread due to the accumulation of combustible materials was also a major factor that hindered initial fire suppression. Therefore, with the cooperation of several companies, we conducted a survey on the accumulation and usage of combustible materials inside warehouses.

Shinya Yanagita

“Optimal physical activity levels that promote brain-organ coupling”

We have used animal models to clarify the relationship between physical activity and brain function (especially antidepressant and anxiolytic effects). However, the optimal amount of physical activity for brain function is not well understood. In addition, the effect of physical activity “quantity” on the relationship between the brain and the skeletal muscles, which are the effector of exercise, is not known at all. Therefore, experimental investigations are being conducted with the aim of clarifying the optimum amount of physical activity and the mechanisms by which an increase in physical (lifestyle) activity can induce adaptive changes in brain function.

Water Frontier Research Center (WaTUS)

Water Frontier Research Center (WaTUS)

1. Overview

Water Frontier Research Center (WatTUS), established on April 2021, is a successor research organization of Water Frontier Science and Research Center which was launched on November 2016 for promoting Research Branding Project "Formation of an Interdisciplinary Research Center for Water at Material Surfaces and Interfaces," supported by the Ministry of Education, Culture, Sports, Science and Technology, Japan. Our research center focused on "water" which is essential for all the lives and their various activities. Especially, interaction between water and materials' surface, namely "water interface", is generally very complicated and particularly difficult to be fully understood. Our aim is to tackle these complicated issues related on "water interface."

We, WaTUS, aims to pursue leading-edge researches and developments relating to "Water Interface" with multi-disciplinarily collaborative researches. Our mission is to perform following missions:

(1) Pursuit of state-of-the-art science and technologies of water interface by collaboration and technical excellence
(2) Establishment of international research core of excellence
(3) Provision of "one-stop service" of water researches for industries
(4) Visualization of TUS through our research activities

Formation of research and development hub for "Water Interface" through our researches means to create the place where researchers all over the world can join and to establish research organization which can provide practical solutions to industries.

To carry our above-mentioned missions, highly intensive collaborations of fundamental researches and technical developments with researchers inside and outside of the center become a key.

2. Organization and Facilities

WaTUS promotes interdisciplinary collaborative researches to achieve our goals. We consist of matrix-based research units with approaches (Materials development, Measurement & Analysis, and Theory & Simulation) and targets (Materials & Water, Life & Water, and Environment & Water). In this 3 × 3 matrix-based research unit (Fig. 3), our center encourages researchers who develop novel materials with high functionality, ones who develop cutting-edge measurement and analysis techniques, and ones who perform advanced theoretical consideration and simulation, to perform intensively flexible collaborative studies expecting synergetic effects. Also, more flexible style of collaboration involving ones outside of the center are appreciated in this center.

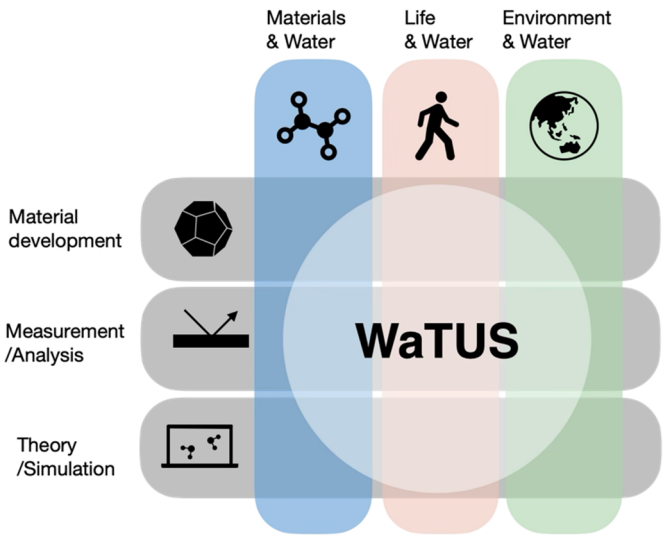

Fig. 1. Research units of the research center

- Materials and Water: this unit pursues research and development considering relation between water and materials from atomic to macroscale
- Life and Water: this unit pursues research and development contributing to human beings and medical diagnostics or medical and biological engineering
- Environment and Water: this unit pursues research and development for environment and industries. Earth science and energy conservation is also included in this unit

WaTUS has advanced facilities with state-of-the-art analytical systems for pursuing leading-edge researches of "water interface"; for example, (i) heterodyne sum frequency generator, (ii) atmosphere-controlled scanning probe microscopy, (iii) sputtering equipment, (iv) interfacial fluorescence microscopy, and (v) high-speed camera system. Also, we are developing a multi-level water simulator, which provide intuitive connection between quantum mechanics, molecular dynamics, and fluid dynamics calculations for water on materials interface.

3. Activity Reports

As mentioned above, our research center consist of three research units, "Materials and Water," "Life and Water," and "Environment and Water." Each units perform research activities with mutual cooperation. Below we report on some of our recent research activities.

3. 1. Development of High-Performance Filter for Microplastics

This study aims to develop a low-cost, high-performance inorganic filter that can capture microplastics, particularly fibrous microplastics (MPs), which pose a serious environmental issue in rivers and oceans. Currently, approximately eight million tons of plastic flow into the oceans annually worldwide, much of which consists of microplastics smaller than 5 mm. Among these, fibrous microplastics, such as microfibers, are especially difficult to collect using existing filters, presenting a significant challenge.

The developed filter is fabricated from a composite material consisting of glass beads (GB) and milled glass fibers (GF). By sintering the composite at 680–720 °C, filter structures with tailored pore sizes are created. Compared to commercially available metal filters, this design offers a more uniform pore distribution and improved resistance to fouling, while keeping production costs low. Furthermore, by controlling the wettability and fiber alignment within the filter, the capture efficiency of fibrous microplastics is further enhanced.

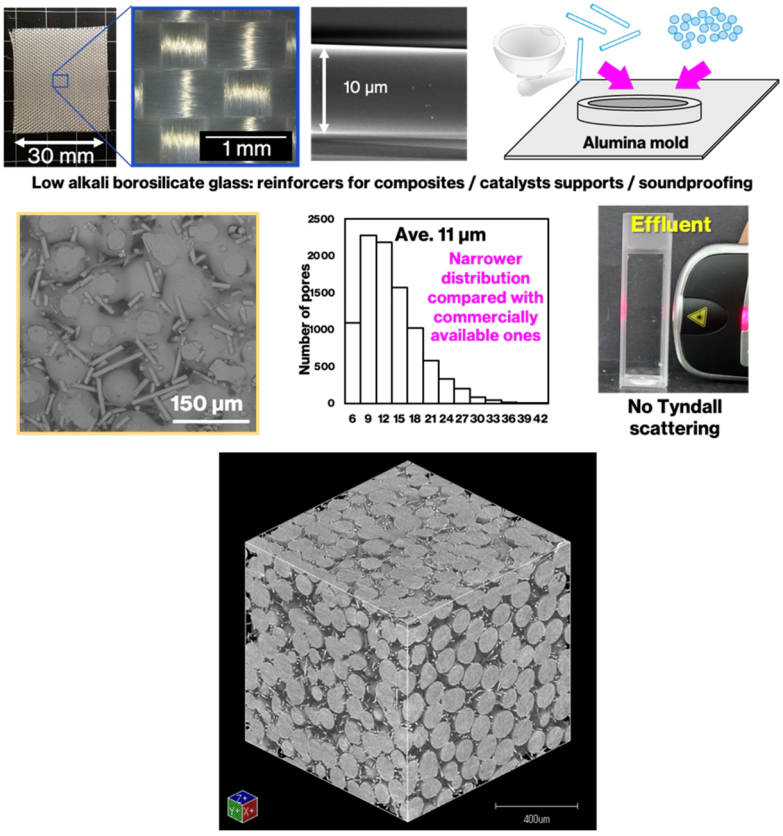

Fig. 2. Composite filter for microplastics

Experimental results confirmed that MPs were successfully trapped inside the filter, with the fibrous structures firmly entangled within the filter matrix.

In addition, for nanoplastics, a multilayered filter structure incorporating layered double hydroxides (LDHs) as the supporting material is also being developed. LDHs possess a layered structure composed of alternating cationic and anionic sheets, enabling electrostatic interactions with the surface charges of nanoplastics to facilitate their adsorption. Such multilayer may allow for stepwise separation and collection of plastic particles of different sizes, with potential application in real aquatic environments in the future.

3. 2. Effect of Moisture in the Friction Environment on the Lubrication Properties of Ionic Liquids

This study investigated how the frictional properties of ionic liquids (ILs), which are gaining attention as next-generation lubricants, are affected by ambient humidity—i.e., the presence of moisture in the frictional environment. ILs are composed solely of cations and anions, and are characterized by their unique properties such as non-volatility, high thermal stability, and high ionic conductivity. Their tunable chemical structures further enhance their potential as advanced lubricants.

Using ball-on-disk tribological tests conducted under vacuum and controlled humidity environments, various hydrophilic and hydrophobic ILs were evaluated for their friction coefficients and wear behavior under relative humidity (RH) ranging from 15% to 80%. The results revealed that hydrophilic ILs tend to exhibit increased friction and wear under high-humidity conditions, where the formation of lubricating films is hindered. Surface analysis confirmed that elevated humidity lead to the desorption or displacement of previously adsorbed cations and anions by water molecules, resulting in the loss of the lubrication layer and a subsequent decline in performance.

On the other hand, hydrophobic ILs were relatively less affected by humidity, demonstrating a certain degree of resistance to wear increase. However, complete control remained challenging, as high humidity also promoted the formation of degradation products such as PO_3^-, which could negatively impact lubricating performance.

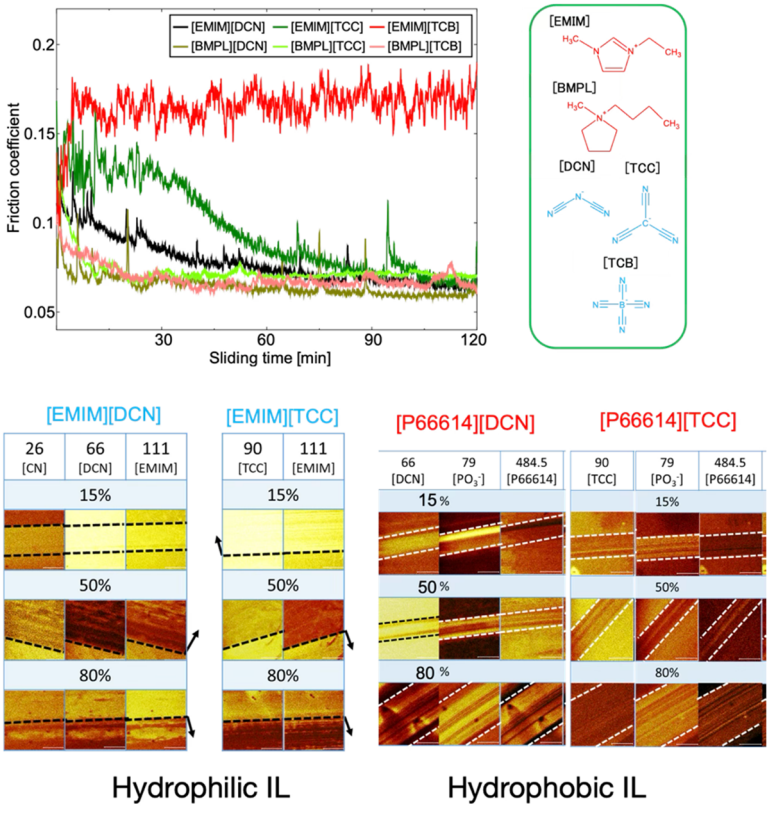

Fig. 3. Friction characteristics and surface analysis of hydrophilic/hydrophobic ionic liquids

Based on these findings, future applications of IL lubrication are envisioned in extreme environments, such as on DLC (diamond-like carbon) surfaces or within space and hydrogen energy systems. This research represents a pioneering effort that goes beyond evaluating basic lubricating performance to address the crucial tribological challenge of interactions between moisture and lubricating films.

4. Challenges and Prospects

As an interdisciplinary research center for “water,” we hope to be a leading organization tackling social issues, in addition to promoting cutting-edge research through mutual collaboration among physics, chemistry, and engineering fields. We are also engaged in international collaboration through overseas research activities and the acceptance of researchers and students, and we intend to continue these efforts in the future. In addition to research activity, we started an educational class of “Advanced Water Science” for all the graduate students in Tokyo University of Science, and more than 250 students were enrolled.

5. Conclusion

While continuing to deepen the research that has been pursued so far, new collaborative projects and industry-academia partnerships have also begun, and further progress is increasingly expected. Following the release of the “Integrated Simulator” announced last year, distribution to interested parties has commenced. In addition, we plan to continue exhibiting at trade shows—an initiative started two years ago—to both present our research on interfacial water science and introduce outcomes while incorporating societal needs.

Major Research Achievements (FY2024)

Academic papers

1. Evaluation of liquid thickness distribution in micropores on moving elastic surfaces, Yoshiyasu Ichikawa, Rikuto Shinozuka, Shinya Sugisawa, Tatsuhiko Hatano, Yoshio Kaji, Isao Kuwayama, Masahiro Motosuke, Rev. Sci. Instrum., Vol. 95, 115102, 2024 (Peer-reviewed)
2. AC electrothermal trapping for efficient nanoparticles enrichment in a microchannel, Ahmed Abdelghany, Yoshiyasu Ichikawa, Masahiro Motosuke, Int. J. Thermofluids, Vol. 32, 100736, 2024 (Peer-reviewed)
3. Structure and dynamics of adsorbed water on carbon nanotubes: a molecular dynamics simulation, Yuki Maekawa, Yusei Kioka, Kenji Sasaoka, Yoshikazu Homma, Takahiro Yamamoto, Jpn. J. Appl. Phys. 63, 085002-1-7, 2024 (Peer-reviewed)
4. Structural Analysis of Interfacial Films of Oil/Water Emulsions Prepared by Emulsification via Lamellar Gels, Kuwabara, Hiroki Ogura, Taku Tsuchiya, Koji Akamatsu, Masaaki Arakawa, Kenichi Sakai, Hideki Sakai, J. Oleo Sci., 73, 12, pp. 1467-1477, 2024 (Peer-reviewed)
5. Direct Bonding of Amino-Modified Silica and Metal Oxides: Condensation Reactivity Explained by Acidity/Basicity of Metal-Hydroxyl Groups, Sho Nagai, Yasuo Hayashi, Shu-hei Urashima, Hiroharu Yui, J. Phys. Chem. C, 128 (12), pp. 21399-21407, 2024 (Peer-reviewed)
6. Low-temperature bonding of glasses: The role of plasma-engrafted surface amino groups, Sho Nagai, Keisuke Nakao, Yasuo Hayashi, Shu-hei Urashima, Hiroharu Yui, J. Am. Ceram. Soc., 107 (5), pp. 2877-2887, 2024 (Peer-reviewed)
7. Retention or repulsion forces induced by bubbles trapped at the base of an immersed microparticle on a substrate, Anna Ipatova, Alexis Duchesne, H. N. Yoshikawa, Pascal Mariot, Corenthin Leroy, Christine Faille, Ichiro Ueno, Georg F. Dietze, Farzam Zoueshtiagh, Phys. Rev. Fluids, 9, 084301, 2024 (Peer-reviewed)
8. Coherent structures by small particles in traveling-wave flows, Shogo Sensui, Shin Noguchi, Keiichiro Kato, Ichiro Ueno, Phys. Rev. E, 110, 015101, 2024 (Peer-reviewed)
9. Low-adhesion and low-swelling hydrogel based on alginate and carbonated water to prevent temporary dilation of wound sites. Ryota Teshima, Shigehito Osawa, Miki Yoshikawa, Yayoi Kawano, Hidenori Otsuka, Takehisa Hanawa. Int. J. Biol. Macromol., 254(3), 127928, 2024. (Peer-reviewed)
10. Effect of CO_2 release behavior on the crosslinking degree of alginate hydrogels prepared with $CaCO_3$ and carbonated water. Ryota Teshima, Shigehito Osawa, Kaoru Hirose, Yayoi Kawano, Akihiko Kikuchi, Takehisa Hanawa, Hidenori Otsuka, Mater. Adv., 5, 6368 – 6372, 2024 (Peer-reviewed)
11. Optimal pH Condition for Hydrogen Production using δ-FeOOH under UV Irradiation, Seongmin Shin, Ken-ichi Katsumata, Kubota Yuta, Nobuhiro Matsushita, Jeongsoo Hong, Opt. Mater., Vol. 157, pp 116372, 2024 (Peer-reviewed)
12. High-frequency oscillation of coalesced vapor bubbles and resultant ambient liquid motion in microbubble emission boiling in subcooled pool, Akira Otake, Hotaka Kobayashi, Kizuku Kurose, Ichiro Ueno, Int. J. Heat and Mass Transf., Vol. 242, 126832, 2025 (Peer-reviewed)
13. The effects of nano frictional stimulation on wear and mechanical property of endothelial cells, Haruto Gato, Kaisei Sato, Shinya Sasaki, Tribol. Online, 19, 4, pp. 324-333, 2024 (Peer-reviewed)
14. A distributed constant equivalent circuit model and a method for estimating parameters for paper-based lactate biofuel cells, Yukiya Yokoi, Daiki Ito, Yuko Yoshihara, Kazuhiro Ishigoori, Isao Shitanda, Noboru Katayama, Electrochim. Acta, Vol. 493, pp14384-14394, 2024 (Peer-reviewed)

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16. Adsorption/desorption of H_2O and phase transition in crystals of cobalt(II) bis(tolylterpyridine) nitrate, Joe Otsuki, Yusaku Kobayashi, Takumi Torisawa, Tomoo Furuhashi, Yoshinao Shinozaki, Kosuke Sugawa, Yoshiyuki Kojima, Hiroki Yoshikawa, Arata Tsukamoto, Makoto Tadokoro, Chem. Lett., 53, upae180, 2024 (Peer-reviewed)
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18. Preparation of anion-uptake powder compact containing layered double oxide and metakaolinite, Shingo Machida, Int. J. Appl. Ceram. Technol., 21, 5, 2024 (Peer-reviewed)
19. Microscopic behavior of nano-water droplets on a silica glass surface, Yuki Araki, Taketoshi Minato, Toyoko Arai, Sci. Rep. 14, 10693-10701, 2024 (Peer-reviewed)
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23. Study on Static and Dynamic Characteristics of Water-Lubricated Hydrostatic Thrust Bearings –Effect of Feed Hole Inlet Shape on Bearing Characteristics, Hidetoshi Ueda, Mitsuhiro Saito, Yusuke Kawamura, Shouhei Kawada, Masaaki Miyatake, Tribol. Int., 191, pp 109127. 2024 (Peer-reviewed)
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25. Key factors controlling number concentrations of non-charged particles: An Experimental study, Tasuhiro Mori, Ayumi Iwata, Ryoya Tabata, Tomoaki Okuda, AAQR, 24, 4, 220382, 2024 (Peer-reviewed)
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Books

1. The Physics and Chemistry of Trans-boundary Air Pollution (3rd ed.), Shinichi Fujita, Kazuhiko Miura, Hiroshi Okouchi, Kazuhide Matsuda, Hiroshi Hayami, Tatsuya Sakurai, Seizando-shoten Pubishing, pp. 46-68, 83-105, 130-150, 2025 (in Japanese)
2. Micro and Nanoscale Fluid Mechanics, Masahiro Motosuke, Ken Yamamoto (co-translated), Morikita Publishing, 2024 (in Japanese)

Public Relations

1. Hidenori Otsuka, Breakthrough in Micelle Technology for Effective Dye and Drug Dispersion, Press release from Tokyo University of Science, 2024
2. Water Frontier Research Center, Tokyo University of Science, Water movement, a mystery principle, Nihon Keizai Shimbun, May 22, 2024
3. Y. Araki, T. Minato, T. Arai, Successful Visualization of “Nano-Water Droplet” Behavior on Glass Surface, Press Release from Kanazawa University, 2024

Awards

1. Yoshikazu Homma, 2024 Industrial Standardization Business Award (Innovation and Environment Bureau Director-General’s Award), 2024 (In Japanese)
2. Yoshiyasu Ichikawa, Young Researcher Award, Visualization Society of Japan, 2024 (in Japanese)
3. Ichiro Ueno, Best paper award, Japan Boiler Association, 2024 (In Japanese)
4. Shohei Kawata, Shinya Sasaki, Best paer Awards, Japanese Siciety of Tribologist, 2024 (In Japanese)
5. Takahiro Tsukahara, Frontier Award, Fluids Engineering Division, the Japan Society of Mechanical Engineers, 2024 (In Japanese)
6. Masaaki Akamatsu, Young Engineer Award of the Division of Colloid and Surface Chemistry, The Chemical Society of Japan, 2024 (in Japanese)

Individual Research Topics

Masahiro Motosuke

“Controlled assemnbly of bionanoparticles using plasmonic bubbles”

When a focused laser beam with a wavelength corresponding to the absorption band is irradiated onto gold nanoparticles or nanostructures, localized surface plasmon resonance induces heating, resulting in the generation of microbubbles with several microns in size. This, in turn, triggers interfacial flows around the bubble, enabling the accumulation of suspended nanoparticles in the surrounding liquid. In this year, we focused on the accumulation of bio-nanoparticles and demonstrated that heat-resistant proteins can be accumulated without losing their functional properties.

Yoshikazu Homma

“Evaluation of structure and physical properties of water confined in nanospace of nanocarbon”

We use molecular dynamics simulations to analyze phase changes in two-dimensional nanostructured water existing on the surfaces of carbon nanotubes (CNTs) and graphene, and in one-dimensional nanostructured water existing in the internal space of CNTs. We aim at construction of phase diagrams of low dimensional water confined in nanospace.

Hideki Sakai

“Evaluation of Structure and Physicochemical Properties of Surfactant Adsorbed Films Formed at the Water/Oil Interface”

The structure and physicochemical properties of surfactant adsorption films formed at the water/oil interface are important factors that control dispersion stability of emulsions. However, effective analytical methods capable of evaluating these facctors have not yet been developed. In this study, the structure and viscoelastic behavior of the adsorption film formed by nonionic surfactants at the water/oil interface were evaluated using indirect Fourier transformation analysis of small-angle X-ray scattering (SAXS) data and interfacial rheological measurements. The correlation between the obtained results and the dispersion stability of emulsions was also investigated.

Takahiro Yamamoto

“Effects of the curvature of carbon nanotubes on the structure and thermodynamics of adsorbed water”

Adsorbed water on carbon nanotubes (CNTs) exhibits unique structural and thermodynamic properties because of surface curvature; however, the curvature dependence of these properties has not been fully clarified. In this study, we conducted classical molecular dynamics simulation to investigate the curvature effects on different adsorption states with as many as two water-layers. When the adsorption water layer is a single layer, the adsorbed water forms a rhombic crystalline ice structure, organizing into an ice nano-ring. Its melting point and dewetting temperature are dependent on the curvature of the CNT and the hydrogen bond distances. By contrast, when the adsorbed water forms two layers, the structure is an amorphous configuration primarily composed of pentamers and hexamers; this structure undergoes a glass transition and exhibits dynamic heterogeneity at temperatures near the glass transition temperature, irrespective of the curvature. This behavior corresponds to the solid-liquid crossover observed in photoluminescence experiments.

Hiroharu Yui

"Elucidation of the cooperative interactions for generating functions at water-materials' surfaces and interfaces by light scattering micro-spectroscopy"

Cooperative interactions between local water molecules and materials' surfaces and interfaces are investigated by light scattering micro-spectroscopy. Especially, the effects of the physical and chemical heterogeneities at their interfaces play the crucial roles for the generation of characteristic properties and functions. The surfaces and interfaces of organic & inorganic materials such as foam films, glasses, and the Earth and planetary substances are studied.

Tadashi Ando

"Evaluation and Refinement of Biomolecular Force Fields in the Generalized Born Implicit Solvent Model"

In molecular simulations of biomolecular systems, it is now a common approach to explore a wide conformational space using extended ensemble methods in systems employing explicit water models. However, this method presents a significant challenge due to its high computational cost. To address this issue, we are working on evaluating and refining force fields to ensure that simulations utilizing the Generalized Born implicit solvent model can achieve accuracy comparable to or exceeding that of explicit solvent models while enabling faster computations.

Yoshiyasu Ichikawa

"Measurement of complex flow behavior"

This study uses optical flow measurement techniques to reveal the complex flow behavior of viscoelastic fluids. We focused on the flow around micro-obstacles, and the velocity distribution in the low-speed regions between obstacles was obtained. Then, the correlation between each low-speed region's behavior was provided. Additionally, the relationship between the viscosity and shear rate was devised.

Ichiro Ueno

"On heat and mass transfer problems near solid-liquid-gas interface"

Dealing with (i) capillary-driven local acceleration of contact line after interaction with micropillar, (ii) high-density heat removal by subcooled boiling, and (iii) coherent structure formation by low-Stokes number particles in closed systems.

Hidenori Otsuka

"Relationship between hydration behavior and biocompatibility of ethylene glycol-modified surfaces"

In vivo, polyethylene glycol (PEG)-modified materials inhibit protein and cell adsorption and confer high biocompatibility, but their immune response reactions have recently become an issue. It is known that the biocompatibility of PEG changes its properties depending on the EG backbone structure. In this study, we investigated the effect of EG skeleton structure, such as linear type and comb type, on the biocompatibility of PEG.

Ken-ichi Katsumata

“Preparation and evaluation of Pd/α-FeOOH for water purification”

Photocatalyst was prepared by coating Pd on the surface of iron oxyhydroxide (α-FeOOH), and the generation of hydrogen peroxide and the adsorption and decomposition of methylene blue (MB), which was prepared as a simulated polluted water, were investigated. It was difficult to confirm the generation of hydrogen peroxide by light irradiation for Pd/α-FeOOH. On the other hand, under acidic conditions, the reduction catalytic action of Pd and photo-irradiation produced hydroxyl radicals, which contributed to the decomposition of MB.

Kizuku Kurose

“Heat transfer characteristics of flat plate heat pipe with closed meandering channel composed of sintered metal porous sidewalls”

A flat-type heat pipe with a closed meandering channel composed of sintered metal porous sidewalls was developed to enhance thermal performance. Its heat transport characteristics were evaluated through temperature measurements and high-speed flow visualization. The effects of liquid filling ratio, inclination angle of heat pipes, and thermophysical properties of working fluids on the heat transfer performance were systematically clarified.

Kenichi Sakai

“Sorption of water vapor to phospholipids under humidity-controlled environment”

The sorption of water vapor to phospholipids (DPPC) was evaluated using a humidity-controlled quartz crystal microbalance with dissipation monitoring (QCM-D) technique. When the temperature increased in a nearly constant humidity environment, the frequency gradually increased regardless of the presence or absence of DPPC. The corresponding energy dissipation values in the presence of DPPC significantly increased at high temperatures. This suggests that the dissipation factor can detect the phase transition of DPPC with high sensitivity.

Shinya Sasaki

“Study on the Mechanism of Low-Friction Behavior of Polymer Materials in Aqueous Solutions”

To reproduce the ultra-low friction phenomena observed on biological surfaces such as articular cartilage and mucous membranes on artificial surfaces in aqueous environments, this study aims to elucidate and replicate the underlying mechanism by measuring the nanostructures formed at the interface between aqueous solutions and solid surfaces using FM-AFM.

Isao Shitanda

“Analysis of Gel Phase Transition Behavior by Rheo-Impedance Method”

The phase transition behavior of poly(N-isopropylacrylamide) gel was analyzed using a rheometer. As the temperature was increased, a capacitive semicircle appeared due to the formation of a sea-island structure in the gel by the phase transition. The correlation between the shear stress and the resistance in the gel is expected to be a new parameter involved in the drug release.

Yutaka Sumino

“Pattern formation of a fluidic system under nonequilibrium condition”

In this research topic, we focused on the pattern formation of fluidic systems with chemical reactions, phase separation, molecular motors, and rheological changes. Such processes have a system under nonequilibrium conditions and create macroscopic patterns. In this fiscal year, we used a system with fingering instability caused by injecting reactive fluids. The permeability of fluids decreases due to the creation of precipitate. Such simple dynamics lead to essential nonlinearity to have fingering instability. We have verified such dynamics using numerical simulation of a simple mathematical model. We also studied droplet systems with active motions.

Makoto Tadokoro

“Study on Molecular Porous Single Crystals Exhibiting High Proton Conductivity via Encapsulated Dynamic Ionic Clathrate Hydrates”

Water clusters confined to porous molecular crystals possessing one-dimensional nano-channels have been found to adopt dynamic structures in a melting state due to the influence of the pore walls. We discovered that these water clusters can simultaneously dissolve electrolyte salts, thereby stabilizing a dynamic ionic clathrate hydrate (DICH). Unlike conventional ice-like ionic clathrate hydrates (ICHs), this DICH is already in a dissolved state, enabling the measurement of proton and other ionic conductivities at temperatures approaching the boiling point of water (around 100 ºC). As a result, DICH represents a distinct, water-based phase that holds promise for functional material development.

Takahiro Tsukahara

“Switching between supercritical and subcritical turbulent transitions in Taylor-Couette-Poiseuille flow”

We performed direct numerical simulations of Taylor–Couette–Poiseuille flow, which occurs between coaxial cylinders with inner-cylinder rotation and axial pressure-driven flow. Under high-radius-ratio conditions, a gradual increase in the axial pressure gradient led to a reverse transition from turbulence in the Taylor–Couette flow to a laminar state, followed by a transition to turbulence dominated by pressure-driven flow. This sequence was identified as a switching between supercritical and subcritical transitions. The anisotropy of the turbulent structures was evaluated using the Lumley invariant. The results provide valuable insights into the transition processes in complex shear flows.

Eiji Tokunaga

“Study of Mechanism of the Interfacial Water Pockels Effect”

We are conducting research to elucidate the physical mechanism that can predict the giant Pockels coefficient of water in the electric double layer at the electrode interface. This year, we investigated whether the Pockels effect of water at the interface of transparent oxide electrodes is dependent on water pressure and magnetic field, and found that there is little dependence at 1-3 atm and 0-2 T.

Shingo Machida

“Development of techniques for stabilizing functional powders in bulk materials”

Photocatalysts, adsorbents, and anti-bacterial materials are highly promising for applications beyond environmental remediation, such as water purification. However, their uses in powder form presents challenges in handling, stability, and practical implementation. To address this, I’m developing techniques to stabilize these functional powders with bulk materials—without detachment or loss of functionality. Such stabilization strategies are not only important for improving water environment on Earth.

Kazuhiko Miura

“Study on climate effects of atmospheric aerosols”

To investigate the effect of anthropogenic aerosols and background aerosols, we are conducting observations on the roof of TUS Building No. 1, and on Mt. Fuji, respectively. The particle concentration measured at the summit of Mt. Fuji in summer decreased to about one-third from 2006 to 2019. We are continuing year-round observations at Tarobo (altitude 1290m) at the foot of Mt. Fuji to see post-coronavirus changes. As a result, we found there was no tendency for a decrease in the total particle concentration in summer from 2017 to 2024, and nuclear mode particles increased in winter.

Makoto Yamamoto

“Study on Numerical Simulation of Icing Phenomenon”

Icing is a phenomenon in which supercooled droplets or ice particles in the atmosphere collide with a wall surface to form an ice layer on the wall surface. When icing occurs on an aircraft, it causes deterioration of aerodynamic performance and mechanical damages due to the collision of shed ice pieces, which causes a serious threat to flight safety. In our laboratory, we are conducting numerical simulation research on developing simulation methods for accurately predicting icing phenomena, evaluating anti-icing and de-icing technologies, and clarifying the impact behavior of droplets on walls and the solidification process.

Masaaki Akamatsu,

“Research on the creation of supramolecular ion sponge for recovery of harmful anions”

The safe use of water resources is an important issue in Goal 6 (Water and Sanitation) of the SDGs. Efficient removal technology for toxic and environmentally polluting anions is required, but conventional water treatment technologies are complicated and require special equipment. In this study, I used a reversible anion recognition system that utilizes the water interface to create a “supramolecular ion sponge” that can freely adsorb anions with general-purpose thermal stimulation. In the future, it is expected to be applied as a new harmful ion recovery technology that can reduce the amount of waste.

Yuki Araki

“Nanoscopic wetting of glass surfaces”

We evaluated the coexistence of nano water-droplets and nano water-film on glass surfaces under humid environment using frequency modulation atomic force microscopy (FM-AFM) and peak force tapping AFM. At low humidity, a water film forms on the glass surface, and the nano water-droplets appear on this film with increasing humidity. During this process, granule-like structures resembling those of weathered glass, as well as changes in the surface Young’s modulus depending on surface morphology, were observed across the glass surface. These findings suggest that dissolution of silica glass by adsorbed water may occur in ambient air. We plan to investigate the weathering mechanism in air in more detail under varying conditions.

Shigehito Osawa

“Polymer–Metal Complexes Aimed at Biomaterial Applications”

Construction of microenvironment, where metal complexes are locally concentrated state, in the aqueous solution by employing metal complexes into the side chains of water-soluble polymers. Evaluating and controlling the reactions in which this unique environment acts as a catalyst and its effects on biomolecules, we develop polymer metal complexes that can be used as biomaterial application including anticancer drugs and antibacterial agents,

Koichiro Kato

“Integration of data science and molecular simulation to study water on material surfaces and in polymer membranes”

Molecular simulations and data science are used to advance the understanding of water structure at the micro- and mesoscale. We have combined coarse-grained simulations and persistent homology to analyze water in fuel cell electrolyte membranes. The water channel structure obtained by coarse-grained simulation was successfully vectorized by persistent homology and linked to proton conductivity.

Shouhei Kawada

“Effect of humidity of lubricating performances of ionic liquids”

The humidity in the friction atmosphere affected the lubricating properties of ionic liquids. In order to prevent the adsorption of ionic liquids on friction surfaces, this topic change the friction environmentsuch as a vacuum, inert gas, or dry air. In addition, it was found that using hydrophobic ionic liquids also demonstrated good lubricating properties even in high humidity environments.

Kengo Manabe

“Functional Surface Development Utilizing Wettability”

We conduct research focused on elucidating phenomena at surfaces and interfaces, particularly concerning surface wettability, and on creating functional composite materials based on these principles. Our work primarily involves linking biomimetics with wettability functions, studying the creation of regular, bio-inspired nano/microstructures, and investigating liquid behavior on these surfaces. Specifically, in this fiscal year, we fabricated bio-inspired honeycomb layered structures using 3D printing. We then applied nanomaterial coatings onto these structures via layer-by-layer deposition. By utilizing the honeycomb walls as barriers to inhibit the detachment of the nanomaterials, we successfully created durable surface structures exhibiting functional wettability.

Tatsuhiro Mori

“Characteristics of charge distributions of submicron atmospheric particles at Noto Peninsula, Japan”

The number concentrations of charged and non-charged particles were measured to estimate the charge distribution of submicron atmospheric particles at Noto Peninsula, Japan, in 2023, using a system combining a parallel-plate particle separator and optical particle counters. The average particle charge number, obtained by fitting the estimated particle charge distribution with a Gaussian distribution, varied significantly with the atmospheric electric field and the ratio of the positive polar conductivity to the negative polar conductivity in the atmosphere. It indicates that charged particles can be efficiently produced in the atmosphere due to the collision charge between ions and particles under the conditions of high electric field. These findings allow a significant improvement in the spatiotemporal distributions of the charged particles.

Yasutaka Yamaguchi

“Wetting and momentum and energy transport at liquid-related interfaces from microscopic viewpointand macroscopic”

I work on the theoretical analysis of microscpic physics of wetting and momentum and energy transport at liquid-related interfaces by using molecular dynamics (MD) simualtions. The topics are extended to dynamic flows induced by evaporation and surface-tension gradient. I also elucidate the mechanism of velocity slip and friction at solid-liquid the interface by MD.

Ken Yamamoto

“Experimental Study Aimed at Elucidating Droplet Dynamics”

The objective of this research project is to experimentally elucidate the dynamics of droplets under conditions where they experience impact or undergo phase changes due to heating. In the current fiscal year, experiments were conducted on the impact of droplets on wet granular beds composed of solid and liquid phases. It was revealed that the behavior differs significantly from impacts on surfaces composed solely of solid material. Additionally, these behaviors were summarized in a phase diagram, and the threshold values defining the boundaries between phases were determined through scaling analysis.

Naoki Watanabe

“Improvement of usability of the Water-Interface Integrated Simulator”

The water-interface integrated simulator we have developed is an integrated simulation tool designed to facilitate numerical simulation analyses of the structure, behavior, and properties of water molecules at material interfaces. We have been utilizing this simulator with researches in WaTUS, and have improved several usability issues identified through its use, such as, handling of errors in molecular dynamics calculations, adjusting the initial positions of water molecules, visibility of graphs for calculation results, responsiveness during data analysis processing, and support for prolonged molecular dynamics calculations.

Soichiro Fujimura

“Computational Approaches for Optimizing Surgical Treatment in Cerebrovascular Diseases”

In this research topic, numerical simulation techniques such as computational fluid dynamics (CFD), computational solid mechanics, and medical image analysis are applied to optimize surgical treatments. By integrating engineering methods into the medical field, the research aims to improve both safety and cost-effectiveness. In cerebrovascular diseases, where hemodynamics and device mechanics significantly influence pathology and prognosis, quantitative simulations provide objective support for diagnosis and treatment. Additional efforts include developing predictive models using statistical analysis and machine learning, as well as optimizing procedures through 3D printing of patient-specific anatomical models.

Shu-hei Urashima

“Development of Sensitive Spectrosopy with a Straightforward Optical Confiquration”

As a research fellow at the Japan Atomic Energy Agency, I developed a simple and highly sensitive absorption spectroscopy technique. In this spectroscopy, a probe light at a wavelength that the solution does not absorb and a pump light at a wavelength that is absorbed are focused on an interface of a transparent material and aqueous solution. Because the temperature coefficients of the refractive index differ between the substrate and the aqueous solution, the heat generated by the absorption of the pump light can be detected as a change in the reflectance at the substrate/solution interface. Applying this method to a dye solution allowed us to achieve a detection limit of 75 nM.

Nucleic Acid Drug Discovery Center

Nucleic Acid Drug Discovery Center

1. Overview

Nucleic acid drugs are gaining attention as a new medicine modality following low-molecular-weight and antibody drugs, and research and development are progressing worldwide. The research fields necessary for developing nucleic acid drugs are diverse, but our university has outstanding researchers in each field. This research center brings together these researchers and strengthens external collaborations to promote the development of nucleic acid drugs unique to our university. The center aims to establish new chemical modification-based nucleic acid synthesis methods, develop artificial molecules to stabilize nucleic acid drugs, and establish drug delivery systems (DDS) and formulation techniques to create new medicines targeting new diseases. Additionally, the center has selected disease areas related to cancer, the immune system, and metabolism as targets for these nucleic acid drugs. It is developing new treatment methods using nucleic acid drugs.

2. Organization and Facilities

The Nucleic Acid Drug Discovery Center is led by Dr. Wada, who has extensive experience establishing a nucleic acid drug discovery venture based on proprietary nucleic acid synthesis technology and in the clinical development of nucleic acid drugs. The center focuses on research and development in the following areas: nucleic acid drug dynamics control (Dr. Nishikawa), design and application of antisense nucleic acid drugs (Dr. Torigoe), polymer carriers for nucleic acid drugs (Dr. Otsuka), formulation of nucleic acid drug molecules (Dr. Hanawa), immune system control using nucleic acid drugs (Dr. Nishiyama), metabolism of nucleic acid drugs (Dr. Higami), cancer therapy using nucleic acid drugs (Dr. Akimoto), target identification and design for nucleic acid drugs (Dr. Miyazaki), RNA editing drug discovery (Dr.Sakurai), immune response to nucleic acid drugs (Dr. Harada), synthesis of nucleic acid-related molecules (Dr. Yoshida), development of new DDS for nucleic acid drugs (Dr. Kusamori), and device design related to DDS for nucleic acid drugs (Dr.Akita). Collaborative research among researchers within the center is already underway or planned (Figure 1).

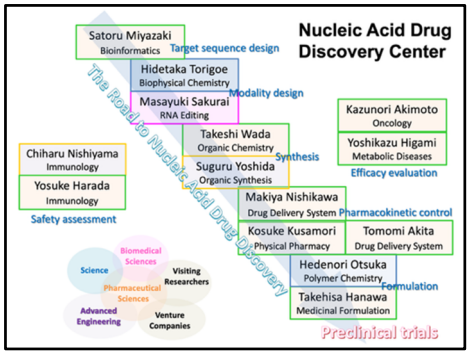

Fig. 1. Members of the Center

The Center fully has the necessary facilities for synthesizing nucleic acid drug molecules. Additionally, it possesses a nuclear magnetic resonance spectrometer (Bruker, AVANCE NEO 500) at Building 18 on the Noda Campus and a mass spectrometer (Waters, Cyclic IMS) at Building 10 on the Noda Campus, enabling structural analysis of synthetic samples and complex biomolecules.

3. Activity Reports

3. 1. Joint Symposium of Nucleic Acid Drug Discovery Center

- ***Development of superior cell and DDS for regenerative medicine***

Date: 7/12/2024

Venue: Fujimi Building, Kagurazaka Campus, Tokyo University of Science

Summary: The Nucleic Acid Drug Discovery Center held a joint symposium with the Development of Superior Cells and DDS for Regenerative Medicine Division. By holding the symposium jointly across the boundaries of the Center and the Division, the event aimed to share new insights and information, thereby strengthening future collaborative research efforts.
Invited lecturers: Prof. Yasuhiko Tabata (Kyoto University)
Prof. Mitsuhiko Shioya (Tokyo University of Science)
Prof. Masaaki Komatsu (Juntendo University)

4. Challenges and Prospects

We will further promote joint research targeting specific areas such as pancreatic cancer, breast cancer, skin wound healing, and COVID-19, which are currently underway at the center, while also advancing research into the application of nucleic acid drugs to fields such as the control of the immune system and lipid metabolism. Furthermore, we have established a method for synthesizing boranophosphate nucleic acids, next-generation nucleic acid drugs expected to replace phosphorothioate nucleic acids, by strictly controlling the stereochemistry of phosphorus atoms. We will further verify their application to antisense nucleic acids and their safety and efficacy. Additionally, we will develop platform technologies such as high-functionality nucleic acids and new drug delivery systems (DDS) utilizing DNA nanotechnology.

5. Conclusion

At this center, we are bringing together the collective wisdom of researchers in nucleic acid medicine and related fields, transcending the boundaries between departments and faculties, with the aim of practical application of nucleic acid medicine, which is attracting attention as a next-generation medicine. There are no other examples of attempts to develop nucleic acid medicine within a university research team, and it can be said that this is a research organization that can only be realized at this university. We will promote research to create nucleic acid medicine from our university.

Major Research Achievements (FY2024)

Academic Papers

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2. DNA/RNA heteroduplex technology with cationic oligopeptide reduces class-related adverse effects of nucleic acid drugs, Masahiro Ohara, Tetsuya Nagata, Rintaro Iwata Hara, Kie Yoshida-Tanaka, Nozomi Toide, Kazunori Takagi, Kazuki Sato, Tomoya Takenaka, Masanori Nakakariya, Kenichi Miyata, Yusuke Maeda, Kazuko Toh, Takeshi Wada, Takanori Yokota, Mol. Ther. Nucleic. Acids, Vol. 35, pp102289, 2024 (Peer-reviewed)
3. Development of cationic oligodiaminogalactoses specifically binding to duplex RNA, but not to duplex DNA, Hidetaka Torigoe, Sumire Nakayama, Tomomi Shiraishi, Kazuki Sato, Rintaro Iwata Hara, Takeshi Wada, Thermochimica Acta, Vol. 738, pp179789, 2024 (Peer-reviewed)
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5. Baicalin-induced hepatocyte toxicity: The critical role of multidrug resistance-associated protein 2, Naohiro Oshima, Kosuke Kusamori, Ryo Takasaki, Noriyasu Hada, Makiya Nishikawa, Integr. Med. Discov., Vol. 9, e25001, 2025 (Peer-reviewed)
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9. Survey and Consideration for Evaluation of Tissue Distribution and Plasma/Serum Protein Binding of Approved Oligonucleotide Therapeutics, Shunji Imai, Yasufumi Fukano, Yutaka Niwayama, Naomi Tamura, Mika Miyoshi, Kei Fukuhara, Hiroshi Kodaira, Norihiko Iwazaki, Yosuke Yamanaka, Norihiro Miyazawa, Hideo Takakusa, Kenta Kadotsuji, Akihiko Goto, Shunsuke Shimada, Tokuyuki Yoshida, Satoshi Obika, Makiya Nishikawa, Takao Inoue, 医薬品医療機器レギュラトリーサイエンス, 55(3), 208-209, 2024 (in Japanese) (Peer-reviewed)
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Individual Research Topics

Takeshi Wada

“Stereoselective synthesis of ProTides”

ProTides are 5'-phosphoramidate nucleotide prodrugs bearing an *O*-aryl group and an amino acid ester. The representative Protides include Remdesivir and Sofosbuvir. These ProTides have a chiral phosphorus center and thier stereoselective synthesis remain challenging. Recently, we have developed a highly stereoselective synthesis of ProTides using an oxazaphospholidine method. The method afforded ProTides with a high stereocelectivity within short reaction time.

Kazuki Sato

“Solution-phase synthesis of boranophosphate DNAs”

Boranophosphate (PB) DNAs are attractive candidates for antisense oligonucleotides due to thier high nuclease resistance and low cytotoxicity. In our laboratory, an *H*-boranophosphonate method was developed for an efficient synthesis of PB-DNAs. However, there is an issue for scalability because *H*-boranophosphonate method was conducted on a solid-support. To address this issue, we have investigated a solution-phase synthesis of PB-DNAs and PB-DNAs up to 12mer were obtained at mg scale.

Makiya Nishikawa, Shoko Itakura

“Efficient delivery of immunosuppressive nucleic acids to antigen-presenting cells”

A151, an immunosuppressive oligodeoxynucleotide (Sup ODN), was modified with stearic acid (SA) to improve its efficacy. SA-modified A151 showed higher binding to serum albumin than phosphorothioate-modified A151. Cytokine production in mouse macrophage-like cell line RAW264.7 cells and in the inguinal lymph nodes of inflammatory model mice was efficiently inhibited by SA-modified A151. These results indicate that SA modification enhances the immunosuppressive activity of A151 through its delivery to antigen-presenting cells.

Shoma Tamori, Kazunori Akimoto

“Identification of cancer prognostic markers and elucidation of molecular functions in cancer stem cells using cancer genomics databases.”

To identify the biomarkers for the early detection and targeted molecules in refractory cancers, we have analyzed cancer genomics databases by data science techniques to isolate prognostic marker candidates and therapeutic target molecules for oligonucleotide therapeutics. In 2024, we isolated SLC20A1 as a new candidate molecule in PDAC. Furthermore, we also proceeded with the function analysis in cancer stem cells of prognostic marker candidates isolated by 2023 and therapeutic target molecule candidates of oligonucleotide therapeutics. In 2025, we will continue to aim to isolate new candidates and advance the functional analysis of molecules that have already been isolated.

Takehisa Hanawa, Kaoru Hirose

“Application of water-soluble polymers as drug carriers”

Xyloglucan, a water-soluble polymer derived from tamarind seeds, is known to gel when combined with polyols and polyphenols. We discovered that it gels when combined with tea catechins, which are a component of tea extract, and that it has potential applications in oral mucosal treatment agents. In the future, we aim to demonstrate its therapeutic effects through administration to mice with oral mucositis models and cell experiments.

Hidenori Otsuka

“Synthesis of gold nanoparticles for all-in-one nano DDS loaded with target-directed macromolecular metal complexes and their anti-lung cancer potentiation of activity and reduction of side effects”

Glycans are present on all cell surfaces and serve as intermediaries for communication with the outside of the cell. Glycan-protein interaction is a central interaction. The application of this interaction to drug delivery systems is still in the process of exploring its potential. In this study, we targeted sugar-binding proteins (lectins) present in cells and tissues, and found that biocompatible and low-toxicity polymeric sugar polymers are important materials that can open the door to DDS.

Hidetaka Torigoe

“Development of the method to artificially repress target gene expression based on quadruplex nucleic acid formation”

G-rich nucleic acids may form G-quadruplex. G-quadruplex is composed of at least two layers of G-quartets, where four guanines are aligned in a cyclic square planar arrangement via Hoogsteen hydrogen bondings. A G-rich sequence in the promoter region of the DNA genome of HIV-1 provirus may form G-quadruplex. The expression level of luciferase gene under the downstream region of the formed G-quadruplex derived from the plasmid in 293T cells was significantly repressed upon the increase in the quadruplex-binding ligand concentration.

“Artificial repression of ZNF746/PARIS protein expression by antisense technology”

ZNF746/PARIS plays a role in regulation of neuron death, and it is associated with Hepatocellular carcinoma. Accumulation of ZNF746/PARIS is associated with Parkinson’s disease. Thus, artificial repression of ZNF746/PARIS expression can be a promising therapeutic target for these diseases. The expression level of mouse ZNF746/PARIS gene derived from the plasmid in 3T3-L1 cells was significantly repressed upon the addition of 0.03 μM antisense nucleic acid. RNaseH may be involved in the repression.

Chiharu Nishiyama, Kazuki Nagata

“Anti-allergic effects of polyphenol, kaempferol”

We identified kaempferol as the most effective activator of RALDH2 expression in dendritic cells through a screening of food ingredients. Kaempferol antagonized Aryl hydrocarbon receptor and activated transcription factors PU.1 and IRF4 in dendritic cells, resulting in enhancement of Treg in vivo and in vitro. We also confirmed that oral administration of kaempferol prevented food allergy in mice. (Allergy 2025)

“Anti-inflammatory effects of a lactic acid bacteria metabolite”

We found that polyunsaturated fatty acid acquired anti-inflammatory effect through enzymatic metabolite by a lactic acid bacterium. The most effective metabolite, gKetoC, suppressed the activation of dendritic cells via the NRF2 pathway and GPCRs. In addition, oral administration of gKetoC ameliorate inflammatory bowel disease in wild-type mice but not in Nrf2 deficient mice. (Front. Immunol. 2024)

“Transcriptional regulatory mechanisms determining commitment between basophils and mast cells”

To elucidate the mechanisms that determine the commitment between basophils and mast cells, transcription factors and epigenetic modifications regulating the gene expression of basophil-specific enzymes, Mcpt8 and Mcpt11, were analyzed. We revealed that the transcription factor C/EBPα positively regulated the gene expression of Mcpt8 and Mcpt11, which were upregulated by histone deacetylases and downregulated by DNA methyltransferases. Gata2 knockdown significantly reduced the mRNA levels of Mcpt8 and Mcpt11, while TGF-β treatment increased those of Mcpt8 and Mcpt11. (FEBS Lett. 2025)

“Immunostimulatory effects of a spore-forming lactic acid bacterium”

We found Heyndrickxia coagulans SANK70258 (in collaboration with Mitsubishi Chemical, Co.) exhibited the highest immunostimulatory activity compared with 7 types of lactic acid bacteria. The peptidoglycan-related fractions of SANK70258 components stimulated dendritic cells via pattern recognition receptors, and induced release of IL-12 and IL-23 from dendritic cells, resulting in the enhanced production of IFN- g from NK cells and IgA from B cells. Oral administration of g-ray-irradiated SANK70258 to mice significantly increased the amount of IgA in the intestine and the number of IgA-expressing B cells in the Peyer’s patch. (Biosci. Biotechnol. Biochem in press)

Yohsuke Harada

“Mechanisms of intestinal epithelial barrier disruption caused by Treg abnormalities”

It is well established that the dysregulation of regulatory T cells (Treg) causes intestinal inflammation. This inflammation is believed to result in the disruption of the intestinal epithelial barrier, which can further exacerbate the inflammatory response. Our study revealed that the disruption of the intestinal epithelial barrier caused by Treg dysfunction could be mitigated by IL-4Rα deficiency. Furthermore, it was also found that IL-13, a ligand for IL-4Rα, was responsible for the intestinal barrier disruption. These findings suggest that IL-4Rα and IL-13 may serve as a promising therapeutic target for inflammatory bowel disease.

Kosuke Kusamori

“Development of cell-based nucleic acid delivery system”

We previously reported that nanoparticles modified on the surface of mesenchymal stem cells (MSCs) were efficiently delivered to cancer cells in co-culture experiments. Here, we demonstrated that MSCs modified with lipid nanoparticles (LNPs) which contained siRNA targeting firefly luciferase gene (siLuc) efficiently inhibited the luciferase activity in luciferase-expressing cancer cells compared to siLuc-containing LNPs.

Suguru Yoshida

“Click Chemistry for the Chemical Modification of Biofunctional Molecules”

We have developed efficient methods for the chemical modification of biofunctional molecules such as nucleic acids to add multifunctionalities. Indeed, we have synthesized new platform molecules having clickable functional groups, which served in the sequential conjugations by triple click reactions. Further studies for applications including the dual modifications of biomolecules such as nucleic acids are ongoing in our laboratory.

Masayuki Sakurai

“Elucidation of Nucleic Acid-Protein Interactions Regulated by Nucleic Acid Base Editing”

Focusing on the dynamics of dsRNA and DNA:RNA hybrid chains within cells. We propose a gene network connected by nucleic acid base modifications, aiming to elucidate a gene expression optimization system where ADAR-mediated A-to-I base editing modifies nucleic acid structure, sequence function, and binding factors. Particular attention is being paid to DNA damage repair mechanisms linked to cellular carcinogenesis and RNA-dependent transcriptional control mechanisms, with efforts underway to elucidate the molecular mechanisms involved.

“Identification of Adenosine Deamination Editing Regions in RNA:DNA Hybrid Double Strands”

The genetic code is described by four nucleotides: A, G, C, and T (U). However, cells contain the enzyme ADAR, which deaminates adenosine, resulting in the conversion of A to G and the editing of adenosine to inosine, which is synonymous in sequence. We have recently discovered that ADAR acts not only on RNA but also on DNA that forms a complementary strand with RNA. In this study, we have developed a unique method for identifying inosine, enabling the labeling and purification of trace amounts of inosine, and are advancing the comprehensive identification of inosine sites in DNA.

“Technology for introducing artificial A-to-I base editing into arbitrary nucleic acid sites”

In this study, we are elucidating the molecular mechanisms of A-to-I RNA and DNA editing and applying them to develop a base editing introduction technology targeting any intracellular RNA and DNA. We aim to develop A-to-I editing guide nucleotides for drug discovery with potential applications in genetic engineering, cancer mutations, single-gene mutation diseases, and antiviral technologies.

Yang Yuxi

“Development of a chemical labeling method for inosine detection”

Identifying A-to-I base editing is challenging due to errors in enzymatic reactions and sequence analysis, making it difficult to ensure accuracy through sequence analysis alone. To address this, this study developed ICLAMP (Inosine Chemical Labeling and Affinity Molecular Purification), a chemical modification method specific to inosine. This method selectively labels inosine using maleimide derivatives, enabling efficient enrichment and identification of editing sites. We will advance the comprehensive identification of RNA and DNA editing in human tissues and cells using this technology.

Tomomi Akita

“Involvement of biological rhythms in the differentiation-inducing effect of activated vitamin D3 for efficient COPD treatment”

In our previous study,we found that active vitamin D3 (VD3) showed alveolar repair effects in a mouse model of COPD. Therefore, in order to aim for an efficient COPD treatment using chronotherapy, we investigated whether biological rhythms are involved in the differentiation-inducing ability of active VD3. As a result, no effect of the time of treatment with active VD3 on the differentiation-inducing effect was observed, but it was revealed that active VD3 affects the circadian rhythm of clock genes and vitamin D receptors, which are the action points of active VD3, in cells after differentiation induction.

Yoshikazu Higami, Yuka Nozaki, Yuhei Mizunoe

“Analysis of adipose tissue energy metabolism variability in obesity and age-related lesions”

In recent years, white adipose tissue has been shown to be not only an energy storage site but also an endocrine tissue that is important for individual metabolism.We have previously identified several mitochondria-associated proteins, E3 ligases, whose expression in white adipose tissue fluctuates in response to obesity and ageing.In this study, we will generate mice genetically engineered for these proteins to elucidate how abnormal energy metabolism in adipose tissue is related to obesity and ageing pathologies.

Satoru Miyazaki

“Proposal of designing nucleica cid drugs for VIRUSES in sillico”

We focused on nucleotide sequences present in SARS-CoV-2, which are less frequently found in humans, for their suitability as targets to avoid off-target effects by targeting SARS-CoV-2.

Based on the five representative sequences for each type, We identified the locations with 12 or more consecutive 10-nucleotide sequences with a frequency less than 100 times, and determined two potential target sequences from the sequences common to all five types. The two sequences were examined structurally by using a secondary structure prediction tool, toxicologically by converting them to sequences with high frequency in humans, and avoidance of folding by GC content calculation. As a result, two sequences were obtained as candidates. We will try to study the hepatotoxicity and nephrotoxicity of these drugs by machine learning methods.

Yoshio Nakano

“Developement of novel machine learning approach to predict human proteases that cleave the spike protein of SARS-CoV-2”

Cleavage of the SARS-CoV-2 spike protein by host proteases is essential for SARS-CoV-2 to efficiently infect host cells. Several such host proteases have been found, including TMPRSS2, Cathepsin L, and furin. However, searching for other proteases that can cleave spike proteins by biochemical experiments is very time-consuming. Therefore, there is a need to establish an in silico analysis method. It is also essential to provide the output of the analysis method in an easily interpretable format such as cleavage probability. In this study, we proposed logistic regression using Elastic Net as a search method for proteases that cleave SARS-CoV-2 spike protein and validated the method. The results showed that although the performance in 5-fold cross-validation was good, it only partially reproduces the results of the biochemical experiments.

“Development of therapeutic drugs for SARS-CoV-2 using infrequent sequences in human genes”

This study attempts to search for effective nucleic acid therapeutics against SARS-CoV-2. In this filed, studies have been focused on the sequence specificity of RNA, however, few studies have been conducted with off-target effects from the design stage. Therefore, to develop targets for nucleic acid therapeutics, bioinformatics is used to investigate sequences present in the SARS-CoV-2 genome and less abundant in human pre-mRNAs, ncRNAs, and mRNAs.

Research Center for Space System Innovation

Research Center for Space System Innovation

1. Overview

By bringing together our research and education activities related to space development and space environment utilization at Tokyo University of Science, we have established a research center for comprehensively studying various technological issues, ranging from basic research to ways of traveling into space.

Specifically, with the following goals in mind, we aim to build a place for co-creation where cross-disciplinary technologies and human resources can be brought together to form a virtuous cycle between the earth and space, in order to solve various issues common to both space and earth (Fig. 1).

- By utilizing photocatalytic technology, which is one of the specialties of our university, we aim to develop life-support technologies in space and to realize a safe and comfortable living environment on earth.
- We will work on demonstrating technologies in space using suborbital spaceplanes under development and the International Space Station, and develop a new “space” market in partnership with industry.
- The Research Center for Space Colony, which has been researching and developing space-stay technologies, will shift its focus to “dual development on earth and in space and the development of space vehicles to bridge the two,” to achieve further strategic development.
- We will provide a place for education based on these research opportunities connected to space, secure and foster Ph.D students and young researchers, and build an environment where they can experience “real” research.

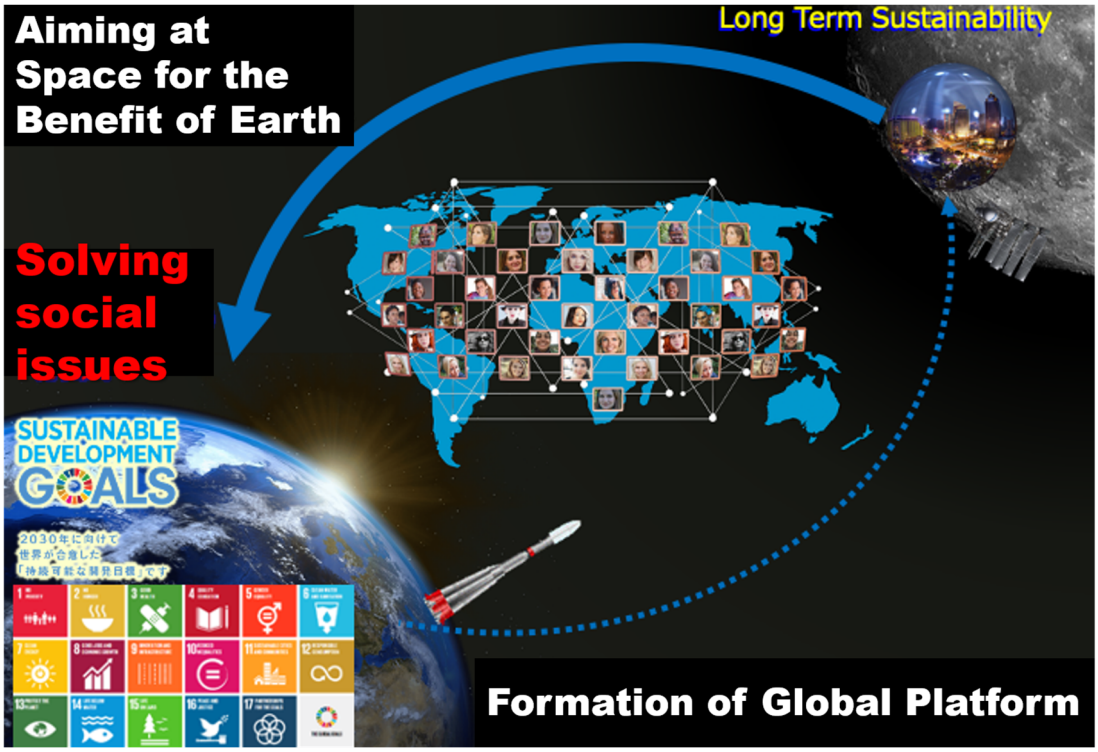

Fig. 1. Dual development on earth and in space.

2. Organization and Facilities

The Research Center is engaged in collaborative research between its four units and coordinates the technologies produced by its research and development processes (Fig. 2). The technologies are rapidly transferred to applications which can effectively utilize them and realize technological advancement that can be used on Earth as well as in the future for usage in space.

Education Unit

"Education utilizing "real" technology and experience that leads to actual use in space"

Utilizing the technologies and research of Tokyo University of Science, such as flight missions, rocket launches, theoretical research in astrophysics, and astronomical observations, for the purpose of education is a great incentive for both researchers and students. In addition to participating in a number of missions, we will work in close cooperation with domestic and international space development organizations, space venture companies, and space development companies, and will actively utilize the results obtained for education.

Photocatalysis International Unit

"Solving resource and environmental problems based on photocatalysis"

Photocatalysts, such as titanium dioxide, are effective for decomposing organic pollutants and have antibacterial and disinfecting properties, due to their strong oxidative decomposition power. In addition, research on artificial photosynthesis using photocatalysts (hydrogen production by water decomposition and generation of valuable substances by carbon dioxide reduction) is being actively conducted. By advancing these studies, we will tackle existing issues on earth that must also be overcome when entering space, such as environmental purification and energy production.

Space Colony Unit

"Advancement of space-stay technologies and promotion of social use, with a focus on space habitation"

We will conduct cross-disciplinary research and development of various technologies related to clothing, food, and housing that have not been directly related to space so far, as well as infrastructure construction technologies in closed environments, such as electric power and telecommunications. In addition, we will collaborate with companies and research institutes on the applied development of space-stay technology designed to allow humans to stay in an extreme closed environment for a long time, aiming to solve social issues such as disasters and food problems on earth, which are common issues for humanity.

Spaceplane Unit

"Development of spaceplanes that allow anyone to travel to and from space"

The Spaceplane Unit conducts research and development on system integration, including system optimization technology, fault-tolerant systems, LOX/LNG engine operation, autonomous navigation technology, composite airframes and propellant tanks, and the legalization of commercial space transportation, all of which are necessary to allow anyone to travel freely to and from space using spaceplanes just like using an airplane, under the slogan "Space is for everyone."

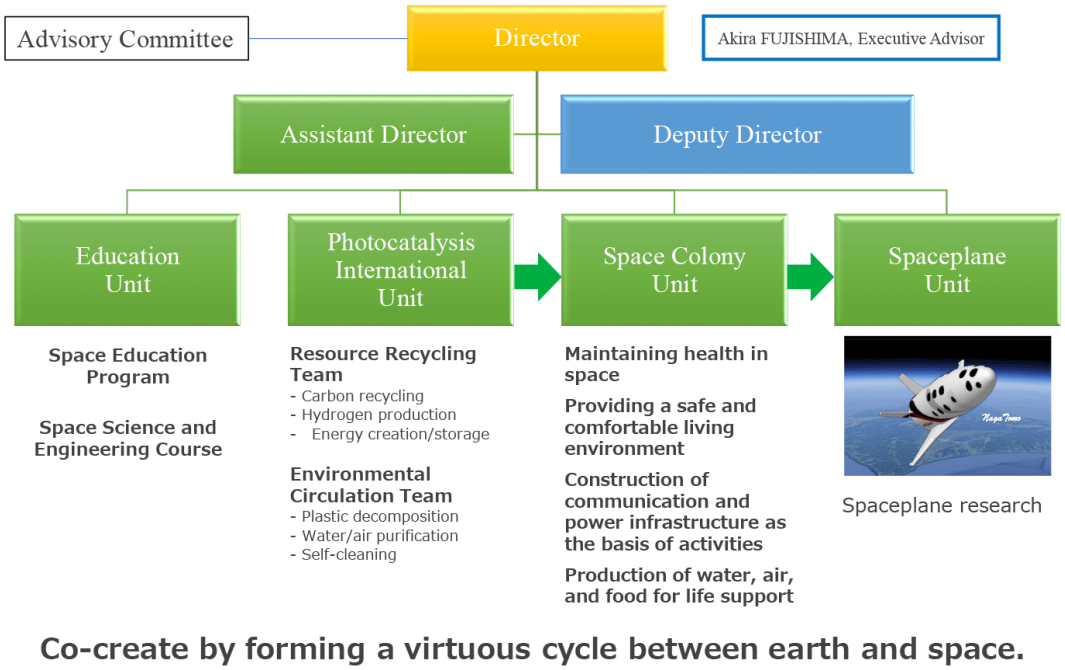

Fig. 2. Research Center for Space System Innovation's structure.

The facilities of the Research Center for Space System Innovation include Building 22 of the Research Center for Space System Innovation, which is comprehensively engaged in research on resource circulation and environmental cleanup.

3. Activity Reports

3. 1. Education Unit

Under the Ministry of Education, Culture, Sports, Science and Technology's (MEXT) Space and Aeronautics Science and Technology Promotion Commissioned Program titled "Human Resource Development Program for Space and Aeronautics," we proposed and were selected for a space education project "Bootcamp in Oita: Developing Talent to Lead Space-Oriented Business," in collaboration with Oita Prefecture and Kunisaki High School. The program began in fiscal year 2024.

In the project high school students and university students who act as their mentors engage in mission-based learning (MBL) through a series of bootcamps. These activities include space business workshops and experimental opportunities such as parabolic flights, featuring participation from professionals at the forefront of commercial space business partner, such as Sierra Space. The students themselves propose missions, design experimental plans, develop equipment, and carry out the missions, thereby fostering talent capable of driving private-sector space utilization and leading the emerging space industry. The program also aims to train educators and mentors capable of nurturing such talent.

In fiscal year 2024, the program selected 16 high school students and 6 university students through an open call. Additionally, a student-run venture company spun off from the Space Education Program, named "Uchu No Manabiya Seed". Over the course of four bootcamps, participants conducted parabolic flight experiments and space business workshops. The program received high praise from external evaluators and business partners and was widely covered in the media.

Furthermore, “Uchu No Manabiya Seed” secured contracts for events such as the “Summer Starry Sky Stay” that is an educational lodging event at Hotel Chinzanso and a space-themed event at the Adachi Lifelong Learning Center, achieving commercial deployment of educational content developed through the Space Education Program.

In addition, established university courses titled “Space Education Program Lecture” and “Space Education Program Seminar” were offered within the Graduate School of Science and Engineering, alongside an open college lecture series on space.

3. 2. Photocatalysis International Unit

The symposium on Photocatalysis was held on 12th December 2024, with the concerted efforts of this unit. Total number of participants was 218. Based on a rigorous review process, the student poster awards were selected, in order to encourage the young researchers.

Photo 1. Symposium opening ceremony.

3. 3. Space Colony Unit

The Space Colony Unit participated in the habitation team of the concept study activities under the Next-Generation Concept Study conducted by the JAXA Tansa Innovation Hub, and the outcomes of these activities were reflected in the habitation part of the international space exploration scenario.

As a result of research and development under the Gundam Open Innovation project “Team Space Life,” four flight models of a small decentralized autonomous environmental sensor (TEM: TSL Environment Monitor) were developed, with the aim of conducting two experiments aboard the Japanese Experiment Module Kibo on the International Space Station during fiscal year 2025. The first launch was carried out on April 21, 2025, via a SpaceX resupply mission, and experiments are scheduled for May 8 and May 16 (as of May 3, 2025).

Additionally, the Gundam Pavilion's official pamphlet for Expo 2025 Osaka introduced "Team Space Life" of Gundam Open Innovation, featuring a two-page bilingual (Japanese-English) interview with the Director of the Center for Space Systems Innovation.

In the field of space habitation R&D, the development of an inflatable module aimed at constructing a space habitation base—conducted jointly with Shimizu Corporation and Taiyo Kogyo—was advanced as part of the full-scale R&D phase (RS) of the Ministry of Land, Infrastructure, Transport and Tourism's STARDUST Program. This effort focused primarily on the examination of materials and joining methods.

In connection with this, under the Moonshot Project Goal 3—"By 2050, realize a co-evolving AI and robotic system capable of autonomous learning and coexistence with humans" (Project Director: Professor Toshio Fukuda)—the subproject led by Professor Yoshida titled "Self-Regenerating AI Robots for Lunar Exploration and Base Construction" progressed with the development of the Homeostatic Inflatable Autonomous Structure (HIDAS). HIDAS is composed of autonomously distributed cells forming inflatable structures with homeostasis, adaptability, and agency. Two demonstration experiments were conducted at the Space Exploration Test Building of the JAXA Institute of Space and Astronautical Science (ISAS), and the project received media coverage.

Furthermore, research outcomes were presented at international conferences, including three presentations—one of which was an invited talk—at the International Astronautical Congress, the world's largest aerospace conference, garnering significant attention.

3. 4. Spaceplane Unit

Regarding the research and development of unmanned suborbital space planes for scientific missions and small satellite launch missions, the Ministry of Education, Culture, Sports, Science and Technology's "SBIR (Small Business Innovation and Research) Space Field (Development and Demonstration of Private Rockets)" was announced in September 2023. After being selected (Phase 1: 2 billion yen until September 2024), we are collaborating with Kawasaki Heavy Industries, IHI, Toray Carbon Magic, Air Water Hokkaido, and nearly 40 domestic and international companies, universities, research and development organizations, etc. In a collaborative system, we proceeded with the development of innovative technology and at the same time began full-scale basic design. From July 2024, we will proceed to detailed design with the aim of starting manufacturing.

In the "flight demonstration of LNG propulsion system using the small experimental rocket aircraft WIRES", which has been carried out as a joint research between Tokyo University of Science and JAXA, we have begun manufacturing the experimental winged rocket aircraft WIRES#015 and flight tests are scheduled for fiscal year 2026. There are plans to conduct a recovery system test using a helicopter at the Self-Defense Force training range, and an avionics system test over Lake Biwa in Shiga Prefecture in the winter.

We are collaborating with the German Aerospace Center DLR Augsburg to develop the world's first composite liquid oxygen tank using a liquid oxygen compatible composite material for which we have applied for an international patent, and with the German Fraunhofer Research Institute to develop a composite liquid methane tank. We are proceeding with prototype production, and plan to conduct performance evaluation tests.

4. Challenges and Prospects

The Research Center for Space System Innovation is a large-scale research center with over sixty associated researchers. These researchers have been active in the Educational, Photocatalytic, Space Colony,

and Spaceplane Units. These people have produced significant science and technology and achieved remarkable results (See the Important Research Results page). For this term, we have selected several large-scale projects in the space field: the “JST Moonshot Research and Development Program,” and the “GUNDAM Open Innovation -TEAM SPACE LIFE-” are prom fostering type oting research and development on space habitation. Unfortunately, JST COI-NEXT ended as a, but companies aiming for space came together and formed the Space Colony Research and Development Union. To continue and success of these projects and union activities is recognized as a vital task in realizing the vision of the directors of the Research Center for Space System Innovation.

Next year, the organization’s goal is to construct systems conducive to cooperation both inside and outside the school by implementing the same research activities as this year and by presenting the technological capabilities of the Research Center to the outside world by enhancing its activities on a global platform.

5. Conclusion

The Research Center for Space System Innovation is aiming to construct a global platform capable of aggregating cross-disciplinary technologies and people of talent by forming “A virtuous cycle between earth and space.”

We are accelerating our initiatives for the realization of future space habitation. Not only the “Space Innovation through Partnership and Acceleration of Collaboration and Technology Program (StarDust Program)”; the “Advanced Technology for Space Development through Utilization of Unmanned Construction” of the Ministry of Land, Infrastructure, Transport, and Tourism; the GUNDAM Open Innovation “SPACE UTILITY PROJECT” for realizing the “Space Century” (directed by Bandai Namco) and the “JST Moonshot Research and Development Program” but also such as participating in research activities in the habitation area of the JAXA Exploration Innovation Hub Next Generation Concept Study Activities.

The key to human space venture is proactive cooperation with universities, research institutes, and private enterprises, both in Japan and overseas. Innovation is fostered by bringing experts together. We will continue to become a new platform for collaboration and a global platform for the aggregation of various technologies and talents, centered around the Research Center for Space System Innovation.

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2. Local structure analysis of negative-electrode oxides for large lithium-ion batteries using quantum beams, Naoto Kitamura, ICPAC Mongolia 2024, Online, 2024
3. In-liquid plasma and functional materials for SDGs application, Chiaki Terashima, International Symposium on Biomimetic Materials Processing 2025, 口頭発表（招待・特別）, 国際会議, Nagoya University, Jan.23.2025
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6. Challenges and Future of Combinatorial Powder Material Exploration Technology in DX, Kenjiro FUJIMOTO, 2024 Powder Metallurgy World Congress & Exhibition (WORLD PM2024), Yokohama, PACIFICO YOKOHAMA

7. A Study on Non-contact Heart Rate Estimation Using Spatio-temporal Characteristics of Blood Volume Pulse, Kosuke Kurihara, Non-linear Workshop (Tutorial), December 2024(in Japanese)
8. Energy and environmental applications of fullerene nanowhiskers, Kun'ichi Miyazawa and Yumi Tanka, Graphene and Carbon Nanostructure Meetings (GMGCN2024), (2024.6.20), WEB
9. Photo-Induced Fast and Reversible Morphological Changes in Micelles Formed by Amphiphilic Lophine Dimers and their Evaluation by in situ SANS Measurement, Hideki Sakai, The 24th International Symposium in Surfactants in Solutions, June 18, 2024, Goa, India. 【Invited Lecture】
10. Photo-Induced Rapid Morphological Changes in Micelles Formed by Amphiphilic Lophine Dimers, Hideki Sakai, Kenichi Sakai, Masaaki Akamatsu, The 38th Conference of the European Colloid & Interface Society (ECIS2024), Copenhagen, Denmark, September 3, 2024【Keynote Lecture】
11. Development and on-Body Tests of Wearable Electrochemical Sensors Fabricated By Screen Printing, Isao Shitanda, PRiME2024, Honolulu, Hawaii Convention Center & Hilton Hawaiian Village, October 10, 2024
12. Development of Impedance Data Collection System and Analysis Method, Noboru Katayama, The 34th Annual Meeting of MRS-J, December 17, 2024
13. Photonic AI Applications, Mikio Hasegawa, ICT Convergence Korea Forum, Korea, 2024
14. 光触媒の基礎と最新技術-人工光合成実現に向けて-, 光機能材料研究会第１００回講演会, 2025 年 3 月 5 日（オンライン開催）(in Japanese)
15. Trial for Space Habitation: Homeostatic Inflatable Decentralized Autonomous Structure (HIDAS), Shinichi Kimura, 30th International Symposium on Artificial Life and Robotics (AROB 2025), Oita, 2025

Patents

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4. 工藤昭彦, 「グリーン水素「夢の燃料」カギは光触媒」,東京新聞(2025 年 1 月 5 日付), 中日新聞（2025 年 1 月 6 日付）(In Japanese)
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2. 赤倉貴子, 関東工学教育協会賞（論文・論説賞）, 関東工学教育協会, 2024 (in Japanese)
3. 今井一翔, 近藤剛史, 材料技術研究協会討論会 2024　優秀口頭講演賞, 材料技術研究協会, 2024 (In Japanese)
4. Hikaru Umezawa, Kosuke Kurihara, Yoshihiro Maeda, Daisuke Sugimura, Norishige Fukushima, and Takayuki Hamamoto, Institute of Electronics, Information and Communication Engineers (IEICE) Technical Committee on Image Engineering (IE) IE Award: Non-contact Heart Rate Estimation from Far-Infrared Video Images Based on Low-Rank Approximation (March 2025) (In Japanese)
5. Masayuki Itagaki, Isao Shitanda, 2024 ANNUALLY MOSR DOENLOADED PAPERS “Electrochemical Impedance and Complex Capacitance to Interpret Electrochemical”
6. YPC Outstanding Presentation Award: Eiji Yoshida, Noboru Katayama, “Formation of Layered Stripe Structure Catalyst Layers in Polymer Electrolyte Fuel Cells Using Electrostatic Spray Method,” The 2024 IEEJ Power and Energy Society Conference, (September 2024)
7. 工藤昭彦, 2025 年電気化学会 電気化学会賞(武井賞)受賞, “カーボンニュートラルを目指した人工光合成型光触媒の開発”, 2024 年 12 月 13 日(in Japanese)
8. Ichiro Ueno, Best paper award, Japan Boiler Association, 2024 (In Japanese)

Individual Research Topics

Sinich Kimura

"Space colony system design and the implementation of related technology in space"

Technology from a range of fields is necessary to maintain the space-colony closed environment that turns the concept into reality. We have developed high-performing space equipment using commercial-off-the-shelf technologies as it is inefficient to develop the underlying technology to be used only in space. We aim to build space colonies using ground-based technology, turning it into technology that can also be used in space.

Hideyuki Suzuki

"Supernova neutrinos and diffuse supernova neutrino background"

Large-scale multidimensional numerical simulations on supernova neutrinos are currently being conducted. I am aiming towards a comprehensive understanding of diffuse supernova neutrino background and cosmic chemical evolution by combining a simplified model that qualitatively reproduces the results of the multidimensional simulations with population synthesis calculations.

Makoto Yamamoto

"Study on Numerical Simulation of Icing Phenomenon"

Icing is a phenomenon in which supercooled droplets or ice particles in the atmosphere collide with a wall surface to form an ice layer on the wall surface. When icing occurs on an aircraft, it causes deterioration of aerodynamic performance and mechanical damages due to the collision of shed ice pieces, which causes a serious threat to flight safety. In our laboratory, we are conducting numerical simulation research on the development of simulation methods for accurately predicting icing phenomenon, the evaluation of anti-icing and de-icing technologies, and the clarification of the impact behavior of droplets on walls and the solidification process.

Chiaki Mukai

"Lunar medicine and space QOL"

I am promoting research and development in Space Medicine for lunar exploration, based on the knowledge of space medical research (physiological countermeasures, psychiatric and psychological support, radiation exposure management and protection, spacecraft environment maintenance, on-orbit medical system development) that has supported the health of astronauts on the Space Shuttle Program and the International Space Station. In doing this, we are adding to the medical and life science fields considering the lunar environment (e.g. variable gravity physiology, effects of regolith on the human body, protection from regolith, development of living space) to the existing space medicine performed in earth orbit.

Kyoko Matsushita

"Research on experiential space education in collaboration with space education programs"

By capitalizing on the expertise in space education that we have accumulated, I have cooperated with new programs to develop new materials, in tandem with promoting examinations for curriculum formation in the graduate school, where I have held lectures since 2022.

Kazuo Watanabe

“Research on Formation Mechanisms for Noble Gas Hydrides”

The presence of cations of various noble gas hydrides such as ArH^+ and HeH^+ in outer space has been well known. In contrast, the presence of neutral gas hydrides that do not have an electric charge has been almost unknown. However, by irradiating a noble gas ion beam onto a metal substrate surface and further exposing it to hydrogen gas, we have detected neutral noble gas hydrides such as ArH and KrH. We are currently studying their formation mechanisms by using thermal desorption spectroscopy.

Takashi Kurabuchi

“A Study on contaminant diffusion behavior under zero gravity conditions using numerical simulation Technique”

In zero-gravity conditions, natural convection driven by buoyancy does not occur, so the diffusion of contaminants is greatly restricted compared to the environment where gravity acts,

and the air environment inside the spacecraft may deteriorate due to localized stagnation. Fundamental study is carried out with the aim of clarifying this problem by combining numerical simulation and ventilation efficiency evaluation techniques.

Mikio Hasegawa

“6G interconnecting terrestrial and satellite networks”

We propose optimization algorithms for 6G networks that utilize space, air, and ground networks. Communication capacity can be improved by interconnecting terrestrial and satellite networks and optimizing network routing. We showed that the overall throughput can be improved by optimization using machine learning.

Tomoaki Tatsukawa

“A study of multi-objective design optimization with severe constraints using evolutionary computation”

Selection of colony construction sites and various space exploration missions have extremely harsh constraints in addition to a multitude of parameters, and it is difficult to efficiently find feasible solutions that simultaneously satisfy multiple performance indicators. I am engaged in research on advanced multi-objective optimization techniques that can be applied to multi-objective problems. This year, I performed basic verification of the efficacy of existing techniques using benchmark problems and actual problems.

Ichiro Ueno

“On heat and mass transfer problems near solid-liquid-gas interface”

Dealing with (i) capillary-driven local acceleration of contact line after interaction with micropillar, (ii) high-density heat removal by subcooled boiling, and (iii) coherent structure formation by low-Stokes number particles in closed systems.

Takayoshi Kohmura

“Development of sensor for space radiation monitoring and its evaluation of radiation durability”

On the airless lunar surface, electronic devices, such as sensors used in monitoring the ambient environment of space colonies, e.g., the visualization sensors for CMOS, and radiation measurement sensors for monitoring exposure are exposed to solar radiation degrading their performance. Therefore, in this research, I am developing radiation measurement sensors that operate normally under high radiation and I am evaluating their durability.

Yuichi Takaku

“Space colony system design and the implementation of related technology in space”

Technology from a range of fields is necessary to maintain the space-colony closed environment that turns the concept into reality. We have developed high-performing space equipment using commercial-off-the-shelf technologies as it is inefficient to develop the underlying technology to be used only in space. We aim to build space colonies using ground-based technology, turning it into technology that can also be used in space.

Chiaki Terashima

“Development of Liquid Fertilizer with Sterilizing Effect for Automated Plant Factories”

In the view of resource recycling, the reformulation of air and water was conducted into liquid fertilisers with anti-algae effects by using of in-liquid technology. The aim is to elucidate the plasma reaction field and make it practical for industrial applications through the present research work under the space system inovation.

Yasushi Idemoto

“Development and structural analysis of next-generation secondary battery materials with high capacity and high safety”

We focused on $Mg_{1.33-y}(V1.67_{-x+y}Mnx)O_4$ as a cathode material for magnesium secondary batteries and succeeded in improving cathode properties by optimizing the metal composition. In addition, as for high-capacity cathode and anode materials used in lithium-ion batteries, crystal and electronic structures of the synthesised powder and the electrode after charging and discharging were clarified by diffraction and total scattering measurements using quantum beams.

Akihiko Kudo

“Z-schematic water splitting and CO2 reduction under visible light irradiation using water as an electron donor over powder-based photocatalysts”

Development of efficient photocatalysts as artificial photosynthesis is an important research topic to achieve carbon neutral society. This year, we aimed to improve activities for Z-schematic water splitting and CO_2 reduction by employing metal sulfide photocatalysts being responsive to long wavelength of visible light and $BiVO_4$ photocatalysts. As a result, we successfully the activities for both water splitting and CO_2 reduction by loading of CrOx/Rh cocatalysts and surface modification with metal sulfides on metal sulfides, respectively.

Shinichi Komaba

“Fundamental study on materials of ultralow-temperature operating battery contribution to self-sufficiency of electricity in space”

We study on materials of sodium-ion and potassium-ion batteries free from minor and toxic metal elements along with that of lithium-ion battery. In FY2024, we analyzed detailed synthesis process of layered sodium manganese oxide and templated hard carbon for Na-ion batteries. Furthermore, we extended our research target to ionic conducting electrolyte solution enabling battery operation at ultralow temperature.

Naoto Kitamura

"Development and structural analysis of next-generation secondary battery materials with high capacity and high safety"

We focused on $MgMn_2O_4$-based nanoparticles and amorphous materials as positive electrode materials for magnesium rechargeable batteries, and succeeded in improving the positive electrode characteristics by optimizing the synthesis method. We also conducted diffraction and total scattering measurements using quantum beams for high-capacity positive and negative electrode materials used in lithium-ion batteries, and clarified the effect of the synthesis process on the atomic configurations.

Yumi Tanaka

"Fundamental Investigation of Static-Contact-Induced Charge Emission in Ceramic Electret Systems"

With a view toward developing novel self-powered energy systems operable in space environments, this study investigates the origin of a newly discovered phenomenon "charge emission behavior" observed in ceramic electrets based on oxyhydroxyapatite (OHA). This phenomenon is characterized by the continuous charging of a connected capacitor simply through static contact between a metal electrode and the OHA electret, suggesting a previously unrecognized charge transport mechanism distinct from conventional electrostatic induction. The behavior of charge eruption was systematically evaluated under various atmospheric conditions (vacuum, dry air, humid air, etc.), revealing that humidity significantly affects the charge eruption rate. Furthermore, it was demonstrated that even under vacuum, the OHA electret could sustain a steady electric current sufficient to charge a capacitor continuously for more than two weeks.

Yuichi Yamaguchi

"Enhancement of water splitting over powder-based single particulate metal oxide photocatalysts"

Photocatalytic water splitting has been paid much attention as an important science technology for achieving a carbon neutral society. Enhancement of the activity of photocatalysts is essential for a practical use. This year, we aimed to improve the activity for water splitting over various Bi and Ti-based oxides by application of polymerizable complex and flux methods instead of a conventional solid-state reaction. As a result, we successfully improved the activities of $Bi_4Ti_3O_{12}$ and $Bi_2Ti_4O_{11}$ photocatalysts.

Tokuhisa Kawawaki

"Creation of fuel cell cathode electrodes using size-controlled platinum clusters"

Fuel cells, which are expected to be a clean power generation material, use a large amount of platinum particulate catalysts because the oxygen reduction reaction at the cathode is the rate-limiting step. However, platinum is an expensive precious metal, so it is important to reduce the use of platinum. In this study, we worked to establish a simple and high-yield method for synthesizing platinum clusters smaller than conventional platinum particles. Furthermore, we aim to create a practical platinum catalyst by applying it to fuel cell cathode electrocatalysts.

Chiaki Ishibashi

"Development and structural analysis of next-generation secondary battery materials with high capacity and high safety"

We focused on $Mg_{1.33-y}(V1.67_{-x+y}Mn_x)O_4$ as a cathode material for magnesium secondary batteries and succeeded in improving cathode properties by optimizing the metal composition. In addition, as for high-capacity cathode and anode materials used in lithium-ion batteries, crystal and electronic structures of the synthesised powder and the electrode after charging and discharging were clarified by diffraction and total scattering measurements using quantum beams.

Hideki Sakai

“Photocatalytic degradation of acetaldehyde: Effect of UV light wavelength”

Last year we have investigated the effect of the wavelength of UV light on the synthesis of rare sugars from gluconodeltalactone using titanium dioxide as a photocatalyst and found that the erythrose formation is promoted when UV light with shorter wavelength (254 nm) was irradiated. In this year, we examined the effect of the wavelength of UV light on the oxidative degradation reaction of gaseous acetaldehyde in details.

Isao Shitanda

“Improvement and Evaluation of Wearable Ion Sensors”

We developed a new ion sensor that provides stable responses immediately after perspiration. By changing the structure of the reference electrode, we were able to achieve rapid response. We conducted implementation evaluation tests using the ion sensor we developed. By monitoring ion components during perspiration, we expect that this sensor will serve as a new marker for pre-disease conditions.

Ken-Ichi Katsumata

“Development of photocatalytic materials for the decomposition of ammonia gas”

The concentration change of ammonia gas in response to ultraviolet light irradiation was measured using a photocatalyst that combined titanium oxide (TiO2) and silver. Under ultraviolet light irradiation at 365 nm and 280 nm, the concentration of ammonia gas in the gas phase decreased. When the number of photons irradiated was adjusted for comparison, it was found that 280 nm showed higher activity than 365 nm.

Kiyoshi Dowaki

“Improvement of the indirect gasification process for purification of bio-hydrogen”

In our studies, the indirect gasification process for purifying bio-hydrogen uses sewage sludge. The process consists of the pyrolyzer, reformer, and preheater. Due to the heat transfer using heat carriers of alumina balls, feedstock is decomposed.

However, the lack of sensible heat would co-generate tar and reduce the volume of syngas. In addition, generating other contaminants would degrade the product quality of bio-hydrogen.

This time, we developed the CFD model based on the kinetics of tar, and we can grasp the heat distribution in the vessel. We also proposed a countermeasure to reduce the amount of tar, improving syngas production efficiency.

Furthermore, adsorption tests were used to argue for the refinery technology of H2S removal. An eco-friendly scheme using metal alloys and mining waste for which a patent was applied was developed.

Takahiro Gunji

“Self-cleaning material using titanium dioxide nano particles supported on a flexible organic polymer thin film”

A suitable structure was investigated by clarifying the relationship between the molecular structure of polysilsesquioxane to support titania nano particles and the physical and chemical properties of self-cleaning film which was prepared by using the materials. In addition, another self-cleaning film was prepared by spin-coating of titanium dioxide nano particles on an organic polymer film having adhesive layer and the durability as photo-catalyst was evaluated. The photo-catalytic ability was increased by pre-treatment of the organic polymer layer by ozone.

Koji Arimitsu

"Grafting of organic silicon polymers to titanium oxide surfaces and application in self-cleaning materials"

I simultaneously prepared titanium oxide macroparticles in a solution containing tetra-isopropyl ortho-titanate and polysilane by sol-gel processing while photochemically grafting the polysilane. I was thereby able to obtain modified titanium oxide particles with smaller particle diameters compared to polysilane-modified titanium oxide particles prepared by conventional solid-phase methods. Furthermore, when I prepared a UV-cured film on which these polysilane-modified titanium oxide particles had been dispersed, I succeeded in preparing a self-cleaning film with higher transparency than conventional films.

Tomonori Suzuki

"Study on the analyses of the sterilization mechanism of photocatalyst"

Peptidoglycan and its components increased the photocatalytic bactericidal effect, increasing the amount of H_2O_2 and decreasing the amount of $^{\bullet}OH$. The photocatalytic bactericidal effect also increased with the addition of a chelating agent and decreased with the addition of catalase. These results suggest that peptidoglycan and its components may generate H_2O_2 from $^{\bullet}OH$. It was strongly suggested that the main active factor in photocatalytic bactericidal activity is H_2O_2.

Kenjiro Fujimoto, Takuro Dazai

"Exploration of composite oxides for NO selective reduction, CO adsorption, and photocatalytic applications"

Based on the NO selective reduction catalytic function and photocatalytic function of materials with a holandite crystal structure, we have been working to improve the synthesis process to increase the specific surface area and active sites. As a result, we have clarified the performance variation of catalytic activity depending on particle morphology. Furthermore, we have identified the possibility of CO adsorption in titanates.

Takashi Kondo

"Research on the development of a conductive diamond powder-packed flow cell"

We have developed a conductive boron-doped diamond powder (BDDP)-packed electrolytic flow cell toward application to efficient water treatment. It was confirmed that electrolysis using this flow cell can remove more than 99% of the total organic carbon in artificial urine. In addition, it was found that the organic matter decomposition rate can be significantly improved by optimizing the dimensions of the BDDP-packed bed, the flow rate, the electrolysis voltage, etc.

Shingo Machida

"Development of techniques for stabilizing functional powders in bulk materials"

Photocatalysts, adsorbents, and anti-bacterial materials are highly promising for applications beyond environmental remediation, such as water purification. However, their uses in powder form presents challenges in handling, stability, and practical implementation. To address this, I'm developing techniques to stabilize these functional powders with bulk materials—without detachment or loss of functionality. Such stabilization strategies are not only important for improving environmental technologies on Earth, but may also become essential when humas live and operate in space.

Toshifumi Tojo

“Research on active oxygen sensors and antioxidants/anticancer drugs through a biomimetic approach”

I have been studying the superoxide anion radical ($O2^{\cdot -}$), the so-called “active oxygen,” which would be incredibly useful in space colonies and on earth, and with which it is possible to confirm health conditions in pre-illness states. Going forward, I will examine the construction of $O2^{\cdot -}$ sensors with greater functionality, superior quantitative performance, and biocompatibility.

Mutsumi Sugiyama

“Research on semiconductor devices for space application”

This study explores the fabrication methods and radiation tolerance of various semiconductor devices for space applications, including $Cu(In,Ga)Se_2$ (CIGS)-based solar cells, Cu_2SnS_3 (CTS)-based solar cells, SnS-based solar cells, NiO-based solar cells, CIGS-based photoelectrodes for hydrogen production, and SnO_2-based carbon dioxide sensors. These semiconductor materials and devices exhibited significantly higher resistance to electron and proton irradiation, as well as superior thermal cycle tolerance, compared to conventional Si-based semiconductor devices. These findings indicate their strong potential for practical application in space environments.

Takayuki Hamamoto

“A study on image sensing for health monitoring”

We study image sensing technology to understand the health status of space visitors. This study focuses on visible and near-infrared light information. We tackle reconstructing images with low noise and high spatial resolution, even in low-illumination environments, by using visible and near-infrared light images acquired simultaneously. Using the reconstructed image information, we also investigate a non-contact heart rate estimation method even when illumination environments fluctuate significantly**.**

Yasuo Kogo

“Construction of Power Generation Systems with the Indoor/Outdoor Power Differential”

Utilizing temperature differential power generation via the Seebeck effect, we are developing a thermoelectric temperature differential power generation system supplying electric power from the indoor/outdoor temperature differential between day and night that occurs in space colonies. Temperature differential power supply by thermal power generation can realize auxiliary power supply at night and in the shade, when solar cells are unable to generate electricity, as well as during the construction of underground space for a colony. We will therefore develop power supply systems in which solar cell power generation and flywheel power storage are interlinked.

Tsutomu Iida

“Construction of Power Generation Systems with the Indoor/Outdoor Power Differential”

Utilizing temperature differential power generation via the Seebeck effect of thermoelectric materials, we are developing a thermoelectric temperature differential power generation system supplying electric power from the indoor/outdoor temperature differential between day and night that occurs in space colonies. Temperature differential power supply by thermal power generation can realize auxiliary power supply at night and in the shade, when solar cells are unable to generate electricity, as well as during the construction of underground space for a colony.

Noboru Katayama

“Modeling and Array Shape Optimization of Paper-Based Lactic Acid Biofuel Cells”

Paper-based lactic acid biofuel cells generate electricity using lactic acid present in human sweat as fuel. These cells are gaining attention as lightweight, thin, and environmentally friendly power sources. One of the key challenges is to enhance power density, which is expected to improve through optimization of electrode geometry. In this study, a two-dimensional simulator was developed to replicate the power generation behavior of the cell. Using shape and topology optimization techniques, we investigated ways to increase the power density. Current efforts focus on improving the output by optimizing the array configuration of series and parallel connections.

Mitsutoshi Tsukimoto

“Development of chemicals for protection from cosmic radiation”

To protect the body from cosmic radiation, I have performed research on chemicals that protect from and attenuate radiation injury and have discovered a substance that protects bone marrow cells, which are prone to radiation injury. In addition, I am also researching the cellular response to radiation under variations in the gravitational direction.

Shinya Yanagita

“Development of TUS original space fitness”

The decline in physical activity is an issue that needs to be resolved in a super-aged society. On the other hand, there is a large overlap between staying and living in space. We aim to solve this problem by developing an online fitness program that can be used anytime and anywhere.

Takahiro Mukaimoto

“Effects of exercise conditions on resistance exercise on excess post-exercise oxygen consumption”

This study aims to examine examine the effects of resistance exercise on exercise types, intensity, order, and rest time between sets, on oxygen intake and energy expenditure during exercise, and on excess post-exercise oxygen consumption (EPOC). It aims to build useful knowledge for planning efficient resistance exercise training programs.

Takako Akakura

“Development of a distance CSCW system using VR”

We are developing an environment for computer supported cooperative work (CSCW) in distant areas and an environment that gives the feeling of working with someone else even if a man is working alone, using VR. The system that realizes interaction between a real person and a person in VR space (avatar) has been shown to be effective in maintaining motivation and reducing the sense of loneliness.

“A study on measurement of user's fatigue using face, utterance and gaze information”

Mental fatigue is a serious problem during long stays in space under lonely state. Therefore, we are constructing a methodology to estimate the state of fatigue based on the biometric information of fatigue. In addition to 51 facial feature points, such as the eyes and the bridge of the nose, the fatigue state is estimated using the Mel-frequency Cepstrum coefficient, which is a kind of vocal cord feature, and eye gaze information.

Momoyo Gota

“Evaluation of Habitability of Small Enclosed Spaces and Development on Planning of Interior Spaces for Space Habitation”

The objective of my research is to develop planning technologies for indoor spaces suitable for human psychology and behavior in space habitation. I am therefore focusing, as basic research, on human psychology and behavior in narrow, enclosed spaces intended for multiple inhabitants, not limited to zero-G, and I have evaluated their performance as a habitation space, and I am investigating/analyzing shapes and arrangements of indoor spaces, as well as human behavior, in actual space habitation.

Masayuki Mizuno

“Study on evacuation behavior under microgravity in space facilities”

Movement of people in micro-gravity condition inside space facilities requires grasping onto handrails attached to walls to move around. In case of hazards such as debris collision or fire, individuals need to evacuate to adjacent modules via a hatch between the modules. This study proposes an effective handrail arrangement for movement during emergency evacuation of individuals or groups according to the results of the past experiments conducted under water.

“Walking experiments using a walking characteristics simulator simulating low gravity conditions on the moon”

The gravity environment is different on the Moon than on Earth, and it is expected that walking on the Moon will be different from walking on Earth. Therefore, the low-gravity walking simulator that NASA used in the Apollo program was recreated on a smaller scale, to analyze the starting and stopping behavior of forward movement with restricted lateral movement. And then, some experiments were conducted using the simulator. Qualitative effects on movement, stopping, and posture control resulting from differences in walking methods are expected to be considered.

Kosuke Kurihara

“A study on multiparameter vital sensing by using image infomation”

We study non-contact sensing technology utilizing image information to acquire the vitals of space visitors. We investigate the method that can measure multivital information from images and construct the framework for stress and emotion estimation methods that can utilize obtained multivital information in an unified manner.

Kazuki Kitabatake

“Development of chemicals for protection from cosmic radiation”

To protect the body from cosmic radiation, I have performed research on chemicals that protect from and attenuate radiation injury and have discovered a substance that protects bone marrow cells, which are prone to radiation injury. In addition, I am also researching the cellular response to radiation under variations in the gravitational direction.

Osamu Sakata

“Research on stress accumulation monitoring technology of long-term residents in closed environments”

When human beings stay for a long period of time in a closed environment such as a space colony, lunar base, or Mars base, which is strongly isolated from the general society on Earth, negative mental stress may accumulate and lead to mental and physical disorders. Since many cases of mental and physical disorders resulting from stress accumulation can become serious symptoms, early detection and early response in daily life and work are effective means of preventing the seriousness of such disorders. In this project, we will conduct research on technology to automatically detect the accumulation of negative mental stress of residents in a natural way in their daily lives, based on causality analysis between various physical quantities such as multiple biometric and environmental information.

Shinji Ogihara

“Research on Microscopic Damage Behavior of Fiber-reinforced Composite Materials”

I have empirically studied the process of microscopic damage occurrence and progression inside materials through various loading forms, focusing on laminated fiber-reinforced composite materials. Furthermore, I have evaluated the effect on the mechanical characteristics of materials accompanying damage occurrence by experiment. I have predicted and compared, by the finite element method and with a damage mechanics model, and studied the validity of the results. I have constructed a foundation for the application of this to material systems with more complex internal structures. I expect my work to contribute to the evaluation of the structural integrity of materials during space operations.

Takahiro Fujikawa

“Research on spaceplane system design and guidance trajectory optimization”

The establishment of system design technologies and autonomous flight guidance technologies are necessary for the development of a spaceplane that can operate like an airplane instead of a disposable rocket. In this study, we have engaged in the development of a multipurpose system optimization technique. We focused on the combination and application of two types of numerical optimization techniques: the gradient method and the evolutionary computation method, as well as a high-speed generation technique for various orbital groups satisfying the terminal constraints.

Jun Koyanagi

“Numerical simulation for the deployment of inflatable structures in space applications”

A numerical simulation of the deployment of an inflatable structure for securing living space on the moon was performed using finite element analysis. In the past, we did not carry out numerical analysis and proceeded with development that relied on experiments. For this reason, the deployment process in outer space could not be tested, and the feasibility was questioned. However, by constructing numerical analysis technology, it became possible to predict the behavior in outer space, and we took a big step towards the realization of development.

Mohammad Fikry

"Study on the mechanical properties and damage behavior evaluation methods of carbon fiber reinforced plastic laminates"

The study aimed to provide guidelines for the development of higher-performance new materials focusing on carbon fiber reinforced plastic (CFRP) laminates by constructing and examining the mechanical properties and damage behavior evaluation methods, along with their modeling. Non-contact and non-destructive methods such as digital image correlation and sampling moiré, as well as in-situ observations using optical microscopes and scanning electron microscopes were utilized to observe and model the detailed process of matrix crack initiation and progression in CFRP laminates. Furthermore, based on these observations, the experimental elucidation of the microscale damage initiation and progression processes in CFRP with complex structures was achieved, and their modeling was also conducted using the finite element method and variational stress analysis.

Research Center for Drug Discovery and Applied Sciences

Research Center for Drug Discovery and Applied Sciences

1. Overview

Most of the products used as medicines by humans comprise carbon-based organic compounds, which are synthesized by combining multiple chemical reactions. However, when it is crucial to perform several reaction steps before achieving the synthesis of the desired compound, considerable time and effort are spent, as well as a considerable amount of waste is generated, thereby adding to the environmental burden.

Our synthetic team is conducting research on reaction methods that can improve the synthetic yield of pharmaceutical products to the maximum, and we have developed a new dehydration condensation agent, namely 2-methyl-6-nitrobenzoic anhydride (MNBA), which can drastically enhance the production efficiency of antibiotics and anticancer drugs.

After the establishment of this new technology, MNBA has been widely used to synthesize new antibiotics, molecular target anticancer drugs, and drugs for diabetes treatment, and more than 14,000 successful results have been reported worldwide.

One of the achievements of this year is the total synthesis of tanzawaic acid B. Tanzawaic acids are organic compounds discovered in 1997 in the Tanzawa mountains area of Kanagawa Prefecture by Professor Daisuke Uemura (then of Shizuoka University) and his colleagues. Tanzawaic acids have antibacterial activity, and various pharmacological activities including antitumor and anti-inflammatory activity have been reported in recent years. We achieved the total synthesis of tanzawaic acid B in 2023 using asymmetric alkylation, asymmetric Mukaiyama aldol reaction, and intramolecular Diels–Alder reaction as key steps. Currently, we were able to establish a method for supplying a large amount of the mother nucleus, which is common to tanzawaic acids, making it possible to develop not only tanzawaic acid B but also antibacterial drugs and anticancer drugs that use tanzawaic acid B as the lead compound. We researched M-COPA, an artificial analog of tanzawaic acid B, and investigated its growth-inhibiting activity on cancer cells.

In 2024, we compared the cell proliferation inhibitory activity of the TKI-refractory lung cancer cell line NCI-H226 using the bioactivity evaluation system owned by our center. We found that a new amine-type analogue of tanzawaic acid B with a hydroxyl group showed good biological activity. Derivatives amine A, amine B, and amine C, which had picolylamine-type side chains, were synthesized in one step from the corresponding aldehyde or methyl ketone by reductive amination reaction, and the three were compared. Amine A had GI_{50} = 1.4 μM, amine B had GI_{50} = 0.54 μM, and amine C had GI_{50} = 1.5 μM, and amine B inhibited the proliferation of cancer cells at sub-nanomolar concentrations. In contrast, the efficacy of the other four existing anticancer drugs was inferior (5-FU: GI_{50} = >100 μM, cisplatin: GI_{50} = >100 μM, gefitinib: GI_{50} = 30 μM, and osimertinib: GI_{50} = 15 μM). Therefore, we were able to find potential applications for the new amine analogues of hydroxytanzawaic acid B as anticancer drugs. In the future, we plan to investigate the metabolic stability using liver microsomes, leading to the creation of new drug lead compounds that are also biocompatible.

2. Organization and Facilities

This research center is a joint organization established in 2023 by progressively reorganizing the chemical biology research department based on practical organic synthesis, whose establishment period expired in 2022. Through close collaboration between the synthetic chemistry group and chemical biology group, we are engaged in research and development aimed at social implementation. The research department head is

Professor Isamu Shiina (Department of Chemistry, Graduate School of Science/Department of Applied Chemistry, Faculty of Science I). The facility is Kagurazaka School Building No. 11 Annex. The Chirality Research Center (2012-2016, Center Director: Isamu Shiina), the predecessor of this research center, purchased a nuclear magnetic resonance measurement device (500 MHz and 300 MHz NMR), a gas chromatograph mass spectrometer, as well as time-of-flight mass spectrometer systems. In addition, the facility is equipped with other analytical instruments such as a single-crystal X-ray structure analyzer and a circular dichroism spectrometer (CD). We made effective use of these high-performance analyzers to promote research.

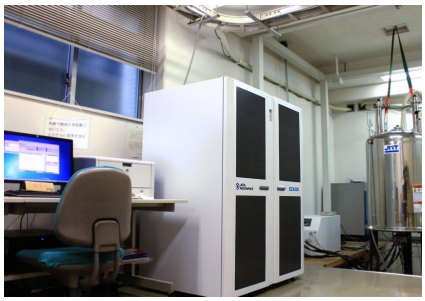

Photo 1. NMR equipment (500 MHz).

3. Activity Reports

3. 1. Area of the Development and Application Group for Practical Organic Synthesis Technology

We have developed research on providing synthetic means, such as practical organic transformations, total synthesis of natural products, asymmetric synthesis using organic catalysts, asymmetric synthesis using metal complexes, dehydration condensation reactions, and asymmetric self-amplification reactions.

3. 2. Area of the Chemical Biology and Drug Development Group

We set a research theme centering on the university's original compound, ridaifen, obtained using the technology of our research center, and proceeded with investigations in the Shiina, Shimonaka, Mano, Higami, and Kuramochi laboratories. In addition, the Shiina, Shimonaka, and Kawasaki laboratories conducted joint research on the evaluation of the biological activity of compounds obtained by asymmetric synthetic technology. In order to expand the application into the research on bioactive compounds, we will practice drug development based on the synthesis of natural products with complex structures. We are conducting research and development of merillianin, which is expected to be applied as a drug for the treatment of nervous system diseases, an antifungal agent based on natural depsipeptide FE399, and an antitumor agent based on tanzawaic acid B and violaceoids.

4. Challenges and Prospects

All the issues set for this year have been resolved. Tumor regression was successfully observed in animal testing by using tanzawaic acid analogs discovered at Tokyo University of Science Shiina Laboratory as novel anticancer agents for cancer types with mutant RTKs that are refractory to existing tyrosine kinase inhibitors (TKIs).

Our projects were adopted as a core organization for AMED [Innovative Cancer Treatment Practical Research Project] in 2022-25 and for JST [Deep-Tech Startup International Expansion Program (D-Global)] in 2024-27. We have established a method for synthesizing tanzawaic acid analogs in a gram scale and have confirmed the effects of anticancer effects on mutated cancers, resistant cancers, and endoplasmic reticulum stress-sensitive cancer cells at a non-clinical level. Currently, to complete the non-clinical studies necessary for the start of clinical trials, we are in the process of acquiring data sets for the preparation of PMDA interview materials. We plan to continue research and development with the aim of social implementation.

5. Conclusion

The Research Center for Drug Discovery and Applied Sciences is an organization that actively supported close collaboration between the organic synthetic chemistry group and the chemical biology group both inside and outside our university, which was launched in 2023, and carried out the project as planned as described above.

During this period, we aimed to make effective use of the organic synthesis methods and compounds developed at our university. We plan to expand our center in aiming to apply them not only to basic research but also to biological research.

Reference Material

(1) 当センターのプロジェクトが JST【D-Global】に採択（2024 年 11 月 1 日掲載），
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Individual Research Topics

Isamu Shiina and Takatsugu Murata

"Development of anticancer agents from naturally occurring products"

Eutyscoparol A is a novel quinol-type compound isolated in 2020. It was suggested that Eutyscoparol A has a common structural skeleton with Violaceoids A–C, consisting of a 2,3-alkylated quinol ether moiety and a hydroxymethyl group. Violaceoid A was also known to have cytotoxicity against cancer cells. As such, since Violaceoids are biofunctional molecules, Eutyscoparols with a common skeleton may also have useful physiological activities, but their detailed physiological activities have not yet been known. This year, we achieved the total synthesis of Violaceoid C, and in addition, we improved the total synthesis method of Violaceoid A that we reported in 2018, making it possible to supply Violaceoid A on a sub-gram scale. This made it easier to convert it to Eutyscoparol A, and we were able to achieve the total synthesis of Eutyscoparol A. We believe that this result will serve as a foundational technology for investigating the detailed pharmacological activity of Violaceoids and Eutyscoparols, and will lead to the development of new drugs in the future.

Tsuneomi Kawasaki

"Search for chiral bioactive compounds and BNCT carrier compounds using Strecker amino acid synthesis"

Amino acids are one of the typical chiral compounds that make up living organisms, and they consist of only the L-enantiomer of the L- and D-enantiomers (homochirality). In a study aimed at elucidating the reaction pathway leading to homochirality in biologically relevant compounds, we elucidated the asymmetric generation and amplification mechanism of aminonitrile, an intermediate in the synthesis of Strecker amino acids. we conducted a cell proliferation inhibitory activity test using amino acid derivatives prepared by the Strecker synthesis, and we found a novel compound that does not affect the proliferation of not only cancer cells but also normal cells. In FY2024, we signed a contract for commissioned research with an external collaborating organization (company) that is conducting joint research with our center, and moved on to evaluating compounds to expand our compound library.

Kouji Kuramochi

"Synthesis and evaluation of biologically active compounds using novel *N*-alkylphenazines and phenazinones"

We are developing a method to synthesize new *N*-alkylphenazines and phenazinones by utilizing regioselective intermolecular coupling reactions. In 2024, we conducted a human cancer cell growth inhibition activity test using the compound. Furthermore, we have concluded contracts with external collaborating institutions (companies) conducting joint research with our center to conduct biological activity tests for antifungal, plant growth inhibition, insecticidal properties, etc., and have expanded our compound library.

Motoyuki Shimonaka

"Screening of novel boron compounds for boron neutron capture therapy (BNCT)"

Various boron-containing compounds, including boronophenylalanine analogues were synthesized by means of asymmetric synthesis in the Shiina and Kawasaki laboratories. The toxicity to cancer cells, normal skin cells, and other cancer cells were examined, and the synthesized compounds were classified into two groups according to the presence or absence of cytotoxicity. As a result of the examination, in addition to the novel compounds that do not affect the proliferation of both cancer cells and normal cells, we also

successfully obtained novel compounds that are selectively toxic to certain cancer cells. In FY2024, we compared the cell proliferation inhibitory activity of tanzawaic acid B and new tanzawaic acid analogues using multiple cell lines, including lung cancer cell lines. As a result of in vitro tests, amine analogues of tanzawaic acid B showed moderate activity, and it is expected that investigating metabolic stability using liver microsomes in the future will lead to the creation of new drug lead compounds with improved biocompatibility.

Yoshikazu Higami

"Biologically activity test of novel cholesterol accumulation-inducing compound (lipoprofen)"

To demonstrate the cholesterol-lowering effect of a new cholesterol accumulation-inducing compound (lipoprofen) found in the Shiina laboratory on the animal level, lipoprofen was intraperitoneally administered to diet-induced obesity model mice for 3 weeks. As a result, lipoprofen administration reduced the total cholesterol level in the blood by about 30%. Furthermore, in the liver of the treated group, an increase in the gene expression of the LDL receptor, which is important for cholesterol uptake, was confirmed, but the cholesterol level did not change. This suggests that lipoprofen lowers blood cholesterol by promoting cholesterol uptake into the liver and promoting its metabolism in the liver. In order to determine the dosage and administration protocol, we conducted a study and found that the blood lipoprofen concentration was 1.17 ± 0.14 μg/mL when lipoprofen was orally administered at a concentration of 50 mg/kg body weight for one week. It was also found that the blood cholesterol concentration was significantly lower in the treatment group compared to the control group.

Yasunari Mano

"Pharmacokinetic study of novel cholesterol accumulation-inducing compound (lipoprofen)"

As a result of single intravenous and single oral administration of lipoprofen to male Wistar rats, blood and urine samples were collected over time, and the pharmacokinetics were analyzed, the elimination half-life was found to be approximately 2 to 3 hours. It was revealed that it is a hepatically metabolized drug with moderate clearance and large distribution volume. Bioavailability was approximately 20%.

Furthermore, we investigated the pharmacokinetics after transdermal administration using the "PassPort® System," a transdermal administration device that opens temporary micropores in the stratum corneum of human skin. An *in vivo* study in rats using the PassPort® System through dermal administration revealed for the first time that the drug was absorbed into the systemic circulatory system and maintained its pharmacokinetics in the blood for a long time. After transdermal administration of 40-80 mg/body of lipoprofen, lipoprofen was absorbed into the blood circulation, reaching C_{max} in 6-9 hours and slowly decreasing with a $t_{1/2}$ of 50-80 hours. Compared with oral administration (t_{max}: 1-2 hours, t1/2: 4 hours) reported in the previous study, the t_{max} was delayed and the $t_{1/2}$ was long in a single transdermal administration, demonstrating the characteristics of a transdermal drug formulation that is absorbed slowly and continues to act for a long time. Linearity was also observed in the dose range of 40-80 mg/body. The residual drug rate in the tape after removal was 14-18%, and the bioavailability was 11-15% when corrected for the dose. Since this was not a large difference compared to oral administration (approximately 20%), it was inferred that transdermal administration using the "PassPort® System" is a useful method of administration of lipoprofen.

Carbon Value Research Center

Carbon Value Research Center

1. Overview

Due to the concern about climate change and global warming, the movement toward decarbonized society is being accelerated globally. In October, 2020, Japanese government announced that Japan would achieve "Carbon neutral" (i.e., net emission of greenhouse effect gas is zero in total) by 2050. The Green Growth Strategy, which connects challenges for carbon neutral with an economical and industrial growth, was formulated. In 2021, the summit among university's presidents on the contributions toward carbon neutral was held and, based on the discussions there, "University Coalition for Carbon Neutrality" was established.

Many efforts are underway around the world to become carbon neutral, a concept that would reduce carbon emissions to virtually zero. The use of renewable energy is a prerequisite for achieving carbon neutrality. This will help to solve the resource, energy, and environmental problems that humanity faces. When it comes to renewable energy use, most people think of solar power and wind power. Looking back at our daily lives, not only electrical energy but also materials such as fuels (chemical energy) and chemical products are indispensable. To synthesize these substances, hydrogen (H) and carbon (C) are needed as the main raw materials. Here, to achieve carbon neutrality, water (H_2O) must be used as the hydrogen source and carbon dioxide (CO_2) as the carbon source. This means that carbon dioxide must be used as a carbon source to synthesize high-value substances such as gasoline, jet fuel, olefins, and alcohols (this is called "Carbon Value").

Based on the social background mentioned above, our university ranked research fields relating to "carbon neutral" as a strategical key area, and then "Carbon Value Research Center", where researchers on artificial photosynthesis, electrochemical CO_2 reduction, secondary batteries, hydrogen usage gathered, was launched in January, 2022.

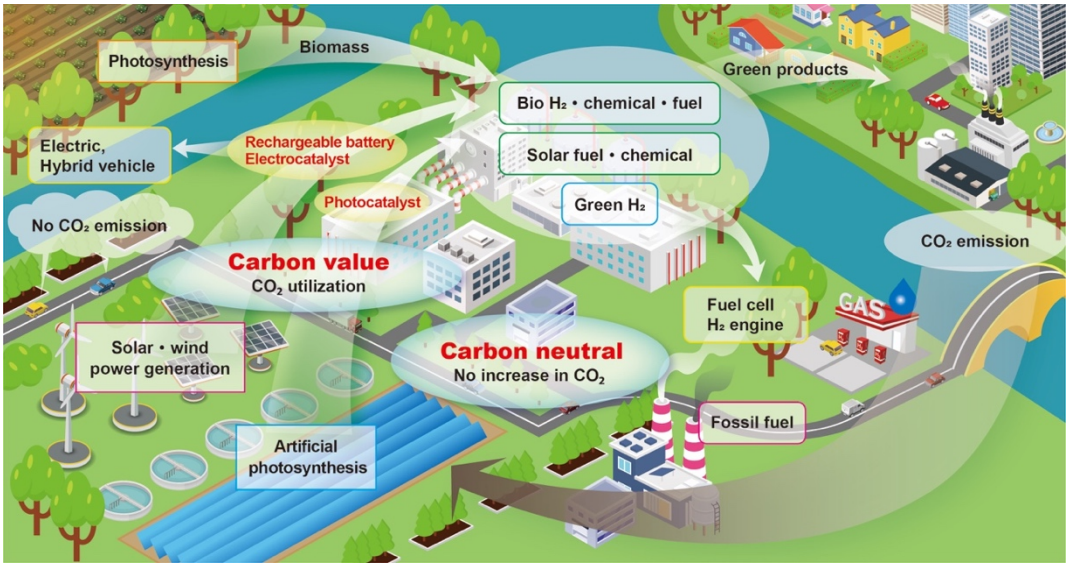

Fig. 1. Future vision that the CV center aims at.

2. Organization and Facilities

The CV center develops original and essential technologies for CARBON VALUE by which CO_2 is converted to valuable products as a carbon source through collaborations. The CV center aims to solve the

resource, energy, and environmental issues by social implementation of the total system based on our basic research through the carbon value technology (Fig. 1).

To convert carbon dioxide into a resource, it is essential to develop science and technology to reduce carbon dioxide (reacting it with electrons or hydrogen) using renewable energy sources such as sunlight. Direct carbon dioxide reduction methods include photochemical and electrochemical methods. Here, light must be solar and electricity must be generated from renewable energy sources (renewable electricity). Another indirect method is the thermocatalytic reduction of carbon dioxide using solar hydrogen (green hydrogen) produced from water using renewable energy. On the other hand, to use renewable electricity, a battery is needed to store it. For this reason, the development of lithium and sodium ion batteries is also an important topic worldwide. Battery technology is not limited to electrolytic synthesis but can contribute to carbon neutrality through its use in electric vehicles and other applications.

Hydrogen is also an essential substance for carbon neutrality. You might think that hydrogen is a clean energy source that fuels fuel cells. Therefore, it must also be linked to fuel cell technology. In addition to this, hydrogen is also essential as a key substance in the chemical industry. Many chemical products are produced chemically using hydrogen as a raw material. One of the most important products is ammonia, which is used in chemical fertilizers. If hydrogen cannot be produced due to depletion of fossil resources, chemical fertilizers cannot be made. This will be a critical issue for humanity. Thus, hydrogen is not only a clean energy source, but is indispensable to support the materials of today's society. In other words, it is no exaggeration to say that anything is possible with hydrogen. The industrial hydrogen production method in modern society is steam reforming, in which fossil resources such as oil, natural gas, and coal are reacted with water at high temperatures. However, this hydrogen production method still has the problems of fossil fuel depletion and carbon dioxide emissions. Running fuel cell vehicles on hydrogen obtained in this way is not a fundamental solution to environmental problems. Therefore, it is desirable to develop a technology to produce hydrogen from water using renewable energy. One such science and technology is artificial photosynthesis, which uses photocatalysis to decomposition of water to produce hydrogen.

The objective of this research center is to develop science and technology to effectively utilize and reduce excess carbon dioxide emissions by converting carbon dioxide, which is an important carbon resource, into valuable substances. Furthermore, we will develop science and technology that will be carbon negative. A typical example of this science and technology is the production of hydrogen through water splitting using renewable energy. Research will focus on the development of photocatalysts, electrocatalysts, and rechargeable batteries necessary for these scientific processes. In addition, we will conduct research and development of fuel cells and bio-hydrogen. We will also proceed with life cycle assessment (LCA: a method for quantitatively evaluating the environmental impact of a product or service over its entire life cycle (resource extraction - raw material production - product production - distribution and consumption - disposal and recycling) at the same time.

2. 1. Research System of the CV Center

About 10 researchers from Tokyo University of Science and 1 visiting professor belong to the CV center. The researchers collaborate with each other and also outside researchers. We work on developments of photocatalysts and semiconductor photoelectrodes for artificial photosynthesis, electrocatalysts for electrochemical reduction of CO_2 using a renewable electricity, and secondary batteries for storage of the renewable electricity, and minimization of platinum in a fuel cell for usage of green hydrogen. In addition, life cycle assessment (LCA) simulation, CO_2 storage and adsorption, biological process, and measurement technology are studied. The collaboration will be expanded to accelerate the research in the future.

2. 2. Main Research Topics in the CV Center

Figures 2 and 3 show research topics and strengths of the CV center.

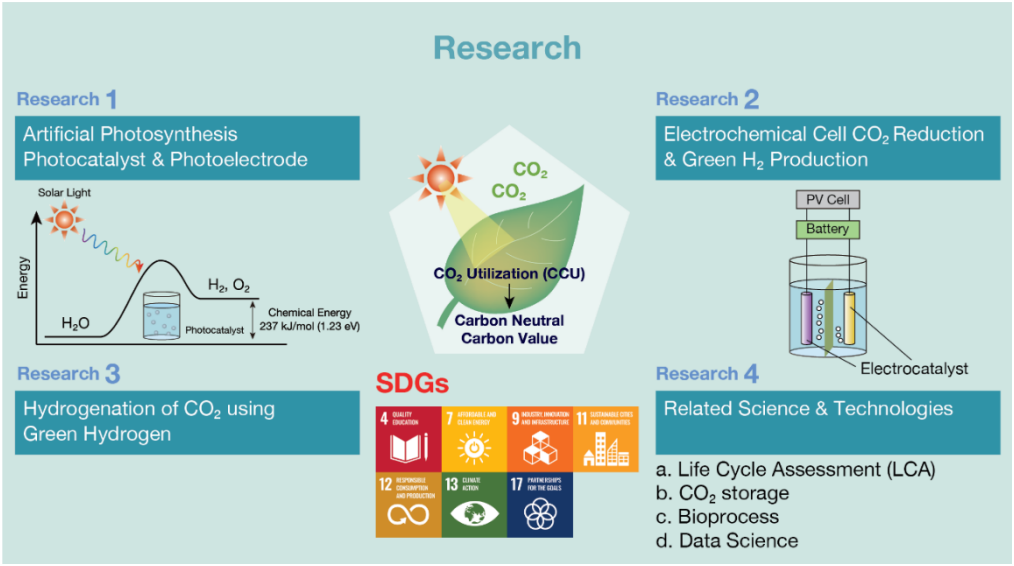

Fig. 2. Research topics of the CV center.

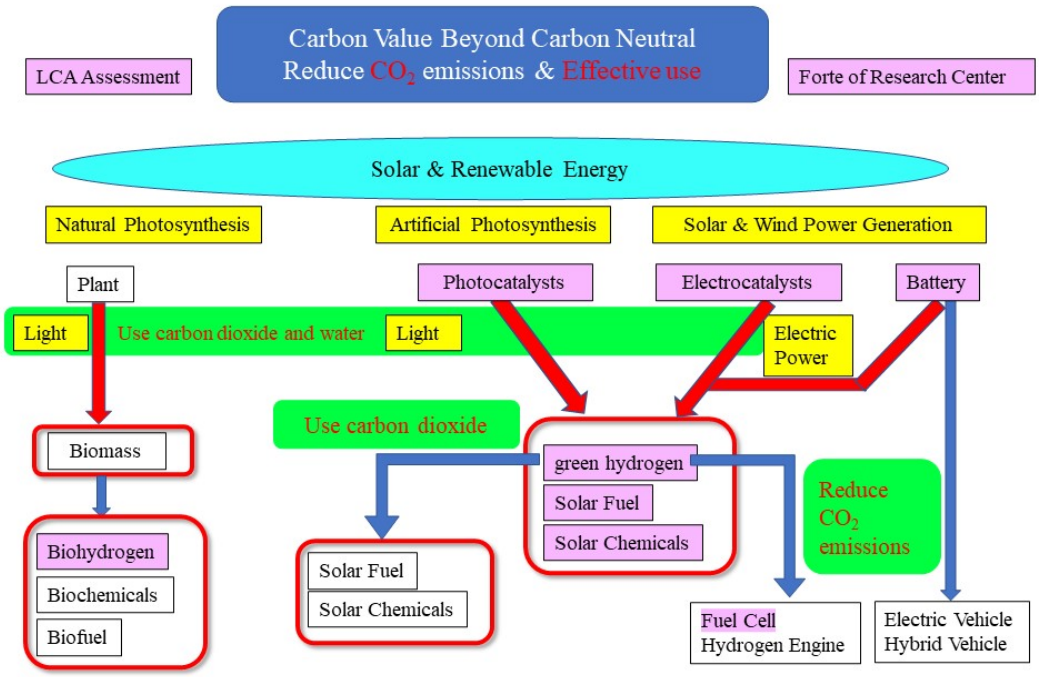

Fig. 3. Strengths of the CV center.

2. 2. 1. Green Hydrogen Production with Renewable Energy

Hydrogen is also an essential material from a perspective of carbon neutral. Because hydrogen burns without emitting CO_2, it is attracted as a clean energy source. In addition, hydrogen is indispensable as a basic material in a chemical industry. Today, an industrial production of hydrogen is based on a steam reforming method, in which fossil fuels (i.e., petroleum, natural gas, and coal) are reacted with water at high temperature. Therefore, consumption of fossil fuels and emission of CO_2 still remains. To achieve carbon neutral, technological development of green hydrogen production from water with renewable energy is desired. The CV center

conducts the research on artificial photosynthesis in which green hydrogen is produced by water splitting using a photocatalyst that is the strength of our university. The green hydrogen can be utilized for a carbon value technology such as hydrogenation of CO_2 to produce valuable compounds in a chemical industry.

2. 2. 2. Manufacturing of Highly Valuable Products by CO_2 Reduction

To manufacture highly valuable products (i.e., gasoline, jet fuel, olefin, and alcohol) from CO_2 as a carbon source, we work on the development of CO_2 reduction technologies. CO_2 reduction by artificial photosynthesis using sun light, H_2O and photocatalysts/semiconductor photoelectrodes, and an electrochemical reaction of CO_2 with renewable electricity are studied for the direct CO_2 reduction.

2. 2. 3. Development of Batteries Supporting Carbon Neutral Society

When green hydrogen is considered as a clean energy, the application to a fuel cell technology becomes important. The CV center works on reduction in an amount of platinum and even platinum free in fuel cells, because platinum is rare and expensive. A secondary battery to store renewable electricity is also a key technology for green hydrogen production and CO_2 reduction by electrochemical reactions. Developments of not only lithium but also sodium ion battery are important from a viewpoint of stable supply of the alkali metal resource. The secondary battery contributes to carbon neutral in an electric vehicle.

2. 3. Facilities

We organize the following instruments.
Transmission electron microscopy (TEM), Scanning electron microscopy (SEM), Automatic X-ray Diffraction Analyzer, X-ray Photoelectron Spectrometer (XPS), etc.

3. Activity Reports

We co-organized “Creating the future by carbon recycling! Exchange among different fields for open innovation” with Nagoya Industrial Science Research Institute and Carbon Recycling Fund Institute. There were 3 invited talks, 10 oral presentations, and 28 exhibitions. We had 224 of participants in person and on-line.

Prof. Roland Marschall (University of Bayreuth, Germany) was invited to give a lecture “Nanostructured Fe-based semiconductors and electrocatalysts for solar energy conversion a Trailblazer”.

We co-organized “the 29h Recent development of photocatalytic reactions” with Photofunctional Material Society and Research Center for Space System Innovation (RIST, TUS). There were 4 invited talks and 49 poster presentations. We had 218 of participants in person and on-line.

Groups of the center have mainly studied development of green hydrogen production and construction of hydrogen utilization system, production of valuable compounds by carbon dioxide reduction, and secondary battery. We published our achievements in various journals and cover pictures with high impact factors.

3. 1. Photocatalyst Group

This group have studied development of photocatalysts for water splitting to produce green hydrogen and CO_2 reduction using water as an electron donor. We collaborate with Prof. Ardo and some professors in USA and published results of precis characterization of a water splitting photocatalyst in *Energy Environ. Sci.* We have also started to study AI utilization to find new photocatalyst materials as a collaboration with NAIST. The results were presented in conferences and published in a Journal. Anti-bacteria using photocatalysts we have found has also been collaborated with an institute.

3. 2. Cluster Catalyst Group

We have developed photocatalysts targeting highly efficient CO_2 reduction, and published a paper on a CO_2 reduction photocatalyst incorporating a hydrophobic ligand into the Au25 NC cocatalyst. In collaboration with Professor G. F. Metha of the University of Adelaide, we also published a paper on Cu14 NC, demonstrating its utility as a CO_2 reduction electrode catalyst. Furthermore, in collaboration with Professor D.-e. Jiang of Vanderbilt University, we reported that Cu58 NC can serve as a highly efficient CO_2 reduction electrode catalyst for methanol synthesis from CO_2.

3. 3. CO_2 Conversion Group

Photothermal catalysts for carbon recycling was studied. The synthesis of solar-thermal CO_2 conversion materials and the development of reaction processes were examined in an industry-academia collaboration. In addition, we have developed a new process with the microwave input while blowing CO_2 into water, and have confirmed the conversion to methanol. Furthermore, we are also vigorously working on the conversion to ethanol and other substances with addition of catalysts in this reaction.

3. 4. Secondary Battery Group

To promote the efficient use of electrical energy, we conducted broad materials research on next-generation rare metal-free battery materials, focusing on layered sodium manganese oxides and template-synthesized hard carbon for sodium-ion batteries. This included studies on synthesis methods and composition optimization using machine learning. In addition to publishing research papers, we also contributed to public outreach by issuing press releases through the university.

3. 5. Physical Property-Control Group

Design principles for ceramic-based thin-film electrets with high surface potential and thermal stability were established, and their electrical properties were elucidated. Collaborative efforts with DENSO Corporation advanced the application of these materials to MEMS-type vibration-energy harvesters. In addition, joint studies with the photocatalysis group explored the potential for reaction control via induction and fixation of internal polarization in photocatalytic systems.

3. 6. CO_2 Capture Group

This group investigated more sustainable photo-CO_2 capture system in water and photo-CO_2 capture system using additional low temperature heating. Photoredox catalytic C-C bond-forming reaction of terminal acetylene and CO_2 was also investigated to expand the scope and elucidate the mechanism.

4. Challenges and Prospects

We organized several symposiums in 2024 as a host. However, an international workshop was not held this year. We are planning to hold an international conference focusing on energy materials for carbon value as an event of RIST. This international conference aims at exchanging opinions with domestic and foreign top scientists and expanding public relations. Individual studies were mainly conducted by our member, while collaborations among the members were not enough still. We enhance not only collaborations among our member but also among universities and institutes outside including foreign countries. Our members have published highly impact results. We will accelerate the output with further extensive studies and expect to give impact in public.

5. Conclusion

We will make the presence of our CV research center high presence in a world by publishing top class achievements through extensive collaborations with universities and institutes.

Major Research Achievements (FY2024)

Academic papers (Peer-reviewed)

1. Temperature Dependence of Photocatalytic Water Splitting under Visible Light Irradiation over Ir- and Sb-Codoped $SrTiO_3$:Al, E. Kikuchi, N. Saito, Y. Yamaguchi, A. Kudo, J. Phys. Chem. C, 2025, 129, 2381-2390
2. Water splitting over transition metal-doped $SrTiO_3$ photocatalysts with response to visible light up to 660 nm, K. Kaiya, Y. Ueki, H. Kawamoto, K. Watanabe, S. Yoshino, Y. Yamaguchi, A. Kudo, Chem. Sci., 2024, 15, 16025-16033
3. Revealing the Role of Redox Reaction Selectivity and Mass Transfer in Current-Voltage Predictions for Ensembles of Photocatalysts, L. Barrera, B. W. Layne, Z. Chen, K. Watanabe, A. Kudo, D. Esposito, S. Ardo, R. B. Chandran, Energy Environ. Sci., 2024, 21, 8254
4. Enhancing Photocathodic Performances of Particulate-$CuGaS_2$-Based Photoelectrodes via Conjugation with Conductive Organic Polymers for Efficient Solar-Driven Hydrogen Production and CO_2 Reduction, T. Takayama, A. Iwase, A. Kudo, ACS Appl. Mater. Interfaces, 2024, 16, 36423
5. Activation of Photocatalytic CO2 Reduction by Loading Hydrophobic Thiolate-protected Au25 Nanocluster Cocatalyst, Y. Yamazaki, Y. Tomoyasu, T. Kawawaki, Y. Negishi, Nanoscale Adv, 2025, 7, 1518-1523
6. Ultrafine Rhodium–Chromium Mixed-Oxide Cocatalyst with Facet-Selective Loading for Excellent Photocatalytic Water Splitting, D. Hirayama, T. Kawawaki, S. Oguchi, M. Ogano, N. Kon, T. Yasuda, A. Higami, Y. Negishi, J. Am. Chem. Soc., 2024, 146, 26808-26818
7. Atomically Precise $Au_{24}Pt$(thiolate)12(dithiolate)3 Nanoclusters with Excellent Electrocatalytic Hydrogen Evolution Reactivity, M. Sera, S. Hossain, S. Yoshikawa, K. Takemae, A. Ikeda, T. Tanaka, T. Kosaka, Y. Niihori, T. Kawawaki, Y. Negishi, J. Am. Chem. Soc., 2024, 146, 29684-29693
8. Electrochemical carboxylation: Green synthesis of atrolactic acid using boron-doped diamond electrodes, Yuvaraj M. Hunge, Toya Inaba, Keizo Ishihara, Kai Takagi, Ryoya Okamura, Hiroshi Uetsuka, Chiaki Terashima, Electrochim. Acta, 2024, 509, 145310/1-145310/9
9. Enhancing CO_2 Reduction: Insights from In-Liquid Microwave Plasma Chemical Vapor Deposition, Aiko Ikeda, Yuvaraj M. Hunge, Katsuya Teshima, Hiroshi Uetsuka, Chiaki Terashima, Energ. Fuel., 2024, 38, 11918-11926
10. $Na[Mn_{0.36}Ni_{0.44}Ti_{0.15}Fe_{0.05}]O_2$ predicted via machine learning for high energy Na-ion batteries, Saaya Sekine, Tomooki Hosaka, Hayato Maejima, Ryoichi Tatara, Masanobu Nakayama, Shinichi Komaba, J. Mater. Chem. A, 2024, 12, 31103-31107
11. New frontiers in alkali metal insertion into carbon electrodes for energy storage, Zachary T. Gossage, Daisuke Igarashi, Yuki Fujii, Masayuki Kawaguchi, Ryoichi Tatara, Kosuke Nakamoto, Shinichi Komaba, Chemical Science, 2024, 15, 18272-18294
12. Stability of RbO_2 as a Discharge Product of Metal–O_2 Batteries, Ryusei Fujimoto, Ryoichi Tatara, Tomooki Hosaka, Daisuke Igarashi, Shinichi Komaba, J. Am. Chem. Soc., 2025, 147, 6747-6752
13. Yasunobu Ando, Shusuke Kasamatsu, Suguru Iwasaki, Yumi Tanaka, “Fitting of nonnegative physical models based on statistical divergence: application to thermally stimulated depolarization currents”, Sci. Tech. Adv. Mater.: Methods, 2025, 5[1], 2441102

Books

1. Transition Metal Dichalcogenide-based Photocatalyst Materials for Hydrogen Production, Yuvaraj M. Hunge, Anuja A. Yadav, Seok-Won Kang, Akira Fujishima, Chiaki Terashima, Advances in

Photocatalysis, Electrocatalysis and Photoelectrocatalysis for Hydrogen Production, Edited by R. Geetha Balakrishna; R. Shwetharani; Theerthagiri Jayaraman, The Royal Society of Chemistry, ISBN: 978-1-83767-235-6, 2024

2. Electrets and their theoretical modeling, Suguru Iwasaki, Yasunobu Ando, Shusuke Kasamatsu, Yumi Tanaka, Interface Ionics: For All-Solid-State Batteries and Solid State Ionics Devices, ELECTROCHEMISTRY (The Materials Research Society Series), Chapter 7, Springer-Nature, pp553-565, 2024

Invited Lectures

1. Photocatalytic CO_2 reduction using water as an electron donor, A. Kudo, (Invited), Pacific Rim Meeting on Electrochemical and Solid State Science (PRiME 2024): L04 - Photocatalysts, Photoelectrochemical Cells, and Solar Fuels 14, Honolulu, Hawaii, 2024
2. Photocatalytic water splitting to form green hydrogen, A. Kudo, (Invited), Pacific Rim Meeting on Electrochemical and Solid State Science (PRiME 2024): Symposium Z02: A Lifetime of Cleaning the Plant, Honolulu, Hawaii, 2024
3. Green hydrogen production and CO_2 reduction using heterogeneous photocatalysts, A. Kudo, (Keynote), International Conference on Artificial Photosynthesis-2024 (ICARP2024), International Conference Center Hiroshima, 2024
4. Greem H_2 production and CO_2 reduction using powdered photocatalysts, A. Kudo, (Keynote), KIChE (Korea institute of chemical engineering) spring meeting, Jeju, Korea, 2024
5. Precise Synthesis of Ligand-Protected Metal Nanoparticles and Nanoclusters for Photoelectrochemical Applications, Tokuhisa KAWAWAKI, (Invited), International Congress on Pure & Applied Chemistry (ICPAC) Mongolia 2024, Holiday Inn Ulaanbaatar Conference Center, Ulaanbaatar, Mongolia, 2024
6. Photoelectrochemical CO_2 Reduction on Diamond Semiconductor, Chiaki Terashima, Hiroshi Uetsuka, Katsuya Teshima, (Invited), 32nd International Materials Research Congress 2024, Cancun, Mexico, 2024

Patents

1. Yumi Tanaka, Hiroki Otsuka, Yusuke Edano, Yoshihiro Kozawa, Noriyuki Matsushita, Kazuhiko Kanoh, US patent: US 12,191,088 B2, “POWER GENERATOR HAVING AN ELECTRET FOR HARVESTING ENERGY”, 2025
2. Yumi Tanaka, Hiroki Otsuka, Yusuke Edano, Yoshihiro Kozawa, Noriyuki Matsushita, Kazuhiko Kanoh, US patent: US 12,119,184 B2, “POWER GENERATOR”, 2024.
3. 今堀龍志, 本山 遼, 化合物、二酸化炭素吸収・放出剤, 二酸化炭素収集方法及び二酸化炭素収集装置, No.7466210, 2024 (In Japanese)

Public Relations

1. 工藤昭彦, グリーン水素「夢の燃料」カギは光触媒, 東京新聞, 中日新聞, 2025. (In Japanese)
2. 川脇徳久, 根岸雄一, 光触媒の水素生成面を選んで極微細な助触媒を担持する技術を開発,日本経済新聞, 2024. (In Japanese)
3. 田中優実, イオンを運ぶセラミックス-未来のエネルギーを担う見えない動きの秘密, 2024 年度東京理科大学公開講座「坊っちゃん講座」, 2024 (In Japanese)

Awards

1. 工藤昭彦, 2025 年電気化学会 電気化学会賞(武井賞)受賞, カーボンニュートラルを目指した人工光合成型光触媒の開発, 2024 (In Japanese)

Individual Research Topics

Akihiko Kudo and Yuichi Yamaguchi

"Development of photocatalysts aiming at production of green hydrogen and highly efficient CO_2 reduction using water as an electron donor"

Production of green hydrogen and CO_2 reduction using water as an electron donor are important research topics to achieve carbon neutral society. This year, we successfully developed various metal sulfide photocatalysts with Chalcopyrite and Stannite structures for sacrificial hydrogen evolution under visible light irradiation. In addition, Sr-doped $AgTaO_3$ photocatalysts were found to be active for CO_2 reduction using water as an electron donor to form CH_4, C_2H_6, and C_3H_8 evolution by loading of Rh-Ni dual metal cocatalysts.

Yuichi Negishi, Tokuhisa Kawawaki

"Enhancement of photocatalytic activity for CO_2 reduction by controlling the surface hydrophilicity of metal nanocluster promoters"

Photocatalytic CO_2 reduction, which reduces carbon dioxide (CO_2) to various useful compounds using light, has attracted attention. In this study, we used ultrafine metal nanoclusters (NCs) with a particle size of approximately 1 nm as cocatalysts and clarified the effects of surface ligands on the activity and selectivity of the photocatalytic CO_2 reduction reaction. The results showed that the introduction of hydrophobic ligands to the Au_{25} NC cocatalyst suppressed the competing hydrogen evolution reaction and improved the selectivity of the CO_2 reduction reaction.

Chiaki Terashima

"Photothermal Catalysts for Carbon Recycling"

CO_2 reduction technology, which views CO_2 as a resource and converts it into a useful resource, is attracting attention. In artificial photosynthesis, TiO_2 photocatalysts can only utilise about 6% of the sunlight, and the R&D into visible light responsiveness is underway. Photothermal catalysts, on the other hand, have a potential to utilise more than 50% of sunlight. Therefore, the synthesis of solar-thermal CO_2 conversion materials and the development of reaction processes will be addressed.

Shinichi Komaba

"Study on materials of next generation battery for efficient utilization of electricity"

As next-generation rechargeable batteries that do not require rare or toxic elements, we are promoting materials research on sodium-ion and potassium-ion batteries. Some of these developments have already begun to be commercialized. In FY2024, we have achieved several research achievements, including the prediction of optimal compositions for layered sodium manganese oxides—promising electrode materials for sodium-ion batteries—using machine learning, analysis of electrode reaction kinetics of Na insertion into hard carbon, and studies on binders and novel electrolytes such as deep eutectic solvents. We have also reported results from fundamental research on Rb–air batteries.

Yumi Tanaka

"Study on Ceramic Electrets for Electrostatic Vibration Energy Harvesters"

To develop electret materials for MEMS-based vibration energy harvesters capable of stably maintaining surface potential under high-temperature conditions, thin films of rare-earth aluminate were fabricated and their electrical properties evaluated. As a result, YAG thin films were found to be promising high-performance electret materials, and annealing was shown to enhance charge retention performance through

structural stabilization. In addition, collaborative efforts with industry led to the fabrication and operational demonstration of MEMS devices incorporating this material.

Tatsushi Imahori

“Development of sustainable carbon-recycle system using sunlight”

We are developing CO_2 capture and release technology using sunlight with photo-switchable CO_2 absorbent that changes the CO_2 absorption state with precipitation and the CO_2 release state with dissolution based on the photoisomerization. In this year, development of highly energy-saving photo-CO_2 capture and release technology was studied. We are also developing sustainable catalytic C-C bond-forming reaction using visible light as the utilization of the recovered CO_2.

Research Center for Multi-hazard Urban Disaster Prevention

Research Center for Multi-hazard Urban Disaster Prevention

1. Overview

In Japan, in addition to geographical and social conditions that allow multi-hazards to occur, there is concern that the damage to infrastructure will become more serious due to the denser urban structure. Based on this background, in order to create and put into practice a new urban disaster prevention science and build a safe and secure society that is sustainable, takes diversity into account, and leaves no one behind, the research center for multi-hazard urban disaster prevention has been established in the RIST on August 1, 2023. The purpose of this center is the following three points.

- We elevate previous research for single hazard such as natural disasters, large fires, and the spread of new infectious diseases into an academic system that can handle multiple hazards. Researchers from different fields collaborate and fuse to create comprehensive breakthroughs in urban disaster prevention.
- While keeping in mind urban disaster prevention based on building a resilient, safe, and secure society, we aim to realize people's well-being by being sustainable (energy saving), environmentally friendly (SDGs), comfortable, improving QOL, and taking health into consideration.
- We actively collaborate with government agencies and private companies from the beginning of research in order to socially implement the academic knowledge and results obtained.

In order to achieve these objectives, while it is natural for individual researchers to promote research on urban disaster prevention and mitigation as has been the case in the past, we will place the utmost importance on actively promoting cross-disciplinary collaboration and fusion between different fields. With this in mind, the center's activity policy is based on the following four points.

- We promote research in urban disaster prevention, especially in the multi-hazard field and disaster prevention informatics field, by collaborating with researchers and engineers outside the university and researchers in our university who specialize in urban disaster prevention of various hazards, data science, and materials.
- The center's activities will not be limited to the "addition" of the research results of individual researchers, but will actively promote horizontal collaboration and fusion among researchers in different fields, resulting in the "multiplication" of research results.
- We actively promote collaboration with local governments and private companies and greatly contribute to improving local disaster prevention and mitigation capabilities.
- We deepen collaboration with leading domestic and international researchers and form an international joint research center related to urban disaster prevention.

2. Organization and Facilities

2. 1. Member List

The member composition of the center as of the end of FY2024 is as shown in Table 1. At this time, there will be a total of 33 members, including 31 faculty members from our university (21 more in FY2024) and 2 members from institutions other than our university (2 more in FY2024). The members are not only experts in various hazards and disaster prevention (earthquakes, fires, floods, tsunamis, volcanoes), but also researchers with a variety of specialties who are not originally specialized in disaster prevention and mitigation (data science, materials, urban development, building environment, medicine, etc.). The number of hazard experts and other experts is roughly half and half, which is a lineup unique to our university. In

addition, from outside, Professor Ochi from the Jikei University School of Medicine, which has a close relationship with our university, and Chief Researcher Taguchi from the National Research Institute for Earth Science and Disaster Resilience (NIED), a designated public institution that plays an important role in disaster prevention administration, have been invited as visiting professors from outside the university, and are conducting research in collaboration with the center. From 2025 onwards, we plan to gradually increase the number of members from within the university and also add researchers from outside the university.

2. 2. Facilities

[Shaking table system]

Table 1. Member of the Center (as of the end of FY2024)

	Affiliation	Position	Name
Director	Department of Civil Engineering, Faculty of Science and Technology	Professor	Yasuo NIHEI
Vice Director	Department of Physics, Faculty of Science Division I	Professor	Takahiro YAMAMOTO
Vice Director	Department of Global Fire Science and Technology, Graduate School of Science and Technology	Professor	Ken MATSUYAMA
Concurrent Faculty	Department of Architecture, Faculty of Engineering	Professor	Takumi ITO
Concurrent Faculty	Department of Architecture, Faculty of Science and Technology	Associate Professor	Yuji MIYAZU
Concurrent Faculty	Department of Industrial and Systems Engineering, Faculty of Science and Technology	Professor	Aya ISHIGAKI
Concurrent Faculty	Department of Applied Mathematics, Faculty of Science Division I	Concurrent Faculty / Professor	Takashi SEO
Concurrent Faculty	Organization for Research Advancement, Research Institute for Biomedical Sciences, Research Division	Professor	Masato KUBO
Concurrent Faculty	Department of Civil Engineering, Faculty of Science and Technology	Assistant Professor	Jin KASHIWADA
Concurrent Faculty	Department of Civil Engineering, Faculty of Science and Technology	Assistant Professor	Yoshitaka KATO
Concurrent Faculty	Department of Information Sciences, Faculty of Science and Technology	Associate Professor	Tomofumi MATSUZAWA
Concurrent Faculty	Department of Mathematics, Faculty of Science Division II	Associate Professor	Asanao SHIMOKAWA
Concurrent Faculty	Department of Architecture, Faculty of Science and Technology	Professor	Yoshifumi OHMIYA
Concurrent Faculty	Department of Global Fire Science and Technology, Graduate School of Science and Technology	Professor	Kazunori KUWANA
Concurrent Faculty	Department of Architecture, Faculty of Science and Technology	Professor	Masayuki NAGANO
Concurrent Faculty	Department of Architecture, Faculty of Science and Technology	Assistant Professor	Hong LIU
Concurrent Faculty	Department of Architecture, Faculty of Engineering	Assistant Professor	Natsuhiko SAKIYAMA
Concurrent Faculty	Department of Applied Physics, Faculty of Advanced Engineering	Professor	Takashi NAKAJIMA
Concurrent Faculty	Department of Mechanical Engineering, Faculty of Engineering	Associate Professor	Ryo INOUE
Observer	Department of Pure and Applied Chemistry, Faculty of Science and Technology	Associate Professor	Isao SHITANDA
Concurrent Faculty	Department of Architecture, Faculty of Science and Technology	Associate Professor	Kozo TAKASE
Concurrent Faculty	Department of Information Sciences, Faculty of Science and Technology	Professor	Munehiro TAKIMOTO
Concurrent Faculty	Department of Information Sciences, Faculty of Science and Technology	Assistant Professor	Shohei TAGA
Concurrent Faculty	Department of Industrial and Systems Engineering, Faculty of Science and Technology	Professor	Ryuta TAKASHIMA
Concurrent Faculty	Department of Industrial and Systems Engineering, Faculty of Science and Technology	Assistant Professor	Kazuya ITO
Concurrent Faculty	Department of Architecture, Faculty of Science and Technology	Professor	Kaori ITO
Concurrent Faculty	Department of Architecture, Faculty of Science and Technology	Special Lecturer (Contract)	Seiya TAKAYANAGI
Concurrent Faculty	Department of Civil Engineering, Faculty of Science and Technology	Associate Professor	Hideki YAGINUMA
Concurrent Faculty	Department of Information and Computer Technology, Faculty of Engineering	Associate Professor	Masaya FUJISAWA
Concurrent Faculty	Department of Electrical Engineering, Faculty of Science and Technology	Assistant Professor	Kaiyu SUZUKI
Concurrent Faculty	Department of Applied Physics, Faculty of Advanced Engineering	Junior Associate Professor	Naofumi ASO
Concurrent Faculty	Department of Civil Engineering, Faculty of Science and Technology	Associate Professor	Makoto NAKAYOSHI
Concurrent Faculty	Research Institute for Biomedical Sciences, Research Division, Organization for Research Advancement	Associate Professor	Yasutaka MOTOMURA
Visiting Professor	Laboratory Medicine, Jikei University	Professor	Sae OCHI
Visiting Professor	National Research Institute for Earth Science and Disaster Resilience	Visiting Professor / Chief Research Officer	Hitoshi TAGUCHI

This system consists of a vibration table capable of simulating large-scale seismic motions and an integrated measurement system (Fig. 1). Its basic specifications include uniaxial excitation, a table size of 1.5 × 1.5 (m), a maximum payload capacity of 5 t, maximum displacement of ±200 mm, maximum velocity of 100 cm/s, maximum acceleration of 2 G under seismic wave input and 1 G under sinusoidal input, and a frequency range of 0.5 to 100 Hz. The system enables vibration testing of buildings, structural specimens, and various types of equipment. It is also possible to conduct tests with human subjects if handrails are installed.

[Large-scale reaction frame]

This system consists of a large steel reaction frame and four hydraulic jacks (Fig. 2). The steel frame measures approximately 5 m in width and 6 m in height. It can accommodate four hydraulic jacks with capacities of 2000, 800, 100, and 50 kN. The facility enables structural experiments on a wide range of materials and components, including wooden walls and beam-column joints, as well as reinforced concrete columns.

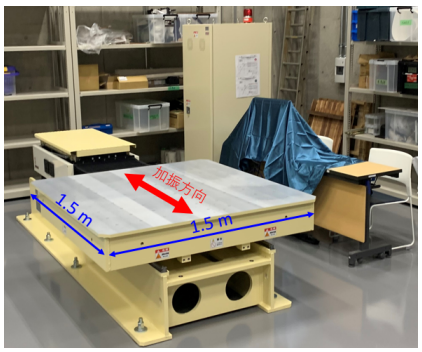

Fig. 1. Shaking table system

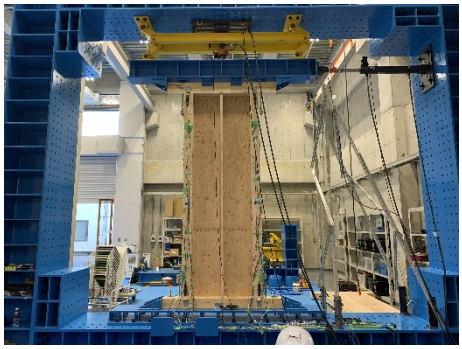

Fig. 2. Large-scale reaction frame

[Seismic loading test facility for structures]

At the Structural Experimental Testing Building on the Katsushika Campus, a reaction frame has been installed, allowing the reproduction and evaluation of structural behavior and failure mechanisms under seismic excitation using portable jacks. This facility enables static loading tests up to 200 kN, and dynamic loading tests up to 20 kN on test specimens up to approximately 2 meters in height and 1.5 meters in width. Additionally, it allows force control based on random vibration waveforms, such as those generated by earthquakes.

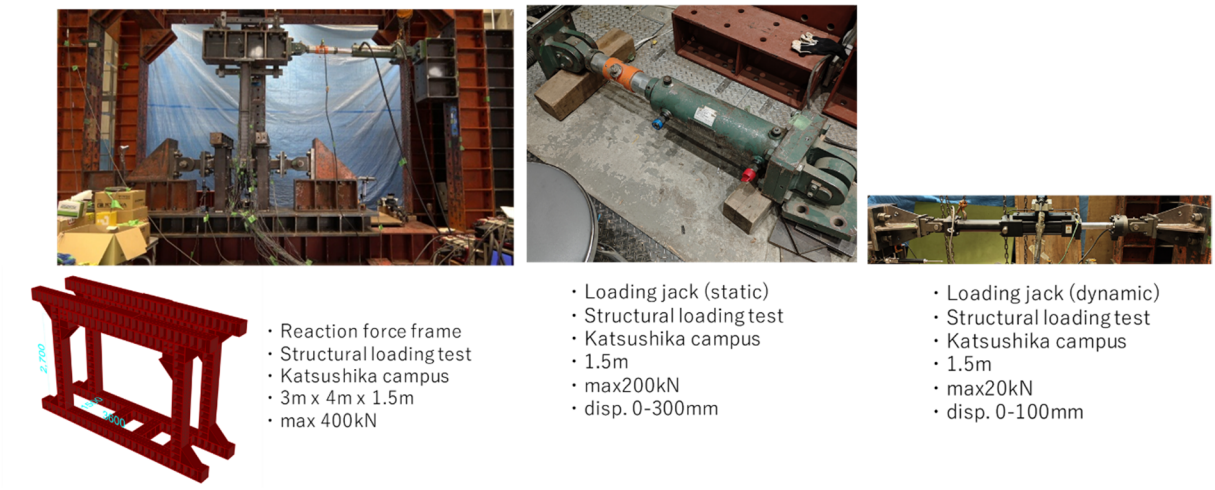

Fig. 3. Seismic loading test facility

[Universal loading test machines and heating tests]

The medium-scale structural experimental testing building on the Katsushika Campus is equipped with 1,000 kN and 2,000 kN universal testing machines, which can perform various load tests—such as tension, compression, bending, and shear—on structural columns, beams, and material specimens (Fig. 4). At the same facility, heating tests of up to 800°C can be conducted on small-scale structural specimens while under load (Fig. 5).

・Heating furnace
・Heating experiment
・Katsushika campus
・1.5m
・max800°C

Fig. 4. Universal loading test machines

・Universal loading test machine
・Katsushika campus
・4m
・max2,000kN
・max50mm/min
・stroke 300mm

Fig. 5. Heating tests

[Multi-hazard (MH) channel for earthquakes, floods, and tsunamis]

This waterway is used to reproduce MH disasters caused by earthquakes, floods, and tsunamis in an experimental waterway (Fig. 6.). The dimensions of the experimental waterway are 33 m in length, 0.60 m in width and depth, and 1.0 m in height, and it is composed of a flood/tsunami waterway (26 m in length), a vibration waterway (5.0 m in length), and a connecting waterway (2.0 m in length) between them. Flood/tsunami experiments are conducted with the three waterways connected. On the other hand, vibration experiments are conducted by removing the connecting waterway and attaching a vibration device to vibrate the vibration waterway. The flood/tsunami waterway is equipped with a large pump (maximum flow rate 0.126 m^3/s). For tsunami experiments, a hydraulically controlled automatic wave step device is installed, and a water level difference of up to 0.9 m can be set in front of and behind the door. The vibration channel can vibrate in one horizontal direction (maximum acceleration of 1000 gal, load of 2.5 tons) and is driven by a pneumatic air cylinder.

Fig. 6. Multi-hazard (MH) channel for earthquakes, floods, and tsunamis

3. Activity Reports

Below is a brief overview of the activities carried out at this center, which places emphasis on collaboration both within and outside the university, and the research conducted by each group.

3. 1. Activities for On-Campus and Off-Campus Collaboration

(1) Open seminars

The “Multi-Hazard Urban Disaster Prevention Research Seminar” was held three times in FY2024 under the auspices of this center. The outline is given below.

1) First session: Saturday, April 20, 2024, 13:00-16:00
   - Participants: 115 from outside the university, 94 from within the university)
   - Topic: 2024 Noto Peninsula Earthquake Investigation and Report “Damage and Issues Caused by Multi-Hazards”
   - Lecturers: 12 faculty members from our university
   - Notes: Co-hosted by the Disaster Prevention and Risk Management Course of the Graduate School of Science and Technology at our university and the Center for Fire Science and Technology.
2) Second session, Tuesday, August 28, 2024, 14:30-17:30
   - Participants: 25 from outside the university, 22 from inside the university
   - Theme: Medical care and disaster prevention
   - Lectures: Professor Ochi Sae, Tokyo Jikei University School of Medicine, “Hospital disaster prevention and research opportunities”

   Director Tanaka Tomoaki, Institute of Disaster Therapy, Chiba University, "Mission of the Institute of Disaster Therapy and efforts to build a resilient society"
3) Third session, Tuesday, December 17, 2024, 13:00-16:00
   - Participants: 55 from outside the university, 14 from inside the university)
   - Theme: Architecture and multi-hazards
   - Lectures: Associate Professor Hida Takanori, Ibaraki University, “Recovery simulation after multi-hazards”

     Professor Emeritus Takada Takeshi, University of Tokyo, “Multi-hazard modeling to ensure urban system performance”

(2) Establishment of the Consortium Preparatory Committee

In order to strengthen collaboration between the Center and external institutions and to implement research results in society, the Consortium Preparatory Committee was established in May 2024 and began activities. As of FY2024, 31 companies are participating, as shown in Fig. 7. The Consortium Preparatory Committee held three study sessions and one general exchange meeting.

1) First study session, Thursday, October 17, 2024, 15:00-18:00, Noda Campus
   Participants: 33 from outside the university, 20 from inside the university
   Presenters: Y. Miyazu, M. Takimoto, M. Nagano, Y. Kato, S. Taga, Y. Omiya, R. Takashima, N. Sakiyama, T. Matsuzawa, I. Shitanda, S. Takayanagi
2) Second study session, Thursday, November 28, 2024, 15:00-18:00, Kagurazaka Campus”Participants: 31 from outside the university, 16 from inside the university
   Presenters: H. Liu, T. Yamamoto, K. Kuwana, K. Ito, J. Kashiwada, A. Ishigaki, N. Aso, T. Seo, K. Suzuki, K. Takase, K. Ito
3) Third study session, Thursday, January 16, 2025, 15:00-18:00, Katsushika Campus
   Participants: 27 from outside the university, 20 from within the university
   Presenters: T. Ito, T. Nakajima, K. Matsuyama, R. Inoue, M. Fujisawa, H. Taguchi, A. Shimokawa, M. Kubo, Y. Nihei, S. Ochi
4) Networking event, Monday, March 24, 2025, 15:00-18:00, Noda Campus
   Participants: 14 from outside the university, 27 from within the university
   Presenters: Ishigaki A., Ito K., Ito T., Omiya Y., Ochi S., Kashiwada J., Kato Y., Kuwana K., Sakiyama N., Shitanda I., Shimokawa A., Takase K., Taga S., Takimoto M., Taguchi H., Nakajima T., Nagano M., Nakayoshi M., Nihei Y., Fujisawa M., Matsuzawa T., Matsuyama K., Miyazu Y., Motomura Y., Liu H.

Fig. 7. Companies participating in the consortium preparatory committee (as of the end of fiscal year 2024)

3. 2. Main Research Topics

At this base, we promoted collaboration on five groups: 1) different hazards, 2) data science and disaster prevention, 3) materials and disaster prevention, 4) disaster prevention measures before, during, and after the occurrence of damage, and 5) regions. The research content of each group is as follows.

1) Collaboration between different hazards (flood * earthquake, fire * flood, earthquake * fire, etc.)

We conducted experimental and numerical simulation studies to evaluate the risk of steel structures during earthquakes and fires and to develop fireproofing methods using materials other than existing general fireproofing materials. We also conducted MH risk evaluations of floods and earthquakes in the five wards. Of these, we selected the Takasago area in Katsushika Ward and estimated MH damage

evaluations and building damage. In addition, we installed IoT monitoring devices in buildings and, based on the damage assessment system, we proposed triage of buildings to be surveyed, dispatch plans for investigators, and evacuation shelter plans.

2) Collaboration between data science and disaster prevention
   Regarding the use of drones in response to multi-hazard disasters, we examined a method of using aerial video taken by drones to obtain physical information such as the dimensions and layout of buildings. We tried to convert videos taken by drones into photographic images, estimate the camera position, convert the data into point cloud data, process the data in Blender, and correct the scale and measure the dimensions. In addition, for application in disaster areas, we developed software to convert the target buildings and terrain into 3D based on the images taken by drones.
3) Cooperation between materials and disaster prevention
   In order to deal with the power shortage after the MH disaster, we developed an energy harvesting device. This year, we developed a new energy harvesting device that aims for water power generation. We developed a device that combines liquid metal and PEDOT/PSS as a material with high elasticity and flexibility. We conducted basic studies and evaluation analysis to increase the amount of power generated. We are also exploring the possibility of using it as a water leakage sensor tool during disasters.
4) Cooperation between disaster prevention measures before, during, and after a disaster
   As a study on evacuation routes immediately after a disaster, we integrated the knowledge of experts at the MH urban disaster prevention center, built a system to encourage appropriate evacuation behavior, and conducted research focusing on evacuation guidance by car during floods.
5) Regional Collaboration
   In collaboration with Katsushika Ward Office, we have begun preparations for research into the earthquake resistance of buildings and indoor environments.

4. Challenges and Prospects

This year, several technical cores in multi-hazard urban disaster prevention research are beginning to take shape, leading to the publication of papers and the acquisition of patents. However, this alone is unlikely to lead to a social contribution or implementation of the results, so we will work closely with government agencies, primarily local governments, to fully implement the technology obtained through this research in society. We aim to realize horizontal expansion into areas such as “space and disaster prevention” and “medical care and disaster prevention,” taking further advantage of the unique characteristics of our university.

5. Conclusion

Taking advantage of the unique features of the Tokyo University of Science, the center is creating a research groups in which researchers with a variety of specialties participate. The center is also actively promoting cross-sectional collaboration, which is the original purpose of the RIST, and is also conducting original research. In the future, the center plans to strengthen its function as a research center on multi-hazards by promoting collaboration with researchers both in Japan and abroad.

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Individual Research Topics

Yasuo Nihei

“Development of multi-hazard research centered on flood damage”

We developed a unified multi-hazard risk assessment method that takes into account the impact of climate change and is not dependent on hazards. Here, we conducted an evaluation of the probability of occurrence (hazard curve) by hazard scale for multi-hazards caused by earthquake motion and heavy rain. We also conducted a survey of building damage as an example of the occurrence of multi-hazards of “earthquake & tsunami” and "tsunami & fire" in the Noto Peninsula earthquake and heavy rain of 2024. As a result, we found that in the case of "earthquake & tsunami," the "MH effect" was observed, which means that building damage differs even with the same tsunami external force, due to the difference in the influence of the preceding earthquake.

Yoshitaka Kato

“Development of tools to experience the attractiveness of engineers involved in infrastructure”

The subject of the tool to be developed by each company was decided. The following types of tools were considered: a type in which participants design infrastructure facilities based on their own ideas and experience the life of the facilities through backgammon (breakwaters, towns centering on railroad stations), a type in which participants experience the creation of different types of structures according to the process of backgammon (bridges, tunnels) without requiring knowledge of the prerequisites, and a type in which participants experience post-disaster emergency restoration response and maintenance of existing structures.

Ken Matsuyama

“Study for the reduction of secondary damage after a large-scale disaster, with a focus on fire prevention measures”

When a large-scale disaster occurs, people are required to live in temporary shelters such as gymnasiums and community centers. In addition to preventing secondary damage (e.g., economy syndrome, infectious diseases), the living environment is being improved to ensure privacy. In particular, the use of cardboard beds and partitions has dramatically improved the living environment and reduced secondary damage. On the other hand, the potential risk of fire is increasing, and fire prevention measures are essential. The purpose of this study is to reduce fire risks in shelters. Therefore, corrugated fiberboard beds will be made fire retardant, and their optimal placement in the shelter will be proposed. First of all, information was collected and surveyed and analyzed in the Cabinet Office guidelines and other laws and regulations, as well as in the existing literature. In the future, experiments using various flame retardant chemicals at the material level of corrugated fiberboard as well as full-scale burning experiments will be conducted. a full-scale scale.

Yoshifumi Ohmiya

“Utilizing drones in the fire prevention field”

We investigated a method to utilize videos taken by a drone to obtain physical information such as dimensions and layout of buildings and furniture. As a procedure for obtaining such information, we first extracted the videos taken by the drone as photographic images. Then, we estimated the camera position using COLMAP, converted the data into point cloud data using NeRF, and processed the data in Blender. Based on the results, we attempted to correct the scale and measure the dimensions. Then, we conducted the investigation on a scale model and were able to clarify the issues with the method we investigated.

Aya Ishigaki

“Research on evacuation guidance and material support in the event of a disaster”

The first theme was to propose a traffic flow control method that considers the risk of flooding on roads in the event of a flood. This project was conducted in collaboration with Nihei Lab. The second theme was to develop a model that integrates post-disaster road repair planning and transportation planning of relief supplies. The model was developed by integrating the knowledge of Yaginuma’s laboratory, which specializes in transportation planning, and our laboratory's knowledge of inventory delivery planning, providing a foothold for the next fiscal year and beyond.

Tomofumi Matsuzawa

“Digital transformation in Support of Disaster Victims”

In recent years, support using IT and ICT technologies has been attracting attention at many disaster areas. We are constructing an interactive communication infrastructure using multiple drones to monitor the situation of disaster areas during and after the disaster. On the communication infrastructure we have constructed, drones will be controlled autonomously to capture images of the disaster area and analyze the current status of the disaster area. Based on the analysis results, we aim to provide evacuation guidance and rescue support for disaster victims.

Kaiyu Suzuki

“Image Processing in Support of Disaster Victims”

To assist disaster-affected areas, we provide support for situational awareness and decision-making based on images obtained from drone-mounted cameras. In particular, we focus on situational understanding through 3D modeling of disaster areas and automated analysis of the damage.

Munehiro Takimoto

“Parallelized Inductive Logic Programming Based on Neuro Symbolic”

In this study, I extend Inductive Logic Programming (ILP), which is a kind of logical A.I., based on Neural Network and implement a practical ILP system through making it work on GPU.

Shohei Taga

“Evacuation Support After Disasters Using UAVs”

In large-scale disasters, it is crucial to promptly provide alternative evacuation routes when the original paths become inaccessible. This study proposes a method where UAVs patrol affected areas, detect blocked routes, and notify smartphones of their locations. Unlike conventional approaches using ad hoc networks—which face security issues—this method embeds location data in the UAV’s SSID. Smartphones then retrieve this information via Wi-Fi scanning. This approach enhances practicality and feasibility in real-world scenarios. Future work will focus on implementing and evaluating the proposed system.

Ryuta Takashima

“Estimating quality-adjusted life years by health economics model”

To address the recent rise in healthcare expenditure due to an aging population, the rational allocation and efficient use of resources, based on scientific evidence, has become indispensable. This study presents a valid quality-adjusted life years (QALY) estimation based on the value of statistical life. We assess the accuracy of conventional QALY estimates while proposing a new, rational, and flexible QALY estimation that combines age and scenario factors, demonstrating their validity. Our numerical analysis suggests that updating QALY by considering regional characteristics such as population, age distribution, and changes in quality of life can lead to a more accurate analysis.

Kazuya Ito

“Energy system assessment and policy formulation integrating environmental load and health risk”

Energy supports all critical sectors, such as healthcare, telecommunications, and logistics, yet remains vulnerable to natural hazards. In the power sector, managing disaster risk alongside decarbonization is essential while maintaining a stable supply. We employ an optimization modeling framework to quantify the impacts of natural hazard events on power systems and their effects on social welfare. From these quantitative results, we aim to provide clear guidance for policymakers by specifying which interventions are required, when and where they should be applied, and to what degree to strengthen resilience and promote sustainability in electric power planning.

Kozo Takase

“Measurement of indoor thermal and air environment and environmental improvement in gymnasiums used as evacuation shelters”

Indoor thermal and air environment measurements during evacuation shelter use in a gymnasium. This survey was conducted in collaboration with the class of “Urban Risk Management 2” (Disaster Risk Management Course). Indoor Thermal Environment Measurement and Improvement Proposals for University Campus Buildings. The survey was conducted targeting Building No. 2 and the Lecture building in Noda Campus to verify the effectiveness of improving thermal comfort during heating and energy-saving effects of air conditioning systems by temporarily partitioning spaces through actual measurements and CFD analysis.

Naofumi Aso

“Physics of Earthquakes, Volcanoes, and Tsunamis as Primary Phenomena of Multi-Hazard Disasters”

While we successfully extracted statistical features of earthquake source migration, we plan to develop a source migration model primarily through numerical simulations. We also revealed the spatial characteristics of seismicity for low-frequency earthquakes in Shikoku. We will examine this relationship with the spatial dependence of more continuously occurring tremors. In evacuation simulations, we analyzed the congestion mechanism in one specific case, and we will clarify universal behavior under various conditions.

Takumi Ito & Natsuhiko Sakiyama

"Monitoring and evacuation security planning for damaged cities and buildings due to multi-hazard disasters combined earthquake and flood"

Hazard map analysis and field surveys were conducted to assess multi-hazard risks in five Koto districts. Takasago in Katsushika Ward was selected for damage evaluation using the Mh index. Discussions with Katsushika officials informed disaster response planning. IoT monitoring devices, developed in Beppu City, were installed to support triage, investigator dispatch, and shelter operations through remote observation. Post-disaster administrative services and recovery processes for earthquake-damaged buildings were also examined. This integrated approach combines technology and planning to enhance disaster management efficiency.

Ryo Inoue

"Research and development of heat-resistant lightweight composite materials"

At the Inoue Laboratory, research activities are focused on composite materials centered around heat-resistant ceramics and the evaluation and analysis of heterogeneous materials under special environments. In the research division, the goal is to develop materials that combine lightweight properties, mechanical strength, and flame resistance. This year, we successfully fabricated composite materials composed of flame-retardant continuous fibers and flame-retardant plastics using 3D printing technology. The evaluation of their mechanical, thermal, and flame-resistant properties revealed that they exhibited superior characteristics compared to existing materials.

Masayuki Nagano and Hong Liu

"Issues on Disaster Prevention and Mitigation for Urban Multi-Hazard Events Based on Lessons from the 2024 Noto Peninsula Earthquake"

This study focuses on the challenges of disaster prevention and mitagation in the context of urban multi-hazard disasters, taking the 2024 Noto Peninsula Earthquake as a case study. The disaster was characterized by a combination of seismic damage, large-scale fires in Wajima City, and severe flooding caused by torrential rainfall in Oku-Noto in September. Field investigations were conducted to verify the extent of these impacts. Based on the findings, interdisciplinary workshops are being held at our research center to explore disaster mitigation and evacuation planning strategies. The ultimate goal is to formulate practical urban disaster risk reduction measures, with Katsushika City serving as a implementation site.

This study evaluates the seismic performance of mid- to high-rise reinforced concrete (RC) buildings subjected to multiple major earthquakes, with a focus on the 2018 and 2024 Hualien Earthquakes in Taiwan. In 2024, two rounds of field surveys and ambient vibration measurements were carried out on RC buildings over ten stories in Hualien City. While several buildings showed no major damage after the 2018 event, significant structural deterioration was observed following the 2024 earthquake. Furthermore, buildings with obvious damage exhibited considerable changes in their natural periods. These findings clarify the effects of repeated strong earthquakes on the dynamic properties and seismic performance of RC buildings.

Takashi Seo

“Studies on Tests for Multivariate Data with Missing Observations and Longitudinal Data, and Multivariate Normality Testing Problem”

This study develops statistical procedures for multivariate data and multivariate normality test, and their application to data related to multi-hazard urban disaster prevention. In particular, we have conducted research on tests of mean vectors and variance-covariance matrices under monotone missing data and on growth curve models for longitudinal data. This year, we succeeded in developing a new test procedure for the sphericity test problem for variance-covariance matrix with monotone missing data.

Asanao Shimokawa

“On calculation of stockpile requirements for allergy-friendly foods”

The purpose of this study is to propose the simulator for local governments which developed to calculate the adequate food reserves for disasters. The specific number of prevalent food allergy sufferers is not known, and the available data and statistical analysis methods used are limited. To address these problem, We predicted the number of food allergy cases based on information on the country's age-specific and prefecture-specific population composition using random-effect models.

Yuji Miyazu

“Evaluation of Water Resistance performance of Flood-Resistant Wooden Houses after Earthquake”

This study focuses on multi-hazard scenarios combined with earthquakes and heavy rains, and evaluates the water-resistance performance of a flood-resistant wooden houses after an earthquake. Vibration tests and water injection tests were conducted on a timber-framed specimen with flood-resistant specifications. The water injection test showed that a slight increase in water leakage due to the damage coused by the vibration tests. Next step is to evaluate the relation between the damage coused by the vibration and the degrading of the water-resistance performance through forced loading tests and shaking table tests.

Kazunori Kuwana

“Early Detection and Scale Modeling of Multi-hazard Scenarios Related to Fire and Explosion Phenomena”

The study aims to establish early detection and scale modeling methodologies for multi-hazard scenarios related to fire and explosion phenomena. In AY2024, scale model experiments simulating flammable gas leakage and dispersion caused by earthquakes were conducted. Using liquefied petroleum gas (LPG) as a high-density gas prototype, experimental conditions were designed based on similarity laws considering buoyancy and inertial forces. The results demonstrated significant differences in dispersion patterns with and without wind. Leakage-diffusion prediction models are discussed based on experimental observations.

Takahiro Yamamoto

“Development of a Monitoring System for the Collapse of Utility Poles and Street Trees”

Collapses of utility poles and street trees caused by typhoons, landslides, and earthquakes frequently block roads, sever evacuation routes, and hinder the passage of emergency vehicles, often resulting in secondary disasters. To minimize these risks, we have been developing a monitoring system that can quickly detect such collapses. This year in particular, we built a prototype of the system and initiated a field demonstration at a designated location.

Isao Shitanda

“Development of a new water immersion sensor”

We have developed a new flexible sensor combining a highly stretchable material, liquid metal (indium-gallium eutectic, EGaIn), and a conductive polymer (PEDOT/PSS). By forming a galvanic couple between the liquid metal and PEDOT/PSS, we have created a mechanism that generates electricity spontaneously. The output from this electricity is used to transmit a signal from a wireless transmission device, enabling the detection of water immersion.

Takashi Nakajima

“Development of Disaster-Response Anomaly Notification System Powered by Energy Harvesting”

We are developing a wireless notification system that converts environmental energies—such as vibration and thermal anomalies—into electricity, allowing either battery-free operation or a hybrid configuration with backup batteries. Concurrently, we are advancing novel energy-conversion materials and ultra-low-power circuits for these systems so that abnormal conditions can be detected and identified with high accuracy in real time.

Jin Kashiwada

“Development of Image Analysis Method for Hazard Database Construction”

This study developed image analysis method capable of quantitatively assessing disaster damage based on images captured during or after disaster events. First, a stabilization technique was developed to process videos recorded by residents during floods, enabling the measurement of spatial velocity distributions. This method was validated through laboratory experiments and applied to the Noto flood disaster 2024. Additionally, a building photo database was established to allow the identification of building locations based on EXIF data and comparisons with pre-disaster images (e.g., Google Street View; GSV). Using photos of damaged buildings and associated damage classifications, an AI-based model was constructed for classifying earthquake and tsunami damage. To address the challenge of limited access to structural details and building age, we have begun training on real estate data to develop building attribute maps derived from GSV imagery.

Kaori Ito

“Tsunami Risk Indicated by Yagō House-Name Vocabulary”

Yagō, local house names in Japan, reflect the geographical and social characteristics of the region. This study aims to clarify the relationship between yagō vocabulary and tsunami damage. The target area is former Karakuwa town, a tsunami-prone area. In this study, kanji characters that comprise yagō are called yagō words, and a set of yagō words is called a yagō vocabulary. We obtained a total of 4639 yagō words with latitude and longitude. We then identified houses located within the tsunami inundation area and conducted F-tests of proportions comparing each yagō word to the mean. As a result, while risk is indicated by geographical yagō vocabulary, the prosperity and centricity of tsunami risk areas are indicated by social yagō vocabulary. These results suggest that people who live in tsunami-prone regions recognize both the associated risks and benefits.

Seiya Takayanagi

“A Study of Demographic and Land Use Change Trends and Factors in Multi-Hazard Areas”

A quantitative trend analysis of population dynamics and land use change in multi-hazard risk areas is conducted using GIS. We compare old towns (villages) and new towns (villages), and analyze the differences in population dynamics and land use change trends as well as the differences in hazard risk, and find differences in land use change depending on which hazard risk is prioritized. We also analyze and discuss the effects of policy guidance such as pre-rehabilitation, community development, and urban planning.

Masaya Fujisawa

“A Study on Lightweight Cryptographic Schemes for Safety Confirmation Systems in Disasters”

One of the requirements in times of disaster is to obtain information to confirm the safety of victims and to grasp the damage situation in the disaster area. To satisfy this, a system for building a temporary network using drones has been proposed. However, when a user shares his safety information with other users through the drone network, there is a risk of information leakage if the other user is malicious. Furthermore, it should be considered that disaster victims require communication terminals to be as small as possible and to have a long battery life as a requirement. Therefore, we propose a cost effective and secure encryption scheme.

Hideki Yaginuma

“Development of travel behavior observation and simulation methods for effective disaster management”

This research aims to advance traffic management during disasters by enhancing observation technologies and deepening behavioral analysis. On the technological side, we develop AI models and learning algorithms specialized in traffic volume measurement. On the analytical side, we develop Activity-Based Model (ABM) that simulate daily individual travel patterns and recovery models for disrupted networks based on resilience theory. Together, these efforts support the establishment of an integrated traffic monitoring and simulation platform that functions effectively in both normal and disaster scenarios.

Masato Kubo

“Medical Care and Disasters"

In order to alleviate the public's long-term anxiety about infection and stress during disasters, we considered incorporating digital transformation into the construction of disaster medical and nursing systems and developing new disaster prevention systems. In addition, the seminar provided an opportunity to discuss how the technologies of the Jikei University School of Medicine, the Chiba University, and the Tokyo University of Science can be applied to the medical field.

Division of Colloid and Interface Science

Division of Colloid and Interface Science

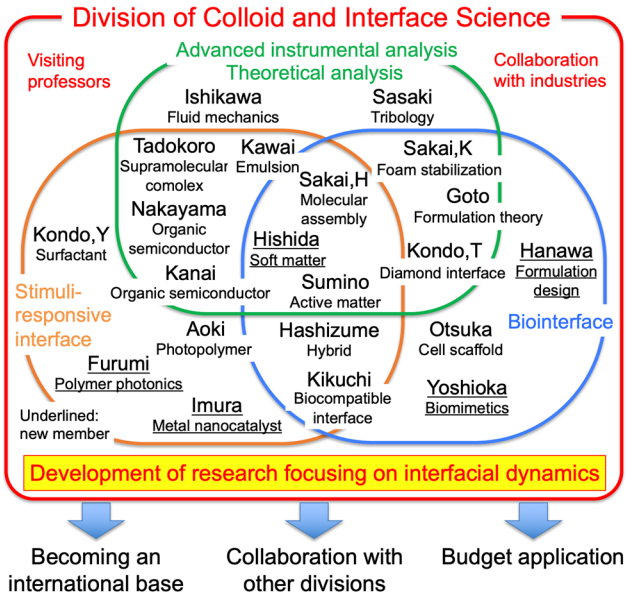
1. Overview

Interface science deals mainly with “particles” (all three dimensions are colloidal dimensions), “lines (wires)” (two dimensions are colloidal dimensions), and “membranes” (only one dimension is colloidal dimension), where at least one of the three dimensions is a colloidal dimension (1 nm - 1 μm). Tokyo University of Science (TUS) has laboratories specializing in interface science in each faculty. The Division of Colloid and Interface Science has over 40-year history since its establishment in 1981 by interface science researchers from each faculty. This division views the interface as a “spatio-temporal functional expression field that integrates different fields”. Starting from the verification and demonstration of conventional interface theories, we aim to create new physical properties, functions, and theories, and ultimately develop unprecedented novel functional materials. Specific research targets are diverse, include soft (mainly organic) materials, hard (mainly inorganic) materials, nanomaterials, and biomaterials. We promote projects from both basic and applied perspectives. Recently, physicists, mechanical engineers in fluid mechanics and tribology, and theoretical scientists have joined the division where most division members were chemists before that. We have developed research activities using a multifaceted approach in the fields of “advanced interface measurement”, “stimuli-responsive materials”, and “biofunctional interfaces”.

From FY2023, together with the new members, we will promote research development with a focus on “dynamics at interfaces” as the most important issue, based on the achievements accumulated by the division so far. For example, in understanding the dynamic functions of materials formed by molecular assemblies, we will understand the linkage of “dynamics of molecules” → “dynamics of molecular assemblies” → “dynamics of functions of molecular assemblies” and link this knowledge to the “creation of functional materials” based on new ideas. In addition, we will promote activities aimed at turning our university and this division into an international research base in interface science research, through active dissemination of our results overseas, participation in international conferences, and collaboration with overseas universities. This fiscal year marks the second year of the new system, and concrete activities based on the above policy have progressed.

2. Organization and Facilities

In this research division, experts who conduct research in the field of interface science through their specializations in material science, physics, bioscience, mechanical engineering, and theoretical science devote research on interfacial phenomena from basic science to applications through information exchange and collaboration with each other while being aware of “dynamics at interfaces”. The main targets of the members are shown in the figure. The underlined members are new members from FY2023 onwards, and this year Associate Professor Mafumi Hishida (Department of Chemistry, Faculty of Science Division I), has



joined the division. We are also collaborating with researchers from overseas and companies.

The division members own or manage various equipment including a light-scattering measurement system, molecular interaction analysis system, atomic force microscope, small-angle X-ray scattering system (SAXS), freeze-fracture transmission electron microscope (FF-TEM), and quartz crystal microbalance with dissipation (QCM-D), interfacial viscoelasticity measuring device, and they are available to other division members. In addition, cryo-TEM and FF-TEM in the Research Equipment Center enable the direct observation of colloidal particles and molecular assemblies dispersed in solutions. Furthermore, a high-performance small/wide-angle SAXS installed in 2020 enables precise structural analyses of molecular aggregates, emulsions, and catalysts from nanometer to micrometer scale. Recently, a fluorescence microscope capable of performing three-dimensional analysis of the intracellular dynamics of drug carriers such as microparticles and liposomes was installed in the Katsushika Campus Co-Creation Building as a registered equipment of the Research Equipment Center.

3. Activity Reports

Research activities

Examples of research progresses focused on "dynamics at interfaces" are as follows. The laboratories of Professor Kenichi Sakai and Professor Hideki Sakai utilized a quartz crystal microbalance (QCM-D) to simultaneously measure the amount of adsorption and energy dissipation in the adsorption dynamics of α-form hydrated crystals formed by surfactant molecules, and discussed the details of the adsorption mechanism.[1)] Professor Yukishige Kondo's laboratory investigated the foam properties of photoresponsive surfactant molecules and discussed the correlation between the structural changes of the molecules due to light irradiation and the dynamics of the foam collapse behavior. Professor Mineo Hashizume's laboratory produced film materials made of polysaccharides encapsulating polymer nanoparticles that carry hydrophobic drugs, and the analysis of the drug release dynamics from the films provided the results supporting a two-step process as the release mechanism.

Regarding the research collaborations among members of the division, for example, Associate Professor Yasuo Nakayama formed highly ordered films of a new n-type organic semiconductor molecule developed by Professor Makoto Tadokoro, and clarified their structures and functional properties together with collaborators from outside TUS.[2)] Professor Hidenori Otsuka, Professor Akihiko Kikuchi, and Professor Takehisa Hanawa also published a paper on their ongoing collaborative research into alginate gels. Several other collaborative research projects are also underway (some of which are listed in the "Major Research Achievements" section).

Activities open to participants outside TUS

This fiscal year's representative events that opened to participants outside TUS are shown below.

• *Summer Symposium 2024, Division of Colloid and Interface Science*

Date: August 6, 2024

Venue: Building No. 13 (Morito Memorial Hall) in Kagurazaka Campus + online delivery via Zoom

Summary: Invited lectures by young researchers were given by Junior Associate Professor Fumiya Kobayashi (Department of Chemistry, Faculty of Science Division I), Assistant Professor Astushi Seki (Department of Chemistry, Faculty of Science Division II), and Junior Associate Professor Yoshiki Niihori (Research Institute of Science and Technology (RIST)), and invited lectures were given by Professor Ryugo Tero (Toyohashi University of Technology) and Professor Hirobumi Shibata (Chiba

Institute of Technology), and lively discussions ensued. In addition, 15 graduate students from the laboratories of the division members and related laboratories gave oral presentations in English (including Q&A sessions). It was a meaningful opportunity not only for the department members but also for the education of the students. The 128 internal and 2 external participants attended the symposium (60 face-to-face, 70 online).

• FY2024 Progress Reports, Division of Colloid and Interface Science

Date: March 11, 2025

Venue: Building No. 13 (Morito Memorial Hall) in Kagurazaka Campus + online delivery via Zoom

Summary: Approximately half of the division members (10 people) reported on this fiscal year's achievements. Also, invited lectures by Professor Kenichi Iimura (Utsunomiya University), Professor Tomokazu Yoshimura (Nara Women's University), Dr. Yasuyuki Kusaka (National Institute of Advanced Industrial Science and Technology (AIST)), Professor Hideto Minami (Kobe University) were given, and very lively discussions took place. The 72 internal and 5 external participants attended the symposium (30 face-to-face, 47 online).

• Division of Colloid and Interface Science Seminar

We held a seminar given by an external lecturer who introduced the latest topics in their related fields.

Others

We co-sponsored the courses relating cosmetics in the Open College of TUS and some division members gave lectures (Professor Hideki Sakai, Visiting Professor Kazutami Sakamoto, and Visiting Professor Toshiyuki Suzuki).

International activities

In addition to English presentations at the summer symposium as described above, the following activities were carried out as international initiatives.

1) The bilateral exchange based on the MOU with the University of Lille in France has continued and the renewal procedure has completed (Professor Hideki Sakai). Also, graduate students from the university are staying in the laboratories of Professor Hideki Sakai and Professor Kenichi Sakai (planned for six months) and conducting the joint research.
2) At the International Chemical Congress of Pacific Basin Societies 2025 (Pacifichem2025, scheduled to be held in December 2025), members of the division (Professor Hideki Sakai, Professor Takeshi Kawai, Professor Mineo Hashizume, Visiting Professor Chein-Hsiang Chang, Visiting Professor Srinivasa Raghavan) will be in charge of the symposium "Frontier of Colloid and Interface Chemistry", and Professor Takeshi Kondo will be in charge of the symposium "Diamond Electrochemistry". Preparations are underway.
3) We planned to publish an English book on the dynamics at interfaces entitled "Colloids and Interfacial Dynamics" (Editors: Professor Mineo Hashizume and Associate Professor Yoshiro Imura), and the proposal was approved by Springer. Domestic and international authors, including members of the division, have prepared the manuscripts, and the editing is currently underway.

4. Challenges and Prospects

It was difficult to make sufficient efforts to acquire large amounts of external fundings. Although many collaborative research projects have progressed, we have not yet reached the stage of organically linking them and proposing new theories and concepts for material development. One issue is that the members' specialties are so diverse that it is difficult to grasp the direction of their ongoing research and academic interests. It is expected that improving the information sharing system will make it easier to explore the possibilities of overall collaboration.

5. Conclusion

This fiscal year has seen progress in research developments with an awareness of "dynamics at interfaces" and signs of expansion of collaborative researches among members. As next fiscal year will be the third year, the last year of the planned schedule, we will strive to comprehensively summarize each research development and activity and communicate it to the next step.

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11. Structural and optical characterization of decahedral-type spherical colloidal clusters, Ryosuke Ohnuki, Yukikazu Takeoka, Shinya Yoshioka, Chem. Mater., 36, 2953–2962, 2024. (Peer-reviewed)
12. A BDD-Au/SPCE-based electrochemical DNA aptasensor for selective and sensitive detection of theophylline, Yeni Wahyuni Hartati, Ratu Shifa Syafira, Irkham Irkham, Salma Nur Zakiyyah, Jarnuzi Gunlazuardi, Takeshi Kondo, Qonita Kurnia Anjani, Prastika Krisma Jiwanti, Diam. Relat. Mater., 150, 111725, 2024 (Peer-reviewed)
13. Solid-phase synthesis of amphiphilic cyclic peptides as a surfactin mimetic, Toshiaki Taira, Ryodai Moriyama, Kenichi Sakai, Hideki Sakai, Tomohiro Imura, Colloids Surf. A, 702, 134989, 2024 (Peer-reviewed)

14. Effect of lipid composition on the characteristics of liposomes prepared using the polyol dilution method, Kaoru Ohishi, Aya Ebisawa, Koji Tsuchiya, Kenichi Sakai, Hideki Sakai, Colloids Surf, A, 699, 134609, 2024 (Peer-reviewed)
15. Preparation of thermoresponsive core-corona particles for controlled phagocytosis via surface properties and particle shape transformation, Syuuhei Komatsu, Takuma Suzuki, Yota Kosukegawa, Masatoshi Kawase, Takuya Matsuyama, Taka-Aki Asoh, Akihiko Kikuchi, J. Controlled Release, 381, 113652, 2025 (Peer-reviewed)
16. Pattern transition of flow dynamics in a highly water-absorbent granular bed, Kojiro Otoguro, Kiwamu Yoshii, Yutaka Sumino, Phys. Fluids, 36, 063105, 2024 (Peer-reviewed)
17. Multi-stimuli-responsive behaviours of fluorenone-based donor-acceptor-donor triads in solution and supramolecular gel states, Mao Suzuki, Atsushi Seki, Syota Yamada, Ken'ichi Aoki, Mater. Adv., 5, 7401–7412, 2024 (Peer-reviewed)
18. Rotational dynamics of water near osmolytes by molecular dynamics simulations, *Yuji Higuchi, Md Abu Saleh, Takahisa Anada, Masaru Tanaka, *Mafumi Hishida, J. Phys. Chem. B, 128, 5008–5017, 2024 (Peer-reviewed)
19. Nanoarchitectonics for improving catalytic performance of α-alumina-supported gold nanoflower by water extraction and ultraviolet–ozone treatment, Yoshiro Imura, Haruna Saito, Yuta Jino, Ryota Akiyama, Clara Morita-Imura, Takeshi Kawai, J. Oleo Sci., 73, 1241–1247, 2024 (Peer-reviewed)
20. Anisotropic dispersion of excitonic bands of the single-crystal pentacene (001) surface as measured by low-energy angle-resolved high-resolution electron energy-loss spectroscopy, Yasuo Nakayama, François C. Bocquet, Ryohei Tsuruta, Serguei Soubatch, F. Stefan Tautz, J. Electron Spectrosc. Relat. Phenom., 279, 147514, 2025 (Peer-reviewed)

Books

1. 塗布しやすく水分を多く含むハイドロゲルシートの調製とその評価, 花輪剛久, 廣瀬香織, in “ゲル化・増粘剤の使い方と新しいゲルの活用事例”, 第 8 章 製剤・DDS に使用されるゲルの設計, 作成, 第 2 節, 技術情報協会, pp 319–327, 2024 (in Japanese)

Invited Lectures

1. Tribology Contributing to A Carbon-Neutral Society, Shinya Sasaki, ASIATRIB2024, China, 2024
2. 昆虫が持つ極小曲面に基づいたフォトニック結晶, 吉岡伸也, 2024 年日本液晶学会討論会・液晶交流会, 富山, 2024 (in Japanese)
3. Preparation of Boron-Doped Nanodiamond and Its Application to Aqueous Electrochemical Capacitors, Takeshi Kondo, Pacific Rim Meeting on Electrochemical and Solid State Science 2024 (PRiME 2024), Honolulu, USA, 2024
4. Photo-Induced Rapid Morphological Changes in Micelles Formed by Amphiphilic Lophine Dimers, Hideki Sakai, Kenichi Sakai, Masaaki Akamatsu, The 38th Conference of the European Colloid & Interface Society (ECIS2024), Copenhagen, Denmark, September 3, 2024 (Keynote lecture)
5. Motion of floating objects induced by the presence of multiple species, Yutaka Sumino, Rencontres Du Vietnam – Soft Matter, Fluids, & Interfaces, Quy Nhon, Vietnam, June 6, 2024
6. テラヘルツ分光法による水和状態解析とソフトマター・生体分子の水和と自己組織化の関係解明, 菱田真史, 第 46 回溶液化学シンポジウムプレシンポジウム, 千葉大学, 2024 年 10 月 22 日 (in Japanese)

7. Well-crystallized epitaxial thin films of molecular semiconductors on organic semiconductor single crystals (II), Yasuo Nakayama, The 10th International Conference on Technological Advances of Thin Films & Surface Coatings (Thin Films 2024), Singapore, 2024

Patents

1. 古海誓一, 山中凜桜, 岩田直人, 複合粒子、膜状部材及び再生複合粒子の製造方法, 特願 2024-166703, 令和 6 年 9 月 25 日 出願 (in Japanese)
2. 酒井秀樹, 五十嵐優作, 深澤龍太郎, 三船匡稀, 岡田茉央, 酒井健一, 坂本一民, 膜透過促進剤、膜透過促進方法及び細胞内送達方法, 特願 2024-134922, 2024 (in Japanese)

Public Relations

1. 大塚英典, 炭酸水を用いて調製したアルギン酸ゲルにおいて CO_2の放出挙動が架橋度に及ぼす影響を解明, プレスリリース, 2024 年 11 月 18 日 (in Japanese)
2. 花輪剛久, 新たな口腔粘膜炎治療薬として有望な茶カテキン含有ゲル剤を開発～使い勝手の良い口腔粘膜炎治療薬の開発に向けて～, プレスリリース, 2025 年 1 月 22 日 (in Japanese)

Awards

1. 佐々木信也ほか, 論文賞, 日本トライボロジー学会, 2024 年 5 月 28 日 (in Japanese)
2. 中山泰生, 細貝拓也, 宮田 哲, アルブレヒト建, 物質・デバイス共同研究賞, 物質・デバイス領域共同研究拠点, 2024 年 5 月 22 日 (in Japanese)

Individual Research Topics

Mineo Hashizume

“Dynamics of molecules in the films consisting of polyion complexes of polysaccharides”

We have been conducting functional evaluations of free-standing films made of polyion complexes of oppositely charged polysaccharides. In this fiscal year, the potential application of the films as hydrophobic drug release carriers was evaluated. Hydrophobic drugs were loaded on nanoparticles of amphiphilic polymers, and the films incorporated the nanoparticles were prepared. When the drug release behavior from the films was evaluated, we obtained results suggesting a two-step release dynamics in which the nanoparticles were released from the film and then the drug was released from the nanoparticles.

Makoto Tadokoro

“Study on proton-conductive membranes operating at intermediate high-temperatures using metal complexes coordinated by azole-based ligands”

Nafion membranes are commonly used as solid electrolytes to conduct protons in fuel cells. However, because they rely on water molecules as the medium for proton transport, their proton conductivity significantly decreases at intermediate temperatures above 100 °C. In this study, we aim to develop a high-temperature proton conductor that utilizes a novel hydrogen-bonded metal complex as the proton-conducting medium.

Hidenori Otsuka

“One-pot synthesis of interpenetrating polymer network (IPN) gels composed of hyaluronic acid and peptides and their self-healing properties”

Hyaluronic acid (HA) produced by microbial fermentation is inexpensive to produce on a large scale with low production cost and low risk of narrow contamination leading to immune response. We have also found that HA has a potent self-assembling effect when coexisting with RADA16 peptide, and we have worked on the one-pot synthesis of IPN gels using HA. The self-repairing IPNs with hydrazone bonding showed mitigation of cell damage under shear stress, which could be developed into an anti-inflammatory transplantation therapy.

Seiichi Furumi

“Self-healing materials of biomass for application to colloidal crystals”

In this project, we successfully fabricated novel self-healable materials by using biomass for applications to colloidal crystals. The self-healing properties appeared by heating treatment at appropriate temperature, thereby enabling the remolding or recycling of the biomass materials. We found that the self-healing abilities and mechanical properties can be easily controlled by changing the chemical structures. Moreover, we prepared the self-healing colorful colloidal crystal films with visible reflection using monodisperse microparticles. The fractured pieces of colloidal crystal film could be merged into the single film without change of its reflection wavelength only by heating treatment.

Satoru Goto

“Dispersion of drugs and their intermolecular interaction in solution”

As drugs are hydrophobic, their solubility dominates their activity and delivery to the target. Enhancement and regulation of aqueous solubility is widely attempted with cyclodextrin inclusion complexes, quasi-stable crystals, and amorphous phases. Drug dissolution requires hydrophobic hydration, like carbon dioxide and methane hydrate, which differs from the dissolution of inorganic salts. Investigation of the intermolecular interaction between medicines and additives would provide a rational strategy and proposals for the aims.

Takehisa Hanawa

“Research on the ground mixture consists of three components: pharmaceuticals – water-soluble polymers – surfactants”

Two-component milling mixtures of pharmaceuticals and water-soluble polymers have been used to improve the solubility of poorly water-soluble pharmaceuticals. On the other hand, three-component milling with surfactants has been conducted to improve dispersion stability. Our research focuses on the contribution of the type and concentration of surfactants to the particulate and solubility of pharmaceuticals during mixing and milling to improve the dispersion stability of pharmaceuticals.

Takeshi Kawai

“Development of stimuli-responsive coloring emulsions”

We have demonstrated that when quaternary ammonium salts and water are added to a toluene solution of a long-chain amidoamine derivative, emulsions with a structural color at a specific temperature range are obtained. Further, we showed that a reduction in the water content of the emulsion results in a change of its color in response to external mechanical stimuli. In this year, we that emulsions with different chain lengths of quaternary ammonium salts change from colorless to colored when stirred. This mechanochromic phenomenon was found to be reversible.

Yukishige Kondo

“Study on the crystals of azobenzene compound linked by polyethylene glycol chains”

A compound bearing azobenzene groups at both ends of a polyethylene glycol (PEG) chain was synthesized, and its needle-like crystals were studied. Upon UV irradiation, the crystals bent and retained the curved shape for extended periods. Heating at 110°C restored them to their original shape. This bending–recovery cycle was repeatable. The shape change is attributed to the reversible photoisomerization of azobenzene between the trans and cis forms.

Hitoshi Ishikawa

“Study of flow control by viscous change”

The viscosity of CTAB/C4AzoNa solution is increased by irradiation of UV light and decreased by visible light. The solution in small gap of rotating coaxial cylinders was irradiated locally by UV light to measure the velocity field. The local irradiation of UV light enables local viscosity change of the solution, changing shear stress distribution. It was found that the velocity difference occurred in the interface of the different viscous region.

Shinya Sasaki

“Research into the effect of friction interface structure on friction behavior”

Friction is a phenomenon that occurs between solid bodies in relative motion, but its behavior is largely governed by molecular-level structures at the interface between the solids. Therefore, in the development of friction materials and lubricants, it is essential to investigate the composition, structure, and mechanical properties of adsorption and reaction films formed at the friction interface, and to clarify their relationship with macroscopic frictional behavior. In this study, we are investigating the formation process of reaction films using an in-situ observation technique for friction surfaces with an atomic force microscope (AFM).

Kaname Kanai

“Elucidation of mechanism of photocatalytic activity of poly(heptazine imide)”

Poly(heptazine imide) (PHI) is a photocatalyst that exhibits a unique function called “dark photocatalytic activity”, a phenomenon in which water can be decomposed to produce hydrogen even in dark conditions. Since PHI also exhibits excellent photocatalytic activity in the irradiated state, stable hydrogen collection can be realized by combining it with dark photocatalytic activity. In this project, we will elucidate the mechanism of the dark photocatalytic activity of PHI by directly observing the electronic structure change of PHI induced by light irradiation.

Shinya Yoshioka

“Structural and Optical properties of the spherical colloidal cluster”

Colloidal particles with diameters of approximately 100 nm can aggregate into spherical structures known as photonic balls. They are expected to be applied as colorants. It is known that the particle arrangement within these structures varies depending on the preparation conditions. We conducted a detailed optical analysis of a specific type exhibiting a decahedral structure. Our findings reveal that the photonic ball exhibits diverse reflection patterns depending on the incident light direction, and that defect-induced reflections appear as streak-like features.

Takeshi Kondo

“Surface-modified conductive diamond-like carbon electrodes for electrochemical detection from blood”

Electrochemical theophylline detection properties of surface-oxidized conductive diamond-like carbon (DLC) electrode were evaluated toward application to electrochemical therapeutic drug monitoring. Linear calibration curves for theophylline detection were obtained in the range of 25-150 μM in bovine plasma and bovine whole blood matrices. In addition, the sensitivity of theophylline detection was stable even after immersion for 96 h in a solution containing bovine serum albumin (BSA), demonstrating that this electrode material has excellent fouling resistance.

Kenichi Sakai

“Adsorption dynamic of α-form hydrated crystals prepared by surfactants”

Adsorption of a-form hydrated crystals composed of cationic surfactants, fatty alcohols, and water was characterized on silica. Quartz crystal microbalance with dissipation monitoring technique revealed that the initial adsorption dynamics were strongly affected by the size of vesicular domains of the α-type hydrated crystals. We also found that the adsorbed mass and viscoelasticity of the adsorption film in the steady state were not affected by the domain size.

Hideki Sakai

"Bilayer permeation dynamics of oily substances through bile salt micelle: influence of molecular structure"

Oil soluble substances ingested orally are solubilized in micelles formed by bile salts in the small intestine and then absorbed. In this year, we investigated the morphological changes of Giant Unilamellar Vesciles (GUVs) and the permeation behavior of oil soluble substances when bile salts of various molecular structures and concentrations were added to the GUVs. The permeation behavior of these oil substances was also investigated.

Akihiko Kikuchi

"Preparation of stimuli-responsive nanoparticles for diagnostic use"

In this study, we aimed to design the interface of micro-/nanoparticles that realize simple diagnosis by utilizing the change in dispersibility of these particles whose surface hydrophilicity and hydrophobicity change with temperature. This year, we introduced mannose or folic acid to the outermost surface of the particles and examined the possibility of their uptake by macrophages and breast cancer cells using fluorescence observation. We confirmed that mannose-introduced hydrophobic spherical particles have an increased ability to be taken up by macrophages, indicating the possibility of macrophage-specific recognition.

Yutaka Sumino

"Experimental and theoretical studies on active interfaces: creation of controlled self-propelled particles"

Self-propelled particles refer to particles that consume external energy to create momentum locally. In this research topic, we focused on the particle motion induced by the reactive nonequilibrium flow on the surface of a solid substrate. Here, we designed the system where the electrophoretic flow is caused by the externally applied electric fields and/or continuous decomposition of solutes. With the air phase, the system comprised four different phases with six different interfaces. By modifying the size of particles, the shape of the substrate, and the illumination of light, we try to control the motion of particles externally.

Ken'ichi Aoki

"Effect of spacer length on the thermal activation of photopolymerization in diacetylenediamide crystals"

Diacetylene crystals with hydrogen-bonding sites are inactive toward photopolymerization when recrystallized from organic solvents. However, the photopolymerization reactivity can be markedly enhanced by the prebaking process. The spacer lengths connecting the diacetylene core and the hydrogen-bonding sites were systematically changed to reveal that the diacetylene crystals with even-numbered spacers exhibit a significant increase in photopolymerization reactivity upon heating process.

Mafumi Hishida

"Physicochemical studies on the mechanisms of self-assembly of soft matter and biomolecules"

Physicochemical study is conducted on the mechanisms by which soft matter and biomolecules such as lipids, surfactants, polymers and proteins self-assemble in water to form various structures. Particular attention is paid to how hydration water is involved in this process.

Yoshiro Imura

“Preparation and catalytic performance of bimetallic Au-Pt nanowires”

The catalytic performances of Au nanocrystals change depending on their shape and bimetallization. Previously, we reported that Au nanowires have high catalytic activity for alcohol oxidation reactions. In this study, we prepared Au-Pt nanowires with an average diameter of 6 nm and examined their catalytic performances for the oxidation reaction of 1-phenylethyl alcohol. The catalytic performances were improved by optimizing the molar ratio of Au and Pt.

Yasuo Nakayama

“Construction and electronic characterization of well-defined molecular semiconductor p-n junctions built on organic single-crystal substrates”

The functionalities of organic electronic devices such as organic solar cells originate from p-n heterojunctions where different kinds of organic semiconductor molecules make direct contact with each other, and the structural designs and electronic properties at such interfaces are the key points of the development. In FY2024, our group has succeeded in the demonstration of photovoltaic responses, by means of photoelectron spectroscopy, at the well-defined hetero-molecular contact that our group has developed in FY2023. We also analyzed the excitonic and vibrational properties on the single crystal samples of a molecular semiconductor and have published these results in two original papers.

Division of Co-creative Design Innovation Research

Division of Co-creative Design Innovation Research

1. Overview

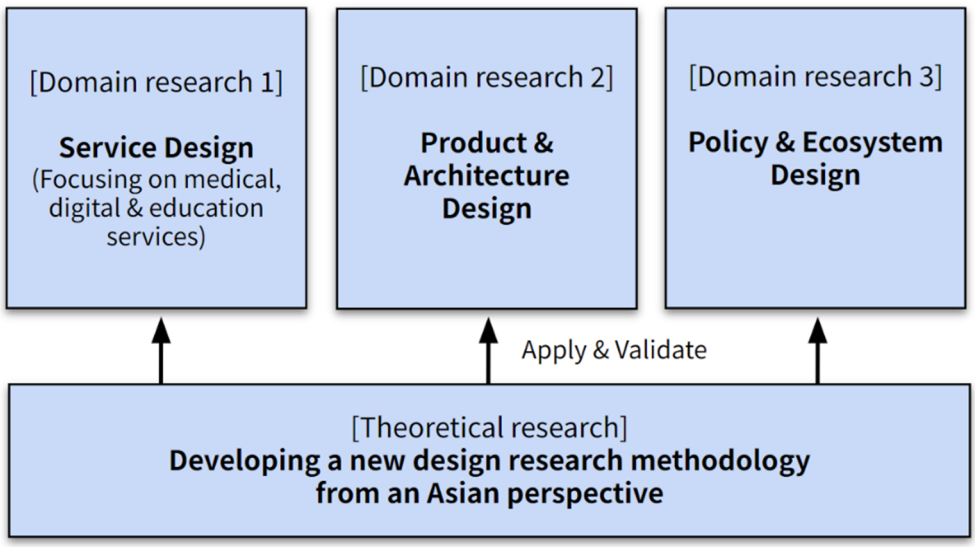
Our mission is to develop and implement design thinking methodologies originating from an Asian perspective, addressing complex interdisciplinary challenges in our time. Our primary objective is to develop and validate design thinking methodologies from an Asian perspective, addressing complex interdisciplinary challenges. Our research goals are: 1) strengthening international collaborations and disseminating research findings, and 2) promoting practice-oriented research through industry-academia partnerships.

2. Organization

Our research division aims to:

- Develop unique design thinking methodologies incorporating Asian perspectives and cultural elements
- Examine and categorize “Japanese and Asian challenges” and “Japanese and Asian approaches”
- Advance research through the integration of social science and engineering approaches
- Enhance collaborations with international research centers in the Asian region
- Construct “Asian-originated design thinking methodologies” and disseminate findings through publications
- Implement industry-academia collaborative projects addressing “wicked problems” faced by corporations and local governments
- Contribute practically through the social implementation of research outcomes

To achieve these goals, we have 4 special interest groups as follows:



3. Activity Reports

3. 1. [Theoretical research] Asian-style Design Thinking Methodology Development Group

This group critically reviews methodologies of US-style and Nordic-style Design Thinking. By closely collaborating with external research institutions in the Asian region, it aims to develop a unique, Asian-originated Design Thinking methodology distinct from both US and Nordic models. In Fiscal Year (FY) 2024, the group held six regular meetings, each featuring presentations by designated members followed by discussions among participants.

3. 2. [Domain research 1] Service Design Group

This group validates Design Thinking methodologies required for developing various services and businesses targeting individuals and groups and evaluates the effectiveness of these methodologies in concrete problem-solving. In FY2024, activities centered on compiling results from design research in the healthcare field and co-design education outcomes at the Oshamambe Campus. These efforts resulted in contributing a chapter to the English-language book "The Power of Design," which is being edited under the leadership of our collaborator, the Singapore University of Technology and Design (SUTD).

3. 3. [Domain research 2] Product/Environment Design Group

This group examines the effectiveness of approaches for fostering innovation through co-design activities within settings such as local communities and office spaces, viewed as venues for human collaboration. In FY2024, the focus was on the industry-academia collaboration "Capstone Project" within the Department of International Design Management, Faculty of Business Administration. The group received project themes from multiple companies and proposed problem-solving measures and product concepts in response.

3. 4. [Domain research 3] Policy/Ecosystem Design Group

This group validates the effectiveness of Design Thinking as a methodology for establishing and refining processes and policies for consensus building and decision-making necessary for collaborative innovation, with a particular focus on entrepreneur support and public policy issues. In FY2024, discussions continued with the Humanities, Arts and Social Sciences (HASS) department at our aforementioned collaborator, SUTD, regarding specific details of future collaboration.

3. 5. Public Seminar (March 1, 2025)

Concurrent with the activities of the four groups, a public seminar titled "New Trends in Design Research 2025: Aiming for Asian-originated Design Thinking" was held on March 1, 2025, to present the outcomes of FY2024 initiatives. Guest speakers Professor Emeritus Tsuyoshi Sunaga from Tokyo University of the Arts and Mr. Keita Nishimura from Hakuhodo DY Holdings delivered lectures on the future direction of design research and education from academic and business perspectives, respectively. An interactive discussion session involving the research members and attendees followed.

Public Seminar Outline:

- Title: "New Trends in Design Research 2025: Aiming for Asian-originated Design Thinking"
- Date & Time: Saturday, March 1, 2025, 13:00 - 15:00
- Target Audience: University affiliates (faculty, staff, students, etc.), external participants, and the general public

- Location:
  - [In-person] Kagurazaka Campus, Fujimi Building
  - [Online] Zoom Webinar
- Fee: Free
- Program:
  - 13:00-13:05: Opening Remarks
  - 13:05-13:35: Guest Speaker Presentation [1] Mr. Tsuyoshi Sunaga
  - 13:35-14:05: Guest Speaker Presentation [2] Mr. Keita Nishimura
  - 14:15-14:55: Interactive Session
  - 14:55-15:00: Closing Remarks

4. Challenges and Prospects

As this fiscal year (FY2024) was the inaugural year for this research division, significant time was required for exploring internal collaborations and preparing to materialize activities, resulting in limited concrete research outcomes thus far. In the next fiscal year (FY2025), we aim to fully operationalize and concretize the activities within each group to generate tangible results. Collaboration with SUTD will also be further specified, with plans to hold joint seminars and other activities in FY2025. Furthermore, we intend to actively identify and collaborate with researchers both inside and outside the university who are engaged in design-related research.

5. Conclusion

Design innovation research in Japan, while influenced by the fluctuations of past North American and European Design Thinking trends, is entering a new phase with the planned establishment of multiple new design-related faculties in the coming years. For example, Ritsumeikan University will launch a ‘College of Art and Design’ in April 2026, and the University of Tokyo will open its ‘College of Design’ in Autumn 2027, offering a five-year integrated Bachelor's-Master's program taught entirely in English. Amidst these developments, our university (Tokyo University of Science, TUS), having already launched two departments in the design field, is positioned ahead in this new wave. Leveraging this advantage, we intend to actively promote and disseminate 'TUS-distinctive' design research centered around the activities of this research division.

Major Research Achievements (FY2024)

Academic Papers

1. Vision Paper for Enabling Generative-AI Digital Platform Using AIDAF in Healthcare and Manufacturing Industry, Yoshimasa Masuda, Jean Paul Sebastian Piest, Rashmi Jain, Donald Shepard, Osamu Nakamura, Tetsuya Toma, Seiko Shirasaka, International KES Conference on Human Centred Intelligent Systems. Springer Nature, August 2024 (Peer-reviewed)
2. VR 会議における他者との対面量に着目した会議の質の分析, 渡会隆哉, 鎌田光太郎, 角 康之, 王子 洋, 高島健太郎, 由井薗隆也, 情報処理学会論文誌コンシューマ・デバイス＆システム（CDS）, 15(1), 1-10, January 2025 (in Japanese) (Peer-reviewed)
3. 集合体理論に基づくオンラインコミュニティ上の消費体験の考察：VTuber とオーディエンスの相互作用の事例を用いて, 柿原正郎, マーケティングジャーナル, forthcoming (2025) (in Japanese) (Peer-reviewed)

Books

1. Meiji Graves in Happy Valley: Stories of Early Japanese Residents in Hong Kong, Yoshiko Nakano and Georgina Challen, Hong Kong University Press, 2024 年 11 月
2. Exploring Culturally Informed Design Innovation in Japan. Junichi Iijima, Yoshiaki Fukami, Masao Kakihara, Kana Matsubara, Chikako Morimoto, Yoshiko Nakano, Kohei Soga, Kentaro Takashima, Toshiyuki Watanabe, Masaki Yagisawa. In “The Power of Design,” Tai Lee Siang and Dr Ong Eng Hong (eds.), Taylor & Francis, forthcoming (2025)

Invited Lectures

1. A Design Innovation Challenge at Tokyo University of Science, Masao Kakihara, Design Innovation Forum - Design Alliance Summit, held by/at Singapore University of Technology and Design, May 15, 2024

Academic support

1. JST 研究開発戦略センター, 『科学技術・イノベーションエコシステムにおける産学橋渡しの課題　―知的財産・デザイン・共創の観点から―』, 2025 年 3 月 CRDS-FY2024-RR-12 (In Japanese, academic support by Junichi Iijima and Masao Kakihara)

Individual Research Topics

Masao Kakihara

“Understanding Consumer Behavior in Digital Environments”

Current research themes include: empirical research on behavioral and attitudinal changes of esports players and various stakeholders; quantitative analysis of consumer information search behavior in digital environments.

Junichi Iijima

“Enterprise Engineering and Design Management”

Current research themes include: research on generating business models based on enterprise ontology.

Ryo Sato

“Abductive Reasoning for Idea Generation”

Current research themes include: formalization of syllogisms using logical calculus formulas; examination of implications for design management and design studies.

Yoshiko Nakano

“International Japanese Studies: Globalization, Connecting Cultures, and Women's Roles”

Current research themes include: area studies, focusing on the globalization of Japanese products and services.

Yoshimasa Masuda

“Digital Strategy Architecture”

Current research themes include: Web informatics and service informatics (digital business models, innovation management, etc.); design studies (Design Thinking approaches, architecture design, etc.); social systems engineering and safety systems (digital strategy architecture, security and privacy, etc.); business administration (digital strategy, smart society, global organizations, etc.).

Michiko Tsubaki

“Marketing Science”

Current research themes include: Kansei informatics (measurement of customer affective responses, product development based on Kansei information); social systems engineering and safety systems (user experience, service innovation, data science); commerce (well-being through consumption, marketing data science).

Kohei Soga

“Materials Engineering of Nanoparticles and Complex Structured Solids”

Current research themes include: development of organic-inorganic composite probes for near-infrared excited bioimaging; synthesis and evaluation of boron icosahedral cluster solids; fabrication and evaluation of rare-earth-containing nanoparticles for full-color 3D image projection.

Toshiyuki Watanabe

“Healthcare and Design”

Current research themes include: design, infographics, illustration, animation, informed consent, visual media, and interfaces.

Chikako Morimoto

“Project Management”

Current research themes include: educational technology (Project-Based Learning, PBL); social systems engineering and safety systems (project management); business administration (team building); control and systems engineering (software development processes).

Masaki Yagisawa

“Development of Design Education in Business Faculties”

Current research themes include: design, design expression, design evaluation methods, drawing/sketching, and three-dimensional expression.

Hyejung Lee

“Digital Transformation, Work design, Sustainability, ICT impact, Information Service”

Current research focuses on new business models and their impact in the Digital Transformation era, the ICT impact on small and creative teams, and organizational sustainability.

Yoshiaki Fukami

“Standardization Strategy, Data-Driven Management, Data Governance, Craft Brewing Business”

Current research themes include: platforms, standardization strategy, innovation ecosystems, data-driven management, data governance, healthcare data, and the craft brewing business.

Mio Suzuki

“Architecture, Cities, and Public Spaces”

Current research themes include: architecture, cities, public spaces, markets (marchés, traditional markets), community development (machizukuri), shopping districts, and housing complexes (danchi).

Kentaro Takashima

“Creative Activity Support Systems”

Current research themes include: knowledge management, creative activity support systems, Design Thinking, and telework support systems.

Development of Superior Cell and DDS for Regenerative Medicine

Development of Superior Cell and DDS for Regenerative Medicine

1. Overview

The objective of this research division is to accelerate the advancement of regenerative medicine by developing “superior cells”, which are therapeutic cells functionally enhanced for in vivo application, and by establishing drug delivery systems (DDS) capable of precisely controlling the biodistribution of various functional molecules, including cells. The developed superior cells and DDS technologies are applied to therapeutic targets such as respiratory, neurological, immune, and oncological diseases, with the ultimate goal of contributing to the development of novel treatment strategies.

This division promotes the project "Development of Superior Cells and DDS to Accelerate Regenerative Medicine" through close collaboration among four integrated research groups. The “Superior Cell and DDS Development Group” is responsible for designing and constructing superior cells, as well as developing DDS technologies to control the in vivo behavior of cells and bioactive substances. Approaches include imparting novel functions to cells, constructing cell spheroids and organoids, and utilizing extracellular particles. The therapeutic potential of these systems is evaluated in disease models. The “Cell Function Control System Development Group” focuses on the creation of novel molecules that regulate cell functions and the development of functional biomaterials to support regenerative and cell-based therapies. The “Physicochemical Properties and Evaluation Group” supports optimization of superior cell and DDS performance by evaluating the physicochemical properties of functional molecules and materials developed by other groups. The “Cell and Organ Regeneration Group” investigates mechanisms of organ regeneration, particularly in the lung and bone, and examines the interactions between the immune system and applied superior cells or DDS in therapeutic contexts.

2. Organization and Facilities

As shown in Figure, 17 researchers from within and outside the university are participating in this research division, which is organized into four groups to promote research on “Development of Superior Cell and DDS for Regenerative Medicine”.

1. Superior cell/DDS Development Group
2. Cell Function Regulation System Development Group
3. Physical Properties Control and Evaluation Group
4. Cell/tissue Regeneration Group

The facilities in our division are located in Building No. 18 on the Noda Campus (former DDS Research Center Building), in addition to the laboratories of participating researchers in the School of Pharmacy and the School of Advanced Engineering. These facilities include an image analysis system, LC/MS system, liquid chromatography system, plasma ionization quantification system, powder characterization system, flow cytometer, ultrafine structure observation system, single crystal X-ray diffraction

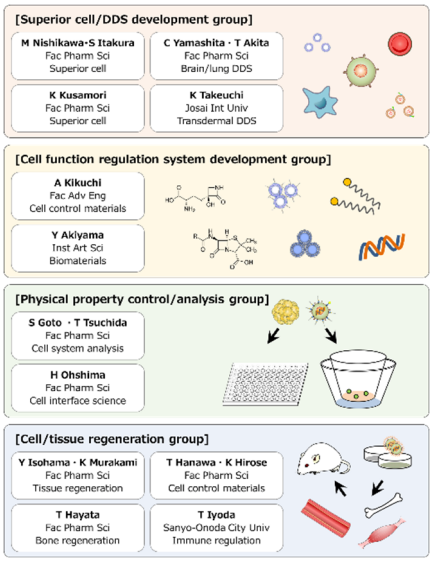


Figure. Members in each group for Development of Superior Cell and DDS for Regenerative Medicine

system, powder X-ray diffraction system, differential scanning calorimetry system, thermogravimetric analysis system, and infrared spectrophotometer, a high-performance respiratory function analysis system, all of which are used jointly within the research divisions to conduct our research topics.

3. Activity Reports

On Saturday, December 7, 2024, the First Joint Symposium of the Nucleic Acid Therapeutics Center and the Research Division for the Development of Superior Cells and DDS to Accelerate Regenerative Medicine was held at the Grand Hall of the Library, Katsushika Campus, Tokyo University of Science. In addition to presentations of the latest research findings from each group, we were honored to welcome Professor Yasuhiro Tabata from the Graduate School of Medicine, Kyoto University, who delivered a special lecture.

3. 1. Superior cell/DDS Development Group

This group has developed a lymphatic vessel network-containing tissue using a cell-layering technique, and demonstrated improved lymphatic flow and immune activation in a secondary lymphedema mouse model. Functionally lipid-based nanoparticles encapsulating active vitamin D_3 were optimized and successfully formulated into an inhalable dry powder capable of achieving clinical dosage levels. Furthermore, nanoparticles containing prednisolone were shown to suppress symptoms and reduce drug dosage when administered prophylactically in a murine model of allergic contact dermatitis, indicating their potential applicability in proactive therapeutic strategies.

3. 2. Cell Function Regulation System Development Group

This group focused on the design of nanocarrier-based drug delivery systems (DDS) with enhanced cellular selectivity and delivery efficiency. As a macrophage-targeted DDS, thermoresponsive microparticles were modified with mannose, and analysis of their shape and surface properties revealed that spherical, hydrophobic, mannose-modified particles exhibited high phagocytosis. In addition, a carrier-free nanocarrier system composed solely of small-molecule drugs and nucleic acid therapeutics was developed. A covalent conjugate between doxorubicin and antisense oligonucleotides, formed via nucleobase-linked chemistry, was successfully self-assembled into nanostructures with an average hydrodynamic diameter of 73.5 nm.

3. 3. Physical Properties Control and Evaluation Group

This group conducted research on physicochemical changes in pharmaceutical compounds and the migration behavior of colloidal particles. Studies included the relationship between polymorphic transitions of indomethacin and its solubility, the inclusion mechanisms and supersaturation behavior of NSAIDs with cyclodextrins, and the effects of drug–drug interactions on solubility. Additionally, theoretical models were developed to describe the transient electrophoresis of droplets and porous microparticles under applied electric fields, in collaboration with international partners. The group also proposed a novel method to calculate Hamaker constants using Hansen solubility parameters, which was applied to assess the stability of dispersion systems.

3. 4. Cell/tissue Regeneration Group

This group conducted research on novel therapeutic targets and DDS applications for age-related and inflammatory diseases. A novel anti-apoptotic function of AQP5 was identified, highlighting its potential as a therapeutic target for pulmonary edema. A prototype wound dressing using water-soluble polymers was also developed and reported. In addition, the group elucidated the roles of Gprc5a and Ctdnep1 in bone

metabolism and clarified mechanisms by which abnormal cell adhesion contributes to kidney dysfunction and amyloid accumulation, proposing new strategies for disease modulation.

4. Challenges and Prospects

This research division, comprising four groups, aims to develop superior cells and drug delivery systems (DDS). Each group conducts independent research while actively collaborating across groups. Now entering its fifth year, the division has steadily advanced, with results published in leading journals. Collaboration among researchers from diverse fields has deepened mutual understanding and led to significant intergroup achievements. Building on these foundations, we will use the program's extension to pursue large-scale research funding and promote global academic and industrial partnerships as part of a forward-looking exit strategy.

5. Conclusion

Since its establishment in 2021, this research division has promoted the development of superior cells and novel therapeutic strategies through close collaboration among its four research groups. Over the past four years, the research objectives set for each fiscal year have steadily yielded tangible results. In particular, by leveraging the strength of a team composed of researchers with diverse areas of expertise, the division has fostered not only intra-group but also active inter-group collaborations, leading to significant achievements aligned with the division's original goals. In the final year of the program, we aim to further strengthen collaborations with industry and overseas research institutions, continuing our core mission of developing superior cells and DDS to accelerate regenerative medicine. In addition, by utilizing the patents acquired to date, we intend to lay the foundation for a research platform that is uniquely possible at Tokyo University of Science.

Major Research Achievements (FY2024)

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2. 植物由来ナノ粒子の疾患治療への応用と核酸デリバリーシステムとしての可能性, 板倉祥子, 草森浩輔, 西川元也, 日本薬学会第 145 年会, 福岡, 2025 (in Japanese)
3. 植物由来エクソソーム様ナノ粒子を用いた新たな植物療法の可能性, 板倉祥子, 草森浩輔, 西川元也, 第 27 回日本アロマセラピー学会学術総会・第 10 回日本ハーブ療法研究会学術講演会 合同大会, 東京, 2025 (in Japanese)
4. Rational Design of Poly- and Mono-DNA-Functionalized Nanostructures for Biomedical Applications, Yoshitsugu Akiyama, 6th International Bio-Medical Interface Symposium 2025, Taiwan, 2025 (in Japanese)
5. 細胞を医薬品にするための DDS 研究, 草森浩輔, 日本薬学会第 145 年会, 福岡, 2025 (in Japanese)
6. アカデミア研究者から伝えたい博士のすすめ, 草森浩輔, 日本薬学会第 145 年会, 福岡, 2025 (in Japanese)
7. DDS 技術を搭載した細胞医薬の現状と今後の展開, 草森浩輔, 一般財団法人バイオインダストリー協会 創薬モダリティ基盤研究会講演会, オンライン, 2025 (in Japanese)
8. 細胞外小胞と核酸の組み合わせによる治療システムの開発, 西川元也, 板倉祥子, 草森浩輔, 第 75 回コロイドおよび界面化学討論会, 宮城, 2025 (in Japanese)
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10. Development of plant-derived nanoparticles as a new class of DDS, Shoko Itakura, Kosuke Kusamori, Makiya Nishikawa, 第 40 回日本 DDS 学会学術集会, 茨城, 2025 (in Japanese)
11. 基礎から学ぶゼータ電位とその応用, 大島広行, 日本化学会コロイドおよび界面化学部会, 東京総評会館, 7 月 11 日-12 日, 2024 (in Japanese)
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16. 細胞医薬品の開発を加速する薬剤学技術, 草森浩輔, 西川元也, 第 4 回令和の薬剤学を考える懇談会(第 59 回薬剤学懇談会研究討論会), 東京, 2024 (in Japanese)
17. 細胞またはミトコンドリアを利用した疾患治療システムの開発, 草森浩輔, 徳島大学大学院医歯薬学研究部(薬学域)DDS 研究センター 2024 年度第 1 回シンポジウム, 徳島, 2024 (in Japanese)
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12. 加藤寛信, 大会長特別賞, 第 27 回日本アロマセラピー学会学術総会・第 10 回日本ハーブ療法研究会学術講演会, 2024 (in Japanese)
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Individual Research Topics

Makiya Nishikawa, Kosuke Kusamori, Shoko Itakura

"Development of lymphatic network-embedded tissue for the treatment of secondary lymphedema"

In FY2024, we developed lymphatic network-embedded tissue using a centrifugation-based cell-layering technique to treat secondary lymphedema. This tissue, composed of mesenchymal stem cells and lymphatic endothelial cells, was successfully constructed and transplanted into a mouse lymphedema model. The graft promoted the formation of lymph node-like structures, improved lymphatic drainage, and reduced limb swelling. Furthermore, T and B cell accumulation and cytokine production upon CpG1018 stimulation were observed within the graft, indicating active immune involvement. These findings suggest that the engineered tissue enables functional lymph node regeneration and holds promise as a therapeutic strategy for secondary lymphedema.

Chikamasa Yamashita, Tomomi Akita

" Research Topics 1"

Building on previous work showing that active vitamin D_3 (VD_3) encapsulated in functional lipid (SS-OP) nanoparticles reduced side effects in a COPD mouse model, we aimed to develop a clinically applicable inhalable formulation. In FY2024, we successfully formulated an inhalable powder of VD_3-loaded SS-OP nanoparticles using a design of experiments approach and genetic algorithm-based optimization. The resulting formulation met clinical dosage requirements and supports the potential of this system for curative COPD treatment through alveolar regeneration.

Issei Takeuchi

"Treatment of allergic contact dermatitis using polymeric drug carriers"

We conducted therapeutic studies using disease model mice to evaluate prednisolone-loaded nanoparticles previously developed for allergic contact dermatitis (ACD) treatment. The results demonstrated that pre-sensitization administration of the nanoparticles effectively suppressed ACD symptoms, indicating their utility in preventive treatment. Moreover, nanoparticle formulation enabled a reduction in the required drug dosage. These findings support the application of this system as a proactive therapeutic approach for ACD.

Akihiko Kikuchi

"Development of an inhalable powder formulation of active vitamin D_3-loaded functional lipid nanoparticles for curative COPD therapy via alveolar regeneration"

For selective delivery of drug carriers to macrophages, which are responsible for early immune response in our body, we prepared thermosensitive nanoparticles with controlled shape and surface properties. In 2024, we prepared mannose-modified thermosensitive nanoparticles to clarify the effects of the shape and surface properties of the particles, as well as the presence or absence of the mannose ligands, on the phagocytic behavior of macrophages. Spherical nanoparticles with hydrophobic Surface property and having mannose moiety are more likely to be phagocytosed. Through the control of these physical properties of prepared nanoparticles, we would regulate selective drug delivery to macrophages.

Yoshitsugu Akiyama

"Design of Carrier-Free Nanostructures Densely Functionalized with Nucleic Acids via Nucleobase Conjugation"

In 2024, we aimed to develop a carrier-free nanostructure composed exclusively of small-molecule and nucleic acid therapeutics for nanoDDS applications. To achieve this, a collaborative research project was conducted. Specifically, doxorubicin was activated at its hydroxyl group and conjugated with an antisense nucleic acid derivative via the amino group on the nucleobase. Dynamic light scattering analysis revealed that the self-assembled conjugates successfully formed nanostructures with a hydrodynamic diameter of 73.5 nm. This nanocarrier is expected to serve as a promising platform material for safe and efficient combination cancer chemotherapy.

Satoru Goto, Tomohiro Tsuchida

"Physicochemical changes induced by drug-drug and drug-cyclodextrin interactions"

This study investigated the impact of polymorphic transition of indomethacin from the α-form to the γ-form on its solubility in various aqueous solvents. Additionally, we examined the inclusion mechanism of 2-hydroxypropyl-β-cyclodextrin with non-steroidal anti-inflammatory drugs (NSAIDs) and the supersaturation behavior of the resulting complexes. Furthermore, the effect of cyclodextrin inclusion on solubility changes caused by intermolecular interactions between acidic NSAIDs and H_2 receptor antagonists was also evaluated.

Hiroyuki Ohshima

"Electrophoresis, diffusiophoresis of particles, and evaluation of hamaker constants using hansen solubility parameters"

In collaboration with the Department of Mathematics, Durgapur University (India), we continued theoretical studies on the electrophoretic and diffusiophoretic behavior of droplets and porous microparticles. A theoretical framework was also developed to describe transient particle motion upon the instantaneous application of electric fields or electrolyte gradients, with a view toward DDS applications. Additionally, a method was proposed and refined for calculating Hamaker constants using Hansen solubility parameters to evaluate the stability of particle dispersion systems.

Yoichiro Isohama, Kazuhito Murakami

"Potential of aquaporin water channels as novel DDS targets"

As part of ongoing research into the novel functions of aquaporins (AQPs), known as water channels, we identified a new anti-apoptotic role of AQP5. In vitro experiments demonstrated that AQP5 conferred resistance to Fas ligand-induced cell death in an expression-dependent manner. Furthermore, in vivo studies using transgenic mice with lung epithelium-specific overexpression of AQP5 showed improved survival following sepsis, reduced epithelial apoptosis, and attenuated pulmonary edema. These findings suggest that AQP5 may serve as a promising therapeutic target for pulmonary edema.

Takehisa Hanawa, Kaori Hirose

"Development of wound dressing material using water-soluble polymer"

In FY2024, we developed a prototype wound dressing aimed at promoting healing, including for oral mucositis. The dressing is based on water-soluble polymers, primarily plant-derived pectin and brown algae-derived alginate, which gel in the presence of divalent ions such as calcium. The material remains in a dry xerogel state until use, and forms a hydrogel upon the addition of water. The prototype was successfully prepared and the findings have been published.

Tadayoshi Hayata

“Identification of novel therapeutic targets and elucidation of pathophysiology in age-related musculoskeletal disorders”

We identified Gprc5a, a downstream effector of the osteoporosis drug teriparatide, as a promising therapeutic target. Gprc5a was found to suppress osteoblast proliferation and differentiation by interacting with bone morphogenetic protein (BMP) receptors and inhibiting their signaling pathways. Furthermore, we discovered that the phosphatase Ctdnep1 plays a key role in preventing excessive osteoclast differentiation, highlighting its significance in bone metabolism and potential for therapeutic application.

Takuya Iyoda

“Regulation of cellular function and abnormal adhesion environments in the progression of age-related diseases”

This study investigates how abnormal cell adhesion and resulting intracellular signaling alterations contribute to the onset and progression of cancer, atherosclerosis, kidney diseases, and chronic inflammation. In FY2024, two key findings were obtained: (1) macrophage-mediated modulation of brain amyloid-β accumulation via adhesion signaling, and (2) excessive activation of adhesion signaling altering renal tissue environments through dysregulation of mesangial cell function.

Renewable Energy Science and Technology Division

Renewable Energy Science and Technology Division

1. Overview

The Photovoltaic Power Generation Technology Research Division has been focusing on research into photovoltaic power generation technology as a clean energy source for the past 15 years, including a reorganization in 2010. Today, however, research and development are not limited to photovoltaic power generation, but also include wind power generation, thermal power generation, and a wide range of other "renewable energies". However, as more and more renewable energies are connected to the grid, the operation of systems and infrastructure for stable power supply have become extremely difficult and important. This division has been reorganized to handle "renewable energies" as a whole by reorganizing the division that has handled only solar energy so far,

(i) Development of materials to reduce the cost of installation and operation to the same level as power generation using fossil fuels

→ Cross-divisional development of basic technology for the development of other power generation materials through knowledge obtained through solar cell research (solar cells, thermoelectric power generation devices, fuel cells, etc.).

(ii) Development of high-efficiency management technology for electricity obtained from various power generation methods

→ Joint development of technologies to utilize power obtained from various power generation methods without waste, such as grid interconnection, fault diagnosis technology, and optimization using AI, in a vertical and cross-sectoral manner within the division

(iii) Development of new materials, new system technologies, etc.

→ Development of budding technologies within the division, such as laminated sheets of solar cells and thermal power generation, integration with agriculture through solar sharing, and integration with energy storage technologies such as chemical batteries and flywheels, and energy storage technologies such as hydrogen production technology.

The department was established in FY2020 with the aim of developing new technologies.

While renewable energy is environmentally friendly, it has serious infrastructure issues such as unstable power supply and high installation and running costs. The goal of this project is to propose a foundation for stable and low-cost power supply through the above 3 research objectives, and to activate and promote research and development of renewable energy utilization technology at Tokyo University of Science. In FY2024, the following external and student activities were carried out in addition to various joint research projects.

+ The 5th symposium of the division "Recent Trends in Renewable Energy Technologies

The symposium on renewable energy technologies was held on January 28, 2025at the Morito Memorial Hall on the Kagurazaka Campus. The lectures were given by leading researchers who are active in these fields. About 100 people from inside and outside the university attended the symposium. In addition, students and others made poster presentations of their research results, and through discussions with researchers and students from inside and outside the university, they were able to gain knowledge that will guide the development of their own research. As described above, we were able to disseminate information on renewable energy technology research at the Tokyo University of Science. In addition, the activity subsidy was used to pay the honorarium for the invited speakers at the symposium.

+ Exhibition of RENEWABLE ENERGY 2025

The 19th Renewable Energy World Exhibition & Forum RENEWABLE ENERGY 2025, one of the largest renewable energy-related exhibitions in Japan, was held on January 29 – 31, 2025, at the West Hall of Tokyo Big Sight. We exhibited research results and demonstration machines related to various renewable energy material systems unique to the Tokyo University of Science, and disseminated information on renewable energy technology and research at the Tokyo University of Science both domestically and internationally. The departmental activity fund was used to pay for the preparation of flyers and transportation expenses for the explanation staff to hold this exhibition and presentation.)

+ Online Seminar on Renewable Energy Technologies

An online seminar was held to introduce the research activities of faculty members within the division, a format originally implemented during the COVID. The event made effective use of features unique to online platforms, such as chat and polling functions, which facilitated active participation through questions and comments. For students, this provided a valuable opportunity not only to deepen their understanding of cutting-edge renewable energy technologies beyond their own laboratories, but also to prepare for job hunting and internship applications.

+ Research Progress Reports among Faculty Members

The research progress of all faculty members has been presented and reported online once every four months. Sharing information among faculty members with different fields and areas of expertise not only deepened knowledge of the latest renewable energy technologies, but also resulted in beneficial debriefing sessions, such as the creation of new joint research projects. Moreover, in order to maintain the department's presence both within and outside the university, as well as to continue serving as a central organization for renewable energy research and development at Tokyo University of Science, a partial restructuring of the team was carried out in the summer of 2024. Following this reorganization, a proposal for departmental activities for the 2025 fiscal year and beyond was submitted and successfully approved.

Through these activities in FY2024, the division's research results and activities were widely disseminated, and suggestions were obtained on how to proceed with future research.

2. Organization and Facilities

The members of the division and their areas of expertise are as follows;

Affiliation of key role	Job title	Name	Main research field
Faculty of Science and Technology Department of Electrical Engineering	Professor	Mutsumi Sugiyama	Semiconductor material engineering / thin film photovoltaic cell
Faculty of Science Division II Department of Chemistry	Professor	Takashiro Akitsu	Coordination chemistry / Photofunctional fuel cells of organic/inorganic hybrid materials
Faculty of Science Division II Department of Physics	Professor	Zhao Xinwei	Semiconductor nano-material engineering / Thin film photovoltaic cell

Faculty of Engineering Department of Electrical Engineering	Professor	Yuzuru Ueda	Electricity and energy engineering / Photovoltaic system
Faculty of Engineering Department of Industrial Chemistry	Associate professor	Morio Nagata	Organic photovoltaic cell, Artificial photosynthesis
Faculty of Science and Technology Department of Electrical Engineering	Associate professor	Junji Kondoh	Photovoltaic power system / Power conditioning system
Faculty of Science and Technology Department of Electrical Engineering	Associate professor	Noboru Katayama	Fuel cells / Hydrogen storage / Diagnosis for energy devices
Faculty of Advanced Engineering Department of Applied Electronics	Associate professor	Takashi Ikuno	Surface and interfaces / Photovoltaic devices / Nanogenerators
Faculty of Science Division II Department of Chemistry	Junior Associate Professor	Tomoyuki Haraguchi	Coordination chemistry / Dye sensitized solar cell
Faculty of Science and Technology Department of Electrical Engineering	Junior Associate Professor	Yuka Takagi	Ferroelectric Materials / Energy Storage, Metamaterials
Faculty of Science Division II Department of Chemistry	Assistant Professor	Daisuke Nakane	Coordination chemistry / Bioinorganic chemistry / Catalytic chemistry
Faculty of Engineering Department of Electrical Engineering	Assistant Professor	Cui Jindan	Photovoltaic system / Energy management system
Faculty of Engineering Department of Architecture	Assistant Professor	Kohei Terashima	Solar heat utilization / Photovoltaic system
Suwa University of Science	Visiting professor	Yoichi Hirata	Photovoltaic power generation system / Wind-power generation / Micro grid
Suwa University of Science	Visiting professor	Yasuyuki Watanabe	Molecular electronics & Bioelectronics / Photosynthetic engineering

Ehime University	Visiting professor	Sho Shirakata	Semiconductor material engineering / Thin film photovoltaic cell, CIGS solar cell
National Institute for Environmental Studies	Visiting researcher	Satoru Ohnishi	Energy economics / Low carbon city management
University of Tsukuba	Visiting researcher	Daisuke Kodaira	Smart grid, energy storage system management, PV generation forecasting
Nagaoka University of Technology	Visiting researcher	Ayaka Kanai	Thin film photovoltaic cell / Optical Properties of Semiconductor

Facilities

The division's laboratory is located on the 4th floor of Building No. 10 at the Tokyo University of Science's Noda Campus, and has been conducting joint research within the division, focusing on research and development of solar cells and transparent conductive films.

3. Activity Reports

As a center for research and development of renewable energy technologies, the division is generally divided into the "Renewable Energy Materials Group" and the "Energy Management Group" to realize new renewable energy materials and power generation systems through vertical integration of technologies, as well as to educate the next generation of researchers and disseminate the technologies to society.

3. 1. About the Renewable Energy Materials Group

With the goal of developing materials to reduce the cost of installation and operation to the same level as power generation using fossil fuels, the knowledge gained through solar cell research will be used as the basic technology for developing other power generation materials (solar cells, thermoelectric power generation elements, fuel cells, etc.), which will be jointly developed across the division in FY2024. Activities have been carried out by each laboratory to reduce the risk of novel corona infection among faculty and students.

Sugiyama proposed an optical evaluation method to elucidate the surface carrier dynamics—referred to as "optoiontronics"—in Cu(In,Ga)Se_2 (CIGS)-based compound semiconductor photoelectrodes for hydrogen production. In addition, he has been engaged in clarifying the degradation mechanisms of CIGS photoelectrodes and developing devices with enhanced durability. Akitsu et al. used a cyano-bridged rare earth-transition metal binuclear complex, known as a photocontrollable molecular magnetic material, as a mediator for the cathode enzyme laccase in biofuel cells, and found that this improved the oxygen reduction catalytic activity, particularly when a magnetic field was applied, i.e., the current density value in CV measurements increased. Nagata developed a novel molybdenum-loaded catalyst for gas-phase photocatalytic hydrogen sulfide decomposition and its high performance: zero-out of 10 ppm of hydrogen sulfide. Moreover, the catalyst can be regenerated through photocatalytic reduction, keeping decomposing hydrogen sulfide to nearly odorless levels. Ikuno engaged in research aimed at enhancing the output of triboelectric generators, which are anticipated to offer low power generation costs. In this device, which generates electricity through the contact and separation between a polymer film and a metal foil, he dramatically increased the output by controlling the geometric structure of the polymer film. Furthermore, he created an artificial synapse that uses time-series light as input, applying it to physical reservoir computing,

a form of non-Von Neumann computing. Haraguchi easily constructed crystal-oriented films of metal-organic complexes (MOFs) using colloidal solutions of metal complex nanosheets for applications such as solar cells, and found that oriented crystalline films could be constructed for various MOFs such as Cu(BDC).Takagi proposed a new material design guideline for controlling the cooling process during the fabrication of ceramics in order to control the structural phase transition of $(Bi_{0.5}Na_{0.5})TiO_3$-$BaTiO_3$ ceramics, with the aim of developing materials for energy storage in ferroelectric ceramics. Nakane confirmed the methanol oxidation ability to formaldehyde by dioxygen catalyzed by the Fe(III) complexes synthesized as anodic electrode catalysts for direct methanol fuel cells. He also modified the Fe(III) complexes on platinum and gold substrates and evaluated their electrochemical properties. Furthermore, he investigated the methanol oxidation catalyzed by the Fe(III) complexes under various condition and mentioned their methanol oxidation mechanism. Watanabe conducted research on a new process technology for organic photovoltaic (OPV) cells, which involves the fabrication of OPVs by ink-jet and electrostatic spraying methods. He also developed an OPV that combines algae cultivation and solar power generation, and succeeded in the amount of power generated by the OPV and oil production by microalgae. Furthermore, we obtained multi-point simultaneous measurement data of the amount of electricity generated by OPVs installed outdoors. Kanai analyzed the defect levels and density of defect states in Cu_2SnS_3(CTS) solar cells using electrical measurements, including admittance spectroscopy measurements, to develop next-generation sulfide solar cells. It was found that interfacial carrier recombination dominates in CTS solar cells. Thus, it was suggested that suppression of interfacial carrier recombination is important to achieve high efficiency.

3. 2. About the Energy Management Group

Based on the plan to jointly develop technologies to utilize power obtained by various power generation methods without waste, such as the development of highly efficient management technologies for power obtained by various power generation methods, grid interconnection, fault diagnosis technologies, and optimization using AI, across the division, in FY2024. Each laboratory has been working on its own activities for this purpose.

Ueda participated in a NEDO project that began in fiscal year 2021, and developed technology to create upward adjustment capacity by systematically suppressing and controlling power generation at solar power plants, as well as short-term forecast evaluation technology for power generation. For short-term forecasting, we developed a method that combines physical and statistical modeling of power generation characteristics with machine learning to develop technology to predict power generation about one hour ahead using solar radiation forecast values with a 5-minute granularity. Kondoh clarified the mechanism that the time required for detection of unintentional islanding by a PCS equipped with the new active method becomes longer when a rotating machine load is connected. It is the absorption of reactive power output from the PCS by the rotating machine load due to transient voltage fluctuations. Katayama used a large-scale data measurement system, which was developed last year for analyzing the impedance characteristics of lithium-ion batteries using machine learning, to accurately estimate the temperature and SoC (State of Charge) of lithium-ion batteries and to analyze the frequency bands that affect the estimation. Cui is developing a market bidding strategy algorithm for the purpose of creating a reserve power in solar power generation, and analyzing the data from the demonstration experiment. In addition, she is using a geographic information system (GIS) to model shade loss in urban areas and building a spatio-temporal model to evaluate the wide-area potential of solar power generation that takes into account weather. Terashima simulated a residential energy supply system of PV/T solar panels, which combine PV panels and solar heat collectors. A system with an ejector refrigeration cycle, which makes cold heat from warm heat with low power consumption, and a system with a frame-integrated water thermal storage were investigated to clarify their energy-saving effects. Hirata

conducted a simulation of power interchange and showed that by sharing power between the storage batteries of two houses, it is possible to keep the SoC of the storage batteries within a moderately effective range. Onishi established a framework for examination and implementation to facilitate the social implementation of combined biomass utilization technologies using waste-based and woody biomass in the Hamadori region of Fukushima Prefecture. Additionally, Onishi is conducting research on designing strategies that integrate regional development initiatives with solutions to social challenges, such as renewable energy deployment, urban planning, and community revitalization. Furthermore, a collective impact strategy is being developed using a regional capital framework to enhance the effectiveness of these initiatives. Kodaira conducted a demonstration of a battery control algorithm based on deep reinforcement learning. The demonstration utilized the practical system developed in the previous year, which enables remote control of residential battery systems via the cloud. We quantitatively clarified discrepancies between simulated control results and actual measurements (charging amount and response accuracy) obtained from the real battery systems.

4. Challenges and Prospects

The objectives of this research division are (i) development of materials to reduce the cost of installation and operation to the same level as power generation using fossil fuels, (ii) development of high-efficiency management technology for electricity obtained from various power generation methods, and (iii) development of new materials and system technology. Continue to promote research and development of renewable energy technologies by leveraging synergies from the vertical integration of technologies, with a focus on (i) the development of high-efficiency management technologies for electricity generated by various power generation methods, and (ii) the development of new material and system technologies. We will activate joint research within the division and create novel concepts for future renewable energy technologies by creating technology roadmaps and other means. Continue to hold symposiums and participate in exhibitions to promote the division's research results to society and exchange technical information on renewable energy for the benefit of future research. In addition, strengthen cooperation among students and create an environment for the promotion of joint research.

5. Conclusion

While renewable energy is environmentally friendly, it has serious infrastructure issues such as unstable power supply and high installation and running costs. This research division is actively promoting the development of fusion research fields, devices, and processes through the active exchange of researchers with different areas of expertise, proposing a foundation for stable and low-cost power supply, and activating and promoting the research and development of renewable energy utilization technology at Tokyo University of Science. We would like to promote Tokyo University of Science as a center for research and development of renewable energy technologies by proposing the foundation for stable and low-cost power supply.

Major Research Achievements (FY2024)

Academic Papers

1. "Optoiontronic" Insights into the Water-Splitting Reaction Mechanism in the Cu(In,Ga)Se_2 Photoelectrode/Electrolyte Interface, Kana Ueda and Mutsumi Sugiyama, ACS Applied Energy Materials, 7 (2024) 10149 (Peer-reviewed)
2. Effects of Li concentration in the precursor solution on NiO thin films deposited using electrostatic spray deposition, Keito Okubo and Mutsumi Sugiyama, Japanese Journal of Applied Physics, 63 (2024) 111006 (Peer-reviewed)
3. Preliminary investigation into the potential of Ge-enhanced Cu_2SnS_3 (CTS) thin film applications for water splitting photoelectrodes, Daiki Kanamori and Mutsumi Sugiyama, Japanese Journal of Applied Physics, 63 (2024) 098003 (Peer-reviewed)
4. Machine Learning-Based Japanese Spot Market Price Forecasting Considering the Solar Contribution, XUE FANG, JINDAN CUI, TAKASHI OOZEKI, and YUZURU UEDA, IEEE Access, 12 (2024) 52452 (Peer-reviewed)
5. Forecasting Wholesale Electricity Market Prices Considering Bidding Conditions Using Price Sensitivity, Shinji Hirota, Jindan Cui, Xue Fang, Takashi Oozeki, Yuzuru Ueda, Advanced Energy and Sustainability Research, (2024) 2400192 (Peer-reviewed)
6. Machine Learning-Based Japanese Spot Market Price Forecasting Considering the Solar Contribution, Xue Fang, Jindan Cui, Takashi Oozeki and Yuzuru Ueda, IEEE Access, 12 (2024) (Peer-reviewed)
7. A spatio-temporal model of wide-area PV generation potential considering shading losses and weather using GIS, Jindan Cui, Taiju Igarashi, and Yuzuru Ueda, Proceedings of the Japan Solar Energy Society Conference, (2024)
8. Self-Powered Dye-Sensitized Solar-Cell-Based Synaptic Devices for Multi-Scale Time-Series Data Processing in Physical Reservoir Computing, H. Komatsu, N. Hosoda, and T. Ikuno, ACS Applied Materials & Interfaces, 17 (2025) 5056-5065 (Peer-reviewed)
9. Effect of adding ionic liquid into polydimethylsiloxane on the output performance of triboelectric nanogenerator, Q. Zhou, Y. Zheng, K. Kinoshita, and T. Ikuno, Japanese Journal of Applied Physics, 63 (2024) 121004 (Peer-reviewed)
10. Dye-sensitized solar cell-based optoelectronic artificial synaptic devices capable of wavelength recognition for physical reservoir computing, N. Hosoda, H. Komatsu, and T. Ikuno, Japanese Journal of Applied Physics, 64 (2025) 037001 (Peer-reviewed)
11. Output Forecasting for Multiple Geographically Distributed PVs Without Meteorological Data, H. Yamamoto, T. Kure, J. Kondoh, D. Kodaira, IEEE Access, 12 (2024) 86997 (Peer-reviewed)
12. Demonstration of Frequency Regulation via Autonomous Load Control, T. Kitamura, T. Kubo, J. Kondoh, IEEE Access, 12 (2024) 104542 (Peer-reviewed)
13. Influence of Induction Machine Loads on Islanding Detection by Inverter-Based Distributed Generation, J. Kondoh, IEEE Transactions on Power Delivery, 39 (2024) 2985 (Peer-reviewed)
14. Photocatalytic Gas-Phase Hydrogen Sulfide Removal Using Mo Cocatalyst: Implementation of Counter-Poisoning Photocycle, Tomofumi Katayama, Morio Nagata, ACS Omega, 10 (2025) 4670 (Peer-reviewed)
15. Gas-Phase H2S Degeneration with Visible-Light Driven Photocatalyst and its Catalytic Process Investigation, Tomofumi Katayama, Morio Nagata, Sulphuric Acid and Industry, 77 (2024) 1

16. Data-Driven Temperature Deviation Estimation of a Proton Exchange Membrane Water Electrolyzer Stack from Electrochemical Impedance Using Machine Learning, N. Katayama, R. Iki, X.X. Chen, K.H. Loo, IEEJ Transactions on Electrical and Electronic Engineering. DOI: 10.1002/tee.70009 (Peer-reviewed)
17. A distributed constant equivalent circuit model and a method for estimating parameters for paper-based lactate biofuel cells, Y. Yokoi, D. Ito, Y. Yoshihara, K. Ishigoori, I. Shitanda, N. Katayama, Electrochimica Acta, 493 (2024) 144384 (Peer-reviewed)
18. Environmental Impact Assessment Considering the Freshness of Frozen Mackerel by Impedance Measurement, A. Kubota, T. Yamasaki, N. Katayama, K. Dowaki, Journal of the Japan LCA Society, 20 (2024) 83 (Peer-reviewed)
19. Dipole pinning and quenching effects on depolarization temperature of ZnO and $(Bi_{0.5}Na_{0.5})TiO_3$ ceramics composites, Kaito Okada, Yuka Takagi, Hyunwook Nam, Hajime Nagata, Journal of the Ceramic Society of Japan, 132 (2024) 330 (Peer-reviewed)
20. Small-signal piezoelectric properties on Mn-doped $BiFeO_3$–$BaTiO_3$ lead-free piezoelectric ceramics, Keisuke Nozoe, Tomoki Oana, Hyunwook Nam, Yuka Takagi, Hajime Nagata, Journal of the Ceramic Society of Japan, 132 (2024) 339-345 (Peer-reviewed)
21. Control of structural phase transition and energy storage behavior through cooling rate in (Bi0.5Na0.5)TiO_3–$BaTiO_3$ ceramics, Yuri Ohshima, Yuta Ochiai, Yuka Takagi, Hyunwook Nam, Hajime Nagata, Applied Physics Letters, 126 (2025) 12908 (Peer-reviewed)
22. Green-light wavelength-selective organic solar cells: module fabrication and crop evaluation towards agrivoltaics, Shreyam Chatterjee, Naoto Shimohara, Takuji Seo, Seihou Jinnai, Taichi Moriyama, Morihiko Saida, Kenji Omote, Kento Hara, Yohei Iimuro, Yasuyuki Watanabe, Yutaka Ie, Materials Today Energy (2024) 101673-101673 (Peer-reviewed)
23. Green-light wavelength-selective organic solar cells for agrivoltaics: dependence of wavelength on photosynthetic rate, Seihou Jinnai, Naoto Shimohara, Kazunori Ishikawa, Kento Hama, Yohei Iimuro, Takashi Washio, Yasuyuki Watanabe, Yutaka Ie, Faraday Discussions, 250 (2024) 220-232 (Peer-reviewed)
24. Industrial Heat Defossilization: A Comparative Analysis of Waste Incineration and Clean Energy Scenarios, Chen, W., Ohnishi, S., Maki, S., Kawai, K., Sun, L., Dong, H., Fujii, M., Journal of Cleaner Production, (2025) 144802 (Peer-reviewed)
25. A Framework Analyzing Co-Creation Value Chain Mechanism in Community-Based Approach: A Literature Review, Ohnishi, S.; Osako, M.; Nakamura, S.; Tsuji, T.; Togawa, T.; Kawai, K.; Suzuki, K.; Yoshida, A.; Gomi, K., Sustainability, 66 (2024) 2919 (Peer-reviewed)
26. Urban-industrial symbiosis practices in Tokyo Metropolis and the indication of carbon emissions reduction and environmental benefits, Sun, L., Du, C., Li, Z., Fujii, M., Dou, Y., Ohnishi, S., Dong, L., Cities, 161 (2024) 105840
27. Influence of Ge inclusion on surface morphologies and growth mechanism of $Cu_2(Sn_{1-x}Ge_x)S_3$ films grown by sulfurization of Ge/Cu/Sn-S precursors, Ayaka Kanai, Kunihiko Tanaka, and Mutsumi Sugiyama, Thin Solid Films, 800 (2024) 140410 (Peer-reviewed)
28. Electrical characterizations on $Cu_2Sn_{1-x}Ge_xS_3$ films with varying x ratios, Ayaka Kanai, Ray Ohashi, Yuki Igarashi, Hideaki Araki, and Kunihiko Tanaka, Thin Solid Films, 803 (2024) 140481 (Peer-reviewed)
29. Influence of sulfurization process in tin sulfide and sulfur mixed vapors on the morphology of Cu_2SnS_3 thin films, Yuki Igarashi, Ray Ohashi, Ayaka Kanai and Kunihiko Tanaka, Journal of Physics D: Applied Physics, 58 (2025) 015309 (Peer-reviewed)

30. Quantile Regression for Probabilistic Electricity Price Forecasting in the U.K. Electricity Market, Y. Osone and D. Kodaira, IEEE Access, vol. 13, pp. 10083-10093, 2025 (Peer-reviewed)
31. Output Forecasting for Multiple Geographically Distributed PVs Without Meteorological Data, H. Yamamoto, T. Kure, J. Kondoh and D. Kodaira, IEEE Access, vol. 12, pp. 86997-87013, 2024 (Peer-reviewed)
32. Development of an efficient vehicle-to-grid method for massive electric vehicle aggregation, M. Seo, D. Kodaira, Y. Jin, H. Son, S. Han, Energy Reports, Volume 11, pp. 1659-1674, 2024 (Peer-reviewed)

Books

1. Physicochemical properties of smart and intelligent nanomaterials for biosensors, K. Muneshige, M. Azam, H. Sakiyama, D. Nakane and T. Akitsu, Smart and Intelligent Nanostructured Materials for Next-Generation Biosensors (Ed. B. D. Malhotra, R. P. Singh, J. Singh, K. R. B. Singh), Chapter 2, pp. 19–41, Elsevier, 2024, ISBN: 9780443191466
2. Comparison of MXene with Other 2D Materials, Y. Sato, D. Nakane, and T. Akitsu, MXenes - Next-Generation 2D Materials: Fundamentals and Applications (J. Singh, K.R.B. Singh, R.P. Singh, C. O. Adtunji Ed.), Chapter 7, pp. 117–128, Wiley, 2024, ISBN: 978-1-119-87399-0
3. Development of Post-Processing Methods for Improving Spatial Resolution in Electrical Impedance Tomography, Takashi Ikuno, Inspection Technology, December 2024, Japan Industrial Publishing Co., Ltd.
4. Surface Treatment, Dispersion, and Composite Technologies of Carbon Nanotubes and Their Industrial Applications (contributing author), Takashi Ikuno, January 2025, Gijutsu Joho Kyokai Co., Ltd.
5. Research and Applications of Carbon Nanotubes (Chapter 1, contributing author), Takashi Ikuno, February 2025, CMC Publishing Co., Ltd.
6. Research and Applications of Carbon Nanotubes (Chapter 3, contributing author), Takashi Ikuno, February 2025, CMC Publishing Co., Ltd.
7. Smart Agriculture Application of Wavelength-Selective Organic Thin-Film Photovoltaic Cells, Yasuyuki Watanabe, Latest Development Trend, Application Development, and Future Prospects of Components for Increasing Efficiency and Durability of Organic Thin-Film Photovoltaic Cells: Issues of See-Through, Module, and Market Development, Barrier Material to Ensure Reliability - Chapter 3: Development and Application Development of Organic Thin-Film Photovoltaic Cell Module, Chapter 3, published October 17, 2024

Invited Lectures

1. Optimized Operation Planning for a System Integrating Solar Power Generation and Storage Batteries Using Data Science, Jindan Cui, Japan Society for the Promotion of Science R052 DX Plasma Process Committee 6th Workshop “Solar Cells x Data Science”, 2024/06/25 (invited oral)
2. Conversion of Plastics into Carbon Nanotubes and Development of Their Applications, Takashi Ikuno, 2024 Nanospace Engineering Seminar, Shinshu University, April 25, 2024 (invited oral)
3. Fabrication of Artificial Optoelectronic Synapses Using Semiconductor Nanostructures and Their Application to Physical Reservoir Computing, Takashi Ikuno, Chiba Prefecture Processing Technology Workshop, Chiba Prefectural Institute of Industrial Technology, October 1, 2024 (invited oral)
4. Physical Reservoir Computing Using Optoelectronic Synaptic Devices Based on Photoelectric Conversion Elements, Takashi Ikuno, Materials AI Symposium, Toyo University, March 1, 2025 (invited oral)

5. Fabrication and evaluation of metal-organic framework thin films, Tomoyuki Haraguchi, International Conference on Advances in Functional Solids, Indian Institute of Technology Kharagpur, Kharagpur, India, Nov. 08–13, 2024 (invited oral)
6. Development of Impedance Data Collection System and Analysis Method, Noboru Katayama, The 34th Annual Meeting of MRS-J, December 17, 2024

Awards

1. M. Akashi, K. Okada, K. Ueda, M. Sugiyama, Y. Honda, and T. Furuya, Received the Excellent Presentation Award at the 2024 Annual Meeting of the Kanto Branch of the Japan Society for Bioscience, Biotechnology, and Agrochemistry (JSBBA) for the presentation titled "Investigation of Photocatalysts Effective for Hydrogen Peroxide Production from Polyphenols" (August 30, 2024).
2. Best Poster Prize: Kazuma Okada and Mutsumi Sugiyama, "Effects of compositional control of the conduction band minimum on Cu(In,Ga)Se_2 photoelectrodes for CO_2 reduction", 22nd International Conference on Ternary and Multinary Compounds (ICTMC-22). September 11, 2024.
3. K. Tanaka, K. Okubo, and M. Sugiyama, The Presentation Encouragement Award at the 2024 Year-End Symposium of the Research Group on Multinary Compounds and Solar Cells, The Japan Society of Applied Physics, for the presentation titled "Surface Morphology Control and Electrochromic Properties of NiO Thin Films Deposited by Electrostatic Spray Deposition (ESD)" (December 14, 2024).
4. Jotaro Yamaguchi, Takashiro Akitsu, Masahiro Furuya, "Effect of adding ionic liquid to the solvent of Schiff base copper (II) complex mediator enzyme electrode", Student Encouragement Award at the 18th Student Research Presentation Session hosted by the Kanto-Koetsu Branch of the Atomic Energy Society of Japan (February 28, 2025)
5. Academia Award, HORIBA Award: Takashi Ikuno, "Ultra-Low Power Artificial Optoelectronic Synaptic Device Inspired by the Eye and Brain," SEMICON JAPAN 2024 (December 2024)
6. Selected as Supplementary Journal Cover Art of ACS Applied Materials & Interfaces:
   H. Komatsu, N. Hosoda, and T. Ikuno, "Self-Powered Dye-Sensitized Solar-Cell-Based Synaptic Devices for Multi-Scale Time-Series Data Processing in Physical Reservoir Computing" (January 2025)
7. YPC Outstanding Presentation Award: Eiji Yoshida, Noboru Katayama, "Formation of Layered Stripe Structure Catalyst Layers in Polymer Electrolyte Fuel Cells Using Electrostatic Spray Method," The 2024 IEEJ Power and Energy Society Conference, (September 2024)
8. YPC Encouragement Award: Masami Sumida, Kouya Honda, Koki Harano, Tomoya Ezawa, Noboru Katayama, Kiyoshi Dowaki, "Simulation Development of Hybrid Power Supply System for H-bike," The 2024 IEEJ Power and Energy Society Conference, (September 2024)
9. Outstanding Student Presentation: Hikaru Arai, Eiji Yoshida, Noboru Katayama, "Power Generation Characteristics of Polymer Electrolyte Fuel Cells with Segmented Catalyst Layers Formed by Electrostatic Spray Method," The 92nd Annual Meeting of the Electrochemical Society of Japan, (March 2025)
10. Poster Award: Jindan Cui, Xue Fang, Takashi Oozeki, and Yuzuru Ueda, "Development of error absorption headroom setting algorithm using bivariate polynomial surface to create reserve power in a PV power plant," 35th International Photovoltaic Science and Engineering Conference (PVSEC-35), Numazu, Japan, Nov. 2024

Individual Research Topics

Mutsumi Sugiyama

“Research on realization of hydrogen generation Device using $Cu(In,Ga)Se_2$ compound semiconductors”

$Cu(In,Ga)Se_2$ (CIGS) compound semiconductors were used to develop hydrogen-producing photoelectrodes, and a method was proposed to elucidate their surface carrier–ion dynamics—referred to as "optoiontronics"—through time-resolved photoluminescence measurements under applied bias. Using this method, part of the degradation mechanism of CIGS photoelectrodes was clarified, and devices with enhanced durability compared to conventional counterparts were developed.

Zhao Xinwei

“Research on perovskite solar cells”

In this year, we theoretically designed the active layer which coveing to the visible wavelength region and has a band gap energy of 2 to 3 eV. The thin films having these narrow band gaps were also fabricated and demonstrated. Our results have been submitted to journal and was under the reviewing process. eveloped perovskite type active layer for the use in the perovskite solar cells. In the next year , a practice perovskite solar cell will be fabricated.

Takashiro Akitsu

“Cyano-bridged rare earth-transition metal complex mediators for laccase”

Laccase is an enzyme that catalyzes the four-electron reduction of oxygen to water, and by utilizing this property, laccase is used as a cathode catalyst in enzyme biofuel cells. Cyano-bridged rare earth transition metal complexes are known as photocontrollable molecular magnets, and this time, for the first time, we have confirmed their structure retention and redox properties in solution, demonstrating that they can act as mediators for laccase. In particular, we found an increase in the amount of current under a magnetic field. Furthermore, the findings from previous research using the two-dimensional inorganic material MXene as an electrode have finally been published in a specialist book.

Yuzuru Ueda

“Research on photovoltaic power generation systems”

Our group conducted research on the development of system technologies, from evaluation technologies such as power generation characteristic evaluation, defect detection, and deterioration analysis of photovoltaic power generation systems, to operation and prediction in power systems, and energy management using photovoltaic power generation systems as distributed power sources on the consumer side. We participated in a NEDO project and conducted research on short-term power generation forecast evaluation technologies and adjustment capacity creation technologies at photovoltaic power plants in fiscal year 2024.

Morio Nagata

“Research on organic solar cells and artificial photosynthesis”

We demonstrate a novel molybdenum-loaded catalyst for gas-phase photocatalytic hydrogen sulfide decomposition and its high performance: zero-out of 10 ppm of hydrogen sulfide. Moreover, the catalyst can be regenerated through photocatalytic reduction, keeping decomposing hydrogen sulfide to nearly odorless levels. In addition, the paper was selected for the Supplementary Cover of ACS Omega.

Junji Kondoh

“Clarification of the Mechanism of Increased Detection Time of Unintentional Islanding Due to Rotating Machine Loads”

PCSs (power conditioning subsystems) for dispersed power generation connected to Japanese low-voltage distribution systems output reactive power to increase the frequency deviation for unintentional islanding detection. When the rotating machine load is connected, the frequency deviation is smaller and the detection time is longer, but the cause of this problem has not been clarified. This study clarified through experiments and numerical analysis that, as a transient phenomenon when the terminal voltage of the rotating machine load fluctuates, the reactive power output by the PCS is absorbed by the rotating machine load, thereby reducing the frequency fluctuation range and increasing the detection time.

Noboru Katayama

“Application of Machine Learning to Energy Technologies”

Research is being conducted on methods combining the impedance method with machine learning and on energy management using reinforcement learning. The former established fundamental technologies to improve reliability, such as temperature and SoC estimation of lithium-ion batteries and temperature distribution estimation of water electrolysis devices. The latter involved foundational studies aimed at optimizing the control and design of energy systems, including air conditioning and various heat sources.

Takashi Ikuno

“Research on Low-Cost Vibrational Power Generation Devices and Artificial Photoelectronic Synaptic Devices”

Research and development have been conducted on triboelectric generators that generate electricity through the contact, separation, or friction of dissimilar materials. By incorporating high-dielectric particles into the polymer film used in triboelectric devices and controlling the film's geometric structure, a significant improvement in output voltage was achieved. Future efforts will focus on enhancing the surface charge density of the polymer to further improve output. In addition, a polymer film embedded with a semiconductor particle array was created to realize an artificial optoelectronic synaptic device that mimics the brain and eyes. This device, responsive to time-series light inputs, has been demonstrated to recognize handwritten digits with approximately 90% accuracy. Future plans include device design aimed at integration with renewable energy systems.

Tomoyuki Haraguchi

“Construction of printable oriented crystalline metal-organic framework thin films”

We have investigated the application of metal-organic frameworks (MOFs) to dye-sensitized solar cells, etc. We found that various MOFs such as Cu(BDC) can be used to construct oriented crystalline films. In the future, we will control the structure and HOMO/LUMO energy levels hierarchically by changing the components, and aim to create dye-sensitized solar cells that absorb light at a wide range of wavelengths and transport electrons with high efficiency.

Yuka Takagi

"Control of Phase Transition in $(Bi_{0.5}Na_{0.5})TiO_3$-Based Ceramics by Cooling Rate and Its Application to Energy Storage"

$(Bi_{0.5}Na_{0.5})TiO_3$[BNT] solid solution ceramics shows a structural phase transition from the ferroelectric phase *R*3*c* to the pseudotetragonal phase *P*4*bm* with increasing temperature. The *P*4*bm* phase is expected to be used in energy storage devices, but it is necessary to keep the *P*4*bm* phase stable at room temperature. To address these issues, we investigated the stabilization of the *P*4*bm* phase by controlling the cooling rate during sintering. We observed the *P*-*E* hysteresis loops and considered the structural phase transition behavior based on the temperature dependences of the coercive electric field E_c and the residual polarization P_r.

Daisuke Nakane

"Development of Fe(III) complex catalysts for anodic electrode of direct methanol fuel cell"

Novel molecular catalysts composed of inexpensive iron ions as catalysts for anodic electrode of direct methanol fuel cells were synthesized and their various spectroscopic properties were clarified. The electrochemical properties of these Fe(III) complexes suggest that they have sufficient catalytic ability for methanol oxidation. The reactions between the Fe(III) complexes and methanol under an oxygen atmosphere at room temperature revealed that these Fe(III) complexes catalyzed methanol oxidation by the oxidizing property of dioxygen, as in the methanol fuel cell. In addition, evaluations of methanol oxidation under various conditions gave important findings of the methanol oxidation mechanism. Furthermore, we succeeded in modifying these Fe(III) complexes on a platinum and gold substrates.

Cui Jindan

"Development of a market bidding strategy algorithm for creating a reserve power in solar power generation" and "Solar power generation potential at the city level using ArcGIS"

With the aim of creating a reserve power for solar power generation, we have integrated the construction of a polynomial approximation surface model for headroom to absorb forecast errors, rare frequency risk analysis, and the creation of entry plan values for two markets. The results have significantly reduced the number of insufficient imbalances. We confirmed the versatility of the model by applying it to multiple locations and analyzed the effects of smoothing and congestion rates. In addition, we are developing a new model for wide-area potential models targeting building roofs, walls, and parking lots in urban areas.

Kohei Terashima

"Research on PV/T solar panel systems"

A residential energy supply system using a PV/T solar panel, which combines a PV module and a solar heat collector, was studied in a simulation. A system with an ejector refrigeration cycle that converts hot water into cold water was studied, and the effects of the solar heat collector and PV/T solar panels areas and the capacity of the hot water storage tank on the energy-saving effects were evaluated. A PV/T solar panel system with a frame-integrated water thermal storage was also studied for annual use, and it was found that energy savings could be achieved while controlling the room temperature within a comfortable range in both summer and winter.

Yoichi Hirata

“Creation and testing of software simulation for power interchange in DC microgrid systems”

Assuming two DC microgrids, we established a simulation system in which when one storage battery is insufficient, power is transferred from the other storage battery. By doing so, we confirmed that the period during which the storage battery's SoC can be kept within a certain range can be extended.

Yasuyuki Watanabe

“Investigation of Shading Conditions for Compatibility between Oil-Producing Algae Cultures and Power Generation by Organic Photovoltaic Cells”

This year's research examined solar matching, which is one of the measures to improve EPR in microalgae biomass production, and to balance power generation by organic photovoltaic (OPV) cells and microalgae cultivation using the transmitted light. The amount of energy input for cultivation was reduced while the amount of energy obtained was successfully increased.

Sho Shirakata

“Research on narrow-gap chalcopyrite semiconductors”

The growth of bulk single crystals and thin films of complex semiconductor materials, which are candidates for new thin-film solar cells, is conducted. Measurements of their basic properties, including crystal structure, bandgap, absorption coefficient, and Raman scattering, are performed. Based on these measurements, a comparison of the characteristics of bulk and polycrystalline materials is conducted. In the fiscal year 2024, the relocation and launch of the deposition and evaluation equipment mentioned above were carried out. In the future, deposition and evaluation of various semiconductor materials are planned.

Satoru Ohnishi

“Design and evaluation for appropriate introduction of renewable energy to the industrial sector, mainly through biomass heat utilization”

To achieve region-led decarbonization, this study aims to facilitate the appropriate integration of renewable energy, with a focus on biomass thermal utilization, into the industrial sector. In consideration of regional planning and social implementation in industrial cities, mountainous areas, and disaster-affected regions, we have developed a vision for renewable energy deployment and established a collaborative framework among the public, private, and academic sectors to construct viable business models. By setting appropriate parameters and conducting evaluations tailored to regional characteristics, we contribute to practical urban development support.

Ayaka Kanai

“Next-generation CTS-based solar cells combining low cost, non-toxicity, and high efficiency”

Next-generation Cu_2SnS_3(CTS)-based solar cells combine the advantages of low cost, non-toxicity, and research has been conducted to improve their efficiency. While we have so far focused on the growth method of the CTS films, we focused on the clarification of defect characteristics in CTS solar cells in this year. Specifically, we revealed the defect levels and density of defect states in the CTS and $Cu_2Sn_{1-x}Ge_xS_3$ solar cells by using admittance spectroscopy measurements, and so on. Furthermore, we analyzed the temperature dependence of the open-circuit voltage and identified that the interface recombination is dominant. These results indicate that suppression of carrier recombination at the interface is important for high efficiency.

Daisuke Kodaira

“Automatic Control of Battery Charging and Discharging via Cloud Based on Deep Reinforcement Learning”

The battery control algorithm developed in this research determines the next day's control parameters in advance based on predicted photovoltaic (PV) generation and electricity prices. This year, we conducted demonstration experiments using the battery control algorithm and remote control system established in the previous year. Specifically, we performed a detailed analysis of differences between simulation results and actual experimental outcomes. Notably, discrepancies caused by charging/discharging losses and communication delays were clearly identified.

Division of Implementation of Sustainable Technology in Society

Division of Implementation of Sustainable Technology in Society

1. Overview

In order to realize a sustainable society, it is important to maintain a balance in all aspects—economic, social, and environmental—that will allow people to continue to prosper from the present to the future. This involves considering various factors, including resource and energy conservation, technological development, and social structural reforms. This division aims to converge the collective wisdom of all members to provide not only ideas but also real products of practical technology to realize a sustainable society, especially in the fields of medical welfare, agriculture, civil engineering, production, industry, and resources and energy, which are directly related to our daily lives. To this end, we will create opportunities to develop new markets through the prototyping of innovative integrated systems, their verification and durability testing, and their commercialization and marketing. We emphasize practicality and application beyond just publishing papers, encouraging startup entrepreneurship, patent applications, and product launches, which will lead to further development.

2. Organization and Facilities

As shown in Table 1, the division currently consists of one Division Head and 24 research collaborators. In addition to members from Tokyo University of Science, we also include researchers from external institutions, bringing together a diverse range of expertise and backgrounds.

Table 1. List of division members

[Director] Faculty of Engineering, TUS	Prof.	Hiroshi Kobayashi
[Vice director] Faculty of Engineering, TUS	Assoc. Prof.	Takuya Hashimoto
[Researcher] Faculty of Engineering, TUS	Prof.	Masayoshi Wada
Faculty of Advanced Engineering, TUS	Prof.	Taketoshi Mori
Faculty of Advanced Engineering, TUS	Prof.	Eiichi Yoshida
Faculty of Advanced Engineering, TUS	Prof.	Yoshio Matsumoto
Faculty of Engineering, TUS	Prof.	Kuniharu Ushijima
Faculty of Science and Technology, TUS	Prof.	Hiroshi Takemura
Faculty of Engineering, TUS	Assoc. Prof.	Ryuzo Hayashi
Faculty of Advanced Engineering, TUS	Assoc. Prof.	Hiroaki Hobara
Faculty of Science and Technology, TUS	Assoc. Prof.	Shogo Arai
Research Institute for Science & Technology, TUS	Assoc. Prof.	Tomohiko Hayakawa
Research Institute for Science & Technology, TUS	Assoc. Prof.	Leo Miyashita
Research Institute for Science & Technology, TUS	Jr. Assoc. Prof.	Huang Shouren
Research Institute for Science & Technology, TUS	Jr. Assoc. Prof.	Tomohiro Sueishi
Faculty of Engineering, TUS	Assist. Prof.	Kenta Nagano
Faculty of Advanced Engineering, TUS	Assist. Prof.	Akishige Yuguchi
Faculty of Advanced Engineering, TUS	Assist. Prof.	Tomoya Sasaki
Faculty of Advanced Engineering, TUS	Assist. Prof.	Sooin Kang
Faculty of Science and Technology, TUS	Assist. Prof.	Masataka Yamamoto
Research Institute for Science & Technology, TUS	Assist. Prof.	Tomoshi Tabata
Azalee Group, Kokujukai – A Social Welfare Co.	Executive Director (Ph.D., M.D.)	Koji Kurusu
Mito Clinical Education and Training Center, University of Tsukuba Hospital	Prof.	Shuji Matsumoto
Cambridge University	Prof.	Fumiya Iida
Faculty of Engineering, TUS	Jr. Assist. Prof.	Kenta Matsumoto

In addition, Table 2 outlines the core technologies possessed by each researcher and their intended applications. With this structure, the division promotes collaborative research and development focused on practical applications, supported by proactive partnerships with external institutions.

Table 2. Organization for collaborative research and development

Application / Technology	Medical & Welfare	Life Support	Agriculture	Civil & Production & Industrial Engineering	Resource & Energy
	•Rehabilitation equipment •Diagnostic equipment •Pathology equipment •Welfare vehicles •Physical support	•Physical support •Monitoring •Autonomous driving •Sports	•Physical support •Automatic cultivation and harvesting •Genetic modification	•Physical support •Digital fabrication •Laboratory automation •Recycling	•Binary power generation
Mobility / Vehicle	Wada, Kurusu	Hayashi, Wada	Kobayashi, Iida, Arai	Arai	
Mechanism / Device	Kobayashi, Hashimoto, Takemura, Iida, Wada, Kurusu, Matsumoto,	Kobayashi, Hashimoto, Takemura, Matsumoto, Iida, Wada, Nagano, Hobara, Kurusu, Matsumoto	Kobayashi, Takemura, Iida, Arai, Hobara	Kobayashi, Hashimoto, Arai	Kobayashi
Image & Signal Processing	Kobayashi, Hashimoto, Takemura, Iida, Arai, Hobara, Hayakawa, Sueishi	Hashimoto, Takemura, Hayashi, Matsumoto, Arai, Hobara, Miyashita, Tabata, Sueishi	Takemura, Iida, Arai, Hobara	Takemura, Iida, Arai, Hobara, Hayakawa	Arai
Analysis / Control	Kobayashi, Takemura, Ushijima, Iida, Wada	Kobayashi, Hashimoto, Takemura, Hayashi, Matsumoto, Wada, Nagano	Iida, Arai	Hashimoto, Yoshida, Ushijima, Iida, Arai	Ushijima, Arai
Robotics / Humanoid	Yoshida, Iida, Arai	Hashimoto, Yoshida	Iida, Arai	Yoshida, Arai, Huang	

3. Activity Reports

A key characteristic of this division is its focus on research and development that leads to real-world applications and commercialization. In fiscal year 2024, this effort resulted in the establishment of two startup companies: Beyond Optical Technologies Inc. and Brush-up Works Inc., and two patent filings.

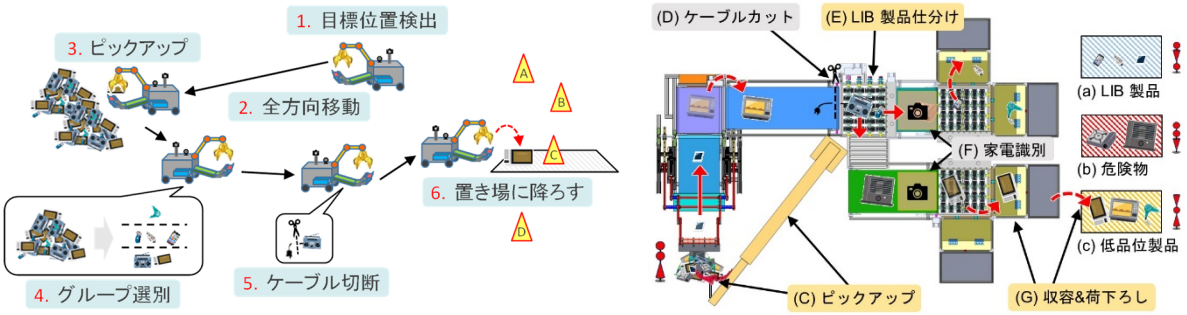
Three major collaborative research projects were conducted, involving multiple faculty members: NEDO Project (commissioned by the New Energy and Industrial Technology Development Organization), Binary Power Generation Project, and Living Lab Project. The following sections summarize the FY2024 activities of these projects, along with division's initiatives such as seminars and site visits.

3. 1. NEDO Project Research Group (Fig. 1)

This project is part of the ongoing NEDO-commissioned initiative titled *"Development of Fundamental Technologies for Processing Waste Electrical and Electronic Equipment toward Advanced Recycling System."* Our division is responsible for a research topic titled *"Development of Advanced Resource Recycling Process Technologies – (1) Development of Product Disassembly System."* This system aims to autonomously identify and sort hazardous items—such as oils, flammable gases, and products containing lithium-ion batteries (LIBs)—from the outdoor stockyard of a recycling plant. For this purpose, we have organized small teams for development task: (1) a target position detection system, (2) an omni-directional vehicle development and control system, (3) a small appliance pickup mechanism, (4) a small appliance identification and classification system, and (5) a power cable cutting mechanism. Each team conducts prototyping and holds a debriefing session every two weeks.

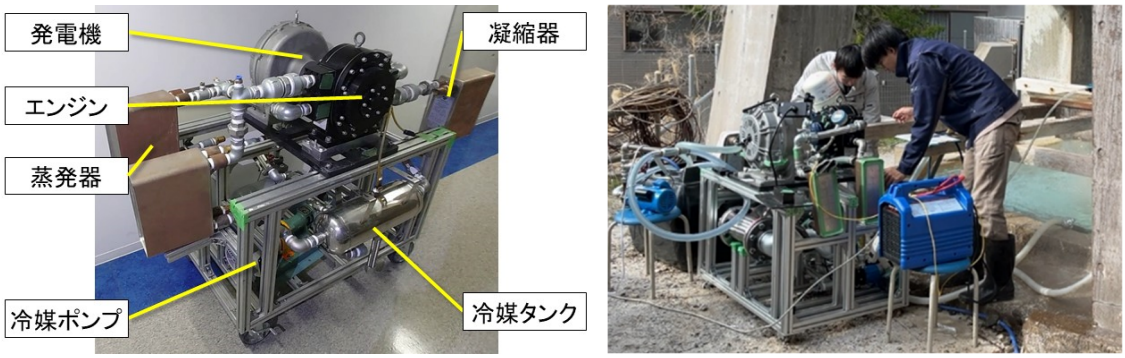
3. 2. Binary Power Generation Project Group (Fig. 2)

Geothermal energy is an environmentally friendly baseload power source with nearly zero CO_2 emissions. Japan ranks third globally in geothermal resources (~23.47 million kW), offering high potential for utilization. However, mainstream flash power systems require high-temperature sources, which limits development locations. Currently, geothermal accounts for only 0.3% of domestic power generation. To address this, Prof. Kobayashi's lab is developing a compact binary power generation system utilizing medium- to low-temperature sources, with a target output of 10 kW. The team is adjusting system parameters, conducting upgrades, and evaluating performance through on-site experiments. At the end of the previous fiscal year, a group site visit was held at the Atagawa hot springs in Izu, Shizuoka Prefecture, where the system was demonstrated.



(a) Project overview (b) Prototype of autonomous sorting system for small discarded home appliances

Fig. 1. Overview of the NEDO Project



(a) Developed power generation unit (b) Field experiment at hot spring source

Fig. 2. Overview of the Binary Power Generation Project

3. 3. Living Lab Project Group (Fig. 3)

Centered around members of the Department of Medical and Robotic Engineering Desing, this project utilizes the Living Lab—a facility equipped with residential features such as a living room, bedroom, kitchen, toilet, washroom, and bath. Observation spaces behind one-way mirrors allow unobtrusive study of human activity. The space is barrier-free and designed for easy movement of wheelchairs and autonomous assistive robots. It also supports motion capture systems. Ongoing cross-disciplinary research includes: design guidelines for assistive robots and welfare devices, evaluation and verification of their effects, and standardization efforts for broader adoption.

3. 4. Activities of the Division

(1) Site Visit (Fig. 4)

Date: January 16, 2025 (Thu) 13:30–15:00

Location: Miwa Central Hospital (Nagasaki City)

Description: A site visit was conducted to observe the utilization of communication robots in the daycare services at Miwa Central Hospital. Participants observed robot demonstrations and exchanged opinions with Prof. Hirokazu Kumazaki (Department of Neuropsychiatry, Nagasaki University) and Dr. Hidenobu Sumioka (Group Leader, ATR).

(2) Research Seminar (Fig. 5)

Date: January 16, 2025 (Thu) 16:30–18:00

Location: Nagasaki University Hospital

Speaker: Prof. Hirokazu Kumazaki

Title: “Social Implementation of Communication Robots in the Field of Psychiatry”

4. Challenges and Prospects

(a) Inside the living lab (b) Measurement of daily living activities

Fig. 3. Overview of living lab project

(a) Robot demonstration (b) Discussion and exchange of opinions

Fig. 4. Site visit: utilization of communication robots in daycare service

(a) Seminar session (b) Many communication robots

Fig. 5. Seminar and facility tour at Nagasaki University Hospital

As described above, the division has begun to establish a collaborative framework in which multiple researchers work together to generate synergistic effects through joint projects. However, given the breadth of expertise represented within the division, we have not yet fully realized its full potential. Moving forward, we will strengthen communication and information exchange among researchers, while actively seeking opportunities for collaboration with external institutions. Additionally, we will actively pursue large-scale external funding opportunities to create an environment where broader and more impactful synergies can be achieved.

As stated in the introduction, one of the distinctive missions of this division is not only conducting research but also striving for the practical implementation of research outcomes and launching startup ventures based on them. We believe these efforts will become a significant strength of our university in the future. To support this mission, we plan to hold entrepreneurship seminars and encourage participation in business competitions to foster a culture that is conducive to startup creation.

Furthermore, we intend to actively involve students in these efforts to enhance entrepreneurship education and create an environment where even students can take the initiative in starting businesses. Through these efforts, we hope to cultivate the next generation of leaders who will support the future of Japan.

5. Conclusion

This division will continue to harness the strengths of Tokyo University of Science as a science and engineering-oriented university, with the aim of realizing and implementing innovative technologies that enhance human life while respecting the environment and conserving resources. To this end, we will foster a collaborative environment in which researchers can inspire and complement one another to produce unique and synergistic outcomes. Moreover, we will further strengthen our efforts to commercialize research outputs—an area that characterizes our division—by actively pursuing productization and implementation that directly address social challenges. Through these initiatives, we strive to establish this division as a model for how academic institutions can contribute tangible solutions to society.

Major Research Achievements (FY2024)

Academic Papers

1. Development of Sweeping Mechanism in Auto-Sort System for Small Home Appliances on the Ground, Daigo Uchino, Kazuki Ooi, Takuma Kyomen, Reita Yamagishi, Keita Takayama, Takuya Hashimoto, Ryuzo Hayashi and Hiroshi Kobayashi, Proceedings of 2024 IEEE International Conference on Robotics and Biomimetics (ROBIO), pp. 354-358, 2024 (Peer-reviewed)
2. Weight reduction of Lower Back Support Exoskeleton: Muscle Suit, Ryota Sato, Hiroshi Kobayashi, Hibiki Nagasawa, Tomoya Yoshida and Takuya Hashimoto, Proceedings of 2024 IEEE International Conference on Robotics and Biomimetics (ROBIO), pp. 2180-2184, 2024 (Peer-reviewed)
3. Interactive segmentation with curve-based template deformation for spatiotemporal computed tomography of swallowing motion, Y. Kimura, T. Ijiri, Y. Inamoto, T. Hashimoto, Y. Michiwaki, PLOS ONE, 19(10): e0309379, 2024.(Peer-reviewed)
4. 物理的インタラクションと人間のモデル化 —接触を伴う物理作用・運動・行動のモデリング—, 吉田英一, 鮎澤 光, 日本ロボット学会誌, Vol. 42, No. 10, p. 953-958, 2024 (Peer-reviewed) (in Japanese)
5. Whole-Body Multi-Contact Motion Control for Humanoid Robots Based on Distributed Tactile Sensors, Masaki Murooka, Kensuke Fukumitsu, Marwan Hamze, Mitsuharu Morisawa, Hiroshi Kaminaga, Fumio Kanehiro, Eiichi Yoshida, IEEE Robotics and Automation Letters, Vol. 9, No. 11, p. 10620-10627, 2024 (Peer-reviewed)
6. Application of Visual Servoing to Drawer Retrieval and Storage Operations, K. Hasegawa and S. Arai, Journal of Robotics and Mechatronics, Vol. 37, No. 2, pp. 412-423, 2025 (Peer-reviewed)
7. Evaluation of the fracture strength of three-dimensional lattice structures containing a crack, Kuniharu USHIJIMA, Takumi MATSUMOTO, Wesley CANTWELL, Mechanical Engineering Journal, Volume 11, Issue 6, pp. 24-00205, 2024 (Peer-reviewed)
8. Finite Strain Measurement and Stress Evaluation for Thin Plate Specimen Using Digital Image Correlation, Satoru YONEYAMA, Keisuke IIZUKA, Kuniharu USHIJIMA, Shota CHINZEI, Junya NAITO, Materials System, Volume 41, pp. 3-10, 2024 (Peer-reviewed)
9. Stress distribution evaluation at localized necking area using the virtual fields method with digital image correlation, Kotaro FUJITA, Keisuke IIZUKA, Satoru YONEYAMA, Kuniharu USHIJIMA, Shota CHINZEI, Mechanical Engineering Journal, Volume 11, Issue 6, pp. 24-00243, 2024 (Peer-reviewed)
10. Relationship between gait asymmetry and time since amputation in individuals with unilateral transfemoral amputation, Hara T, Hisano G, Kobayashi T, Pillet H, Morishima R, Mizuno Y, Hobara H., Journal of Biomechanics, 183, 112622, 2025 (Peer-reviewed)
11. Vehicle Self-Position Estimation Using Lighting Recognition in Expressway Tunnel for Visual Inspection Flow, Yushi Moko, Yuka Hiruma, Tomohiko Hayakawa, Yushan Ke, Yoshimasa Onishi, Masatoshi Ishikawa, Journal of Robotics and Mechatronics, Vol.36 No.3, pp. 746-757, 2024 (Peer-reviewed)
12. Utilizing High-Speed 3D Vision for a Commercial Robotic Arm: Direct Integration and the Dynamic Compensation Approach, Shouren Huang, Wenhe Wang, Leo Miyashita, Kenichi Murakami, Yuji Yamakawa, Masatoshi Ishikawa, Journal of Robotics and Mechatronics, Vol.37 No.2, pp. 424-433, 2025 (Peer-reviewed)
13. Apollon Mark: Bounce Mark Visualization System for Ball Sports Judgement Using Prediction-based Preceding Mirror Control, Himari Tochioka, Tomohiro Sueishi, Masatoshi Ishikawa, SICE Journal of Control, Measurement, and System Integration, Vol. 17, Issue 1, pp.164-175, 2024 (Peer-reviewed)

14. High-speed all-in-focus 3D imaging method based on liquid lens focus scanning, Huayu Cheng, Lihui Wang, Satoshi Tabata, Yuan He, Yan Hu, Jiang Liu, and Zhiwei Mou, Applied Optics, Vol.63, Issue 21, pp.5602-5610, 2024 (Peer-reviewed)

（他 多数）

Invited Lectures

1. SusHi Tech Tokyo 2024 Global Startup Program, 小林 宏, 東京, 2024 (in Japanese)
2. 積層造形時に生じる形状不整を考慮したラティスの強度評価とエネルギ吸収構造への応用, 牛島邦晴, 第五回高速変形時の計測技術および材料モデルパラメータ同定技術に関する研究会, 2024 (in Japanese)
3. Faster, Higher, Stronger: Technology and Sporting Fairness, Hobara H., Open Your Mind Seminar, BME Paris at Arts et Métiers ParisTech, France, 2024
4. Biomechanics of running and jumping in Para-athletics, Hobara H., Korea National Sport University (KNSU) International Conference, Korea, 2024
5. ビジョンを使ったロボットマニピュレーション, 荒井翔悟, Co-Creation Park KAWARUBA「計測自動制御学会システムインテグレーション部門マニピュレーション部会」, 東京, 2025 (in Japanese)
6. Measurement of Tolerance Limits for Video Latency Using High-speed Cameras and High-speed Projectors, Tomohiko Hayakawa, International Display Workshops (IDW 2024), PRJ1-3, pp.896-898, Sapporo, 2024
7. 次世代生産システムに向けた知能ロボットの検討 : 高速ビジョンの役割, 黄 守仁, JST/WINDS 公開特別シンポジウム「高速ビジョンによる多次元デジタルツイン計測と再構築」, 東京, 2024 (in Japanese)
8. Dynamic Projection Mapping Technologies Pioneered by High-speed Vision, Leo Miyashita, Tomohiro Sueishi, Satoshi Tabata, Tomohiko Hayakawa, Masatoshi Ishikawa, The 5th International Conference on Emerging Technologies for Communications (ICETC 2024), Kitakyushu, Japan, 2024

Patents

1. 小林 宏, 腕補助装置, 出願番号 2024-104177, 2024 (in Japanese)
2. 小林 宏, 仕分対象物選別システム, 及び識別体, 出願番号 2024-198359, 2024 (in Japanese)

Public Relations

1. 小林 宏, 腰の負担を軽減 高所作業向けアシストスーツを発表, テレ東 BIZ, 2024.10.2 (in Japanese)
2. 小林 宏, 「イノフィス、アシストスーツ 2 種投入　農業・建設で力発揮」, 日刊工業新聞, 2024.10.3 (in Japanese)
3. 保原浩明, 「パラ進化支える技術、迫る五輪記録　陸上 100m は 0.8 秒差」, 日本経済新聞, 2024.9.5 (in Japanese)
4. 橋本卓弥, 「“知的な”筋トレマシンに注目　31 日まで東京ビッグサイトで「町工場見本市」」, 産経新聞, 2025.1.30 (in Japanese)
5. 荒井翔悟, 【東京理科大学】ラーメンを全自動で作るロボット!?様々なロボットを研究する教授に土佐兄弟が突撃!!, https://www.youtube.com/watch?v=MtMcZvlCSjQ&t=41s, 2025.2.20 (in Japanese)

Awards

1. 張楽平, 橋本卓弥, 小林 宏, SI2024 優秀講演賞, 公益社団法人 計測自動制御学会 SI 部門, 2024 (in Japanese)
2. 林 隆三, 自動車技術会技術部門貢献賞, 公益社団法人 自動車技術会, 2024 (in Japanese)
3. 荒井翔悟, SI2024 優秀講演賞, 公益社団法人 計測自動制御学会 SI 部門, 2024 (in Japanese)
4. 宮下令央, 末石智大, 田畑智志, 早川智彦, 石川正俊, マガジン論文賞, 電子情報通信学会通信ソサイエティ, 2024 (in Japanese)

Individual Research Topics

Hiroshi Kobayashi

“Development and commercialization of muscle suits for motion support, startup establishment, and development of binary power generation equipment”

The goal of this division is to commercialize products and acquire rights (patents), and we have achieved these goals with two products: muscle suits that provide movement support. We also founded CoreHealth Co., Ltd. to spread the world's first ultra-quick posture correction business using muscle suits. In order to solve the energy problem that is essential for sustainability, we are developing a binary power generation device that uses hot springs as a heat source, and conducted demonstration tests on site to demonstrate the possibility of power generation.

Masayoshi Wada

“Research on design and control of omnidirectional movement mechanisms”

In our Lab., Research on the design and control of omnidirectional mobile mechanisms are conducted to realize robotic vehicle that can move in any direction, turn, and travel around curves very precisely. In particular, we have proposed the wheel power transmission design with two motors, and motor control methods with multiple drive wheels, called an active caster, that has a caster structure where the wheel axle and steering axis do not intersect to achieve omnidirectional movement. We are also studying autonomous driving systems and remote-control systems for omnidirectional vehicles.

Taketoshi Mori

“Research on image sequence processing of portable ultrasonic image and online identification”

Development of compact and portable ultrasound equipment is progressing. These devices are designed to send measured video to a computer or tablet at any time, and image processing at the destination is a prerequisite. Portable ultrasound echo machines are designed for portability, so the images they produce are coarse and noisy. Generally, they are used for medical judgment, fault determination, and anomaly detection based on the subjective judgment of a trained person, but automatic image identification methods are being introduced. We are developing a method for detecting regions of high anomaly likelihood in video images based on deep machine learning of images correctly annotated with human-assigned anomalies.

Eiichi Yoshida

“Research on contact estimation from motion via vector quantization learning”

We have developed a method for learning symbols as a discrete representation that relates a motion with a contact sequence through vector-quantized variational autoencoder (VQ-VAE) and self-attention mechanism. We have demonstrated that contact forces and states can be reconstructed from input motion by applying the proposed method to the walking motion as an example. We have also showed that the reconstructed contact force and states can be utilized for dynamic analysis such as joint torque computation during the motion.

Yoshio Matsumoto

“Research on communication support technologies using robot”

We are conducting research on the use of social robots to assist people in the fields of medicine, nursing care, welfare, and education. Specifically, we are developing technologies to screen for delirium and cognitive decline based on voice (acoustic and linguistic features) and facial image (gaze and facial expression features) data obtained while interacting with the robot, and are conducting workshops on social robot programming to improve the social skills of children with ASD.

Kuniharu Ushijima

“Research on reducing rolling resistance in airless tires using linked zigzag structure”

We propose a new design of a non-pneumatic tire (NPT) that makes use of a linked zig-zag structure to achieve low rolling resistance characteristics. With this specially designed structure, the proposed NPT possesses a rolling resistance coefficient (RRC) about 30% lower than that of the conventional NPT, as verified by the finite element analysis (FEA) technique. It is explained that the linked zig-zag structure can transfer applied load from the bottom to the top through intermediate rings. This reduces the local stress concentration of the structure, especially that in the elements near the ground.

Hiroshi Takemura

“Research on maintenance robots at recycling factories”

In actual automation operations, it is not only necessary to autonomously control equipment and systems but also to have a mechanism that automatically and autonomously resolves frequent minor problems such as clogging in equipment. Therefore, the initial device for maintenance robots and the principal prototype design of the maintenance robot is started.

Ryuzo Hayashi

“Research on path generation methods considering terrain features using deflection curves of discrete element beam model”

As a technique for defining driving lanes in high-precision digital road mapping for automated vehicles, this study proposed a method for generating a route for roads sections with no demarcation lines, such as those within intersections. The proposed method uses a deflection curve of a discrete element beam model, which generates paths with a small bulge and takes into account geographic features. This study also examined the ride comfort and controllability of the vehicle when it is driven along a route created with the proposed method.

Hiroaki Hobara

“Research on human mobility reconstruction using biomechanical methods”

In this year, biomechanical studies to quantify and evaluate the asymmetric gait mechanics in individuals with functional impairments were conducted. First, the asymmetric trajectories of the center of foot pressure (COP) during walking in the individuals with lower limb amputation were identified. Further, the asymmetric anteroposterior force production through running-specific prosthesis were found in individuals with unilateral transfemoral amputation. We also performed a systematic review to evaluate orthotic intervention on running kinematics and kinetics.

Takuya Hashimoto

“Research on swallowing function evaluation and its clinical application”

The decrease in swallowing function notably affects QOL, but the quantitative assessment of its function is challenging as it is an in vivo motion that cannot be directly observed. To address this problem, we have been developing a device using PVDF film to simultaneously measure muscle activity, swallowing sounds, and laryngeal elevation during swallowing. We are now focusing on devising a method to automatically identify swallowing intervals from a variety of signals measured in daily activities using this device, aiming for practical applications.

Shogo Arai

“Research on automated consumer electronics dismantling system”

The number of discarded consumer electronics is increasing every year, and we need to improve the recycling rate to promote the resource recycling process. On the other hand, unlike manufacturing processes, dismantled objects are small in quantity and of various types. Therefore, the conventional teaching-and-playback method using positioning jigs in the dismantling process cannot be expected to promote the resource recycling process. Therefore, a general-purpose automated disassembly system that does not require positioning jigs is essential. This research aims to construct an automated disassembly system for consumer electronics to contribute to the achievement of the SDGs.

Tomohiko Hayakawa

“Research on high-precision imaging in mobile environments”

When capturing images with a camera during high-speed traveling, movements can lead to blurring and a decrease in image quality. To address this issue, we are developing an imaging system that utilizes mirror rotation for optical axis control, enabling image capture comparable to stationary conditions.

This system can be installed on vehicles and has been shown through experimental results to be capable of capturing images with high quality even while traveling at speeds of up to 100 km/h on public roads. Furthermore, it can be utilized for inspecting fine cracks, such as those measuring 0.2mm, on tunnel ceilings.

Huang Shouren

“Research on human-machine cooperation via 2D/3D gaze control interfaces”

I am engaged in research on human-machine integration and collaboration aimed at enhancing human functionality by combining human cognition with robot. Specifically, in order to improve the welfare of people with severe sensory-based motor disorder or musculoskeletal disorders, a robotic assistance method is proposed to realize extended sensing, locomotion as well as manipulation for a user to interact with the environment utilizing a 2D/3D gaze interface. Specifically, the proposed method focusses on the situation where a user desires to explore the environment beyond their physical perception capability, requiring the robotic assistance of realizing extended sensing. The proposed 2D/3D gaze interface is wearable, unrestrained to users, and it is straightforward to give commands for robot control.

Leo Miyashita

“High-speed motion sensing technologies and dynamic projection mapping”

Recent AI is going to establish the foundation for industrial and technological innovation that will enable various tasks without human intervention and build a sustainable society. In this context, sensing as input to AI systems, and display as output are becoming increasingly important. Then, this year I focused on developing a system for hierarchically identifying and tracking dynamic objects, and a method for simultaneously executing projection display and high-speed 3D shape measurement.

Tomohiro Sueishi

“Research on Micro-change Imaging using High-Speed Optical System Control”

In situations where spatiotemporal resolution for image-based measurement is limited due to constraints such as the number of pixels in the imager or the device's form factor, it becomes difficult to capture minute local changes across wide areas or in confined spaces. To address these challenges, this research focused on developing measurement techniques that leverage high-speed vision and dynamic control of optical systems. Specifically, I worked on: a system for visualizing tennis ball bounce marks; a strategy for high-speed spin measurement in table tennis; liquid lens control technologies for measuring subtle eye movements and iris authentication without head fixation; and a system for measuring cardiogenic vibrations in the trachea using an endoscope.

Kenta Nagano

“Research on actuator control for collaborative robots with humans”

A study on force control of actuators for robots collaborating with humans was conducted. We proposed compliance control without force sensors by utilizing angle sensors attached to the input and output sides of the gearbox that constitutes the actuator. The proposed method achieved position tracking and flexibility against external forces due to force control by dynamically changing the virtual impedance according to external forces. Furthermore, a reduction in the force generated during contact was achieved by controlling the contact force with the environment based on angle sensor information.

Satoshi Tabata

“Research on High-speed 3D Measurement and Display System”

In this research, a real-time high-speed 3D scanning system has been developed by combining high-speed 3D shape measurement using a segmented pattern with high-speed 6DoF tracking based on small-displacement assumption. Moreover, high-speed 3D display based on dynamic anamorphosis has also been realized by using the cylindrical mirror.

Akishige Yuguchi

“Research on life-support robots through interaction”

With a focus on human-robot interaction, I conduct research on life support robots and understanding of human behavior and actions using robotics and information engineering technologies, aiming to realize robots that can coexist with humans or are easy to handle. Specifically, I develop devices and methods for measuring and analyzing caregiving skills and evaluating their effects on humans through psychological experiments to adapt such skills to robots.

Sooin Kang

“Research on the electrical analysis and measurement of human hemodynamics”

For continuous and non-invasive vascular observation under various conditions, we have successfully developed an impedance tomography method and established an image reconstruction technique utilizing spectroscopy data. We aim for accurate estimations of vascular states using a localized impedance tomography approach that considers morphological characteristics specific to each vessel and develop an arm robot for automatic vascular tracking assistance using skin impedance.

Division of Research Alliance for Mathematical Analysis

Division of Research Alliance for Mathematical Analysis

1. Overview

This division has been established in April 2020, as the succession of Division of Mathematical modeling and mathematical analysis. The aim of our division is to make alliance research over mathematical analysis, numerical analysis, physics, chemistry, biology and engineering.

We make research alliance based on Three groups (Group of mathematical physics, Group of mathematical biology and Group of mathematical engineering).

Group of mathematical physics

The aim of the group is to establish original numerical method for Schrödinger equations based on representation of solutions via wave packet transform by K. Kato et al. and apply it to condensed matter physics. We have succeeded in establishing original numerical method and are applying it to computing numerical solutions of Schrödinger equations.

Group of mathematical engineering

This is a research group focused on mathematical analysis of various phenomena in continuum mechanics and applying to inverse problems. Especially, we study fracture phenomena for elastic structures, motion of vortex filaments, faulting rupture in seismology and so on. As regards inverse problems, we deal with reconstruction problems for discontinuity embedded in a medium, such as cracks, cavities, inclusions and obstacles, from observed data, which are arising from non-invasive tests for a living body, non-destructive tests in engineering and inversion of source process in seismology. The aim of the group is to provide theoretical foundations and their numerical implementation.

Group of mathematical biology

We investigate asymptotic behavior of solutions of mathematical models including epidemiological models and Keller–Segel system for cancer invasion. One of our study is a free boundary problem that describes the spatial propagation of a transmitted disease. By a joint work among E. Ishiwata, T. Ushijima, Y. Enatsu, we have obtained a new result for existence and nonexistence of a traveling wave solution (a solution propagating in a direction with the same profile and the same speed). Starting February 2018, we have organized regular seminars relating to infectious diseases in Kagurazaka campus. In the seminar, talks on infectious diseases are given by researchers in the field of mathematics, biology, medical science.

2. Organization and Facilities

We have 18 members from our university (8 members from Department of Mathematics, 1 member from Department of Physics, 1 members from Department of Applied Mathematics, Faculty of Science, 2 members from Department of Information and Computer technology, Faculty of Engineering, 4 members from Department of Mathematics, Faculty of Science and Technology, 2 members from Institute of Arts and Sciences.

URL of our web-page is the following:

https://www.rs.tus.ac.jp/ma-alliance/index.html

3. Activity Reports

3. 1. Group of Mathematical Physics

We try to apply the representation of the solutions to Schrödinger equations by Kato et al. to condensed matter physics. We have succeeded in numerical computation by using our representation for Schrödinger equations in one space dimension with some potentials. Since October 2021, Kato and Ushijima have been trying to develop numerical computation with our representation for application to physics.

3. 2. Area of Mathematical Engineering

The purpose of this group is to conduct mathematical analysis of various phenomena in continua (elastic bodies and fluids) and to study inverse problems as their application to engineering and other fields. In FY2024, we considered mathematical analysis of some viscoelastic models describing creep phenomena and obtained a qualitative theory, including the existence of solutions. This result was published in international academic journals. We also held a FINLAND-JAPAN WORKSHOP in Helsinki, August 26-30, 2024, to discuss the application to the inverse problem of fault rupture during earthquakes and the numerical simulation of the results of the inverse problem obtained so far, and to plan future joint research plan was made. We also studied the motion of a vortex filament by use of the generalized Hasimoto transformation.

3. 3. Group of Mathematical Biology

Our group studies dynamics of mathematical models in biology, including epidemiological models and Keller-Segel models.

E. Ishiwata, T. Ushijima, Y. Enatsu, and K. Kato organized a seminar on infectious diseases that has started in 2018 in Kagurazaka campus. We invited Dr. Shinji Nakaoka (Hokkaido University) to give a talk on a mathematical model of zoonotic diseases. We discussed analysis and numerical simulations for a renewal equation, preclinical diagnostic data and infection dynamics for COVID-19.

We held a HyFlex workshop on applied mathematical sciences that aims at student education. The organizers are E. Ishiwata, T. Ushijima, Y. Enatsu, and T. Suzuki. We provided researchers and students from both inside and outside the university with an opportunity to give a presentation on applied mathematical sciences. There were a lot of participants and students actively interacting with each other. We are planning to hold this workshop next year.

On a joint work for a diffusive epidemiological model with a free boundary, E. Ishiwata, T. Ushijima, and Y. Enatsu have regular discussions. We investigate the existence of semiwave (a traveling wave spreading in a half space) and speed of the semiwave. For a diffusive SI (Susceptible-Infected) epidemiological model with a free boundary, we have obtained a partial result on the existence of the semiwave when there are no diffusion terms for susceptible individuals. Applying fixed point theorems, we also investigate the existence of the semiwave when there are diffusion terms both for susceptible individuals and infected individuals.

4. Challenges and Prospects

The object for the group of mathematical physics is to get a scheme to compute solutions to Schrödinger equations by our method using wave packet transform.

Big aim of the group of mathematical engineering is to give a mathematical theory for non-destructive testing. We have some partial results but it would not be satisfactory.

The group of mathematical biology has a plan to make a theory for diffusive epidemiological model. Up to now our theory treats only one dimensional case.

5. Conclusion

We have worked on each three group as the last section and as each members by themselves.

Next year, we are going to renewal the division as “Division of mathematical modelling”.

Major Research Achievements (FY2024)

Academic Papers

1. Non-smoothness of the fundamental solutions for Schrödinger equations with super-quadratic and spherically symmetric potential, K. Kato, W. Nakahashi and Y. Tadano, J. Math. Phys. 65 Paper No. 071506, 2024 (Peer-reviewed)
2. Non-smoothness of the fundamental solutions for Schrödinger equations with super-quadratic and radially symmetric potential in two dimensions, K. Kato, W. Nakahashi and Y. Tadano, SUT J. Math. 60 pp.79—96, 2024 (Peer-reviewed)
3. Remarks on estimates in modulation spaces and Wiener amalgam spaces for Schrödinger equations with sub-quadratic potentials, K. Hamaoka, K. Kato and S. Takizawa, J. Math. Anal. Appl., 547, Paper No. 129312, 2025 (Peer-reviewed)
4. Regularizing effect in a Keller-Segel system with density-dependent sensitivity for L^p-initial data of cell density, Yuya Sugawara, Yuya Tanaka, Tomomi Yokota, Journal of Mathematical Analysis and Applications, Volume 540, Issue 1, Paper No. 128577, 16 pp., 2024 (Peer-reviewed)
5. Asymptotic stability of disease-free equiblibria in a diffusive logistic SIR epidemic model with saturated incidence and treatment rates, Ryota Nakiyama, Yuya Tanaka, Tomomi Yokota, Discrete and Continuous Dynamical Systems, Series B, Volume 30, Issue 2, pp. 642-667, 2025 (Peer-reviewed)
6. Behavior in time of solutions to a degenerate chemotaxis system with flux limitatio, Monica Marras, Stella Vernier-Piro, Tomomi Yokota, Nonlinear Analysis - Real World Applications, Volume 81, Paper No. 104215, 12 pp., 2025 (Peer-reviewed)
7. Quantum annealing with error mitigation, Yuta Shingu, Tetsuro Nikuni, Shiro Kawabata, Yuichiro Matsuzaki, Phys. Rev. A, Vol. 109, 042606, 2024 (Peer-reviewed)
8. Universal scaling laws of quantum spatial search in complex networks, Rei Sato, Tetsuro Nikuni, Kayoko Nohara, Giorgio Salani, Shohei Watabe, Phys. Rev. Research, Vol. 6, 043119, 2024 (Peer-reviewed)
9. Digital-analog variational neural-simulation hybrid eigensolver with classical shadow, Yuta Shingu, Yukun Zhang, Yuichiro Matsuzaki, Tetsuro Nikuni, Xiao Yuan, Yiming Huang, Jpn. J. Appl. Phys., Vol. 64, 02SP44, 2024 (Peer-reviewed)
10. Two-Step Quantum Search Algorithm for Solving Traveling Salesman Problems, Rei Sato, Gordon Cui, Kazuhiro Saito, Hideyuki Kawashima, Tetsuro Nikuni, Shohei Watabe, IEEE Transactions on Quantum Engineering, Vol. 6, 3100712, 2025 (Peer-reviewed)
11. Discrete Lotka–Volterra systems with time delay and its stability analysis, Y. Yamamoto, T. Yamamoto, T. Kuroiwa, K. Oka, E. Ishiwata, M. Iwasaki, Physica D-Nonlinear Phenomena, 474, 134562, 2025 (Peer-reviewed)
12. Detecting a sign of severe fire events by image processing, N. Thinnakornsutibutr, K. Kuwana, M. Mizuno, T. Ushijima, S. Yazaki, Journal of Thermal Science and Technology, Vol 19, No. 2, 2024 (Peer-reviewed)
13. Early warning signals of flashover in compartment fires, N. Thinnakornsutibutr, K. Kuwana, M. Mizuno, T. Ushijima, S. Yazaki, Fire Safety Journal, Vol 150, Part A, 2024 (Peer-reviewed)
14. Inverse scattering for repulsive potential and strong singular interactions, Atsuhide Ishida, Journal of Mathematical Physics 65 (2024), no. 8, Paper No. 082101, 10 pp. (Peer-reviewed)
15. Domain characterization for Schroedinger operators with sub-quadratic singularity, G. Metafune and M. Sobajima, Nonlinear Differential Equations Applications, 32, no. 16, 2025 (Peer-reviewed)

16. The effect of inhomogeneous terms for asymptotic profiles of solutions to second-order abstract evolution equations with time-dependent dissipation, M. Sobajima, Journal of Mathematical Analysis and Applications 542, no. 1, Paper No. 128794, 18 pp., 2025 (Peer-reviewed)
17. Lifespan estimates for semilinear damped wave equation in a two-dimensional exterior domain, M. Ikeda, M. Sobajima, K. Taniguchi and Y. Yakasugi, Calculus of Variations and Partial Differential Equations, 63, no. 9, Paper No. 240, 2024 (Peer-reviewed)
18. Optimal decay for one-dimensional damped wave equations with potentials via a variant of Nash inequality, M. Sobajima, Journal of Differential Equations, 408, pp117-139, 2024 (Peer-reviewed).
19. Nonlocal to Local Convergence of Phase Field Systems with Inertial Term, Pierluigi Colli, Shunsuke Kurima, Luca Scarpa, Appl. Math. Optim., 90 (2024), Paper No. 21 (Peer-reviewed)
20. Forward and inverse problems for creep models in viscoelasticity, Hiromichi Itou, Victor A. Kovtunenko, Gen Nakamura, Philosophical Transactions of the Royal Society A, 382, 20230295, 2024 (Peer-reviewed)

Books

1. Non-smooth variational problems and applications in mechanics (Philosophical Transactions of the Royal Society A, Volume 382, Issue 2277), Victor A. Kovtunenko, Hiromichi Itou, Alexander M. Khludnev, Evgeny M. Rudoy (Eds.), The Royal Society Publishing, 2024

Invited Lectures

1. Instability of standing waves for cubic-quintic NLS with delta potential, Masahito Ohta, The 14th AIMS Conference on Dynamical Systems, Differential Equations and Applications, Abu Dhabi, UAE, 2024
2. Boundedness of solutions to a quasilinear chemotaxis system for tumor invasion via maximal regularity, T. Yokota, Niigata-Ekimae Ouyou-Kaiseki Kenkyu-kai, 2025 (in Japanese)
3. Mourre inequality for non-local Schrödinger operators, Atsuhide Ishida, An afternoon on the spectral theory of pseudo-differential operators, Sapienza University of Rome, April 9th,2024
4. On inverse scattering for time-decaying harmonic oscillators, Atsuhide Ishida, Analysis seminar, Alfréd Rényi Institute of Mathematics, May 9th, 2024
5. Mourre inequality for non-local Schrödinger operators, Atsuhide Ishida, Fractional Calculus, Probability and Non-local Operators 2024, Basque Center for Applied Mathematics, May 22nd, 2024
6. 分数階シュレディンガー作用素のロルニック型摂動について(On Rollnik-type perturbations for fractional Schrödinger operators), Atsuhide Ishida, Suurikaiseki seminar, Tokyo Metropolitan University, June 28th, 2024
7. Mourre inequality for non-local Schrödinger operators, Atsuhide Ishida, 2nd Analysis Mathematica Conference, Alfréd Rényi Institute of Mathematics, July 29th, 2024
8. 分数階シュレディンガー作用素のロルニック型、ストゥンメル型および加藤型摂動について (On Rollnik, Stummel and Kato-type perturbations for fractional Schrödinger operators), Atsuhide Ishida, Operator seminar, Kyoto University, December 2nd, 2024
9. On inverse scattering for time-decaying harmonic oscillators, Atsuhide Ishida, Theoretical and numerical approaches for inverse problems, Research Institute for Mathematical Sciences, January 21st, 2025
10. Stummel-type perturbations for fractional and relativistic Schrödinger operators, Atsuhide Ishida, Himeji Conference on Partial Differential Equations 2025, Egret Himeji, March 3rd, 2025

Individual Research Topics

Keiichi Kato

“Representation of solutions to Schrödinger equations via wave packet transform”

We have the representation of solutions to Schrödinger equations via wave packet transform in 2011. Our subject is to apply the representation to physics. Recently we develop numerical computation using the representation with Ushijima who is a member of our division from October, 2021.

Masahito Ohta

“Studies on stability of standing waves for nonlinear Schrödinger equations”

We studied standing wave solutions for nonlinear Schrödinger equation with an attractive delta-function potential, a repulsive cubic nonlinear term, and an attractive quintic nonlinear term in one spatial dimension. We obtained some results on the stability of standing wave solutions.

Tomomi Yokota

“Study on chemotaxis models”

In a joint work with Professor Yuya Tanaka (Kwansei Gakuin University) et al., a result on regularizing effect in a Keller-Segel system with density-dependent sensitivity and a result on asymptotic stability of constant equiblibria in a SIR epidemic model with saturated terms were obtained. Also, in a joint work with Professors Monica Marras and Stella Vernier-Piro, a result on finite-time blow-up in a degenerate chemotaxis system with flux limitation was obtained.

Tetsuro Nikuni

“Quantum Algorithms and Quantum Many-Body Systems”

We advanced theoretical studies on optimization problems and quantum many-body systems using quantum computing techniques. In particular, we achieved significant results in areas bridging quantum information processing and statistical physics, including the proposal of an error mitigation method for quantum annealing, and the elucidation of universal scaling laws in quantum spatial search on complex networks. Furthermore, we developed a quantum variational algorithm incorporating the classical shadow technique, and proposed a two-step quantum search algorithm to tackle the traveling salesman problem, thereby constructing a theoretical foundation for practical applications of quantum computation.

Hiromichi Itou

“Study on theoretical analysis of mathematical model of viscoelasticity and inverse problems related to nondestructive testing”

We considered mathematical analysis of viscoelastic models describing porous materials such as rock and concrete, as well as crack problems of coupled poroelastic models stemming from hydraulic fracturing. In consequence, we established a qualitative theory, including the existence of solutions. Also, the inverse problem of cracks in linear elastic bodies related to nondestructive testing was studied, deepening the previous reconstruction method. For these applications, numerical simulations and experiments of the obtained results, as well as collaboration with other fields, are planned.

Atsuhide Ishida

“Study on spectral theory, scattering theory and inverse problems for non-local Schrödinger operators”

Non-local Schrödinger operators are appeared in a lot of physical models and have the rich mathematical backgrounds. For such non-local Schrödinger operators, I will conduct research on spectral and scattering theory that are basic topics in quantum physics. Moreover, I will apply these results to inverse problems determining the uniqueness of the interactional potential functions.

Mieko Tanaka

“Nonlinear eigenvalue problems for p-Laplacian and (p,q)-Laplacian”

I analyzed the kth eigenvalue of the spherically symmetric p-Laplacian with Ryuji Kajikiya and Satoshi Tanaka. We obtained results on the behavior of eigenvalues when p moves, and on the monotonicity and non-monotonicity of the eigenvalues. In the joint work with Vladimir Bobkov, we succeeded in showing the existence of multiple solutions in partial differential equations related to the (p,q)-Laplacian eigenvalue problem. In addition, we have also analyzed the eigenvalues of p-Laplacian, which are characterized a little differently from the variational eigenvalues.

Yoichi Enatsu

“Dynamical analysis of epidemiological models and prey-predator models”

My research theme is stability of stationary solutions of epidemiological models and prey-predator models. For epidemiological models, the current interest lies in the existence of semiwave of diffusion equations with a free boundary and stability analysis of delayed models. For prey-predator models, we study stability and bifurcation theory for the case where hunting cooperation among predators.

Masashi Aiki

“Research on Vortex Motion”

Research on fluid motion has many aspects, and vortex motion is one of the most fundamental factors which determine the motion of fluids. My research is concerned with the mathematical analysis of the motion and interaction of vortex rings. A vortex ring is a thin vortex structure, for which its motion can be approximated as the motion of a closed curve in space. Specifically, we consider motions of multiple vortex rings aligned on a common axis and construct mathematical models which describe such motions. We also analyze the model to investigate the possible motion patterns of the rings and study the stability/instability of particular patterns.

Motohiro Sobajima

“Asymptotic behavior of solutions to damping wave equations”

This research investigates the asymptotic behavior of solutions to several wave equations with damping and potential terms. In cases where the equation includes a potential or is posed on a bounded domain, there are fewer effective tools available compared to the standard initial value problem. This study approaches such problems from an operator-theoretical point of view.

Shunsuke Kurima

“Study of proving existence of solutions and using time discretization methods for phase-field systems”

I could confirm that existence of solutions to a nonlocal phase-field system with inertial term can be proved by using a time discretization method. Also, I could verify that we can prove existence of solutions to a singular (local) phase field system of conserved type by convergence from a singular nonlocal phase field system of conserved type.

Division of Smart Healthcare Engineering

Division of Smart Healthcare Engineering

1. Overview

The Division of Smart Healthcare Engineering originates in the Biosystems Research Division established in April 1983. In April 1988, the Intelligent Systems Engineering Division was established to research a wide range of topics from basic to applied fields based on the principle of "adding intelligence to engineering systems, taking over the Biosystems Research Division. Furthermore, with the reorganization of the Research Institute for Advanced Science and Technology into the Research Organization for Advanced Science and Technology in November 2005, the Intelligent Systems Engineering Division was reorganized, with the new mission of "developing human-friendly and human-like intelligent systems through the mutual collaboration and integration of the fields of software application and network, hardware, energy and environment, and fundamental theory. After the 15-year activity with many achievements based on the principles of "Human-like intelligent systems" and "Research and development for medical and space applications of human-like, autonomous, and human-friendly intelligent systems", the division was temporarily dissolved. Subsequently, in April 2022, the Division of Smart Healthcare Engineering was established with the aim of "creating a society in which all people can lead a high quality of life (QOL) social life as a matter of course," advocating a smart healthcare system that further develops medical applications of intelligent systems (22 members as of March 31, 2025). The division targets elemental technologies for (1) sensing a wide range of biological information, (2) brushing up hardware, (3) energy and information transmission to devices, and (4) stable and pure information communication, as well as cross-sectional collaborative research with a total system in mind.

The annual Measuring Instrument Workshop, which has been held since FY2022, took place on Friday, April 26, and Wednesday, May 15, FY2024, jointly sponsored by Tokyo Denki Sangyo Co., Ltd. and Yokogawa Test & Measurement Corporation. While the primary participants were students newly assigned to laboratories, students from other departments also took part. Attendees received foundational training in the use of oscilloscopes, power meters, and integrated measurement systems.

On Sunday, November 24, we participated in the Faculty of Integrated Research's exhibition booth at Homecoming Day, presenting the current status and challenges of our division through posters. Furthermore, on Monday, November 25, we delivered an oral presentation at the RIST Forum 2024, again highlighting the division's current activities and issues.

On Monday, December 23, the division organized a special workshop featuring a lecture by Assistant Professor Ayaka Tabuchi of the University of Electro-Communications. This event provided a valuable opportunity for academic exchange and learning, both within and beyond the division.

The annual Research Results Presentation Meeting was held in person on Thursday, March 13, 2025, and included a networking session. Two invited lectures were delivered: "Evaluation of Skeletal Muscle Function by Bioimaging" by Professor Yutaka Kano, Vice President of the University of Electro-Communications, and "Research on Knit Sensors for the Realization of Wear Devices" by Dr. Konami Izumi, Senior Researcher at the Human Augmentation Research Center, National Institute of Advanced Industrial Science and Technology (AIST). In addition, representatives of nine research groups gave brief presentations on their work, and 42 student poster sessions were conducted. In particular, the duration of the poster session was extended in response to student feedback from the previous year, which emphasized a desire for more time and a broader audience to share their research.

In summary, this year's activities proved to be highly significant for the future advancement of the field and served as a meaningful bridge to the next generation.

2. Organization and Facilities

2. 1. Composition of Division

Figure 1 depicts the future of implantable medical devices that support a society of health and longevity, as an example of the research agenda that this division is pursuing. Patients wearing advanced medical devices such as implantable artificial hearts be provided with a safe and secure life through constant remote monitoring and device control by doctors and other medical professionals of their biometric information and device operation status. For such hardware, highly efficient energy transmission, miniaturization of integrated circuits, and low power consumption are needed. In addition, a bi-directional and secure wireless communication system is envisioned for communication and control, which is indispensable for telemedicine. The Smart Healthcare System Research Division is divided into the following four groups, which conduct individual elemental technology research and cross-disciplinary collaborative research aiming for a total system.

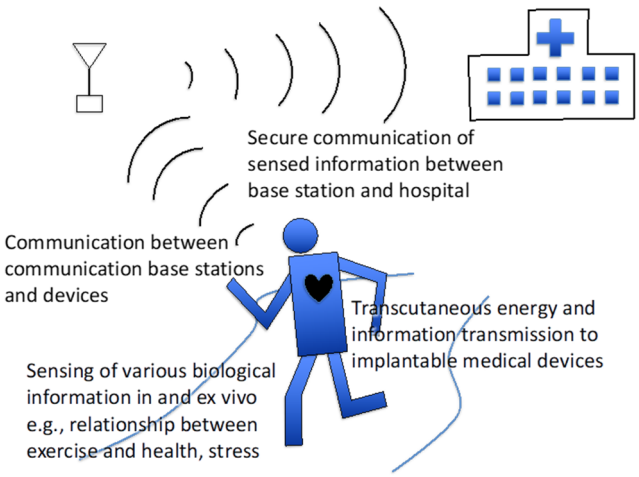


Fig. 1. Examples of research topics in the division.

(1) Sensing of biological information

Exercise has a panacea effect on health and longevity. Research is being conducted to clarify the mechanism of health promotion and longevity through exercise. We conduct research to elucidate the mechanism of health promotion and longevity through exercise. We conduct research to visualize “mental health,” which is generally difficult to measure, based on the measurement of various non-invasively obtainable biological information such as ECG (Electrocardiogram), PPG (Photoplethysmography), EDA (Electro dermal activity), peripheral body temperature, and respiration, and also to visualize "mental health" which is generally difficult to measure. Based on the me asurement of various non-invasive biological information such as EDA (Electro dermal activity), peripheral body temperature, and respiration, we conduct research to visualize “mental health,” which is generally difficult to measure, and to propose measures to promote behavioral change.

(2) Integrated circuits and signal processing

The multifunctionality of each system leads to larger size and higher power consumption. Miniaturization and low power consumption of high-frequency analog circuits are indispensable issues to be considered, and research is conducted on miniaturization and low power consumption of high-frequency front ends in the GHz band, including low-noise amplifiers and mixers. Furthermore, in signal processing of information from sensor systems, we aim for higher resolution and lower power consumption of the conversion circuit ADC that converts analog signals to digital signals and the conversion circuit DAC that converts digital signals to analog signals. In addition, to improve the yield rate, which is inevitable for supplying integrated circuits at low prices, we conduct research on variation analysis and variation-resistant circuits.

(3) Energy and information transmission to devices

We transmit energy for driving and information for controlling devices implanted in the body, such as

implantable artificial hearts and locomotion meters for small animals, percutaneously between inside and outside the body, and construct a system that is friendly to the electromagnetic environment. In addition, the effects of high-frequency magnetic fields generated by percutaneous energy transmission on the body is investigated together with the sensing group.

(4) Stable and secure information communication

The information and communication environment can be broadly classified into the hardware aspect of communication devices and the software aspect of information exchange via the Internet. In the former, we aim to develop antennas with high radiation efficiency that contribute to low power consumption of the system. For the latter, the division develop a wireless communication system with high-performance error control and strong communication functions for high reliability, and a VPN between sites that connects multiple research sites to create a "virtual communication environment unique to this division" using virtual private circuits.

As of March 31, 2025, this division has 11 members: Faculty of Science and Technology (T. Yamamoto, S. Akashi, K. Higuchi, A. Hyogo, T. Hara amd R. Miyauchi), Faculty of Pharmaceutical Sciences (A. Saito, D. Yamada, Y. Nozaki), Faculty of Advanced Engineering (M. Umezawa), Institute of Arts and Sciences (S. Yanagida), Professor Emeritus (K. Koshiji), and 8 external members: Tokyo City University (T. Matsuura), Tokyo Polytechnic University (F. Koshiji), Nippon Institute of Technology (K. Ota), Tokyo International University (N. Kubota), Ochanomizu University (M. Kobayashi), Toyama Prefectural University (Ryo Kishida), Institute of Science Tokyo (H. Sato), and Zenkigen (I. Hashimoto), Nippon Medical School (S. Yokobori), Saitama Medical Center, Jichi Medical University (C. Umeda)　a total of 22 interdisciplinary researchers. The group is capable of covering a wide range of fields, including hardware, software, communication/networking, and energy systems, through joint and collaborative research using the facilities and equipment owned by each member.

2. 2. Facilities and Equipment

The main research facilities and equipment are listed below.

(1) Analog integrated circuit chip analysis equipment

Analog integrated circuit chip analysis equipment (manufactured by Nihon Micronics Co., Ltd.) is capable of measuring and analyzing integrated circuits on unpackaged bare chips, and is equipped with a voltage/current detection unit and a measurement analysis unit (Fig. 2).

Fig. 2. Analog integrated circuit chip analysis facility. (Left: Voltage and current detection section, Right:

(2) Vector signal generator

This is a synthesized signal generator with high output, low phase noise, and I/Q modulation capability, and is an indispensable measurement device as a reference signal source at high frequencies (Fig. 3).

Fig. 3. Vector signal generator.

(3) Oscilloscope (with TDR function)

Waveform observation equipment with a frequency bandwidth up to about 20 GHz is

indispensable for evaluating the characteristics of very high-frequency signal transmission lines, very high-speed differential signal transmission lines, and for measuring the location of reflection sources (TDR). It is useful not only for ordinary signal waveform observation, but also for research on microwave imaging for radar and medical applications (Fig. 4).

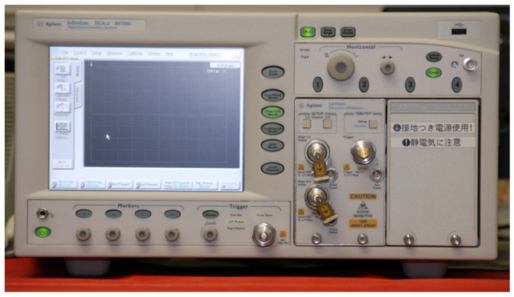


Fig. 4. Oscilloscope with TDR.

(4) Compact near-infrared spectrometer

This compact device integrates a light source and detector and can acquire optical reflectance spectra in the near-infrared range from 900 to 1700 nm in wavelength by placing it close to a sample. It is possible to measure the wavelength range where information Abbot the deep part of the living body can be obtained without absorption by hemoglobin or water. In particular, this compact device can acquire data in the wavelength region where weak absorption corresponding to overtones and coupling tones overlap in the infrared region where bioorganic molecules show strong absorption, and is expected to be applied to non-invasive estimation and monitoring of in vivo information.

(5) EEG Logger

This device is capable of recording both EEG and EMG signals in small laboratory animals such as mice and rats. By eliminating overhead tethering cables, which often interfere with measurement, the system enables stress-free data collection without restricting the animals' movement. Owing to its versatility, this instrument is particularly valuable for research on the biological effects of electromagnetic fields—a field in which global data accumulation remains a pressing need.

As of March 31, 2025, this division has 22 interdisciplinary researchers including 12 members from Tokyo University of Science and 10 members from external institutes: T. Yamamoto, S. Akashi, K. Higuchi, A. Hyogo, T. Hara, and R. Miyauchi (Faculty of Science and Technology); A. Saito, D. Yamada, and Y. Nozaki (Faculty of Pharmaceutical Sciences); M. Umezawa (Faculty of Advanced Engineering); S. Yanagita (Institute of Arts and Sciences), K. Koshiji (Professor Emeritus); T. Matsuura (Tokyo City University); F. Koshiji (Tokyo Polytechnic University); K. Ota (Nippon Institute of Technology); N. Kubota (Tokyo International University); M. Kobayashi (Ochanomizu University); R. Kishida (Toyama Prefectural University); H. Sato (Institute of Science Tokyo); I. Hashimoto (Zenkigen); S. Yokobori (Nippon Medical School); C. Umeda (Saitama Medical Center, Jichi Medical University). The group can cover a wide range of fields, including hardware, software, communication/networking, and energy systems, through joint and collaborative research using the facilities and equipment owned by each member.

3. Activity Reports

Four research groups—the Sensing Group, Integrated Circuits and Signal Processing Group, Device Operation and Control Group, and Information and Communication Group—conduct both independent fundamental research and interdisciplinary research in collaboration with one another. The current activities and key research topics of each group are outlined below. The outcomes of these research projects are presented in the Proceedings of the Research Achievement Report Conference of the Smart Healthcare System Research Division for FY2024, as well as at major academic and international conferences.

3. 1. Sensing Group

3. 1. 1. Area of Umezawa

Methods for separating and concentrating biologically-derived nanoscale structures (nanoparticles), especially extracellular vesicles (EVs) by their sizes have been investigated. Especially, development of the methods for fractionation of EVs to elucidate the intracellular origin of cell-derived membranous vesicles, which may be involved in metabolic disorders and aging, is our target. In FY2024, the differences in the encapsulated proteins by the nanoparticle sizes and their potential functions were revealed. In addition, the mechanisms of changes in the protein folding microenvironment related to health and diseases are being reported. In FY2025, we plan to continue this investigation to elucidate their biological significance and implications of these differences.

3. 1. 2. Area of Yanagita

In this group, researchers in the fields of physiology and electrical engineering have combined to develop and evaluate the implementation of sensing technology for analysing 'increased physical activity', which is one of the research targets in behavioural physiology, and have conducted various studies through measurements in animal models and humans.

This year, the following issues were tackled.

- Development of a device to measure the total amount of physical activity, rather than exercise, in animal models.
- Creation of animal models that simulate increased physical activity.
- Development of a minimally invasive device to measure physical activity.
- Analysis of heart rate variability using photoplethysmography.

3. 1. 3. Area of Ota group

The group is researching technologies that support speech assistance for individuals with speech impediments, non-contact motion measurement, and biometric monitoring, with the goal of developing engineering systems that enhance quality of life. This year, the following topics were explored:

- Silent speech recognition technology
- Speech synthesis using limited voice samples
- Motion measurement using drones
- Non-contact pulse wave measurement and emotion estimation

3. 2. Integrated Circuits and Signal Processing Group

3. 2. 1. Area of Hyogo, Miyauchi, Matsuura, Kishida

The following are the main research topics conducted by the Hyogo, Miyauchi, Matsuura, and Kishida Group:

- Development of a method utilizing a delay circuit to prevent breakdown in the latter-stage operation of Zoom ADCs
- Investigation of high-order noise shaping in noise-shaping SAR ADCs employing an error feedback architecture
- Proposal of a reference voltage correction technique to mitigate conversion errors caused by insufficient inter-stage gain in two-stage pipeline SAR ADCs

・Analysis of internal operational amplifier (op-amp) requirements and proposal for simplified op-amp designs in noise-shaping successive approximation ADCs
・Termination processing techniques in averaging methods for Flash ADCs

3. 3. Device Operation and Control Group

3. 3. 1. Area of K. Koshiji and Yamamoto

Koshiji and Yamamoto are engaged in comprehensive research to ensure the stable operation of implantable medical devices, starting with transcutaneous energy transmission. Their work includes improving energy transfer efficiency, enabling bidirectional information exchange between the internal and external environments of the body, evaluating the biological effects of magnetic fields generated during energy transmission, and developing simulated living body models for testing.

In collaboration with Umeda, they are also developing preventive devices aimed at reducing accidents in clinical settings and conducting field demonstrations to evaluate their practicality. Several of these projects are being conducted in partnership with Saito, Yanagida, Yamada, and Nozaki from the Sensing Group, as well as Umeda from the Clinical Engineering and Medicine Group.

The team's main research topics include:

・Eye detection-based systems for concentration monitoring
・Development of fat-equivalent phantoms for microwave mammography
・Biological impact studies of 85 kHz magnetic fields on mouse brain activity
・Assessment of emotional and cognitive effects of magnetic field exposure in animal models
・Wireless power transfer for long-term optical stimulation in small animals
・Implantable motion sensing systems powered by external solenoid-generated magnetic fields
・Transcutaneous energy transfer using push-pull Class-E amplifiers
・High-speed optical communication for pediatric ventricular assist devices
・Applications of dielectric heating in food thawing and low-temperature cooking
・Development of a ring-type device for stress evaluation using heart rate variability analysis

These research efforts contribute to the advancement of implantable medical technology, safety in clinical practice, and bioelectromagnetic field evaluation, with a strong emphasis on practical implementation and interdisciplinary collaboration.

3. 4. Information and Communication Group

3. 4. 1. Area of Higuchi and Hara

・Beam Selection Method Based on Horizontal-and-Vertical Angle-Domain Adaptive Beam Grouping for Massive MIMO Analog Beamforming Using NOMA in Cellular Downlink
・Autonomous Decentralized TRP Group Selection Method to Maximize System Throughput in Downlink Distributed MIMO
・Autonomous Decentralized TRP Group Selection with Bandwidth Allocation Among TRP Groups in Downlink Distributed MIMO with Overlapped TRP Group Configuration
・Autonomous Decentralized User Association Method to Maximize System-Level Throughput Satisfaction Rate in Co-existing Networks with HAPS and Terrestrial BSs
・Inter-Network Interference Coordination Using Protected Band in Co-existing Networks with HAPS and Terrestrial BSs

・Frequency Block-Dependent Sleep Control of Base Stations Based on Distributed DQN for Improving Energy Efficiency Both in Up and Downlinks
・Active User Detection Using Short-Pilot Structure for Grant-Free Access Based on Independent Component Analysis
・Channel Estimation Based on FISTA for OTFS Transmission in the Presence of Fractional Doppler

3. 4. 2. Area of F. Koshiji

F. Koshiji et al. have been studying optically transparent antennas that can be worn on the body. The radiation efficiency of the obtained antenna is almost equivalent to that of small antennas built into portable and wearable devices. The antenna is practical in terms of both transparency and radiation efficiency.

4. Challenges and Prospects

An interdisciplinary research framework is essential to realizing a society in which all people can enjoy a high quality of life as a matter of course. In line with this vision, the division comprises researchers from a wide range of fields, both within and outside the university. To foster internal collaboration and external dissemination of research findings, the division regularly organizes research meetings, measurement instrument workshops for students, and research achievement reporting sessions.

The Advisory Committee has played a significant role in generating valuable research outcomes, promoting researcher interaction, and contributing to student education. As the committee's activities are extended for another two years, there are heightened expectations to articulate a clear future vision, to establish the division's identity as a core research center within the University of Science, and to further cultivate research with originality rooted in the university's mission. The committee has expressed strong encouragement in these directions. Moving forward, the division aims to build a new collaborative research system that integrates the outcomes of fundamental technologies across various fields and promotes deeper interdisciplinary cooperation.

5. Conclusion

The division was established in FY2022 to advance research on elemental technologies—including biosignal sensing, miniaturization and low-power design of integrated circuits, wireless power transmission, and communication technologies utilizing antennas and wireless systems—as well as the integration of these technologies. In FY2024, the division held a series of research meetings and research achievement reporting sessions involving students and participants from outside the university, thereby deepening internal research collaboration and "planting seeds" for future interdisciplinary initiatives. The Advisory Committee convened to assess the division's progress, identify future challenges, and reaffirm its strategic direction. With the reclassification of COVID-19 to a lower-risk category, the societal relevance and importance of the division's research themes have become increasingly evident, prompting renewed attention to its activities. Now entering a two-year extension period, the division is poised to further enhance collaborative research, establish new partnerships, and pursue external funding opportunities. Through these efforts, the division aims to strengthen its role as a research hub and to clearly demonstrate the societal value and academic contributions of its work.

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11. 池田翔幾 (指導教員：樋口健一), IEEE VTS Tokyo/Japan Chapter 2024 Young Researcher's Encouragement Award, October 2024
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15. 八木雄太 (指導教員：樋口健一), IEEE VTS Tokyo/Japan Chapter 2024 Young Researcher's Encouragement Award, October 2024
16. 今井 啓 (指導教員：山本隆彦)The Asia-Pacific Symposium on Applied Electromagnetics and Mechanics (APSAEM 2024) Best Presenter Award, July 2024
17. 稲田琴美 (指導教員：山本隆彦)エレクトロニクス実装学会回路・実装設計技術委員会奨励賞, December 2024 (in Japanese)
18. 稲田琴美 (指導教員：山本隆彦)ライフサポート学会奨励賞, March 2025 (in Japanese)

Individual Research Topics

Masakazu Umezawa

“Optical and Computational Analysis of Interactions of Nanoparticles with Biomolecules”

Changes in the protein folding by the microenvironments developed by gold nanoparticles and organic solvents are investigated using optical (ultraviolet and infrared) and computational (molecular dynamics) techniques. The principle underlying such changes are revealed. The potential of biomedical implications of such changes is the target in our next step.

“Size-Specific Fractionation and Analysis of Adipocyte-Derived Microvesicles”

A microfluidic device was developed for size-specific enrichment and fractionation of adipocyte-derived microvesicles (ADMs). In addition to the difference in the types and amounts of mRNAs contained in ADMs by the sizes of ADMs, the differences in proteins are becoming unveiled via analysis of the fractionated samples. Investigation of the biological significance of those differences by the size of ADMs is the next issue.

Shinya Yanagita

“Optimal physical activity levels that promote brain-organ coupling”

We have used animal models to clarify the relationship between physical activity and brain function (especially antidepressant and anxiolytic effects).However, the optimal amount of physical activity for brain function is not well understood.In addition, the effect of physical activity "quantity" on the relationship between the brain and the skeletal muscles, which are the effector of exercise, is not known at all.Therefore, experimental investigations are being conducted with the aim of clarifying the optimum amount of physical activity and the mechanisms by which an increase in physical (lifestyle) activity can induce adaptive changes in brain function.

Yuka Nozaki

“ Effect of mitochondrial quality on aging in white adipose tissue ”

In recent years, white adipose tissue is known to be an endocrine tissue that is important for the metabolism of individual.We have previously identified several mitochondrial quality-related proteins whose expression in white adipose tissue changes in response to metabolic improvement, obesity and ageing. In this study, to elucidate the function of mitochondrial factor in l metabolism and ageing using genetically engineered mice model.

Akira Hyogo, Ryo Kishida, Tatsuji Matsuura

“Research on high linearization of radio frequency (RF) circuits”

Mixers and other components used in radio frequency (RF) circuits are required to be highly linear for next-generation 5G communications. We have proposed a highly linear RF system by developing a circuit configuration called current bleeding. We believe that these studies will become increasingly important as next-generation communications progress in the future.

“Research on noise reduction and efficiency improvement of switching power supply circuits”

Hysteresis control is one of the control methods for switching power supplies, and its advantages are high load response and simple control circuit configuration. On the other hand, hysteresis control has a problem of noise in the audible range at light loads, which makes noise suppression difficult. We have proposed a control method that allows the hysteresis voltage to be varied so that the switching frequency does not overlap with the audible frequency band, thereby reducing audible noise.

“Measurement and Evaluation of Hot Carrier Injection Phenomena Using Ring Oscillators”

As integrated circuit devices continue to shrink in size, reliability issues caused by aging degradation phenomena, such as Hot Carrier Injection (HCI), have become increasingly pronounced. In this study, we propose an evaluation circuit utilizing a ring oscillator (RO) and conduct experimental measurements. The RO’s stage-switching capability enables measurement of degradation primarily influenced by HCI. The measurement results obtained using this circuit were approximated by an exponential function with respect to time, with the exponential parameter ranging from 0.30 to 0.46, indicating that HCI was the dominant degradation factor. These findings provide useful insights for accurate degradation assessment and the development of effective countermeasures in medical equipment, where high reliability is essential.

Kenichi Higuchi, Takanori Hara

“Research on High-Capacity and High-Reliability Wireless Commnication Systems“

In order to realize high-capacity and high-reliability wireless communication, which is essential for smart healthcare systems that utilize intercommunication with multiple medical devices and sensors, the wireless communication method with multi-antenna transmission for high capacity, advanced error control for high reliability, and cooperative transmission technologies among multiple communication nodes are studied. By integrating link-level and network-level methodologies, we aim to realize high-capacity and high-reliability wireless communication systems with limited radio resources.

Kenko Ota

“Research on Speech Assistive Technology”

To assist individuals with speech impairments caused by factors such as laryngectomy, we are developing advanced speech assistive systems. Our research includes two main components: (1) silent speech recognition using visual features extracted from lip movements to estimate speech content, and (2) speaker-dependent speech synthesis that can generate natural-sounding speech from a limited amount of the speaker’s voice data.

“Research on Non-Contact Motion and Biometric Measurement Technology”

This research focuses on developing methods to measure human motion and biometric signals using primarily low-cost camera systems. For motion analysis, we are investigating a technique for 3D gait measurement utilizing multiple drones to capture walking motion from various angles. In terms of biometric monitoring, we are developing a method to estimate emotional states based on physiological signals, pulse waves using the photoplethysmography (PPG) technique applied to facial video data.

Koji Koshiji, Takahiko Yamamoto

“Development of a Breast-Equivalent Electromagnetic Phantom”

Electromagnetic phantoms that replicate the electrical properties of human tissues are useful for testing electromagnetic compatibility (EMC) and related characteristics under conditions that closely resemble actual usage, particularly in implantable or body-contact medical devices. In this study, we are developing a fat-equivalent phantom designed for the 1–15 GHz frequency band, assuming application in microwave mammography for breast cancer screening.

“A Study on Low-Temperature Cooking Using Dielectric Heating”

In recent years, low-temperature cooking—where food is gently heated in water baths—has gained popularity for offering novel textures and flavors. However, conventional methods require large amounts of water and electricity, posing practical challenges. This study proposes a low-temperature cooking method using dielectric heating, in which food is placed between two electrode plates and directly heated by electric current. Particular focus is given to evaluating factors such as the amount of drip loss during heating and the number of viable bacteria remaining after cooking.

“Wireless Power Transmission for Small Animal Tracking Systems and Its Biological Effects”

Small animal locomotion tracking in experimental research typically relies on compact motion sensors. Wireless power transmission to these devices is expected to facilitate battery-less operation, contributing to further miniaturization and extended measurement durations. This study investigates the development of such non-contact power transmission systems, as well as assessing the biological effects of electromagnetic wave exposure on living organisms.

Fukuro Koshiji

“Research on optically transparent antennas”

In recent years, many antennas (array antennas) are used in the Internet of Things and fifth- and sixth-generation mobile communication systems to improve communication characteristics. However, the placement of array antennas on the surface of devices and systems causes problems that impair the design of devices and systems. In this study, we aim to realize a high-performance transparent antenna that achieves both optical transparency and electrical characteristics by using a transparent conductive film.

“Research on body area networks and biomedical information sensing”

In body area networks, antennas and electrodes that are in proximity or contact with the living body are key devices in communication and sensing technologies. In this research, the structure and arrangement of antennas and electrodes that enable stable and highly efficient signal transmission in the vicinity of the living body are investigated, and research on biomedical information sensing technology that applies these antennas and electrodes is also conducted.

Division of Biological Environment Innovation

Division of Biological Environment Innovation

1. Overview

Academic experts in the fields of environmental adaptation, biological interactions, molecular evolution, co-evolution, and ecology of living organisms have formed three subgroups “the section of environmental adaptation”, “the section of molecular evolution”, and the “section of nature symbiosis”. In order to create an academic research field that breaks through the classical concepts and barriers of environmental biology, evolutionary science, and ecology, we produced new technological seeds that would contribute to protecting our lives in a global environment that is always changing.

2. Organization and Facilities

<Section of Environmental Adaption>

We explored to find the mechanisms underlying biological sensing of environmental stress, and develop new technologies including environmental stress-adaptive cultivation systems.

- Elucidation of the mechanisms underlying the evolution and diversity of lives
- Development of significant plant lines adapted for environmental stress tolerance and biological interaction, leading to the creation of next-generation organic cultivation systems using immunostimulants and companion plants that contribute to reduced pesticide use.

Members: Gen-ichiro Arimura, Kazuyuki Kuchitsu, Ryuichi Nishihama, Hisataka Ohta, Fuminori Takahashi, Takuya Uemura, Takumi Tomoi, Takuya Sakamoto (Kanagawa Univ.), Sachihiro Matsunaga (The Univ. of Tokyo)

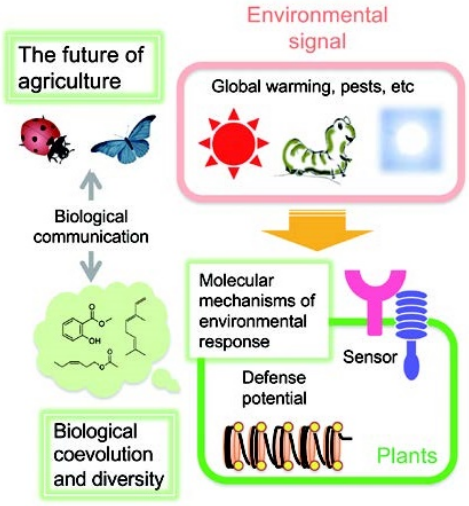


Fig. 1. Elucidation and application of environmental sensing mechanisms in various organisms

<Section of Molecular Evolution>

We analyzed the mechanisms of genomic evolution and biology’s central dogma that enable adaptation and diversification of life from the viewpoint of evolution, which had been overlooked in the past. We also aimed to develop new life system technology beyond conventional conceptions.

- Elucidation and utilization of minimum components and the mechanism of biological protein synthesis system of life on Earth.
- Development of new life system technology based on RNA technology

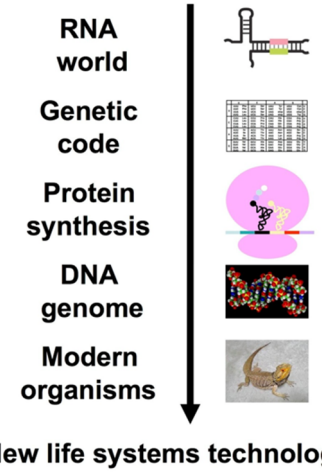


Fig. 2. Elucidation of the evolutionary process of life and its application to new life system technologies

Members: Koji Tamura, Toshiki Furuya, Mitsunori Shiroishi, Masayuki Sakurai, Takashi Nakajima, Kazunori Okada (The Univ. of Tokyo), Akiko Soma (Chiba Univ.)

<Section of Nature Symbiosis>

We advanced scientific knowledge that contributes to the conservation of ecosystems and biodiversity, and develop technologies for assessing risks of chemical substances to living things and for managing and improving the air, water, and soil environment.

- Elucidation of environmental factors and mechanisms that affect future biological production
- Development of analytical methods for atmospheric molecules and environmental chemicals, and of methods for assessing the effects on living organisms

Members: Shinichi Miyagawa, Shinichi Satake, Yoshitsugu Akiyama, Yutaka Sumino, Takuya Saito (NIES)

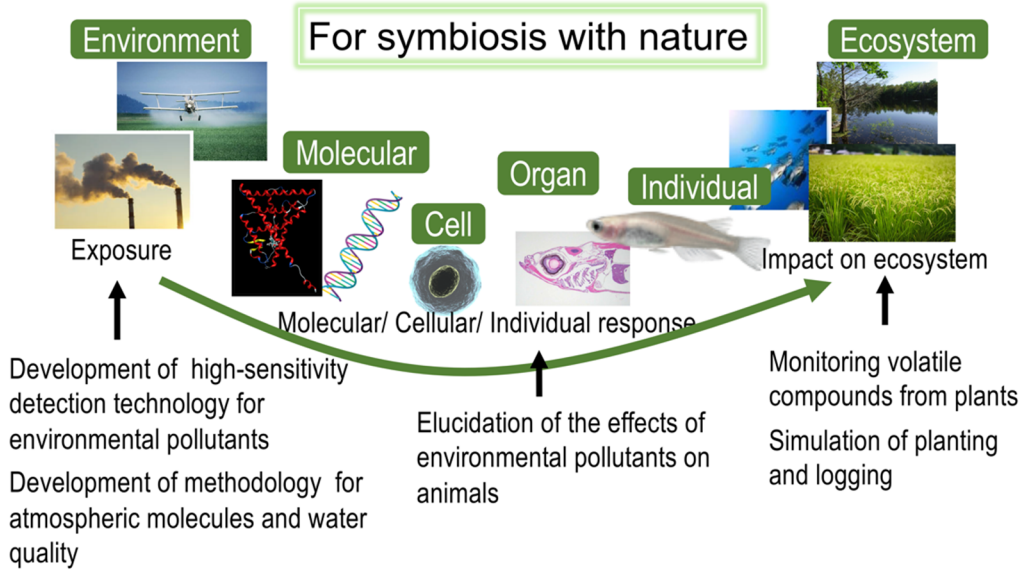


Fig. 3. Strategy for the development of applied technologies for symbiosis with nature

3. Activity Reports

In each research division, members with initiatives in their respective research areas co-worked in terms of “food” and “environment. The following public symposiums and seminars were held as part of the overall activities.

Symposium

November 9, 2024

Outcome: To advance research in bioenvironmental innovation, symposiums were held this year on three themes: “Communication Woven by Life,” “Crosstalk Between Molecular Evolution and Biological Evolution,” and “The Molecular Basis of Diverse Living Systems.” These events brought together division members, leading researchers, and students from the university. The symposium was conducted on stie, and also served as a great opportunity that could be a seed for fusion research unique to the Tokyo University of Science.

March 17, 2025

Outcome: We invited two plant researchers from overseas and hosted an international public symposium titled “ImpeTUS for TUS Plant Science” in collaboration with members of this division engaged in plant environmental response research, which is one of the core research areas, as well as faculty members from Tokyo University of Science. This symposium served as an excellent opportunity to showcase our university’s activities in the field of plant research both inside and outside the university, while also fostering the foundation for future international collaborative research.

Seminar

2024.6.14

Dr. Massimo E. Maffei (University of Turin, Italy)

Title: Microbial volatiles (mVOCs) interact with plants and promote growth by gene modulation and oxidative stress

2024.6.21

Dr. Massimo E. Maffei (University of Turin, Italy)

Title: Quantum biology of plant magnetoreception: growing plants outside the geomagnetic field

2024.7.9

Dr. Tatsuya Sawasaki (Ehime University)

Title:「膜タンパク質の細胞内・外領域インタラクトーム解析技術」(in Japanese)

2024.7.26

Dr. Hiroaki Shimada (Tokyo University of Science)

Title:「不思議の国の dMac3。こしかた ゆくすゑ」(in Japanese)

2024.11.15
Dr. Lluís Ribas de Pouplana (IRB Barcelona and ICREA, Spain)
Title: The evolution of the Genetic Code, and its functional limits

4. Challenges and Prospects

We will explore the mechanisms by which life adapts and diversifies, and evolution occurs in a rapidly changing habitat environment. Our aim is also to develop technological seeds that contribute to our food and health quality.

We will create a new revolutionary academic field that has never existed by fusing individually developed research areas such as environmental biology and ecology.

Major Research Achievements (FY2024)

Academic Papers

1. Spider mite tetranins elicit different defense responses in different host habitats, Endo Y., Tanaka M., Uemura T., …, Arimura G., Plant J., 121:e70046, 2025 (Peer-reviewed)
2. Histone modification-dependent transcriptional regulation of defense genes in early response of Arabidopsis to Spodoptera litura attack, Yusuf A., Wakaya K., Sakamoto T., Uemura T., …, Arimura G., Plant Cell Environ., 48:3257-3268, 2025 (Peer-reviewed)
3. Cracking the plant VOC sensing code and its practical applications, Arimura G., Uemura T. Trends Plant Sci., 30:105-115, 2025 (Peer-reviewed)
4. The powerful potential of amino acid menthyl esters for anti-inflammatory and anti-obesity therapies, Takasawa S., Kimura K., Miyanaga M., Uemura T., Hachisu M., Miyagawa S., …, Shiroishi M., … Arimura G., Immunology, 173:76-92, 2024 (Peer-reviewed)
5. A high-accuracy dynamic dilution method for generating reference gas mixtures of carbonyl sulfide at sub-nanomole-per-mole levels for long-term atmospheric observation, Nara H., Saito T., Umezawa T., Tohjima Y., Atmos. Meas. Tech., 17:5187–5200, 2024 (Peer-reviewed)
6. Evolution and diversification of the momilactone biosynthetic gene cluster in the genus Oryza. Priego-Cubero S., …, Okada K., Becker C. New Phytol., 245: 2681-2697, 2025 (Peer-reviewed)
7. Real-time live imaging of cytosolic hydrogen peroxide and Ca^{2+} of Marchantia polymorpha gemmalings reveal immediate initial responses of plant cells triggered by nonthermal plasma irradiation, Tsuboyama S., …, Kuchitsu K., Plant Physiol. Biochem., 216:109172, 2024 (Peer-reviewed)
8. Roadmap for the next decade of plant programmed cell death research. Kacprzyk J., …, Kuchitsu K., …, McCabe PF, New Phytol., 242:1865-1875, 2024 (Peer-reviewed)
9. Precipitation induced filament pattern of injected fluid controlled by structured cell, Tanaka S., Otoguro K., Kunihiro M., Ishikawa H., Sumino Y., Phys. Rev. E 109:065105, 2024 (Peer-reviewed).
10. Pattern transition of flow dynamics in a highly water-absorbent granular bed, Otoguro K., Yoshii K., Sumino Y., Phys. Fluids, 36:063105, 2024 (Peer-reviewed)
11. Extensive tip-splitting of injected organic liquid into an aqueous viscoelastic fluid Yoshii K., Otoguro K., Sato A. P., Sumino Y., Front. Phys. Sec. Complex Physical Systems, 12:1332187, 2024 (Peer-reviewed)
12. MID1-COMPLEMENTING ACTIVITY regulates cell proliferation and development via Ca^{2+} signaling in Marchantia polymorpha, Iwano M., Suetsugu N., Nishihama R., …, Plant Physiol. 197: kiae613, 2025 (Peer-reviewed)
13. A non-canonical BZR/BES transcription factor regulates the development of haploid reproductive organs in Marchantia polymorpha, Furuya T., …, Nishihama R., …, Kondo Y., Nature Plants:785-797, 2024 (Peer-reviewed)
14. Conserved CKI1-mediated signaling is required for female germline specification in Marchantia polymorpha, Bao H., …, Nishihama R., Yamaoka S., Kohchi T., Current Biol., 34:1324-1332, 2024 (Peer-reviewed)
15. Convergent evolution of water-conducting cells in Marchantia recruited the ZHOUPI gene promoting cell wall reinforcement and programmed cell death, Lu Y.T., …, Nishihama R., …, Goodrich J., Current Biol., 34:793-807, 2024 (Peer-reviewed)
16. Infrared free electron laser-irradiated polyleucine does not exert aggregates-induced aversive effects on mouse brain, Mori A., Shiroishi T. Fujioka J., Nakajima T., Mitsui S, Suginoma H., Kakuta Y., Zen H., Nakamura K, Brain Disorders, 14:100137-1~11, 2024（Peer-reviewed）

17. 圧電性高分子を用いた振動エネルギーハーベスティング, 中嶋宇史, 日本画像学会誌, 63 巻, pp 168-175, 2024 (Peer-reviewed) (in Japanese)
18. Binding characteristics of the doxepin E/Z-isomers to the histamine H1 receptor revealed by receptor-bound ligand analysis and molecular dynamics study. Kaneko H., Korenaga R., Nakamura R., Kawai S., Ando T., Shiroishi M., J. Mol. Recognit., 37:e3098, 2024 (Peer-reviewed)
19. Development of allosteric ribozymes for ATP and L-histidine based on the R3C ligase ribozyme, Akatsu Y., Mutsuro-Aoki H., Tamura K., Life, 14:520, 2024 (Peer-reviewed)

Books

1. 植物が食害誘導的に揮発性物質を生産するメカニズム, 有村源一郎, 小澤理香, in 植物の多次元コミュニケーションのダイナミクス, 高林純示(監), NTS, pp. 258-265, 2025 (in Japanese)
2. 寄主植物の誘導抵抗性と制御機構, 有村源一郎, in ハダニの科学, 佐藤幸恵、他(編), 朝倉書店, pp 99-102, 2024 (in Japanese)

Invited lectures

1. The system for the detection of VOCs in plants and its practical applications, Arimura G., International symposium on plant phenology and climate feedbacks mediated by BVOCs (PCF2024), Gifu, 2024
2. Orchestration of plant defense signaling: impact of herbivores' oral factors including symbiotic microorganisms and elicitors, Arimura G., XXVII International Congress of Entomology (ICE2024), Kyoto, 2024
3. 温度に依存する爬虫類の性決定システム, 宮川信一, 第 12 回実験動物科学シンポジウム, 那覇, 2024 (in Japanese)
4. Exploring Molecular Mechanisms Underlying Rapid Long-Distance Signal Propagation and Information Processing in a Non-Vascular Model Plant, *Marchantia polymorpha,* Kuchitsu K, QBIC Small Workshop on Bio-information, Noda, 2024
5. Roles of reactive oxygen species in plant development: Growth control and immediate initial responses by nonthermal plasma irradiation, Kuchitsu K, 8th International Symposium on Plasmas & Fine Bubbles, Shanghai, China (hybrid) 2024
6. Interrelationship among calcium, ROS and electrical signals in the rapid long-distance propagation in a nonvascular liverwort *Marchantia polymorpha*, Kuchitsu K, EMBO Workshop “Plant Calcium Signaling", Lisbon, Portugal, 2024
7. Interrelationship among Ca^{2+}, ROS and electrical signals in the rapid long-distance propagation in *Marchantia polymorpha,* Kuchitsu K, International Marchantia Workshop 2024, Hiroshima, 2024
8. Decentralized Information Processing in Plants, Kuchitsu K, International Joint Workshop of QP45& QBIC 2025, Noda, 2025
9. Motion of floating objects induced by the presence of multiple species, Sumino Y., Rencontres du Vietnam Soft matter, fluids & interfaces, Quy Nhon, Vietnam 2024
10. Collective motion of colloids induced by the presence of binary size, Sumino Y., Workshop: The physics of self-organising active matter, Edinburgh, UK 2024
11. Active motion of self-propelled pairs made with different species, Sumino Y., 26th Samahang Pisika ng Visayas at Mindanao National Physics Conference in conjunction with 2024 International Meeting on Complex Systems, Manila, Philippine 2024
12. Formation of self-propelled pair induced by the presence of binary-type elements with surface flow, Sumino Y., Gel Symposium 2024 (14th International Gel Symposium), Okinawa, 2024
13. Driving droplet: active motion of droplet using wettability, Marangoni flow, and aggregate formation,

Sumino Y., The Workshop on “Greener Pesticide Spray Management — Towards a Sustainable Future”, Kolkata, India 2025

14. Auxin signaling and its communication with photosynthesis for growth and developmen-tal control in the liverwort *Marchantia polymorpha*, Nishihama R., International Conference on the Molecular Biology of Streptophytes (ICMBS), Shenzhen, China, 2024

Patents

1. 秋山好嗣, 上村真生, 志水洸輝, 渡邉賢吾, 和田壮太, 国内優先出願, ポリマー鎖修飾ナノ粒子群及びその製造方法、並びに重合開始基修飾ナノ粒子群及びその製造方法, 特願 2024-150544
2. 伊勢健冬, 中嶋宇史, 山添雄介, 圧電ケーブルユニット、及び検知システム, 特願 2024-158574
3. 伊勢健冬, 中嶋宇史, 山添雄介, 圧電ケーブル、及び検知システム, 特願 2024-158575
4. 中嶋宇史, 佐藤智浩, センシング装置, 特願 2024-144567

Public Relations

1. 有村源一郎, 植物における匂い(VOC)の作用と認識メカニズムに迫る ～環境にやさしく持続可能な農業・園芸技術の実現に大きく貢献～, 毎日新聞, 2024 (in Japanese)
2. 有村源一郎, ローズ精油でトマトの害虫防除　理科大が技術開発　農薬代替えの新素材期待, 科学新聞, 2024 (in Japanese)

Awards

1. Arimura G. et al., International Journal of Molecular Sciences : Top View Papers of IJMS in 2023

Individual Research Topics

Yoshitsugu Akiyama

"Precise design of hairpin DNA-gold nanoparticle monoconjugate with a single-dye molecule for targetable molecular beacon strategies"

The present study exploited a molecular beacon-gold nanoparticle monoconjugate possessing galactose derivatives (Gal-monoMB-AuNP) that specifically recognize asialoglycoprotein receptor on hepatocyte and hepatoma. A remarkable increase in fluorescence intensity of Gal-monoMB-AuNP was observed in the presence of target DNA with partial sequences for diagnostic biomarkers of cancer (TK1 mRNA). Also, WST assay resulted in no toxicity to HepG2 cells. These results will allow to develop *in vivo* cancer targeting and fluorescent bioimaging.

Gen-ichiro Arimura and Takuya Uemura

"Fundamental research for food and environmental conservation learning from biological interactions"

Plants are known to possess solid immune response mechanisms. One such response is "sensing" attack by herbivorous animals. We highlight the major types of elicitors/volatile organic compounds and the underlying cellular signaling, and states that this could spur research on organic farming practices that could prevent the use of harmful pesticides.

Hisataka Ohta

"Application of acid stress response mechanism of cyanobacteria"

Cyanobacteria are capable of producing various substances from carbon dioxide with light energy and have attracted attention as hosts for producing biofuels and bioplastics with low environmental impact. In this study, we identified genetic mutations involved in fat droplet accumulation and genes involved in biofilm formation that play a role in several response mechanisms to acid stress in cyanobacteria.

Kazunori Okada

"Research on the evolution of biosynthetic gene clusters for diterpene-type antibacterial compounds in plants"

Biosynthetic genes for momilactone, a diterpene phytoalexin found in rice, are organized on the rice genome as a gene cluster. In this research project, the existence of the momilactone biosynthetic gene cluster and its induction mechanisms via oxylipin signaling were elucidated from the viewpoint of genomics and biochemistry. This is an important discovery for investigating the evolution of gene clusters in plants and their biological implications.

Kazuyuki Kuchitsu and Takumi Tomoi

"Physiological functions and target molecules of reactive oxygen species enzymatically produced in the plant cell wall"

Although reactive oxygen species (ROS) are typically considered to be highly toxic substances, ROS generated by the plant enzyme Rbohs are involved in a variety of physiological functions. Genetic and molecular physiological studies using a model liverwort have shown that actively generated ROS are essential for regulating cell elongation, division, differentiation, and morphogenesis as well as stress responses. We have been studying the molecular targets of ROS and molecular mechanisms of ROS-mediated regulation in plant cells.

Takuya Saito

"Biogenic volatile organic compounds in the atmosphere"

Volatile organic compounds (VOCs) emitted from various anthropogenic and natural sources are involved in air pollution and climate change, and also play an important role in stratospheric ozone depletion. Based on field measurements of VOCs emitted from natural sources, we better understood the feedbacks between the biosphere and the atmosphere via VOC emissions.

Takuya Sakamoto and Sachihiro Matsunaga

"Studies on epigenetics and chromatin dynamics in environmental adaptation"

The regulatory mechanism of chromatin dynamics was studied focusing on centromere dynamics, and the novel regulatory complex CII-LINC in plants was identified. In addition, we developed an imaging technique to detect epigenetic alternations induced by environmental stimuli, and succeeded in establishing a technique for live imaging of specific histone modifications.

Masayuki Sakurai

"Studies on deaminating editing of nucleotide adenosine bases in evolutionary adaptation of organisms"

In the Central Dogma of Life, there is a mechanism that modifies the chemical structure of four types of bases in expression regulation. In this study, we are attempting to elucidate the mechanism of modification to inosine bases, which is the result of RNA adenosine base deamination reaction. We have developed a highly accurate inosine identification method and identified 30,000 inosine sites, including 17,000 novel sites, in human brain transcripts with 97% accuracy.

Shin-ichi Satake

"Simulation of cultivated fields with *Cyperus malaccensis* Lam."

In this study, "honami" of Cyperus malaccensis Lam. was reproduced to establish a simulation technique that can reproduce the waves of it and predict the wind flow over it and in it related to its growth accurately. Vortex structures and vegetation oscillations were visualized.

Mitsunori Shiroishi

"Studies on molecular recognition mechanisms of animal and plant cell membrane receptors and antibodies"

We elucidated the recognition mechanism of doxepin isomers on the histamine H1 receptor. We also analyzed the pH-dependent functions of various GPCRs using Saccharomyces cerevisiae. We constructed an insect cell expression system for cell membrane receptors involved in plant environmental responses. We also performed binding analysis and crystal structure analysis of anti-D-amino acid antibodies and the autoantibody rheumatoid factors (RFs).

Yutaka Sumino

"Spatio-temporal pattern formation induced by rheological change of external/internal media"

Living organisms, especially plants, composed of collective number of cells. Such cells communicate locally, yet establish macroscopic spatio-temporal order spontaneously. This process should be supported by so-call dissipative structure generated under far-from-equilibrium conditions. In our study, we focus on the branching-like pattern formed under injection of fluid owing to the rheological change of external and internal media. We created experimental systems, and extracted essential features of these system using mathematical model.

Akiko Soma

“Identification of tRNA repertoires in plant organelles”

Organelles contain their own gene expression systems, while it is general that insufficient species and copies of tRNA genes are found in the organelle genomes. We analyzed anticodon sequences of organelles of single-cell algae, and found that the some tRNAs are modified to enlarge their decoding capability. Such mechanism allows a small set of tRNA repertoire to decode codons.

Fuminori Takahashi

“Elucidation of long-distance signaling under environmental stress conditions in plants and its application to crop”

We identified sensor modules that recognize drought stress conditions in roots and promote a synthesis of abscisic acid which is required for acquisition of drought stress tolerance in leaves. Especially, we analyzed the downstream signaling of receptors including transcription factors and regulatory factors. We further applied those findings to rice for generating environmental stress resistance crops.

Koji Tamura

“Research on the origin and evolution of the genetic code that lies at the core of bio-environmental innovation”

Aiming to develop new life-system technologies that are unconventional by analyzing the mechanism of action of genome evolution and central dogma that enable adaptation and diversification of life from the perspective of evolution that has been overlooked in the past.

Takashi Nakajima

“Studies on mechanism of piezoelectricity of biopolymers”

Odd-Nylon extracted from castor oil and fibroin contained in silk are known to have piezoelectric properties. These materials are environmentally conscious and are expected to be applied to new sensors and actuators that work in vivo. In this study, the piezoelectric properties of biopolymers were quantitatively evaluated, deepening an understanding of the mechanism of piezoelectricity to apply them to biological systems.

Ryuichi Nishihama

“Studies on the mechanisms of environmental control of plant growth using a liverwort”

We discovered a highly conserved signal transduction pathway in which the phytohormone auxin, which plays important roles in environmental responses and developmental regulation, is perceived at the cell surface, and rapidly regulates cellular activities by phosphorylation. Furthermore, this pathway was found to be mediated by the Raf-like kinase PRAF, which we previously identified as a photosynthesis signaling component. We also found that Marchantia utilizes the conserved pathway for defense signaling and that the activation of a proton pump in stomatal cells is mediated by a newly identified photosynthesis-dependent phosphorylation mechanism.

Shinichi Miyagawa

“Analysis of the mechanisms of interaction between the environment and organisms for symbiosis with nature”

All living organisms are constantly affected in various environment cues and a developing animal ingeniously exploit such external environmental factors to alter its own phenotype to enhance its own survival and the ability of its offspring to reproduce in future. This phenomenon is called phenotypic plasticity. We elucidate the mechanisms of how animals receive environmental factors and translate it into intracellular signals, to understand the interaction between organisms and their environment.

Toshiki Furuya

“Research on utilization of microbial and enzymatic functions”

Microorganisms that activate plant immune responses have high potential for application as biocontrol agents in agriculture, as they function like vaccines in plants without causing unwanted adverse effects. We study a method to detect microorganisms that activate the plant immune system based on plant-microbe interactions. In addition, there is growing interest in environmentally friendly synthetic approach to production of chemicals from the viewpoint of SDGs, and we study bioprocesses using enzymes and renewable resources.

Research Group for Advanced Energy Conversion

Research Group for Advanced Energy Conversion

1. Overview

The development and use of highly efficient energy systems are a matter of urgency, because the exhaustion of petroleum resources and the resultant economic instability are a call to action. The problem is conspicuous in our country since it depends heavily on the import of petroleum. Studies are being carried out in the Division of Ecosystem Research and the Advanced EC Device Research Division, on the development and testing of an electrochemistry device for commercialization purposes.

The United Nations has set 17 targets as global SDGs, and these targets are indispensable for future technical development. The following two relate to our research group:

SDG 7: “Ensure access to affordable, reliable, sustainable, and modern energy for all.”

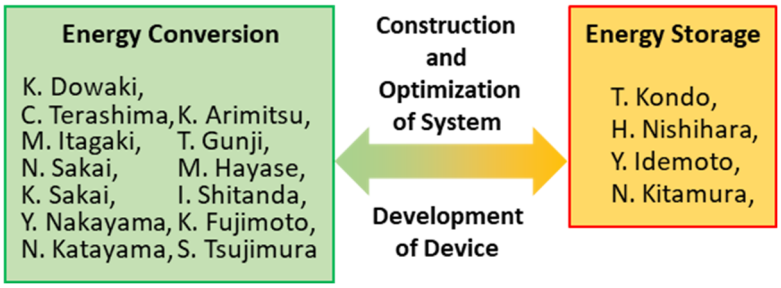
SDG 12: “Ensure sustainable consumption and production patterns.”

In our research group, we will study the development and environment-friendly use of new energy, following a product of the Advanced EC Device Research Division, on electrochemical devices, hydrogen energy, heat energy, and light energy.

Our research group consists of two teams: the research team for energy transformation and the research team for energy storage. The research team for energy transformation takes charge of the development of technology and materials for the generation and transformation of energy. The research team for energy storage takes charge of the development of technology and materials on the storage and utilization of energy. Both teams cooperate mutually with the aim of building a system for the generation, transformation, storage, and utilization of energy. When an advanced energy device is created, its development is accelerated by cooperation between group members beyond the limit of their specialty and research fields, to overcome current problems and improve the fundamental knowledge level among group members, furthering collaboration.

Based on “Only at TUS”, a researcher on the front line participating in this research should be able to accumulate information and technological know-how from scholars in the various fields and achieve high technical development and originality.

A characteristic feature of our research group is the inclusion of the “Sustainable Energy Systems and Materials” course from the Graduate School of Science and Technology curriculum. The participation of both students and teachers is indispensable for the development of new materials and systems. We plan to hand-down technology and knowledge from generation to generation through research proceeds of students who carry the science and technology of the next generation, and we plan for an aggressive exchange between students and teachers to achieve the goal of this research group early.



2. Organization and Facilities

<Research on energy conversion>

Based on outcomes from the Division of Ecosystem Research and the Advanced EC Device Research Division, the development of highly efficient, environment-friendly organic synthetic processes, and highly sensitive and functional light-reactive polymers are advancing. One of the aims of this research group is the development of new catalytic reactions for the highly selective reduction of carbonyl groups to methylene groups, to be used in applications for organic compounds made up of elements other than oxygen. Another objective of this group is the development of a polymer that responds to multiple forms of energy, by designing a polymer that reacts stepwise to light and heat. In addition, high-speed material screening will be carried out using a combinatorial experimental method.

The generation and utilization of bio hydrogen will be proposed in relation to SDG 12, based on life-cycle assessment (LCA). A system consisting of the generation of hydrogen from waste wood, its purification, storage, and use in the generation of electricity through fuel cells, as well as in charge storage in capacitors will be built and evaluated based on LCA.

We will manufacture a printable wearable biofuel cell with paper and transfer sheet. For example, a fuel cell that uses organic material in urine as fuel can be used for urine detection (Elderly care, health maintenance). By using lactic acid in sweat as fuel, one can monitor the health of athletes. In order to make the wearable device, we prepare mesoporous carbon materials suitable for use as enzymes, and then develop a printable paper device using the carbon as the electrodes.

In the development of the polymer electrolyte fuel cell, we synthesize a metal-complex-supported conductive diamond as the electrode catalyst and develop a novel silicon-based polymer as the electrolyte.

<Research on energy storage>

We aim to prepare high-capacity electrodes with structures that are well controlled at atomic-to-micro levels and perform high-throughput material screening, and device-oriented electrochemical and structural analyses. For optimization of nano- and micro-structures of the electrodes, we will prepare the powder using liquid-phase synthetic methods like solvothermal synthesis, and then perform a surface coating on the pristine powder.

Atomic configurations of the materials will be simulated computationally for theoretical screening. In addition, we will investigate degradation mechanisms of the batteries under various operation conditions, by means of selected electrochemical techniques such as in-situ analyses of the atomic and electronic structures using neutron and synchrotron X-ray sources and in-situ electrochemical impedance spectroscopy (EIS) by cooperating with energy conversion group. This strategy enables us to produce a customized and appropriate device design based on a working condition and a purpose of use.

3. Activity Reports

In this research group, we also encourage the progress of a joint research by the members in addition to the individual research work by a member.

a) The gas purification of in the Blue Tower demonstration plant (AGM/Advanced Gasification Module) and the development of gas purification by two step PSA. (Dowaki and Gunji)
b) Development of fuel cell system using storage of hydrogen by adsorption aiming the application as a mobile battery. (Dowaki and Katayama)

c) Development of rapid health monitoring system of lithium ion secondary battery. (Itagaki and Katayama)
d) Development and evaluation of wearable bio fuel cell. (Shitanda, Tsujimura, Katayama, and Itagaki)
The homepage of this research group was made in Japanese and English.
This research group is joint to the Energy and Environment Course which is located to the Graduate School of Science and Technology to encourage young researchers. Our members attend the Poster Competition on August, 26, 2022.

We supported international conference Advances in Corrosion Protection by Organic Coatings 2024 (ACPOC 2024), which was held at TUS Seminar House, on September, 16 to 19.

In addition, we supported First Bioelectrochemistry Workshop in 2024 (2024 First Bioelectricity Chemical Workshop), which was held at TUS Noda campus, on April, 4.

Furthermore, we held a lecture of the Young Researchers in The Surface Finishing Society of Japan, which was held at TUS Noda campus, on November, 8.

4. Challenges and Prospects

a) Promotion of joint research intra- and inter-research group.
b) Setting a target number for joint research and positive promotion.
c) Holding a lecture and a meeting for presenting research.
d) Holding and support of the international conferences.
e) Acquisition of research funds.
f) Management of laboratories. (No. 10 building 4th floor. Research rooms Nos. 4 and 9)

Major Research Achievements (FY2024)

Academic Papers

1. Sol-Gel Reaction of Tetraethoxysilane, Hexaethoxydisiloxane, and Octaethoxytrisiloxane: Differences in Siloxane Precursor Oligomers Depending on Raw Materials, Yohei Sato, Tatsuya Iwashina, Naoya Tanihata, Masashi Nakamura, Seiji Watase, Ryohei Hayami, Kazuki Yamamoto, Takahiro Gunji, ACS Applied Polymer Materials, 6, pp. 12197-12206, 2024
2. Discrete coordination nanochains based on photoluminescent dyes reveal intrachain exciton migration dynamics. Ryojun Toyoda, Naoya Fukui, Haru Taniguchi, Hiroaki Uratani, Joe Komeda, Yuta Chiba, Hikaru Takaya, Hiroshi Nishihara, Ryota Sakamoto, Nature Commun., 16, 1367, 2025
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7. Operating-temperature dependence of the average and electronic structures of $0.4Li_2MnO_3$–$0.6Li(Mn_{1/3}Ni_{1/3}Co_{1/3})O_2$, Yasushi Idemoto, Yuiko Koitabashi, Chiaki Ishibashi, Naoya Ishida, Naoto Kitamura, Electrochemistry, 92, 107003, 2024
8. Relationship between Network Topology and Negative Electrode Property in Wadsley–Roth Phase $TiNb_2O_7$, Naoto Kitamura, Hikari Matsubara, Koji Kimura, Ippei Obayashi, Yohei Onodera, Ken Nakashima, Hidetoshi Morita, Motoki Shiga, Yasuhiro Harada, Chiaki Ishibashi, Yasushi Idemoto, Koichi Hayashi, NPG Asia Materials, 16, 62, 2024
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Books

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2. International Symposium on Inorganic Environmental Materials 2023 (ISIEM 2023), Kenjiro Fujimoto, Mamoru Aizawa, Naoyuki Matsumoto, Hiroaki Mori, New Journal of Chemistry, 48 pp. 1232-1232, 2024

Invited lectures

1. ホスホン酸を側鎖とするポリシルセスキオキサンの合成と物性, 郡司天博, 山本一樹, 第 73 回高分子討論会, 新潟大学 (新潟県新潟市), 2024 (in Japanese)
2. Coordination Nanosheets — Electro-functional 2D Polymers of Metal Complexes, Hiroshi Nishihara, PRiME2024, Hawaii, USA, 2024
3. Functional materials and their synthesis using of in-liquid plasma method, Chiaki Terashima, Hiroshi Uetsuka, Katsuya Teshima, 5th International Conference on Materials Science & Engineering (Materials-2024), San Francisco, CA, 2024
4. Atmospheric Corrosion Sensors Fabricated by Screen-printing, Masayuki Itagaki, 75th Annual Meeting of the International Society of Electrochemistry, Montréal, Canada, 2024
5. Application of screen-printed electrodes to wearable biosensing devices, Isao Shitanda, Wised2024, Centre de Recherche en Neurosciences de LYON–CRNL, 2024
6. 蓄電池材料の全散乱データを用いた原子配列モデリングとトポロジー解析, 北村尚斗, 日本化学会第 105 春季年会, 大阪, 2025 (in Japanese)
7. Electrochemical Applications of Conductive Boron-Doped Diamond Powders and Nanoparticles, T. Kondo, 2024 MRS Fall Meeting & Exhibit, Boston, USA, 2024
8. Challenges and Future of Combinatorial Powder Material Exploration Technology in DX, Kenjiro Fujimoto, 2024 Powder Metallurgy World Congress & Exhibition (WORLD PM2024), Yokohama, PACIFICO YOKOHAMA, 2024
9. インピーダンスデータ収集システムと解析方法の開発, 片山 昇, 第 34 回日本 MRS 年次大会, 2024 (in Japanese)
10. Well-crystallized epitaxial thin films of molecular semiconductors on organic semiconductor single crystals (II), Yasuo Nakayama, The 10th International Conference on Technological Advances of Thin Films & Surface Coatings (Thin Films 2024), Singapore, 2024

Patents

1. 硫化水素吸着方法、硫化水素吸着装置及び硫化水素吸着方法を用いた水素ガス製造方法, 出願日：2024 年 10 月 28 日, 出願人：ＤＯＷＡホールディングス株式会社・学校法人東京理科大学, 発明者：佐藤王高, 公文翔一, 堂脇清志, 北山秀翔, 濱﨑麻優, 国内特許出願 (特願 2024-189360) (in Japanese)

Public Relations

1. 有光晃二, 西野 孝, 辻井敬亘, 扇澤敏明, 材料系 4 学会トップ座談会　コラボレーションで新たな可能性拓く, 化学工業日報, 2024 (in Japanese)

Awards

1. Masayuki Itagaki, ECS Fellow, The Electrochemical Society, 2024
2. 四反田功, 清山賞, 電気化学会 化学センサ研究会, 2025 (in Japanese)
3. Mayu Hamazaki, Hisashi Kamiuchi, Mitsuo Kameyama, Kiyoshi Dowaki, Best Oral Presentation Award, The 13th Joint Conference on Renewable Energy and Nanotechnology (Fukuoka, Japan), 2025
4. 吉田英司, 片山 昇, YPC 優秀発表賞, 令和 6 年電気学会電力・エネルギー部門大会, 2024 (in Japanese)

Individual Research Topics

Takahiro Gunji

"Studies on the polysilsesquioxanes having proton conductivity"

Polysilsequioxanes having phosphonic acid moiety as a side chain was synthesized and the proton conductivity was evaluated as a function of temperature and humidity. Polysilsesquioxanes having phosphonic acid moiety as a side chain was synthesized by the hydrolytic polycondensation of 3-mercaptopropyl(trimethoxy)silane and the following thiol-ene reaction and alcoholysis. The thin film was prepared and the conductivity was evaluated under high-humidity or low-humidity as a function of temperature.

Hiroshi Nishihara

"Studies on metal complex two-dimensional materials 'coordination nanosheets'"

Synthesis, structural analysis, elucidation of properties and functions, and application of coordination nanosheets composed of combinations of metal ions and planar organic ligands have been carried out. It was revealed that the chemical structure and physical properties of bis(diimino)copper nanosheets can be controlled by changing the conditions of the liquid-liquid interface synthesis method. We have discovered that a new material, bis(terpyridine) nickel nanosheets, is a nearly colorless, transparent, flexible film that exhibits a reversible redox activity. An in-plane heterojunction coordination nanosheet (tmFe/tmCu), which exhibits rectifying behavior, was easily prepared under mild conditions by immersing a portion of a Zn_3BHT coordination nanosheet (BHT: benzene hexathiol) first in a Cu^{2+} solution and then in a Fe^{2+} solution for the rest.

Chiaki Terashima

"Development of diamond photocatalyst for highly efficient CO_2 conversion"

Diamond semicondoctor has a potential to reduce the CO_2 molecules with high efficiency due to its wide bandgap energy and the high reduction energy by the conduction band edge. We focused to use the diamond materials in the research work with two strategies. One is to utilize the excimer lamp for ultraviolet wavelength by using of low power, in order to excite the diamond photocatalyst. Second is to modify the diamond nanomaterials with co-catalysts such as Ag, Cu, Sn and their core-shell structures.

Koji Arimitsu

"Synthesis and properties of sulfonic acid-modified polysilane as an alternative to Nafion"

We synthesized an amphiphilic polysilane modified with styrenesulfonic acid, and investigated its heat resistance and thermal decomposition behavior, which revealed that it has high thermal stability. Furthermore, we performed an evaluation of the electrochemical properties of this polymer, and found that it has electrochemical performance equivalent to that of Nafion.

Masayuki Itagaki

"Development of electrochemical methods to evaluate electrochemical energy devices"

Some electrochemical methods were developed to evaluate electrochemical energy devices like lithium-ion battery and polymer electrolyte fuel cell, etc. For example, a precise electrochemical impedance method has been developed to analyze degradation of lithium-ion batteries equipped in electric vehicles and aircrafts. And new surface treatments and its evaluation method have been developed for high durability of polymer electrolyte fuel cells.

Isao Shitanda

“Research on Flexible Organic Batteries”

A new radical organic secondary battery was fabricated using a nonflammable and nontoxic 1 M Na_2SO_4 aqueous solution as the electrolyte. Electrodes were made by screen-printing, and acrylic cells or laminated cell type rechargeable batteries were fabricated and electrochemically evaluated. The laminated cell type organic radical rechargeable battery was subjected to a constant-current charging test at 30 C-rate for 10 cycles, resulting in a discharge capacity of 10.2 mAh/g and an energy density of 11.2 Wh/kg. These results indicate that the battery can be charged and discharged 3 to 60 times faster than conventional lithium-ion batteries.

Yasushi Idemoto, Naoto Kitamura

“Development of new cathode materials for magnesium rechargeable batteries and investigation of discharge and charge mechanism”

Average, local, and electronic structures and cathode properties of spinel-type oxides with various metal compositions were investigated, and it was found that Mn-substituted $Mg_{1.33}V_{1.67}O_4$ exhibits good discharge capacity retention. It was also demonstrated taht the cathode properties of $MgMn_2O_4$ was improved by partially substituting Fe or V for Mn.

Norio Sakai

“Development of the novel synthetic method of organosulfur compounds toward electroconductive materials”

We focused on the development of the effective synthetic method of organosulfur compounds, the structure of which would be applied to electrochemical devises. We planned to develop a reductive sulfidation of *O,S*-acetal using a newly developed trityl cation derivative as a catalyst. It was found that when *O,S*-acetal was treated with phenylsilane as a reducing agent in the presence of a catalytic amount of a *para*-methoxy group-substituted trityl cation derivative, the corresponding sulfide was obtained in a good yield.

Kiyoshi Dowaki

“Improvement of the indirect gasification process for purification of bio-hydrogen”

In our studies, the indirect gasification process for purifying bio-hydrogen uses sewage sludge. The process consists of the pyrolyzer, reformer, and preheater. Due to the heat transfer using heat carriers of alumina balls, feedstock is decomposed. However, the lack of sensible heat would co-generate tar and reduce the volume of syngas. In addition, generating other contaminants would degrade the product quality of bio-hydrogen. This time, we developed the CFD model based on the kinetics of tar, and we can grasp the heat distribution in the vessel. We also proposed a countermeasure to reduce the amount of tar, improving syngas production efficiency. Furthermore, the refinery technology of H_2S removal was argued through adsorption tests. An eco-friendly scheme using metal alloys and mining waste was developed. Note that the patent for this scheme has been applied.

Masanori Hayase

"Miniature fuel cell with monolithically fabricated electrodes"

We have studied a miniature fuel cell with monolithically fabricated electrodes. The output of the cell has significantly improved, and performance degradation due to flooding has become apparent. Therefore, a transparent PDMS flow channel cover was designed and prototyped. Long-term power generation tests over 10 hours were conducted while observing the water behavior in the flow channel. As a result, fluctuations in output on the scale of a few hours were observed and the complex behavior caused by the generated water was revealed.

Takeshi Kondo

"Improvement in Energy Density of Conductive Nanodiamond/Aqueous Electric Double-Layer Capacitors"

In order to increase the energy density of electric double-layer capacitors using boron-doped nanodiamond (BDND) and high concentration $NaClO_4$ aqueous electrolyte, we investigated the MnO_2/BDND composites which can exhibit pseudocapacitance. By depositing MnO_2 on the BDND, the capacitance increased by 1.2 times and a cell voltage of 2.6 V was maintained in a two-electrode system using 8 M $NaClO_4$ as an electrolyte, demonstrating that a high energy density can be achieved. Cycle and float tests confirmed that the MnO_2-BDND/8 M $NaClO_4$ system was durable to large cell voltages.

Kenichi Sakai

"Adsorption characteristics of phosphorus-type anti-wear agents in ester-based stocks"

The adsorption of phosphorus-type anti-wear agents on an iron oxide surface in ester-based stocks was characterized. The combination of experimental results based on frequency modulation atomic force microscopy and quartz crystal microbalance with dissipation monitoring technique suggested that competitive adsorption of the ester-based stocks and the anti-wear agents occurred on the iron oxide surface.

Kenjiro Fujimoto

"Study on the synthesis conditions and performance of $LiNi_{0.5}Mn_{1.3}Ti_{0.2}O_4$ as a cathode material for lithium-ion secondary batteries"

The correlation between synthesis conditions and electrode properties of $LiNi_{0.5}Mn_{1.3}Ti_{0.2}O_4$, discovered in the exploration of multinary oxides, has been investigated. The lattice constant increased linearly with increasing calcination temperature, which was attributed to an increase in the degree of oxygen deficiency. As a result, the amount of Mn^{3+} in the structure changed, affecting the discharge potential and capacity retention.

Noboru Katayama

"Temperature Deviation Estimation of Proton Exchange Membrane Water Electrolyzer Stack Using Electrochemical Impedance Spectroscopy and Neural Networks"

We developed a machine learning-based method to estimate temperature variations in proton exchange membrane water electrolysis (PEMWE) stacks using electrochemical impedance spectroscopy (EIS) data. Artificial impedance data at various temperature differences were created by merging measurements from uniformly heated stacks. A dual active bridge DC/DC converter applied DC and AC currents for impedance sampling. A deep neural network was trained to predict average temperatures and variances from impedance spectra, achieving accuracies within 2°C and 5°C, respectively. This approach shows promise for temperature monitoring in PEMWE systems.

Yasuo Nakayama

“Construction and electronic characterization of well-defined molecular semiconductor p-n junctions built on organic single-crystal substrates”

The functionalities of organic solar cells originate from p-n heterojunctions where different kinds of organic semiconductor molecules make direct contact with each other, and the structural designs and electronic properties at such interfaces are the key points of the development. In FY2024, our group has succeeded in the demonstration of photovoltaic responses, by means of photoelectron spectroscopy, at the well-defined hetero-molecular contact that our group has developed in FY2023. We also analyzed the excitonic and vibrational properties on the single crystal samples of a molecular semiconductor and have published these results in two original papers.

Seiya Tsujimura

“Development of High-Performance Enzyme Electrodes”

We develope effective interface between enzymes and electrodes to enhance the performance of electrohcemical biosensors and biofuel cells that use enzymes as electrocatalysts. In particular, we focus on the development of organic mediators that facilitate electron transfer between enzymes and electrodes. We are working on immobilization of redox mediator on porous carbon materials and modification of polymers. The obtained materials will be applied to printed electrochemical devices.

Modern Algebra and Cooperation with Engineering

Modern Algebra and Cooperation with Engineering

1. Overview

It is important for mathematics, which has more than 2000 years of history for research, to interact with other research fields outside mathematics. The research area of pure mathematics is roughly divided into three parts, algebra, geometry, and analysis. One can think that algebra and analysis are two wheels of a cart, via geometry and geometric objects. In its long history, analysis, which treats mainly continuous objects, has been developed in interaction with various engineering technologies. On the other hand, algebra, which treats mainly discrete objects, has interacted with information science, information technology, electrical, mechanical engineering, etc., and produced many essential results and effects for modern human life since the 20th century. Our division based on algebra is going to cooperate with another division "Research Alliance for Mathematical Analysis" and become a basis of science and technology to cooperate with various research areas. Our final goal is to make our division a center of research on algebra and algebra-based engineering.

2. Organization and Facilities

The division consists of various researchers belonging to Tokyo University of Science, whose research fields are number theory, arithmetic geometry, algebraic geometry, commutative algebra, representation theory, automorphic forms, algebraic topology, discrete mathematics, combinatorial design, computational mathematics, computer algebra, cryptology, information security, coding theory, applied algebra, and statistical science.

In the past, these researchers have cooperated with each other in the occasion of seminars, workshops, and international meetings. As an activity of this division, we pursue further cooperative relationships not only inside the division, but also outside the division, and we are going to produce many research collaborations between pure mathematics and engineering.

The division consists of three groups for purely mathematical research and four for applied research. The pure mathematics groups hold seminars, workshops, and symposiums on algebra, algebraic geometry, number theory, etc. The applied research groups make a place for the engagement of researchers in pure mathematics and engineering by proposing and developing many research plans for both sides. Furthermore, the division does cooperative research by continuously pursuing deep cooperation with Research Alliance Center for Mathematical Sciences, Tohoku University.

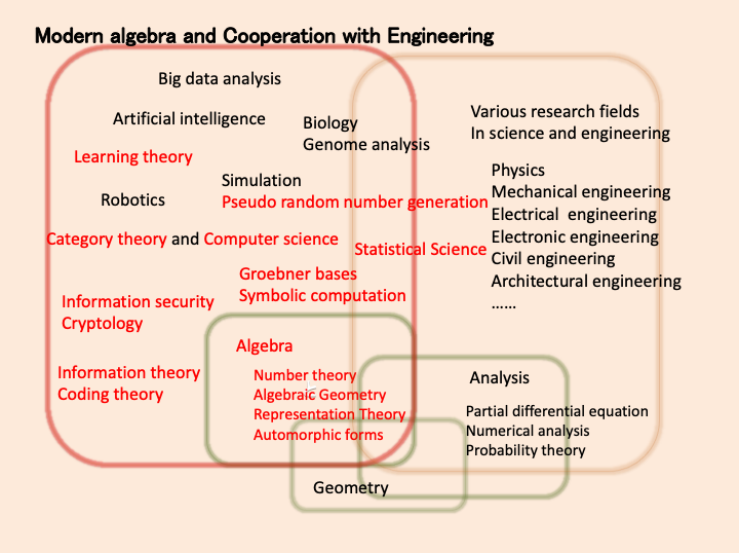

Fig. 1. Research Map.

Name	Job title	Affiliation	Main research field
Hiroyuki Ito	Professor	Department of Mathematics Faculty of Science and Technology	Algebraic geometry Applied algebra
Katsunori Sanada	Professor	Department of Mathematics Faculty of Science Division I	Ring theory
Masanari Kida	Professor	Department of Mathematics Faculty of Science Division I	Number theory
Naoko Kunugi	Professor	Department of Mathematics Faculty of Science Division I	Representation theory
Yosuke Sato	Professor	Department of Mathematical Information Science Faculty of Science Division I	Computer algebra
Hiroshi Sekigawa	Professor	Department of Mathematical Information Science Faculty of Science Division I	Computational Mathematics
Hiroki Aoki	Professor	Department of Mathematics Faculty of Science and Technology	Automorphic forms
Nobuko Miyamoto	Professor	Department of Information Sciences Faculty of Science and Technology	Discrete mathematics Combinatorial designs and their applications
Kouji Tahata	Associate professor	Department of Information Sciences Faculty of Science and Technology	Categorical Data Analysis Analysis for square contingency tables
Takao Satoh	Professor	Department of Mathematics Faculty of Science Division II	Algebra, Geometry
Katsusuke Nabeshima	Associate professor	Department of Mathematical Information Science Faculty of Science Division I	Computer algebra
Yoshitaka Hachimori	Associate professor	Department of Mathematics Faculty of Science and Technology	Algebra Number theory
Toru Komatsu	Associate professor	Department of Mathematics Faculty of Science and Technology	Number theory
Tomokazu Kashio	Associate professor	Department of Mathematics Faculty of Science and Technology	Number theory
Hisanori Ohashi	Associate professor	Department of Mathematics Faculty of Science and Technology	Algebraic geometry
Yasutaka Igarashi	Associate professor	Department of Electrical Engineering Faculty of Science and Technology	Information security Cryptanalysis
Kenta Noguchi	Associate professor	Department of Information Sciences Faculty of Science and Technology	Graph theory
Takashi Nakamura	Associate professor	Noda Division Institute of Arts and Sciences	Analytic number theory
Ayako Itaba	Junior associate professor	Katsushika Division Institute of Arts and Sciences	Algebra Noncommutative algebraic geometry
Genki Koda	Assistant professor	Department of Mathematics Faculty of Science Division I	Algebraic number theory
Yuta Kozakai	Assistant professor	Department of Mathematics Faculty of Science Division I	Representation theory
Yuki Ishihara	Assistant professor	Department of Mathematical Information Science Faculty of Science Division I	Computer algebra
Yuya Matsumoto	Assistant professor	Department of Mathematics Faculty of Science and Technology	Number Theory Algebraic Geometry
Yoshinosuke Hirakara	Assistant professor	Department of Mathematics Faculty of Science and Technology	Number Theory
Makoto Enokizono	Assistant professor	Department of Mathematics Faculty of Science and Technology	Algebraic Geometry

Fig. 2. List of Members.

3. Activity Reports

Our division promotes research through the following two styles.

a) Researchers learn deeply about a wide range of topics close to each other's specialties, share the latest research results, and incorporate useful methods for solving the problems they are pursuing.

b) We solve problems by intensively discussing and cooperating on a single problem or theme.

In 2024, we further began to fully develop the research base through collaboration with a specific research promotion project that utilizes inter-divisional collaboration between our department, Research Alliance for

Mathematical Analysis, and Division of Digital Transformation.

For style a), three research meetings (one jointly with Tohoku University) were held on topics related to each research group, and a total of 30 seminars and lectures on algebra and ring theory were held in both Kagurazaka and Noda.

On the other hand, in the method of b), we invited collaborators from outside the university to hold a series of lectures on three different topics as the central topic. In particular, the algebraic geometry and commutative algebra group invited three researchers from Japan and overseas to conduct collaborative research with related researchers.

Additionally, as part of our collaborative activities with society, we co-hosted a collaborative mathematical lecture series by business people and corporate researchers in conjunction with Research Alliance for Mathematical Analysis, and Division of Digital Transformation.

It was also good that the special articles on "Deepening and Broadening of Modern Algebra" in the April 2024 issue of Science Forum, which focused on research in the research department, was able to widely communicate research trends.

4. Challenges and Prospects

With the cooperation of the Specific Research Promotion Project, we were able to operate as a research hub for algebra in a broad range of areas. In particular, the series of lectures by leading experts in fields that seem to be trending was very well attended, as it was also held online. We would like to continue to use this as one direction.

On the other hand, due to various constraints, we feel that the wide range of fields that our division covers has not been fully realized in forming the base. As for collaboration with other fields, the series of lectures on tropical geometry and its applications held at the end of the fiscal year may be one example that could lead to new developments, but we believe that we need to provide more opportunities like this and continue to explore them. We are still exploring ways to collaborate with companies, and would like to consider future collaboration methods. Due to various circumstances, activities based on the agreement with Tohoku University were not particularly utilized in 2012, so we look forward to future activities, including personnel exchanges.

5. Conclusion

Working in collaboration with the Specific Research Promotion Project, we have made great progress in establishing the base. On the other hand, the amount of administrative work involved in planning, drafting, and implementation has increased, placing a burden on the department's researchers. It would be good to place more emphasis on international activities in the future. In addition, exchanges with applied fields are slowly but surely beginning to take shape, so we look forward to seeing this from next year onwards. The department will be established for five years from 2021 (including a two-year extension), but we would like to continue to be active in the next year as well, with an eye towards future developments.

Major Research Achievements (FY2024)

Academic Papers

1. Note on Coleman's formula for the absolute Frobenius on Fermat curves, Tomokazu Kashio, Annales de l'Institut Fourier, vol.74 no.3, 1229-1250, 2024 (Peer-reviewed)
2. Arithmetic equivalence under isoclinism, Masanari Kida, Communications in Algebra, vol 52 No.7 pp.3010-3017, 2024 (Peer-reviewed)
3. Linear recurrent sequences providing decomposition law in number fields, Hori Haruto and Kida Masanari, Ramanujan Journal, 66 Article 58, 17pp, 2025 (Peer-reviewed)
4. Relative stable equivalences of Morita type and Morita equivalences for blocks of finite groups, 刃刀直子, 鈴木香一 数理解析研究所講究録 2287 巻, 94 -- 98, 2024 年 6 月 (in Japanese)
5. Lifting of relative stable equivalences of Morita type for blocks of finite groups, Naoko Kunugi, Kyoichi Suzuki Proceedings of the 56th Symposium on Ring Theory and Representation theory, 70 - 74, 2025 年 2 月
6. On unstable twisted rational cohomology groups of the automorphism groups of free groups, Takao Satoh, Journal of Topology and Analysis, Pages 1-37, 2024 (Peer-reviewed)
7. ヴィーフェリッヒ素数の多項式の類似, 長田長龍, 武田渉, 関川 浩, 京都大学数理解析研究所講究録 2280 RIMS 共同研究(公開型), Computer Algebra―Foundations and Applications, pp. 96-103, 2024 (in Japanese)
8. 因数分解を利用した多変数多項式の decomposition, 徳田陸成, 武田 渉, 関川 浩, 京都大学数理解析研究所講究録 2280 RIMS 共同研究(公開型), Computer Algebra―Foundations and Applications, pp. 104-112, 2024 (in Japanese)
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10. Diagonals–Parameter Symmetry Model and Its Property for Square Contingency Tables with Ordinal Categories, Kouji Tahata and Kohei Matsuda, Symmetry, 16, 768, 2024 (Peer-reviewed)
11. Bayesian Predictive Probability Based on a Bivariate Index Vector for Single-Arm Phase II Study With Binary Efficacy and Safety Endpoints, Takuya Yoshimoto, Satoru Shinoda, Kouji Yamamoto and Kouji Tahata, Pharmaceutical Statistics, pp 1-14, 2024 (Peer-reviewed)
12. Generalized Marginal Cumulative Homogeneity Model for Multi-way Contingency Tables, Satoru Shinoda, Ayumu Uehara, Ryuya Yahagi, Takuya Yoshimoto and Kouji Tahata, Journal of Statistical Theory and Practice, 18, 47, pp 1-14, 2024 (Peer-reviewed)
13. Asymmetry Plus Association Models for Ordinal Square Contingency Tables, Kengo Fujisawa, Koki Makishima and Kouji Tahata, Journal of Statistical Theory and Applications, 23, pp 427–441, 2024 (Peer-reviewed)
14. Visualizing departures from marginal homogeneity for square contingency tables with ordered categories, Satoru Shinoda, Takuya Yoshimoto, and Kouji Tahata, Information Visualization, pp 1-14, 2024 (Peer-reviewed)
15. A generalized ordinal quasi-symmetry model and its separability for analyzing multi-way tables, Hisaya Okahara and Kouji Tahata, Japanese Journal of Statistics and Data Science, pp 1-26, 2025 (Peer-reviewed)
16. GDD Type Spanning Bipartite Block Designs, Shoko Chisaki, Ryoh Fuji-Hara and Nobuko Miyamoto, Journal of Combinatorial Design, to appear https://doi.org/10.1002/jcd.21976, 2025 (Peer-reviewed)
17. Li coefficients and the quadrilateral zeta function, Kajtaz H. Bllaca, Kamel Mazhouda and Takashi Nakamura, Canadian Mathematical Bulletin, 67 (2024), no.3, 860—871 (Peer-reviewed)

18. A deterministic method for computing Bertini type invariants of parametric ideals. Shinichi Tajima and Katsusuke Nabeshima. Mathematics in Computer Science, Vol.18, Article: 14, 2024 (Peer-reviewed)
19. On the radical of a polynomial ideal with parameters. Ryosuke Kuramochi, Kazuki Tanaka and Katsusuke Nabeshima. Proc. Computer Algebra in Scientific Computing (CASC 2024), Lecture Notes in Computer Science. Vol. 12865, Springer. 193--214, 2024 (Peer-reviewed)
20. Merging multiple algorithms for computing comprehensive Groebner systems using parallel processing. Natsu Wada and Katsusuke Nabeshima. Proc. Computer Algebra in Scientific Computing (CASC 2024), Lecture Notes in Computer Science. Vol. 12865, Springer. pp.373--391, 2024 (Peer-reviewed)
21. Generic Groebner basis of a parametric ideal and its application to a comprehensive Groebner systems. Katsusuke Nabeshima. Applicable Algebra in Engineering, Communication and Computing, Vol. 35, pp. 55--70, 2024 (Peer-reviewed)
22. Comprehensive standard system for generalized mixed module and its application to singularity theory. Hiroshi Teramoto and Katsusuke Nabeshima. Journal of Algebra and its Applications, Vol. 23, Issue No. 13, Article No. 2450221, 2024 (Peer-reviewed)
23. An implementation of the Suwa method for computing first order infinitesimal versal unfoldings of codimension one complex analytic singular foliations. Shinichi Tajima and Katsusuke Nabeshima. Journal of computational algebra, Vol. 10, 100015, 2024 (Peer-reviewed)
24. Spanning bipartite quadrangulations of triangulations of the projective plane, Kenta Noguchi, SIAM Journal on Discrete Mathematics,38,1250-1268 (Peer-reviewed)
25. Spanning trees for many different numbers of leaves, Kenta Noguchi, Carol T. Zamfirescu,Discrete Mathematics and Theoretical Computer Science,26:3 Paper No. 17 (8 pp) (Peer-reviewed)
26. Non-Hamiltonian Cartesian products of two even dicycles, Kenta Noguchi, Carol T. Zamfirescu,Journal of Graph Theory,108, 368-373 (Peer-reviewed)
27. Normal subgroups and support τ -tilting modules, Ryotaro Koshio, Yuta Kozakai, J. Math. Soc. Japan 76 (2025) no. 4, : 1279–1305 (Peer-reviewed)
28. Representation theory of skew braces, Yuta Kozakai, Cindy Tsang, Int. J. Group Theory 14 (2025), no. 3, 149–164 (Peer-reviewed)
29. Clifford's theorem for bricks, Yuta Kozakai, Arashi Sakai, J. Algebra 663 (2025), 765–785 (Peer-reviewed)
30. On inductions and restrictions of support τ -tilting modules over group algebras, Ryotaro Koshio, Yuta Kozakai, Symposium on Ring Theory and Representation Theory Organizing Committee, Matsumoto, 36–39 (2024)

Books

1. 特殊関数探訪（担当箇所 : 第５部内の「楕円関数とヤコビ形式」）, 数学セミナー編集部［編］ 青木宏樹 ほか２６名［著］, 日本評論社, 355 ページ中 15 ページ（302-316）担当, 2024 年 9 月 30 日発行 (in Japanese)
2. Proceedings of the SCSS 2024 Work in Progress Workshop. Katsusuke Nabeshima and Stephen M. Watt (Eds) Sun SITE Central Europe, RWTH Aachen University, 2024. http://ceur-ws.org/Vol-3754/

Invited Lectures

1. Variations on the theme of arithmetic equivalence, Masanari Kida, 第 2 回新潟代数シンポジウム, The 2nd Niigata Algebra Symposium Niigata University, 2024-11-28
2. 冪乗剰余の第二補充法則に関して, 加塩朋和, プロジェクト研究集会 2024, 伊豆長岡温泉ホテルニュー八景園, 2025(in Japanese)

3. On periods and the absolute Frobenius on Fermat curves, 加塩朋和, L-functions and Motives in Niseko2024, 北海道ニセコ町, 2024(in Japanese)
4. The Andreadakis conjecture for the McCool groups, 佐藤隆夫, 第 50 回変換群論シンポジウム, タイムズ岡山タカシマヤ 1 階 NPD 貸会議室, 2024 年 11 月 22 日.
5. The Andreadakis conjecture for the McCool groups, 佐藤隆夫, Hyperbolic Manifolds and Geometric Group Theory, 大阪大学大学院理学研究科数学教室 E404, 2024 年 12 月 8 日.
6. 無視できない欠測を含む正方分割表における対称性の検定, 田畑耕治, 統計関連学会連合大会, 東京, 2024
7. Supersingular abelian surfaces in characteristic 2 and inseparable Kummer Surfaces, Yuya Matsumoto, Theory and Applications of Supersingular Curves and Supersingular Abelian Varieties, II, RIMS (Kyoto University), 2024.
8. Inseparable Kummer surfaces, Yuya Matsumoto, Japanese-European Symposium on Symplectic Varieties and Moduli Spaces - 8th Edition, RIMS (Kyoto University), 2024.
9. 正標数の有理二重点について (in Japanese), 松本雄也, 特異点と McKay 対応, Tokyo University of Science, 2024.
10. Inseparable Kummer surfaces, Yuya Matsumoto, Arithmetic Geometry, Algebraic Geometry and Analytic Geometry — celebrating Kazuhiro Fujiwara's 60th birthday, The University of Tokyo, 2024.
11. 非分離 Kummer 曲面 (in Japanese), 松本雄也, Algebraic Geometry Seminar, The University of Tokyo, 2024
12. 有限 skew brace の表現論, 小境雄太, 山口代数セミナー, 山口大学, 2024 年 6 月 15 日 (in Japanese)
13. τ-tilting theory and silting theory of skew group algebra extensions, Yuta Kozakai, Derived categories and cotilting theory: conference honoring Jun-ichi Miyachi on the occasion of his 65th birthday, 東京学芸大学, 2024 年 9 月 19 日
14. 有限skew brace の表現について, 小境雄太, 対称性と幾何セミナー, 早稲田大学, 2025年1月10 日 (in Japanese)

Public Relations

1. 青木宏樹, 全国の大学・大学教授・大学博物館の情報サイト「学びの地図」に, インタビュー記事（経歴・研究・進学のアドバイスなど）が掲載, オンライン（web ページ）2024 年 7 月 (in Japanese)

Individual Research Topics

Hiroki Aoki

“Research on automorphic forms of several variables by using Jacobi forms ... from an explicit and constructive point of view”

I have been continuously working on the theory of automorphic forms of several variables, which is an important research topic in algebra, especially in number theory. My research is mainly from an explicit and constructive point of view. I also collaborates with my graduate students on related topics on number theory.

Hiroyuki Ito

“Deformation theory of 2-dimensional quotient singularities in positive characteristic and interdisciplinary projects”

For the research on mathematics, I studied the deformation theory of surface singularities in positive characteristic. Especially, the deformation of additive group scheme quotient singularities of purely inseparable type into finite group quotient singularities of Artin-Schreier type. In relation to purely inseparable phenomena, I classified singular fibers of quasi-hyperelliptic fibrations which are a local theory for algebraic surfaces, and obtained a theorem that derives surface invariants, which are global theories.

In addition, from the perspective of interdisciplinary fusion, as the head of the Modern algebra and Cooperation with Engineering Division, I had hosted seven domestic and international research conferences and other events through a mathematical science collaboration project with the DX Division, as well as held exchange meetings with corporate researchers.

Tomokazu Kashio

“Research on Algebraic Number Theory”

We have provided a formula that generalizes the second supplement to the law of quadratic reciprocity and Euler's conjecture. Furthermore, we investigated the relationship between Coleman's formula on the Frobenius action of the Fermat curves and CM theory, showed that the formula automatically follows from a kind of continuity of the Frobenius action.

Masanari Kida

“Coincidence of Artin L-functions”

Two number fields are said to be arithmetically equivalent if they share a Dedekind zeta function. I extended and weakened the condition by using Artin L-function. I found some examples of such fields and studied the conditions for such number fields to exist.

Naoko Kunugi

“Studies on Morita and Derived equivalences for blocks of finite groups”

When constructing Morita equivalences or derived equivalences between blocks of finite groups, there is a method of constructing and lifting stable equivalences of Morita type. In 2024, we considered relative stable equivalences of Morita type, which is a generalization of stable equivalences of Morita type, and developed a method of lifting relative stable equivalences of Morita type to Morita equivalences.We also considered images of simple modules under stable equivalences of Morita type for blocks of finite groups with metacyclic Sylow subgroups.

Takao Sato

“The Andreadakis problem for the McCool groups”

Let F be a free group of finite rank. An automorphism of F which maps each of the element of a fixed basis of F to its conjugate is called a basis-conjugating automorphism of F. All of such automorphisms form a group called the McCool group. Recently, J. Darne, N. Enomoto and I showed that the Andreadakis-Johnson filtration of the McCool group does not coincide with its lower central series.

Hiroshi Sekigawa

“Research on polynomial decomposition”

There are some advantage in application if a polynomial f can be represented by the composition as f=g(h), where g and h are polynomials. Unfortunately, almost all polynomials cannot be represented as composition of polynomials; however, a near polynomial to f that can be represented by a decomposition is sufficient for some applications. In 2024, for a multivariate polynomial f, we carried out research on algorithms to find a near polynomial to f that can be represented as a composition, where the distance between two polynomials is measured by the Hamming distance or the Euclidean distance.

Kouji Tahata

“Research on Modeling in Square Contingency Tables”

In the analysis of qualitative data, contingency tables are one of the fundamental analytical tools. In particular, when analyzing square contingency tables, where the row and column classifications are the same, the focus is on symmetry analysis rather than statistical independence. This study explores the modeling of symmetry and asymmetry in square contingency tables and its applications. Specifically, the research will investigate the following aspects: Information-theoretic interpretation of models; Properties of goodness-of-fit test statistics; Measures of deviation from the model; Application to real-world data. Through this study, we aim to contribute to both the theoretical development and practical application of analytical methods for square contingency tables.

Nobuko Miyamoto

“Construction of Mutually Orthogonal Block Sequences”

A block sequence is a partition of a set into subsets (called blocks) of equal size. Two different block sequences are said to be orthogonal if the size of the intersection between any block from one sequence and any block from the other remains constant. In this study, the problem of constructing such mutually orthogonal block sequence is reformulated as an assignment problem involving sets of points in projective geometry satisfying certain conditions, and investigates this approach.

Takashi Nakamura

Research Interests

Zeta functions, L-functions, Complex and real zeros,Multiple zeta functions and values,Functional equations, Functional relations, Riemann hypothesis.

Kenta Noguchi

“A study on graphs on closed surfaces, particularly for the connectivity, spanning subgraphs, and cycles”

Continuing from the last year, I have been doing research for graphs on closed surfaces, particularly on: graphs whose dual has low connectivity, homeomorphically irreducible spanning trees, connectivity of a spanning plane subgraph of 1-plane graphs, and cycles of polyhedrally embedded graphs.

Yoshitaka Hachimori

“Isomorphism classes of modules over Iwasawa algebra and applications to Iwasawa Theory”

I studied the set M_f of isomorphism classes of $¥Lambda$-module with characteristic polynomial f over the Iwasawa algebra $¥Lambda$. In particular, I examined a candidate of new invariant of the module which detects which element in M_f the module belongs to, and method to compute the invariant explicitly. I also tried a method to determine the isomorphism class of the chi-part of the module U/C, the semi-local units modulo cyclotomic units of the Z_p-extension of an abelian field k, especially in the case $¥chi(p)=1$.

Katsusuke Nabeshima

“Studies on computational methods of algebraic systems with parameters”

Effective computational methods for comprehensive Groebner systems and standard systems have been introduced in the context of symbolic computation. Their applications to deformations of hypersurface singularities, versal unfoldings, and several invariants of singularities have also been studied. Moreover, these computational methods have been implemented in the computer algebra systems Risa/Asir and Singular.

Yuya Matsumoto

“On inseparable Kummer surfaces”

Previously I introduced the notion of inseparable Kummer surfaces. They are not Kummer surfaces in the usual sense but have similar properties. This year, I formulated a conjecture that inseparable Kummer surfaces appear as limits of suitable families of K3 surfaces that are Kummer surfaces in the usual sense.

Division of Medical Data Sciences

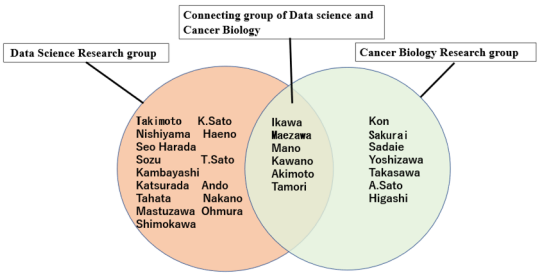
Division of Medical Data Sciences

1. Overview

The implementation of “Medical Data Sciences” is indispensable for establishing preventive and therapeutic methods for the complete cure of diseases. This research division aims to solve medical problems by combining data science methods and cancer biological experimental methods. We aim to create a Medical Data Sciences at TUS by forming international scientific network.

2. Organization and Facilities

It forms three sub-groups of interdisciplinary research fields as “Data Science Research section”, “Cancer Biology Research section” and “Connecting section of Data science and Cancer Biology”. We worked on research activities aiming at the creation of interdisciplinary “Medical Data Sciences” by broken old academic research fields.



(Data Science Research Section)

Takimoto M., Nishiyama H., Seo T., SozuT., Katsurada K., Tahata K., Matsuzawa T., Ohmura H., Sato K., Haeno H. Harada T., Shimokawa A., Sato T., Kambayashi A., Ando S., Nakano Y.

(Cancer Biology Research Section)

Kon S., Sakurai M., Sadaie M., Yoshizawa K., Takasawa R., Sato A., Higashi K.

(Connecting Section of Data science and Cancer Biology)

Ikawa T., Maezawa S., Mano Y., Kawano Y., Akimoto K., Tamori S.

We used the common facilities of the departments to which each member belongs. In addition, we used Laboratory 8 on the 3rd floor of Building No. 10 in the Noda campus. Members' own equipment was brought in as shared equipment in the experiment space. A server for data analysis was used in the server room on the second floor of Building 19. Following the relocation of the Faculty of Pharmaceutical Sciences to Katsushika campus, the server was moved from the server room on the second floor of Building 19 on the Noda Campus to the first floor of Building 9 (managed by Associate Professor Hiroshi Haeno of the Institute of Life Sciences). In order to increase the level of security when analyzing medical data from the National Cancer Center, surveillance cameras were installed in addition to the existing electronic key management system.

3. Activity Reports

In each research group, division members with initiative in each research field gathered together to work on basic research to promote “Global TUS” from the perspective of data science medicine. The overall research activities were posted on the division's website (in Japanese and English), and the Data Science Medical Research Division Symposium was held on November 2, 2024. The symposium was held entirely

in person, and was a good opportunity to seed the interdisciplinary research that this research division aims to achieve. In addition, the target diseases were expanded to include mental disorders in addition to cancer.

3. 1. Area of Data Science Research Section

I) Establishment and verification of specific data science research methods

Using our unique data science methods (AI, XAI, mutual information, PRV (Proportional reduction in variation) measure, etc.) to stratify patients using public cancer multi-omics databases, the group has isolated candidate factors for predicting prognosis, candidate molecular targets for treatment, and candidate biomarkers for late recurrence. Furthermore, using bioinformatics methods, the department has proposed a mathematical model of cancer progression that takes into account cancer-immune interactions. In order to reflect the results of the research activities in improving the education of the university, the department cooperated in the establishment of a graduate course (Graduate School of Pharmaceutical Sciences, Advanced Medical Data Science (Applied) for PhD students).

II) Collaboration with the National Cancer Center (NCC)

Regarding the “Large-scale clinical data, SCRUM-Japan MONSTER SCREEN utilization platform,” we have been working with the URA to create our university's internal regulations for Drs and students to handle NCC data. Based on this, we have concluded a contract to use KASHIWARP (December 2024) and started actual analysis. In addition, we have been working to build a cooperative system for NCC researchers in the educational aspect of our university, and three NCC-EPOC researchers gave lectures in Career Learning C (an elective course for the first half of the third year) for the Faculty of Pharmaceutical Sciences. This was a valuable opportunity for our university, which does not have a medical school or hospital.

III) Collaboration with the Jikei University School of Medicine

With the cooperation of our university's URA, we have been working on establishing a collaborative research system for “Establishing a foundation for integrating data on patients with psychiatric disorders attending the four affiliated hospitals of the Jikei University School of Medicine,” and have applied for and received approval from the Jikei University School of Medicine Institutional Review Board (IRB) for a central review, which was also approved by our university’s IRB (December 2024). In connection with this, Dr. Odaka from the Jikei University School of Medicine gave a lecture at the research department's symposium on November 2, and Dr. Akimoto gave a lecture at the 8th Jikei University School of Medicine/Tokyo University of Science Joint Symposium (December 2024), deepening the research collaboration.

III) Collaboration with other external research institutions

In a joint research project with MD Anderson Cancer Center (USA), we proposed a mathematical model of cancer progression that takes into account cancer-immune interactions. We also promoted collaboration with

the Moonshot Development Research (Prof. Shigeo Ohno at Juntendo University) and joint research with Kyoto University, contributing to the identification of biomarkers to predict future cancer from pre-disease states using data science methods, which is the main goal of this development research project. Assistant professors and young graduate students also participated in research exchange meetings and actively presented their research results. This enabled us to collaborate with cutting-edge cancer biology research at the national level. Furthermore, we promoted the establishment of a domestic and international joint research system with Juntendo University, the Beckman Institute at City of Hope (USA), and IMU (Malaysia).

3. 2. Cancer Biology Research Section

To understand the detail mechanism of the natural history of cancer, we aim to introduce data science methods into experimental methods of cancer biology. In this year, we continued to build the academic foundation for this purpose.

3. 3. Connecting Section of Data science and Cancer Biology

In order to clarify the mechanism of action in cancer progression in the natural history of cancer and to identify new molecular targets and biomarkers, we aim to integrate these approaches by introducing unconventional data science methods. This year, we have been promoting functional analysis of new molecular targets and biomarkers isolated from the perspective of xAI, statistics, and mutual information, and have been building an academic foundation by introducing mathematical models to analyze cancer heterogeneity.

4. Challenges and Prospects

By holding face-to-face symposiums, cross-disciplinary collaborative research and information exchange were possible. However, in order to widely appeal to the world the significance of research in this field at TUS, we are working on measures to strengthen collaboration with faculty members at the Katsushika and Kagurazaka campuses, collaboration with external institutions other than the National Cancer Center and the Jikei University School of Medicine, and international collaboration, as the members are biased toward the Noda campus. In addition, in order to form the foundation for future medical care that predicts and prevents diseases early and extends healthy lifespan, we will expand the target diseases from cancer to lifestyle-related diseases (diabetes, high blood pressure, arteriosclerosis, allergies, dementia, and mental illnesses). Since research aimed at the social implementation of research results is thin, we need to promote collaboration with “manufacturing research” toward social implementation, especially with the Nucleic Acid Drug Discovery Center, Division of Smart Healthcare Engineering, Research Center for Multi-hazard Urban Disaster Prevention, and Research Center for Space System Innovation. We aim to obtain large budgets based on the research division, and to present the results of joint research between division members in academic conferences and academic papers more than ever before.

5. Conclusion

Based on the research results up to this year, we aim to form a foundation and social implementation at TUS to return the results of a series of " Medical Data Sciences " research activities to society. This is expected to prevent cancer (disease), extend healthy life expectancy, and realize high QOL and social reintegration for cancer patients. Furthermore, we will create a field of " Medical Data Sciences " that has never been seen before in Japan by fusing the research fields that have developed independently, such as data science research and cancer biology research.

Major Research Achievements (FY2024)

Academic papers

1. Identification of a Gene Expression Signature to Predict the Risk of Early Recurrence and the Degree of Immune Cell Infiltration in Triple-negative Breast Cancer, Sato K, Miura K, Tamori S, Akimoto K,, Cancer Genomics Proteomics 21,316-326, 2024 (Peer-reviewed)
2. Co-expression of SLC20A1 and ALDH1A3 is associated with poor prognosis, and SLC20A1 is required for the survival of ALDH1-positive pancreatic cancer stem cells, Matsuoka I, Kasai T, Onaga C, Ozaki A, Motomura H, Maemura Y, Tada Y, Mori H, Hara Y, Xiong Y, Sato K, Tamori S, Sasaki K, Ohno S, Akimoto K, , Oncol Lett. 8(3):426, 2024 (Peer-reviewed)
3. Asymmetric cell division of ALDH1-positive cancer stem cells generates glycolytic metabolically diverse cell populations, Tamori S,Mastuda C, Kasai T, Ohno S, Sasaki K and Akimoto K, Scientific Reports. 15,13932, 2025 (Peer-reviewed)
4. Sphericity Test on Variance-Covariance Matrix with Monotone Missing Data, Tetsuya Sato, Ayaka Yagi, Takashi Seo, Journal of Statistical Theory and Practice, 19:16, 2025 (Peer-reviewed)
5. Determination of three C18-oxygenated steroids in adrenal lesion segments in primary aldosteronism by super-selective adrenal venous sampling and LC/ESI-MS/MS, Y. Mizumoto, A. Hirakawa, Y. Sugiura, T. Nishikawa, K. Nishimoto, Y. Mano, T. Higashi, BIOMEDICAL CHROMATOGRAPHY., 38 (5), e4851, 2024 (Peer-reviewed)
6. Prevalence of colonoscopy in Japan using a large-scale health claims data compared to esophagogastroduodenoscopy, Yoshida N, Maeda-Minami A, Ishikawa H, Mutoh M, Tomita Y, Kobayashi R, Hashimoto H, Inoue K, Hirose R, Dohi O, Itoh Y, Mano Y, JOURNAL OF GASTROENTEROLOGY, 59, 457-467, 2024 (Peer-reviewed)
7. Classification of Therapeutic Antibodies based on the Analysis of their Side Effects, Yuta Okumura, Satoru Goto, Masahiro Ishiguro, Megumi Minamide, Kanji Hasegawa, Yasunari Mano, Tomohiro Tsuchida, Japanese Journal of Drug Informatics, 26 (2), 57-64, 2024 (Peer-reviewed)
8. Effect of Dental Follow-Up on Dental Consultation and Checkup Rates for Patients With Diabetes: A Multicenter Before–After Study, Sekiya S, Mano Y, Suzuki T, Tanaka R, Harigai S, Shikamura Y, Cureus Journal of Medical Science, 16(12), e75145, 2024 (Peer-reviewed)
9. Characteristics of drugs with oral frailty patients among community pharmacy visitors: a cross-sectional study, Maeda-Minami A, Takashima M, Morisaki Y, Ehara S, Kato S, Saito K, Tanaka T, Shikamura Y, Mano Y., BMC Oral Health, 24(1), 1514, 2024 (Peer-reviewed)
10. Fentanyl analogs exert antinociceptive effects via sodium channel blockade in mice, Kasai S, Ogawa N, Takagi M, Takahashi Y, Makino K, Arita H, Takahashi H, Yoshizawa K, Biol Pharm Bull., 47 pp.872-877, 2024 (Peer-reviewed)
11. Further evidence for blood-to-brain influx of unconjugated bile acids by passive diffusion: Determination of their brain-to-serum concentration ratios in rats by LC/MS/MS, Shibuya T, Sato A, Nishimoto-Kusunose S, Yoshizawa K, Higashi T, Steroids, 204, e109397, 2024 (Peer-reviewed)
12. Improvement of midpoint imputation for estimation of median survival time for interval-censored time-to-event data, Nakagawa Y, Sozu T, Therapeutic Innovation & Regulatory Science 2024 (Published online) (Peer-reviewed)

13. Rationale and design of prospective, multicenter, double-arm clinical trial to investigate the efficacy of tofogliflozin on left ventricular diastolic dysfunction in patients with heart failure with preserved ejection fraction and type 2 diabetes mellitus (TOP-HFPEF Trial), Ito S, Nakajima Y, Fukuda H, Izumi C, Nakazawa G, Yamashita H, Matsuhisa H, Inoko M, Toyoda S, Takiuchi S, Kataoka T, Izumiya Y, Abe Y, Sozu T, Sakata Y, Emoto M, Inoue T, Kitakaze M, Cardiovascular Drugs and Therapy (Accepted) (Peer-reviewed)
14. Multicenter study of clinical significance of preoperative prognostic nutritional index in patients with resectable nonsmall cell lung cancer, Takahashi M, Aoyama A, Hamaji M, Sozu T, Kobayashi M, Nakagawa T, Ishikawa M, Miyahara R, Huang Cheng-long, Fujinaga T, Sakai H, Katakura H, Sonobe M, Okumura N, Kayawake H, Menju T, Miyamoto E, Miyata R, Okada H, Kono T, Sumitomo R, Date N, Fukada T, Matsumoto A, Sakaguchi Y, Date H, Surgery Today (Accepted) (Peer-reviewed)
15. Potential bias models with Bayesian shrinkage priors for dynamic borrowing of multiple historical control data, Ohigashi T, Maruo, K, Sozu, T, Sawamoto R, Gosho M, Pharmaceutical Statistics (Accepted) (Peer-reviewed)
16. Rationale and design of an exploratory, randomized, open-label, multicenter clinical trial to investigate the efficacy of long-acting β2-agonist/long-acting muscarinic antagonist on heart failure complicated by chronic obstructive pulmonary disease (COPD-HF Trial), Hayashi H, Ito S, Fukuda H, Sata M, Abe Y, Fujimoto K, Fukuda D, Hanajima Y, Horii M, Ikehara N, Inoko M, Izumi C, Izumiya Y, Nakayama T, Sozu T, Toyoda S, Watanabe M, Yokoi M, Kitakaze M, Circulation Reports (Accepted) (Peer-reviewed)
17. A Simple Negative Benchmark Generation for Safety Checking, Tsutomu Kumazawa, Munehiro Takimoto, Yasushi Kodama, Yasushi Kambayashi, In International Conference on AI-empowered Software Engineering - AIESE 2024 Formerly Joint Conference on Knowledge-based Software Engineering – JCKBSE, 2024 (Peer-reviewed)
18. Efficient Inductive Logic Programming Based on Neural Networks, Tomo Nakazawa, Moeko Okawara, Tsutomu Kumazawa, Yasushi Kambayashi, Munehiro Takimoto, Eleventh Annual Conference on Computational Science and Computational Intelligence, to appear (Peer-reviewed)
19. Multi-grain Parallel Processing of Intuctive Logic Programming, Moeko Okawara, Munehiro Takimoto, Eleventh Annual Conference on Computational Science and Computational Intelligence, to appear (Peer-reviewed)
20. Speech Synthesis from IPA Sequences through EMA Data, Koki Maruyama, Shun Sawada, Hidefumi Ohmura, Kouichi Katsurada, In Proc. APSIPA2024, 120 (2024) (Peer-reviewed)
21. Flexible Melody Harmonization with Rhythmic Complexity based on Cognitive Music Theory, Honoka Hida, Shun Sawada, Kouichi Katsurada, Takuro Shibayama, Hidefumi Ohmura, In Proc. AIMC2024 (2024) (Peer-reviewed)
22. 土田耕平, 澤田 隼, 桂田浩一, 大村英史, “J-POP アカペラアレンジにおけるシラブルの楽曲構造ごとの使用傾向と楽器との関係性の分析,” 情報処理学会, 第 142 回音楽情報科学研究会 (SIGMUS), 福岡, 2025 (in Japanese)
23. Diagonals–Parameter Symmetry Model and Its Property for Square Contingency Tables with Ordinal Categories, Kouji Tahata and Kohei Matsuda, Symmetry, 16, 768, 2024 (Peer-reviewed)
24. Bayesian Predictive Probability Based on a Bivariate Index Vector for Single-Arm Phase II Study With Binary Efficacy and Safety Endpoints, Takuya Yoshimoto, Satoru Shinoda, Kouji Yamamoto and Kouji Tahata, Pharmaceutical Statistics, pp 1-14, 2024 (Peer-reviewed)
25. Generalized Marginal Cumulative Homogeneity Model for Multi-way Contingency Tables, Satoru Shinoda, Ayumu Uehara, Ryuya Yahagi, Takuya Yoshimoto and Kouji Tahata, Journal of Statistical Theory and Practice, 18, 47, pp 1-14, 2024 (Peer-reviewed)

26. Asymmetry Plus Association Models for Ordinal Square Contingency Tables, Kengo Fujisawa, Koki Makishima and Kouji Tahata, Journal of Statistical Theory and Applications, 23, pp 427–441, 2024 (Peer-reviewed)
27. Visualizing departures from marginal homogeneity for square contingency tables with ordered categories, Satoru Shinoda, Takuya Yoshimoto, and Kouji Tahata, Information Visualization, pp 1-14, 2024 (Peer-reviewed)
28. A generalized ordinal quasi-symmetry model and its separability for analyzing multi-way tables, Hisaya Okahara and Kouji Tahata, Japanese Journal of Statistics and Data Science, pp 1-26, 2025 (Peer-reviewed)
29. Classifying MCI with rs-fMRI and deep learning, Ryosuke Minami, Narumi Yoneda, Ryo Hatano and Hiroyuki Nishiyama, Proceedings of the Joint Symposium of The Thirtieth International Symposium on Artificial Life and Robotics (AROB 30th 2025), pp. 9 – 14, 2025 (Peer-reviewed)
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Invited Lectures

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Patents

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2. Sakurai, M., Yang, Y., Nakayama, K., Okada, S., Wada, T., Sato, K., "A Novel Technique to Explore Adenosine Deamination via Inosine Chemical Labeling and Affinity Molecular Purification", PCT/JP2024/030315, (International application), 2024

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Awards

1. 瀬尾 隆, 日本統計学会賞, 一般社団法人日本統計学会, 2024 (in Japanese)
2. 薬学部薬学科６年萩原理斗（指導教員 真野泰成, 前田絢子）最優秀演題賞（ポスター発表）, 第 26 回医薬品情報学会総会・学術大会,2024 (in Japanese)
3. 松澤智史, データ解析コンペティション 敢闘賞, 日本 OR 学会, 2025 (in Japanese)
4. 安藤宗司, 優秀研究者奨励賞, 東京理科大学, 2025 (in Japanese)

Individual Research Topics

Shoma Tamori and Kazunori Akimoto

“Isolation of prognostic biomarkers by analyzing patient genomics databases using information theory" "Mathematical model analysis of cancer heterogeneity caused by asymmetric division of cancer stem cells”

We proceeded with the above two research projects. In order to establish a new methodology for identifying biomarkers that predict late recurrence at the time of diagnosis, one of the major clinical challenges, functional analysis of late recurrence prognostic biomarker candidates isolated in the previous year was conducted. In addition, we examined the characteristics of TNBC-type breast cancer. Furthermore, we isolated SLC20A1 gene as a prognostic biomarker for pancreatic cancer. In 2025, this new methodology will be applied to other cancer types and functional analysis of the isolated molecules will be conducted. In addition, the mechanism by which asymmetric cell division of ALDH1A3-positive cancer stem cells causes heterogeneity in cancer glycolytic metabolism was clarified and a mathematical model was developed. In 2025, analysis of the mechanism of acquisition of heterogeneity in lipid metabolism will be conducted in a similar manner.

Takashi Seo

“Studies of Tests for Mean Vectors and Covariance Matrices and a Test for Adequacy in Growth Curve Model with Monotone Missing Data”

This study is concerned with tests of mean vectors and covariance matrices with monotone missing data. In particular, we studied the test of a mean vector with two-step monotone missing data for two-sample problem, a test of covariance matrix when the covariance matrix has a sphericity structure, tests for sub-mean vectors, and a test for adequacy and the simultaneous confidence intervals for mean parameters in growth curve model.

“A Study of Multivariate Normality Testing Problem”

This study is concerned with test statistics and its approximate null distribution using multivariate kurtosis and multivariate skewness for the multivariate normality testing problem. An improvement of test statistic with two-step monotone missing data were discussed and a new test statistic based on the multivariate sample skewness. A numerical evaluation for normal approximation was given through Monte Carlo simulations.

Yasunari Mano

“Prevalence of colonoscopy in Japan using a large-scale health claims data compared to esophagogastroduodenoscopy”

Prevalence of colonoscopy (CS) is an important countermeasure against colorectal cancer (CRC). We used health claims data for a comparison with esophagogastroduodenoscopy (EGD) in Japan. The annual rates in 2012/2015/2019 were 3.4%/4.5%/5.3% for CS respectively and increased gradually from 2012 to 2019. Those were 7.0%/7.9%/7.4% for EGD, respectively, and did not increase. The prevalence rates of CS and EGD were 25.3% and 36.2%, respectively, among participants who had been enrolled for 8 years. Using large-scale data, we determined the status of CS and EGD in Japan.

Kazumi Yoshizawa

“Evaluation of Pain in Tumor-Bearing Mouse Models”

In this study, we evaluated cancer-related pain and changes in pain-associated factors using tumor-bearing mouse models implanted with murine cancer cell lines (LLC and B16). B16-bearing mice did not show significant changes in pain threshold, whereas LLC-bearing mice exhibited a decreased threshold. Gene expression analysis revealed higher levels of pain-related genes, such as CCL2 and COX-2, in LLC compared to B16. Additionally, the concentration of prostaglandin E2 was higher in the culture supernatant of LLC cells. These findings suggest that the release of nociceptive mediators from cancer cells may be closely associated with the severity of cancer pain.

Tsugumichi Sato

“Pharmacoepidemiological studies using medical information databases”

Pharmacoepidemiological studies using medical information databases were conducted as below: “Identifying drug-induced liver injury by machine learning”, “Evaluation of the effectiveness of orphan drugs”, “Association between uterotonics use and adverse events in mothers and children”, “Analysis of near miss reports in community pharmacies”, “Occurrence of steroid-induced glaucoma in children”, “A novel method to avoid bias in case-crossover studies”, and “Exploring of novel effectiveness of disulfiram in humans”.

Takashi Sozu

“Bayesian Methods to Accelerate Drug Development Process”

It is necessary to develop a clinical trial design that can accelerate the drug development process. This study evaluates and develops new Bayesian methods for study design and data analysis to utilize historical data, assuming the following three situations:

Situation 1: Phase I dose-finding study of a combination of two anticancer drugs

Situation 2: Clinical trials with multiple primary endpoints

Situation 3: Clinical trials utilizing historical data from multiple studies.

Munehiro Takimoto

“Parallelized Inductive Logic Programming Based on Neuro Symbolic”

In this study, I extend Inductive Logic Programming (ILP), which is a kind of logical A.I., based on Neural Network and implement a practical ILP system through making it work on GPU.

Kouichi Katsurada

“Speech synthesis from articulatory movements”

We propose two models to synthesize speech from articulatory movements which include movement of lip and tongue when producing voices. There are several methods for recording articulatory movements, but in this study, we attempted to synthesize speech sounds from articulatory movements recorded by Electromagnetic Articulography (EMA) and real time magnetic resonance imaging (rtMRI). We constructed a model to synthesize speech sounds from EMA through the International Phonetic Alphabet (IPA) and a model to synthesize speech sounds from rtMRI through the Mel-spectrogram, and confirmed that the models generated speech sounds with good sound quality.

Kouji Tahata

“Research on Modeling in Square Contingency Tables”

In the analysis of qualitative data, contingency tables are one of the fundamental analytical tools. In particular, when analyzing square contingency tables, where the row and column classifications are the same, the focus is on symmetry analysis rather than statistical independence. This study explores the modeling of symmetry and asymmetry in square contingency tables and its applications. Specifically, the research will investigate the following aspects: Information-theoretic interpretation of models; Properties of goodness-of-fit test statistics; Measures of deviation from the model; Application to real-world data. Through this study, we aim to contribute to both the theoretical development and practical application of analytical methods for square contingency tables.

Hiroyuki Nishiyama

“Classifying MCI with rs-fMRI and deep learning”

Early diagnosis of mild cognitive impairment (MCI) is crucial for effective treatment. Hence, resting-state functional magnetic resonance imaging (rs-fMRI) combined with deep learning has shown promise for MCI diagnosis. However, because the number of available rs-fMRI of possibly patients of MCI instances tends to be limited, using large amount of rs-fMRI data once is challenging, often resulting in poor generalization performance of machine learning models. Therefore, to develop high generalization model despite small dataset, we propose to use the combination of rs-fMRI data and transfer learning. Specifically, we made heatmaps about functional connectivity (FC) among regions of interest (ROI) from rs-fMRI data and used them as training and test data for the pre-trained model.

Mahito Sadaie

“Exploring Vulnerability of Telomerase-Independent Cancer and Developing Strategy to Suppress the Cancer”

Telomere maintenance is essential for cancer cell proliferation. There are two types of cancer cells: those that maintain proliferation in a telomerase-dependent manner, and those that are telomerase-independent. Telomerase-independent telomere maintenance is often observed in refractory cancers, such as sarcomas. In this study, we aim to elucidate the mechanism of action of compounds that inhibit the proliferation of telomerase-independent cancer cells and to identify novel genes that are essential for proliferation to discover therapeutic reagents for telomerase-independent cancer and therapeutic target molecules.

Tomokatsu Ikawa

“Elucidation of molecular mechanisms and search for new therapeutic targets using a mouse model of acute lymphoblastic leukemia”

It is essential to develop new treatments for refractory/relapsed acute lymphoblastic leukemia (ALL) based on elucidation of the pathogenic mechanism. We recently succeeded in creating a mouse model of ALL development using multipotent hematopoietic progenitor cells. Thus, we will elucidate the molecular mechanism of disease onset and identifying new therapeutic targets using this mouse model.

Akira Sato

"Mechanism of 5-Fluorouracil resistance via regulation of nucleic acid metabolism pathways in human colorectal cancer cells"

We examined the involvement of the regulation of nucleic acid metabolism pathways in the metabolic activation of 5-FU using 5-FU-resistant colorectal cancer cells. We showed that the downregulation of OPRT and RR, and the dependence of 5-FU metabolism on the OPRT-RR pathway contribute to the resistance mechanism against 5-FU.

Ryoko Takasawa

"Exploration and Activity Evaluation of Novel Glyoxalase I Inhibitors"

In this study, we performed *in silico* screening for GLO I inhibitor candidates by using piceatannol (IC_{50}: 0.708 ± 0.0406 μM) as a lead compound, and evaluated their *in vitro* GLO I inhibitory activity. Candidate compounds Comp1 and 2 inhibited GLO I activity in a dose-dependent manner. The IC_{50} of Comp1 was 16.1 ± 1.36 μM, and that of Comp2 was 0.824 ± 0.0845 μM. It was found that Comp1 had a weaker inhibitory effect than piceatannol, and Comp2 had an inhibitory effect equivalent to that of piceatannol. In the future, we will examine the antiproliferative and apoptosis-inducing effects of these compounds on cultured cancer cells.

Kyohei Higashi

"Functions of spermidine and eukaryotic translation factor eIF5A in cancer cell proliferation and invasion"

Long-term oral administration of spermidine (SPD) induces autophagy, resulting in the activation of aged cell functions. For this reason, SPD has attracted attention as a geroprotector. However, SPD is also involved in cancer malignancy; therefore, it is necessary to clarify the role of SPD in cancer cell proliferation in more detail. In this study, we amied to demonstrate that eIF5A2, which is hypusinated using SPD as a substrate, plays an important role in cancer-specific proliferation and explore its inhibitors.

Atsushi Kambayashi

"Research on Physiologically-based Biopharmaceutics Modeling"

Physiologically-based Biopharmaceutics Modeling (PBBM) for virtual bioequivalence (BE) simulations, physiologically-based IVIVC for modified release formulations, clinically relevant dissolution specifications, food effects on drug absorption, and drug-drug interactions in absorption process.

Keiko Sato

"Research on a metric to evaluate molecular phylogenetic trees"

Constructing phylogenetic trees based on molecular data is important not only for considering the evolution and classification of organisms, but also for understanding how genes retain information and how they transmit it to create life, which is the basis of life science. However, it is currently diffi-cult to determine which phylogenetic analysis method is most appro-priate for the target sequences, and which of the resulting phylogenetic trees best reflects the true phylogeny. This study introduces an information-theoretic metric to uniformly evaluate which phylogenetic analysis method can construct a more reliable phylogenetic tree.

Taku Harada

"A Study on the Application of Deep Reinforcement Learning to Stock Trading Considering the Trading Period"

In stock trading, it is important to consider the trading period in order to make appropriate trades. Therefore, this paper proposed a method for applying deep reinforcement learning to learn stock trading behaviors by considering the trading period. This paper evaluated the effectiveness of the proposed method through simulation experiments.

So Maezawa

"Multi-omic profiling reveals the mechanism of mammalian gametogenesis"

In recent years, in vitro gametogenesis from pluripotent stem cells has been developed to overcome infertility, particularly germ cell aplasia. However, there is a lack of efficient and reproducible methods for inducing the differentiation of functional sperm and oocytes. To develop the epigenome editing-based in vitro gametogenesis by rewriting germ cell-like epigenome into pluripotent stem cells, we here aim to clarify the epigenetic regulation during mammalian gametogenesis by multi-omics analysis. In the current fiscal year, we conducted integrative analyses of scRNA-seq and scATAC-seq data derived from mouse and marmoset testes. This analysis uncovered part of the transcriptional regulatory network that orchestrates mammalian spermatogenesis.

Masayuki Sakurai

"Studies on Deaminating Editing of Nucleotide Adenosine Bases in Evolutionary Adaptation of Organisms"

In the Central Dogma of Life, there is a mechanism that modifies the chemical structure of four types of bases in expression regulation. In this study, we are attempting to elucidate the mechanism of modification to inosine bases, which is the result of RNA adenosine base deamination reaction. We have developed a highly accurate inosine identification method and identified 30,000 inosine sites, including 17,000 novel sites, in human brain transcripts with 97% accuracy.

Hiroshi Haeno

"Elucidation of the mechanisms of aneuploidy acquisition in cancer cells"

90% of solid tumors exhibit chromosomal aneuploidy. On the other hand, it is also true that chromosomal aneuploidy poses harmful stress to normal cells. Therefore, identifying the factors necessary for cancer cells to acquire and adapt to chromosomal aneuploidy is a crucial task. Hence, we focus on the stress response induced by chromosomal aneuploidy and aim to identify the signaling pathways that are key to cancer cell survival under chromosomal aneuploidy stress, as well as elucidate how cancer cells overcome chromosomal aneuploidy stress.

Hiroshi Haeno

"Mathematical analysis of cancer development using public data on local cancer recurrence"

After surgical resection, cancer often recurs. Data on recurrence rates have been accumulated for each type of cancer, and these values vary widely among different cancer types. This suggests that the carcinogenesis in different tissues and the frequency of mutation accumulation in normal areas after resection differ among cancer types and subtypes. In this project, we aim to comprehensively elucidate tissue-specific carcinogenesis processes based on disease-free survival data for each cancer type and subtype by applying the mathematical model of carcinogenesis.

Shunsuke Kon

“Identification of cell competition marker(s) in normal epithelial cells”

In the current fiscal year, we conducted a screening using cultured cells to identify cell competition markers, which have not yet been established. As a result, THBS3 was identified as a strong candidate gene. We then analyzed the molecular behavior of THBS3 using our laboratory's established cell competition model mouse, in which mosaic induction of activated Ras mutant cells in epithelial tissue can be achieved by administering a low dose of tamoxifen. The analysis revealed increased expression of THBS3 in normal cells adjacent to Ras mutant cells, suggesting that THBS3 is upregulated specifically in normal cells during cell competition.

Asanao Shimokawa

“Construction of decision tree using prior information”

In many cases, non-parametric estimators with simple empirical distributions for covariates are used to construct decision trees. In recent years, however, advances in data collection and storage technology have meant that there is many information of covariate distribution available for model building other than learning data. Therefor, we proposed the construction method for decision trees using these prior information. The performance of the method was investigated through simulations.

Tomofumi Matsuzawa

“Study of ad hoc network routing between mobile devices”

With the development of IoT, automobiles and home appliances are now connected to the Internet, and it is estimated that the number of IoT devices will exceed about 29 billion by 2030. Current communications in mobile devices communicate with other devices via fixed devices such as base stations, but there is demand for communications that do not (cannot) use base stations, such as during disasters or congestion. We are engaged in research on routing methods that use multiple paths with maximum flow problems and fewer nodes as specific bottlenecks.

Shuji Ando

“Study on Models and Measures in Square Contingency Tables”

We proposed some new models having the structure of symmetry or asymmetry, revealed the relation between the proposed and existing models. Additionally, we proposed some measures for analyzing the degree of departure from the model. We showed that the utility of the proposed methods through the real data analyses and numerical experiments.

Hidefumi Ohmura

“Searching for applied research using sound”

I have conducted research about music and media art. I have also conducted research about communication and interaction by applying technologies in cognitive science or artificial intelligence. I will integrate and utilize the knowledges obtained through these studies to explore application studies on sound. For example, I am working on sounds for meditation in fitness and the automatic generation of sounds in an ossuary.

Yohei Kawano

“Exploratory Research for Drug Repositioning Candidate Drugs Applicable to Malignant Tumors”

Drug discovery research has been conducted by targeting abnormalities discovered in pathological or molecular biological studies. However, productivity in drug discovery research remains poor. Recently, with the development of the receipt database (medical big data), an environment has been created in which research can be conducted backward looking to track drug exposure and disease onset in humans over a long period of time. The objective of this study is to explore and find drug repositioning candidates through basic research and pharmacoepidemiological studies using medical big data.

Yoshio Nakano

“Development of therapeutic drugs for SARS-CoV-2 using infrequent sequences in human genes”

This study attempts to search for effective nucleic acid therapeutics against SARS-CoV-2. In this filed, studies have been focused on the sequence specificity of RNA, however, few studies have been conducted with off-target effects from the design stage. Therefore, to develop targets for nucleic acid therapeutics, bioinformatics is used to investigate sequences present in the SARS-CoV-2 genome and less abundant in human pre-mRNAs, ncRNAs, and mRNAs.

Division of Digital Transformation

Division of Digital Transformation

1. Overview

This research division aims to give high-performance and more accurate big data processing manners with mutual feedback between machine learning systems and statistical analyses of their results, based on mathematical foundations at various levels. They include mathematically redesigning machine learning systems and implementing highly accurate and safe AI. Eventually, they achieve highly confidential big data processing, through statistically analyzing the results generated by the systems. We believe that the challenges of this division will open new horizons for big data processing.

2. Organization and Facilities

2. 1. Research Hierarchy

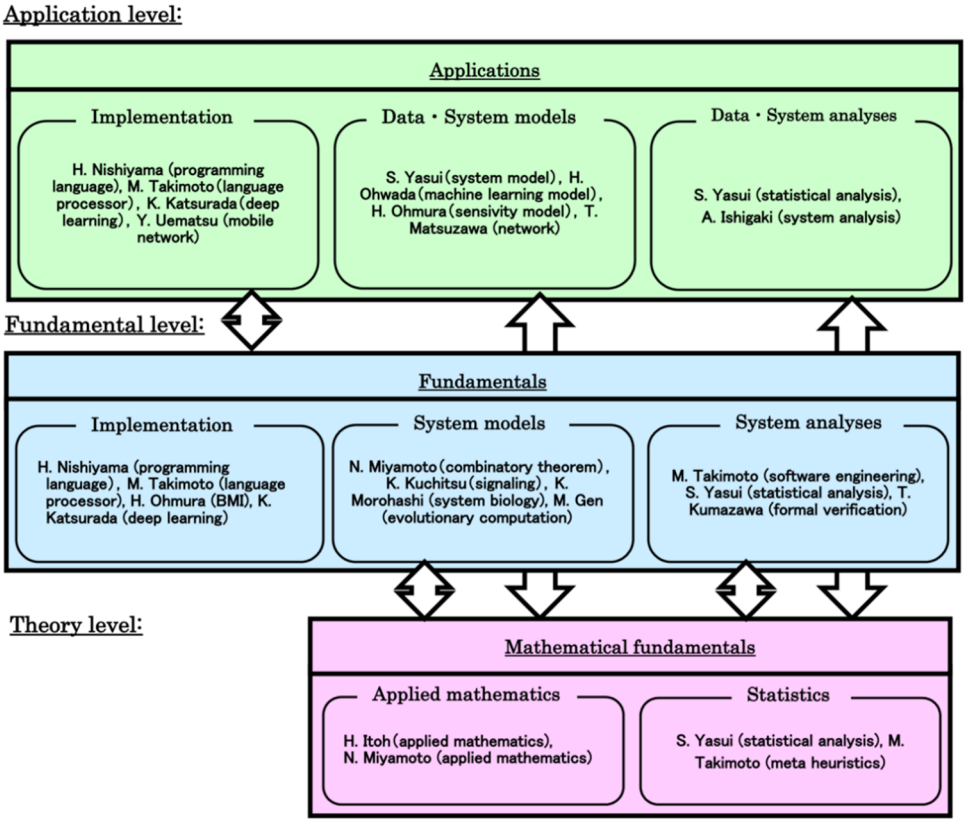

Fig. 1. Relations between research areas.

As shown in Fig.1, we address the issues of big data processing in three hierarchical levels, “applications”, “fundamentals, and “theories” as follows:

2. 1. 1. Applications

At this level, members who are specialists in each application investigate issues of the applications based on their expertise, propose approaches to solve the issues, and check the validity of results given by the solution. In the process, they give new models based on the characteristics of the applications and develop systems implementing the models. The results given by the systems are validated in mathematical methods.

2. 1. 2. Fundamentals

At this level, members directly improve the performance of fundamental techniques such as AI and machine learning and propose new approaches of them. The improvement of performance includes network performance in distributed systems and sensor networks, and the learning performance of AI through parallel and distributed techniques. The new approaches include improvements of parallelism in instruction level on GPU, improvement of accuracy of existing machine learning, and development of new machine learning models based on biological systems. The fundamental techniques and systems developed in the level are validated in mathematical methods.

2. 1. 3. Theories

At this level, members give proofs of techniques with black box parts such as deep learning and machine learning. Furthermore, through knowledges obtained in the process, they propose new methods or system models.

2. 2. Division Facilities

- GPGPU parallel computing servers

We introduced them to analyzing the relations between calves for milk cows and the manners of suckling. They consist of high-performance GPGPU machines x5, Pascal Tesla P100 (GPU: P100 x 1, CPU: 6 Cores x 2) x 3, and Pascal Titan X (GPU: Titan X, CPU: 6 Cores x 2) x 2 (Fig. 2). Currently, we are developing a new inductive logic programming that makes parallel learning available on the servers.

Fig. 2. GPGPU parallel computing servers.

3. Activity Reports

We have collected FY2024's achievements of the division members and have made proceedings in March 2025, as shown in Fig. 3. On March 19th, 2025, we held the "Tokyo University of Science Research Institute for Science & Technology (RIST) 2024 Digital Transformation Research Division Results Report Meeting" on the 6th floor of Building 7 on our Noda Campus. Besides, we participated in and jointly held the 2024 Digital Transformation Course Seminar of the Graduate School of Science and Technology, which was held on August 24, 2024. In addition, in a joint project with the National Cancer Center (NCC), we are also working with the Data Science Medical Research Division (representative: Professor Akimoto, Faculty of Pharmacy) to closely link the latest data science technology with medical data and conduct research to realize highly accurate preventive techniques and progress predictions. Moreover, a workshop (DTW: Digital Transformation Workshop) hosted by this research division will be held at the international conference PETRA (The PErvasive Technologies Related to Assistive Environments) 2025, which will be held on the island of Corfu in Greece from June 25th to 27th, 2025, with Professor Kanbayashi, a member of this division, as the representative.

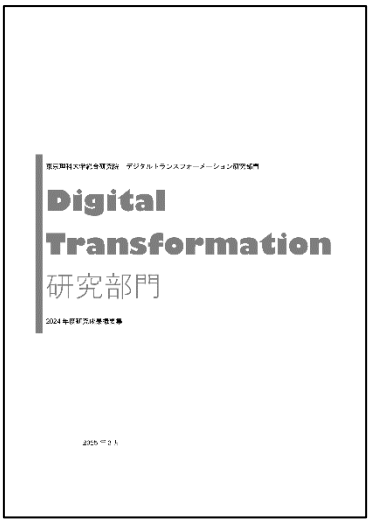

Fig. 3. FY2024's DX proceedings.

3. 1. Research Results Report Meeting

On March 19th, 2025, we held the “Tokyo University of Science Research Institute for Science & Technology (RIST) 2024 Digital Transformation Research Division Results Report Meeting” on the 6th floor of Building 7 on our Noda Campus. At this research results report meeting, we had four presentations by members of our research department to report their results, and 12 research results were reported in poster presentations. In addition to members of the research department, students participating in research from each laboratory also participated in this research results reporting session, and active discussions were held in the lecture hall and poster presentation venue with a total of 42 participants. Furthermore, after the results reporting session, a social gathering was held to further discuss the research results.

3. 2. “Medical Care Based on Cancer Genomics and Data Science”（Collaboration with NCC）Group

We have begun collaborative research at multiple levels, from improving efficiency at surgical sites to data mining of large-scale databases of cancer cases. Ethical reviews of research division members and consideration of database access conditions are almost complete, and in collaboration with the Data Science Medical Research Division (representative: Professor Akimoto of the Faculty of Pharmaceutical Sciences), we have completed preparations to share data with the National Cancer Center.

3. 3. Workshop Held at the International Conference PETRA2025

At the international conference PETRA (The PErvasive Technologies Related to Assistive Environments) 2025 to be held on the island of Corfu in Greece from June 25 to 27, 2025, Professor Kanbayashi, a member of this division, will be the representative and host a workshop (DTW: Digital Transformation Workshop) organized by this research division. A total of four papers have been accepted as research results from this research division and are scheduled to be presented at this workshop.

4. Challenges and Prospects

This research division will enter its fourth year in 2024, and held a research results presentation for the second consecutive year. In addition, our division plans to present the results of its research at a workshop it will host at the international conference PETRA2025. The joint research with the National Cancer Center is now ready to share data, and it will continue to work to translate the joint research into more concrete results. In other sub-projects, members will also work closely together to publish results and further develop the project as it approaches its final year.

5. Conclusion

Through each activity on practical application problems, members at the application, foundation and theory levels have come together to create a system for realizing a safe and secure model, and results have been achieved. As we move towards the final year, we will continue to promote the establishment of a safe and secure big data processing framework that is even more general than before, and aim to expand on individual results and project outcomes, as well as to verify those results.

Major Research Achievements (FY2024)

Academic Papers

1. A Simple Negative Benchmark Generation for Safety Checking, Tsutomu Kumazawa, Munehiro Takimoto, Yasushi Kodama, Yasushi Kambayashi, In International Conference on AI-empowered Software Engineering - AIESE 2024 Formerly Joint Conference on Knowledge-based Software Engineering – JCKBSE, 2024. (Peer-reviewed)
2. Efficient Inductive Logic Programming Based on Neural Networks, Tomo Nakazawa, Moeko Okawara, Tsutomu Kumazawa, Yasushi Kambayashi, Munehiro Takimoto, Eleventh Annual Conference on Computational Science and Computational Intelligence, to appear. (Peer-reviewed)
3. Multi-grain Parallel Processing of Intuctive Logic Programming, Moeko Okawara, Munehiro Takimoto, Eleventh Annual Conference on Computational Science and Computational Intelligence, to appear. (Peer-reviewed)
4. Speech Synthesis from IPA Sequences through EMA Data, Koki Maruyama, Shun Sawada, Hidefumi Ohmura, Kouichi Katsurada, In Proc. APSIPA2024, 120 (2024-12). (Peer-reviewed)
5. Flexible Melody Harmonization with Rhythmic Complexity based on Cognitive Music Theory, Honoka Hida, Shun Sawada, Kouichi Katsurada, Takuro Shibayama, Hidefumi Ohmura, In Proc. AIMC2024 (2024-9). (Peer-reviewed)
6. GDD Type Spanning Bipartite Block Designs、Shoko Chisaki, Ryoh Fuji-Hara and Nobuko Miyamoto, Journal of Combinatorial Design, to appear https://doi.org/10.1002/jcd.21976, 2025. (Peer-reviewed)
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13. Estimation of the Burden Factors of Order Pickers by Bayesian Network: Approach Based on Heart Rate Variability Analysis, Yurika Ono, Aya Ishigaki and Aya Saito, Proceedings of the SICE Festival 2024 with Annual Conference, 6 ページ，2024. (Peer-reviewed)
14. Analysis of the Effect for Second-hand Products' Selling Price in EC Platform by Hedonic Regression, Hiromasa Ijuin, Kazuya Ito, Aya Ishigaki, Proceedings of the 5th Asia Pacific Conference on Industrial Engineering and Operations Management, 10 ページ, 2024. (Peer-reviewed)
15. Predicting Selling Status of Second-hand Products on EC Platform Based on Morphological Analysis and Classification, Hiromasa Ijuin, Aya Ishigaki, Proceedings of the 20th Global Conference on Sustainable Manufacturing, 8 ページ, 2024. (Peer-reviewed)

16. Caching Method for Information-Centric Ad Hoc Networks Based on Content Popularity and Node Centrality, Masaki Koide, Naoyuki Matsumoto and Tomofumi Matsuzawa, Electronics, Vol. 13, No. 12:2416, pp. 1-14, Jun, 2024 (Peer-reviewed)
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18. An example of peer-to-peer network surveillance systems preventing man-in-the-middle attack, Toyonari Iwata, Shigeo Akashi and Tomofumi Matsuzawa, Proceedings of the 2024 5th International Conference on Computing, Networks and Internet of Things, pp. 650-654, Jul, 2024 (Peer-reviewed)
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42. Classifying MCI with rs-fMRI and deep learning, Ryosuke Minami, Narumi Yoneda, Ryo Hatano and Hiroyuki Nishiyama, Proceedings of the Joint Symposium of The Thirtieth International Symposium on Artificial Life and Robotics (AROB 30th 2025), pp. 9 – 14, 2025. (Peer-reviewed)
43. Estimating Difficulty of Bouldering Problems Using Skeletal Features from Climbing Videos by Regression Approach, Toshimasa Tahara, Ryo Hatano, Hiroyuki Nishiyama, Proceedings of the Joint Symposium of The Thirtieth International Symposium on Artificial Life and Robotics (AROB 30th 2025), pp. 107 – 112, 2025. (Peer-reviewed)

44. Sentiment Analysis Based on Ratings of Product Reviews Using BERT and SHAP, Takahiro Hayashi, Ryo Hatano, Hiroyuki Nishiyama, Proceedings of the Joint Symposium of The Thirtieth International Symposium on Artificial Life and Robotics (AROB 30th 2025), pp. 590 – 595, 2025. (Peer-reviewed)
45. Increase throughput of AST model by using token merging technique based on audio data features, Tomonori Mikasa, Ryo Hatano, Hiroyuki Nishiyama, Proceedings of the Joint Symposium of The Thirtieth International Symposium on Artificial Life and Robotics (AROB 30th 2025), pp. 776 – 781, 2025. (Peer-reviewed)
46. Kernel-Level Malware Analysis and Behavioral Explanation Using LLMs, Narumi Yoneda, Ryo Hatano, Hiroyuki Nishiyama, Proceedings of the 17th International Conference on Agents and Artificial Intelligence (ICAART2025), Vol. 3, pp. 443 – 450, 2025. (Peer-reviewed)

Invited Lectures

1. Exploring Molecular Mechanisms Underlying Rapid Long-Distance Signal Propagation and Information Processing in a Non-Vascular Model Plant, Marchantia polymorpha, Kuchitsu K, QBIC Small Workshop on Bio-information, Noda, 2024
2. Roles of reactive oxygen species in plant development: Growth control and immediate initial responses by nonthermal plasma irradiation, Kuchitsu K, 8th International Symposium on Plasmas & Fine Bubbles, Shanghai, China (hybrid) 2024
3. Interrelationship among calcium, ROS and electrical signals in the rapid long-distance propagation in a nonvascular liverwort Marchantia polymorpha, Kuchitsu K, EMBO Workshop Plant Calcium Signaling, Lisbon, Portugal, 2024
4. Interrelationship among Ca^{2+}, ROS and electrical signals in the rapid long-distance propagation in Marchantia polymorpha, Kuchitsu K, International Marchantia Workshop 2024, Hiroshima, 2024
5. Decentralized Information Processing in Plants, Kuchitsu K, International Joint Workshop of QP45& QBIC 2025, Noda, 2025
6. How Plants Sense and Respond to Their Environment: Living in Harmony with Nature and Harnessing Plant Potential, Kuchitsu K, JAPAN-KENYA CO-CREATION SYMPOSIUM, Noda, 2025
7. 人とロボットの協働作業で広がる生産システム工学の世界, 石垣 綾, 一般社団法人 日本機械学会 2024 年度年次大会, 愛媛大学 城北キャンパス, 2024 年 9 月 11 日. (in Japanese)
8. High-dimensional discriminant analysis under the strongly spiked eigenvalue model, Aki Ishii, RIMS Symposium “Modeling and Learning of Stochastic Dynamics, Research Institute for Mathematical Sciences, 2024.
9. Statistical inference on high-dimensional covariance structures under the SSE models, Aki Ishii, Yumu Iwana, Kazuyoshi Yata and Makoto Aoshima, 科研費シンポジウム「International Symposium on Theories, Methodologies and Applications for Large Complex Data」, Tsukuba International Congress Center, 2024.
10. Hybridizing Evolutionary Algorithm and Reinforcement Learning for Scheduling Problems, Mitsuo Gen, Invited talk, May 13, 2024: Graduate School of Management, Xi’an Jaotong University, Xian, China.
11. Evolutionary Algorithm and Q Learning for Distributed Flow-Shop Scheduling Problems, Mitsuo Gen, Invited talk, May 14, 2024: College of Economics and Management, Nanjing Univ. of Aeronautics & Astronautics, Nanjing, China.
12. High-Speed Train Scheduling Problems: Metaheuristics & Machine Learning Approach, Mitsuo Gen, Invited talk, May 15, 2024: College of Transportation Eng., Tonji University, Shanghai, China.

13. Advances in Intelligent Techniques for Robot-based Assembly Line and Scheduling Problems, Mitsuo Gen, Tutorial lecture, International Conference on Production Research in America ICPRA-2024), July 21st ~ 25th, Ohio University, Athens, USA: Online Presentation.
14. Enhancing Multiobjective Metaheuristics with Machine Learning for Scheduling: Case Study of High-Speed Train Scheduling on GPU, Mitsuo Gen, Keynote talk, Sept. 10th~12th, 2024, IEOM Asia Conference in Tokyo, Conference Center, Waseda University, Tokyo, Japan.
15. A Multi-Agent Approach for Evacuation Support Systems, Yasushi Kambayashi, IARIA Congress 2024, Porto, Portugal, July 2, 2024.
16. エージェント間通信のための動的認識論理，秦野亮，日本 OR 学会 社会と技術・システムのイノベーション研究部会 研究会, 2024. (in Japanese)

Awards

1. PC ゲームを活用したプロジェクトマネジメント演習による協働的問題解決の実践, 纐纈潤大, 石垣綾，安井清一, PC カンファレンス 2024, 学生論文賞. (in Japanese)
2. 需要の非定常変動環境下におけるベイジアンネットワークを用いた解釈性のある安全在庫量の決定, 木本翔太，石垣綾，有水大地，森山健，井對貴之, 第 23 回情報科学技術フォーラム（FIT2024）, FIT 奨励賞. (in Japanese)
3. 高齢者と若者の身体的特性の違いを考慮したオーダーピッキング作業者の負担要因の推定, 小野百合香，石垣 綾，斎藤 文, 第 23 回情報科学技術フォーラム（FIT2024）, FIT 奨励賞. (in Japanese)
4. A Proposal of the Matching Seat Allocation Model for Hot -Desking: Externalities and Complementarities, Fumikazu Hoyano, Aya Ishigaki, he 5th Asia Pacific Conference on Industrial Engineering and Operations Management (IEOM 2024), Undergraduate Research Competition, Second Place
5. 飲料販売データに基づいた日本における適正な砂糖税導出の試み, 小野百合香，纐纈潤大, 木村真心，佐藤豪栄，石垣 綾, 公益社団法人日本経営工学会 2024 年 秋季大会, Best Presentation Award. (in Japanese)
6. サプライヤ選択が持続可能なサプライチェーン構築に与える影響 ーマルチエージェントシミュレーションを用いた分析, 纐纈潤大, 成田柊介, 石垣 綾, 一般社団法人 情報処理学会第 87 回全国大会，学生奨励賞. (in Japanese)
7. 松澤智史, データ解析コンペティション 敢闘賞，日本 OR 学会, 2025. (in Japanese)
8. Tomofumi Matsuzawa, Outstanding Research Award, 5th International Conference on Computing, Networks and Internet of Things, 2024.
9. 安藤宗司, 優秀研究者奨励賞, 東京理科大学, 2025. (in Japanese)
10. 2024 - Research.com Computer Science in Japan Leader Award (Mitsuo Gen: Computer Science H-index & Awards - Academic Profile | Research.com).
11. IARIA Best Paper Award, Yasushi Kambayashi, July 4, 2024.

Individual Research Topics

Munehiro Takimoto

“Parallelized Inductive Logic Programming Based on Neuro Symbolic”

In this study, I extend Inductive Logic Programming (ILP), which is a kind of logical A.I., based on Neural Network and implement a practical ILP system through making it work on GPU.

Hayato Ohwada

“Applications of machine learning”

I focus on leveraging machine learning and deep learning techniques across various domains. My recent work includes the development of novel in silico screening systems for plant defense activators, efficient estimation of cow's location using sensor data, interpretation of arrhythmia classification, machine learning model development for selecting coils in cerebral aneurysm treatment, and real-time automatic water break detection in mares. Additionally, I have contributed to the development of machine-learning models for medical applications and automated animal behavior classification using wearable sensors. My research emphasizes practical applications of AI for solving real-world problems across agriculture, healthcare, and environmental monitoring.

Hiroyuki Ito

“Deformation theory of 2-dimensional quotient singularities in positive characteristic and interdisciplinary projects”

For the research on mathematics, I studied the deformation theory of surface singularities in positive characteristic. Especially, the deformation of additive group scheme quotient singularities of purely inseparable type into finite group quotient singularities of Artin-Schreier type. In relation to purely inseparable phenomena, I classified singular fibers of quasi-hyperelliptic fibrations which are a local theory for algebraic surfaces, and obtained a theorem that derives surface invariants, which are global theories. In addition, from the perspective of interdisciplinary fusion, as the head of the Modern algebra and Cooperation with Engineering Division, I had hosted seven domestic and international research conferences and other events through a mathematical science collaboration project with the DX Division, as well as held exchange meetings with corporate researchers.

Kouichi Katsurada

“Speech synthesis from articulatory movements”

We propose two models to synthesize speech from articulatory movements which include movement of lip and tongue when producing voices. There are several methods for recording articulatory movements, but in this study, we attempted to synthesize speech sounds from articulatory movements recorded by Electromagnetic Articulography (EMA) and real time magnetic resonance imaging (rtMRI). We constructed a model to synthesize speech sounds from EMA through the International Phonetic Alphabet (IPA) and a model to synthesize speech sounds from rtMRI through the Mel-spectrogram, and confirmed that the models generated speech sounds with good sound quality.

Nobuko Miyamoto

“Construction of Mutually Orthogonal Block Sequences”

A block sequence is a partition of a set into subsets (called blocks) of equal size. Two different block sequences are said to be orthogonal if the size of the intersection between any block from one sequence and any block from the other remains constant. In this study, the problem of constructing such mutually orthogonal block sequence is reformulated as an assignment problem involving sets of points in projective geometry satisfying certain conditions, and investigates this approach.

Kazuyuki Kuchitsu

“Elucidation of the mechanism of action of a putative plant defense activator based on large-scale analysis of gene expression patterns”

In order to better understand the mechanism of action of a putative plant defense activator we discovered recently, we conducted a comprehensive large-scale transcriptomic analysis of temporal changes in gene expression patterns associated with the activator treatment. Our results indicate that the activator can activate both the jasmonic acid pathway and the salicylic acid pathway, which are typically considered to act antagonistically, as well as stimulate specialized metabolism. These findings provide new insights into the molecular mechanisms underlying plant defense activation by this novel compound.

Aya Ishigaki

“Design and implementation of human-centric production and logistics system”

In the field of production and logistics, there is a need to design automation systems with high intelligence and autonomy that make the best use of people, machines, and technology. This year, continuing on from last year, we conducted two projects: (1) designing human-robot collaborative work that is easy for people to work in, and (2) developing a hybrid model of data-driven and field-oriented model-based approaches, and added one new theme, (3) workplace design to improve work engagement, to A human-centric production and logistics system was developed.

Hiroyuki Nishiyama

“Summary information generation technique for newborn calves using a high-speed logic-based machine learning system”

Through the utilization of a high-speed logic-based machine learning algorithm, we have successfully developed a system that applies logical rules based on the shipping weight of calves as a reference to generate summary information explaining the growth status of new calves from various data obtained through mammal robots. This study verifies the efficacy of the system by applying it to data collected from multiple dairy farms.

Seiichi Yasui

“Design of learning for data-driven problem solving”

We research educational methods to improve statistical problem-solving skills using golf as a subject. We capture and analyze data on putting behavior and analyze the factors that affect the ball rolling distance. Using the obtained findings, we aim to develop practical learning materials that enable students to acquire statistical thinking through putting golf using an educational engineering approach. By integrating behavior analysis and data-driven instructional design, we propose a new form of experiential learning that excels in comprehension and retention.

Hidefumi Ohmura

“Research on digital representation and manipulation in music and communication”

We developed a system detecting errors in musical performance based on digital sound data of musical instruments. We also developed a communication system using mixed reality combining virtual reality and reality, which solves the discord in remote communication.

Tomofumi Matsuzawa

“Study of ad hoc network routing between mobile devices”

With the development of IoT, automobiles and home appliances are now connected to the Internet, and it is estimated that the number of IoT devices will exceed about 29 billion by 2030. Current communications in mobile devices communicate with other devices via fixed devices such as base stations, but there is demand for communications that do not (cannot) use base stations, such as during disasters or congestion. We are engaged in research on routing methods that use multiple paths with maximum flow problems and fewer nodes as specific bottlenecks.

Aki Ishii

“Test for High-Dimensional Correlation Vectors”

We have developed a method for testing high-dimensional correlation vectors for high-dimensional data such as genomic data. Our method can be used as a preliminary test for estimating the correlation structure between genes and gene networks. We have developed a method for high-dimensional data that includes large amounts of noise, which cannot be handled by previous research. The method we have developed has been proven to be highly accurate theoretically, and we have demonstrated the usefulness of the method through numerical experiments and analysis of real data.

Shuji Ando

“Study on Models and Measures in Square Contingency Tables”

We proposed some new models having the structure of symmetry or asymmetry, revealed the relation between the proposed and existing models. Additionally, we proposed some measures for analyzing the degree of departure from the model. We showed that the utility of the proposed methods through the real data analyses and numerical experiments.

Ryo Hatano

“Constructive study of dynamic epistemic logic for information flow analysis”

In this study, from the perspective that “modal logic is the logic that handles the content of information”, we reconsider dynamic epistemic logic, which captures changes in the agent's epistemic state, as an extension of modal logic, which handles the flow of information. We then attempt to prove directly the completeness of the well-known Hilbert-style axiomatization and construct a new cut-free sequent calculus by providing an alternative semantics of DEL.

Kengo Morohashi

"Development of a new parallel distributed method that mimics biological systems"

To elucidate the parallel distributed processing in living organisms, I focused on the intracellular networks of living organisms. Particularly, I compared the combinations of transcription factors, and the target gene sets between the primitive land plant, *Marchantia polymorpha,* and the higher plant, Arabidopsis thaliana, to investigate the relationship between land plant evolution and transcription factor complex networks. I also investigated the dynamics of small molecules that interact with transcription factors.

Mitsuo Gen

"Research on Hybridized Algorithms using Multi-objective Evolutionary Computation and Reinforcement Learning for Real-time based Scheduling"

As a field of cutting-edge technologies aimed at automation and database in the manufacturing industry, the development of high-speed real-time based scheduling using evolutionary computation and reinforcement learning has been attracting attention, and a paper that surveyed the research and development status applied to the latest production and logistics system optimization problems.

1) Hybrid-type Multi-objective Evolutionary Computation and Reinforcement Learning-based development: In order to speed up hybrid multi-objective evolutionary computation, we developed a new evolutionary calculation method that combines traditional PSO methods with multi-directional updates, and an algorithm that combines reinforcement learning Q-learning methods, and reported and proposed it to an international journal.

2) Application of intelligence technology to the scheduling problem of robot-based assembly line/flexible job shop: A tutorial lecture was given at the ICPRA International Conference on the development of a new intelligence technology that combines the two-stage method of hybrid evolutionary computation (EDA+TLBO) into a multi-purpose FJSP (Mo-Flexible Job-shop Scheduling Problem) model, as well as the effectiveness of various FJSP numerical examples, as well as the effectiveness of multi-purpose VRP-TW problems using a multi-purpose evolutionary calculation method that incorporates the high convergence method (FCMD) for multi-way search for a Pareto optimal solution.

3) Application to sustainable logistics problems: There are many interests in research into optimal design of reverse logistics (SCLSC) that integrates closed-loop models such as reuse, reproduction, and recycling, and the development of case studies using advanced evolutionary calculation algorithms using AI for logistics and delivery problems in the Sustainable Development Goals (SDGs). As one of applied researches by metaheuristic algorithm to a case model, the production and sales of fresh foods has been published and reported in an international journal.

Yasushi Kambayashi

"A Study of an Evacuation Support System Using UAVs and Ad-hoc Networks"

We are exploring the feasibility of an unmanned aerial vehicle (UAV) system to support evacuation in mountainous areas. We focus on addressing evacuations in mountainous areas. Mountainous areas are prone to landslides caused by heavy rain. It is crucial for people there to evacuate before such disasters occur. It is also important to make them evacuate after earthquakes occur. In order to address these problems, we have proposed an evacuation support system that uses two types of UAVs. One type of UAVs, which we call monitoring UAVs, conducts road condition checks and collects information about affected individuals, while another type of UAVs, which we call guiding UAVs, guides the evacuees. The guided route is not simply the shortest path. The UAV selects the most suitable route based on factors such as route safety and congestion levels. The monitoring UAV that grasps the situation informs the guiding UAVs of the route status as needed,

allowing the guiding UAVs to dynamically adjust the evacuation route. Both UAVs share information by exchanging messages by way of a control server through ad hoc communication through an opportunistic network. We have developed a series of simulators to demonstrate the effectiveness of our system. In the previous work, the simulator setting was not realistic enough. We have improved our simulator, and the current one reflects the reality well, and gives us many insights.

Yukio Uematsu

“Toward digital transformation on mobile network”

In recent years, mobile networks, represented by 5G, have been undergoing digital transformation in term of cloudification, openness, etc. We are engaged in research and development of AI technologies (such as anomaly detection) that contribute to data management, data quality, and operations of these mobile networks.”

Tsutomu Kumazawa

“Lightweight Model Checking based on Swarm Intelligence with Multiple Swarms”

Model checking is one of the formal verification techniques of software systems. We aim to develop a novel check method based on multi-swarm Particle Swarm Optimization in order to improve the performance of model checking and comprehensibility of check results. In order to adapt multi-swarm to model checking, we decompose the whole search space of model checking into small subspaces for each swarm. We also utilize effective heuristic techniques that make model checking more lightweight and comprehensible. We finally conduct the performance evaluation by applying it to benchmark problems.

Statistical Science Research Division

Statistical Science Research Division

1. Overview

In this research division, the researchers interested in the underlying common theory gather to improve the level of study on essential theories and methods. Additionally, we aim to create new theories in the age of data science and develop new fields.

This division is composed of two research groups, “the Mathematical Statistics Basis Group” and “the Applied Statistics Research Group”, and will promote research in collaboration with the Data Science Center.

2. Organization and Facilities

This research department is roughly divided into two groups that conducts research in the following fields.

(1) Mathematical Statistics Basis Group

(Leader: Hiroki Hashiguchi (Department of Applied Mathematics, Faculty of Science Division I))

The “multivariate analysis group” comprises faculty members from Kagurazaka, Katsushika, and Noda Campuses and visiting associate professors. Focusing on the existing research themes of each faculty member, “multidimensional missing data analysis,” “high-dimensional data analysis,” “random matrix theory,” and “dimension reduction method,” we will conduct research with a view to developing the Applied Statistics Research Group. The “statistical model group” comprises faculty members from Kagurazaka and Noda Campuses and conducts research on topics such as “statistical modeling and model selection,” “nonparametric methods,” and “contingency table analysis.” The method, handled by the Mathematical Statistics Basis Group, has a clear theoretical background and acts as a white box. However, the method of solving a “real-world problem” has a black-box aspect, such as in heuristics and deep learning. In constructing the theory of AI and data science, how to clarify the black-box-like solution of the latter using the methodologies of the former, as well as other methodologies, will be asked.

(2) Applied Statistics Research Group

(Leader: Takashi Sozu (Department of Information and Computer Technology, Faculty of Engineering))

In the field of “medical statistics (biostatistics), “ the faculty members of Katsushika Campus will conduct research activities related to the methodology of research design and data analysis, focusing on medical research. In particular, the Department of Information and Computer Technology, Faculty of Engineering, has an excellent and internationally acclaimed research track record, and new research is expected through intra and inter-group interactions. Research on the development of educational methods and systems via quantitative analysis in “educational engineering” will be conducted mainly by the faculty members from Kagurazaka Campus. Additionally, in recent years, the field of “sports statistics” has been gaining attention, and the faculty members from Noda Campus and visiting associate professors are actively conducting research in this field. Moreover, we plan to conduct joint research involving student exchange programs.

Regarding the “statistical machine learning/mathematical optimization field,” research on “natural-language processing that integrates statistical/ machine learning and symbolic modeling,” “large-scale nonlinear optimization problems related to

big-data analysis and machine learning,” and “statistical methods for computer-based data mining and

pattern recognition" will be conducted mainly by the faculty members from Kagurazaka Campus.

Moreover, regarding one of the objectives of this research department, "collaboration with external institutions, such as companies, through a Data Science Center," a "data analysis team," which comprises research coordinators appropriate for each research content, will be formed, and joint research will be conducted.

3. Activity Reports

Each group conducted the following activities.

3. 1. The Mathematical Statistics Basis Group

Through the 13th, 14th, 18th, and 19th statistical science seminars, research introductions of laboratories belonging to the group, presentations of the latest research topics, and research introductions by external lecturers were conducted. At the 13th seminar, Professor N. Ejima (Kurume University) introduced research on generalized linear models and entropy. At the 14th seminar, Mr. K. Shimizu, a third-year doctoral student at the Graduate School of Science, Tokyo University of Science, presented his research results on eigenvalue distribution theory for singular beta-Wishart matrices. At the 18th seminar, Mr. H. Yamaguchi, a third-year doctoral student at the Graduate School of Science, Tokyo University of Science, presented research results on the bootstrap method for ranked set samples and equivalence tests for functional data. At the 19th seminar, Professor S. Nakagawa (Okayama University of Science) introduced research on normality tests. We also refer to "Major Research Achievements" for individual research achievements.

3. 2. Applied Statistics Research Group

The biostatistics team (Takashi Sozu and Tomohiro Shinozaki (Department of Information and Information and Computer Technology, Faculty of Engineering) and Shuji Ando (Department of Information Science, Faculty of Science and Technology)) conducted research on the study design and data analysis of medical research.

(1) Design of medical research

- Overview of model-assisted design for phase I dose-finding trials in oncology (Japanese Journal of Biometrics 2022)
- Optimal dose escalation methods using deep reinforcement learning in phase I oncology trials. (Journal of Biopharmaceutical Statistics (Accepted))
- Copula-based model for incorporating single-agent historical data into dual-agent phase I cancer trials (Statistics in Biopharmaceutical Research (Accepted))

(2) Data analysis of medical research

- Reference values for nerve conduction and coefficient of variation of R-R interval parameters in healthy subjects with normal ankle reflexes (Peripheral Nerve 2022)
- Intravenous tranexamic acid in percutaneous kidney biopsy: A randomized controlled trial (Nephron 2022)
- Identification of high-risk groups in urinalysis: Lessons from the longitudinal analysis of annual check-ups. (Healthcare 2022)

- Association of cardiac autonomic neuropathy assessed by heart rate response during exercise with intradialytic hypotension and mortality in hemodialysis patients (Kidney International 2022)
- Impact of grip strength and gait speed on exercise tolerance in patients with pulmonary hypertension without left heart disease (Heart and Vessels 2022)
- An equation to predict peak heart rate for prescribing exercise intensity in middle-aged to older patients requiring hemodialysis (European Journal of Applied Physiology 2022)
- Association of medial arch support of foot orthoses with knee valgus angle at initial contact during cutting maneuvers in female athletes: a controlled laboratory study (BMC Sports Science Medicine and Rehabilitation 2022)
- Bias amplification in the g-computation algorithm for time-varying treatments: a case study of industry payments and prescription of opioid products.（BMC Medical Research Methodology 2022）
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4. Challenges and Prospects

We will continue to conduct statistical science seminars that include graduate students and post-graduate students across campuses and departments to promote publicity activities (enhancement of the website) and a deeper understanding of each other's theoretical research. Furthermore, we are considering building an environment in which students from laboratories in other fields can also participate in seminars and other activities across campuses, leading to joint research. In addition, we will promote collaboration with the Medical Data Sciences Research Division of the Research Institute for Science & Technology, and continue to strengthen ties with the Data Science Center at the Tokyo University of Science.

5. Conclusion

Nine statistical science seminars were held jointly with the Data Science Center at the Tokyo University of Science. We plan to continue to strengthen our collaboration and conduct educational activities and joint research with external organizations such as companies that consult with us via the Data Science Center at the Tokyo University of Science. In the coming year, we will continue to aim to raise the level of research on essential theories and methods, create new theories for the data science era, and explore new fields.

Major Research Achievements (FY2024)

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2. 岩﨑拓海, 清水康希, 橋口博樹, 最大・最小固有値の比の正確分布とその数値計算, 学生研究発表賞, 日本計算機統計学会第３８シンポジウム, 2024 (in Japanese)
3. 松崎拓也, 横野光, 宮尾祐介, 川添 愛, 狩野芳伸, 加納 隼, 佐藤理史, 東中竜一郎, 杉山弘晃, 磯崎秀樹, 菊井玄一郎, 堂坂浩二, 平 博順, 南 泰浩, 新井紀子, 言語処理学会 30 周年記念論文賞, 言語処理学会, 2024 (in Japanese)
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6. 渡辺雄貴, 東京理科大学優秀研究者賞, 東京理科大学, 2024 (in Japanese)
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Individual Research Topics

Takashi Seo

“Studies of Tests for Mean Vectors and Covariance Matrices and a Test for Adequacy in Growth Curve Model with Monotone Missing Data”

This study is concerned with tests of mean vectors and covariance matrices with monotone missing data. In particular, we studied simultaneous tests of mean vector and covariance matrix, tests of covariance matrix when the covariance matrix has a structure, tests of partial mean vectors, and a test for adequacy in growth curve model with two-step monotone missing data.

“A Study of Multivariate Normality Test Problem”

We discussed the test statistics and its approximate null distribution using multivariate kurtosis and multivariate skewness for the multivariate normality testing problem. A modified normalizing transformation statistic under complete data and a new test statistic under monotone missing data were proposed. A numerical evaluation for normal approximation was given through Monte Carlo simulations.

Takeshi Kurosawa

“Study on EIV model and Robustification methods”

We considered error in variables (EIV) model and robustification methods. As for the EIV, we focus on problems in regression models and assume the situation that explanatory variables have errors. As for the robustification problems, we assume the situation that a response variable has an error, and then we estimate the regression parameters in the model correctly. Finally, we considered a robust coefficient of determination using the estimated regression parameters.

Hiroki Hashiguchi

“Study of the theory and application of random matrices”

This study is concerned with the distribution theory of eigenvalues of a random matrix and its application to the real world. In this year, we proposed a new method for calculating the null distribution for the distribution of the ratio of the maximum eigenvalue to the minimum eigenvalue, and a new method for calculating multivariate Laguerre polynomials. We also proposed an exact testing method for principal component vectors in principal component analysis.

Takuya Matsuzaki

“Study on Neural Models for Language, Speech, and Character Image Processing”

We conducted research on the properties of neural language models and diffusion models, and on the applications of these models. Specifically, we conducted basic research on domain adaptation by continual pre-training of BERT, memory and recall mechanisms in state-space models, and text generation by diffusion models, as well as research on their applications to speech synthesis, speech recognition, text image processing, machine translation, and translation of formal proofs into natural language.

Hidetoshi Murakami

“Study on the theory and application of two-sample nonparametric test statistic”

In this research, we focus on the theory and application of tow-sample nonparametric test statistic. In many applications, the assumption of specific distribution can often not be ascertained due to limited sample sizes. Then, nonparametric method is widley use to analyze data in many applications. We proposed two-sample nonparametric test statistics with theoretical properties and derived the distributions of proposed test statistics under the null and alternative hypotheses. We investigated the power of proposed statistic by simulation study and showed the validity of proposed statistic comparing with the existence statistics. We include illustrations of the proposed tests using real data.

Etsuo Miyaoka

“Study on a framework of new statistical inference”

Today, in data science with big data and machine learning, we need new framework of statistical inference. We hope that this department will be lending the field.

Michiko Tsubaki

“Study on the creation of UX and evolution of management based on the understanding of customer well-being trends”

The purpose of this study is to develop a service informatics methodology that can create customer experience value that increases Consumer Well-being by enabling companies and customers to co-create value and encourage the development of customer well-being, 1) the development of method to extract emotional customer behavior from large-scale data on customer behavior to understand superior customer experiences, and 2) Capturing the various levels of well-being behind customer emotions and extracting the conditions under which changes in customer social attributes lead to a balance between the well-being of others and one’s own well-being.

Shin Ando

“Study on Geospatiotemporal Tranformer for Crowd Flow Prediction”

In this study, we developed a transformer for crowd flow prediction, that efficiently captures geospatial and temporal dependencies. Crowd flow data, such as records of trips for on-demand and shared vehicle services are accumulated by its origin and destination locations, resulting in a higher order of complexity compared to conventional traffic records, accumulated at single locations. Furthermore, geospatial and temporal dependencies are difficult to capture with image and video processing transformers. Several new methods for self-attention and positional encoding were proposed to overcome these challenges. In the empirical study using taxi and bike-sharing datasets, our proposed methods outperformed previous state-of-the-arts.

Nobuhiko Terui

“Study on Business Data Science for Marketing Decisions”

We considered data science study on large-scale and unstructured business data for the optimal marketing decisions.

Takashi Sozu

“Bayesian Methods to Accelerate Drug Development Process”

It is necessary to develop a clinical trial design that can accelerate the drug development process. This study evaluates and develops new Bayesian methods for study design and data analysis to utilize historical data, assuming the following three situations:

Situation 1: Phase I dose-finding study of a combination of two anticancer drugs

Situation 2: Clinical trials with multiple primary endpoints

Situation 3: Clinical trials utilizing historical data from multiple studies.

Kouji Tahata

“Research on Modeling in Square Contingency Tables”

In the analysis of qualitative data, contingency tables are one of the fundamental analytical tools. In particular, when analyzing square contingency tables, where the row and column classifications are the same, the focus is on symmetry analysis rather than statistical independence. This study explores the modeling of symmetry and asymmetry in square contingency tables and its applications. Specifically, the research will investigate the following aspects: Information-theoretic interpretation of models; Properties of goodness-of-fit test statistics; Measures of deviation from the model; Application to real-world data. Through this study, we aim to contribute to both the theoretical development and practical application of analytical methods for square contingency tables.

Sadao Tomizawa

“Decomposition of Measures from Symmetry for Square Contingency Tables with Ordered Categories”

We proposed the measures to represent the degree of departure from each of symmetry, global symmetry and conditional symmetry for collapsed ordinal square contingency tables. We also gave theorem that the measure of symmetry is equal to the sum of the measure of global symmetry and that of conditional symmetry.

Yuki Watanabe

“Impact of Others’ Note-Taking Visualization on Classroom Interaction”

The purpose of this study was to investigate whether visualization of others’ note-taking promotes interaction in the classroom and improves note-taking and instruction. We developed a tablet-based note-taking support system and conducted two studies. The results showed that high school students improved their sense of classroom community and note-taking through visualization. Therefore, we found that interaction among students was facilitated. Furthermore, the visualization of class comprehension by the system allowed the teacher to change the instruction in class, which could improve the students' understanding of the content. Thus, we suggested that the visualization promotes interaction between the teacher and the students.

Toshiya Iwashita

“Testing procedure for elliptical symmetry based on a random matrix distributed over the Stiefel manifold”

The joint distribution of Studentized residuals based on sample drawn from (multivariate) elliptical population is uniformly distributed over the Stiefel manifold. By making use of this property, we try to develop methods to test elliptical symmetry by transformations of random matrix.

Hiroshi Yabe

“Study on numerical methods for nonlinear optimization”

We considered numerical methods for solving nonlinear optimization problems. We proposed a proximal structured quasi-Newton method based on the Broyden family for unconstrained minimization of a composite function whose Hessian matrix has a special structure, which includes LASSO, and we showed its global convergence. Furthermore, we dealt with a trust-region sequential quadratic programming method with a nonsmooth merit function, and we analyzed the convergence to a second-order critical point.

Asanao Shimokawa

“Construction of decision tree using prior information”

In many cases, non-parametric estimators with simple empirical distributions for covariates are used to construct decision trees. In recent years, however, advances in data collection and storage technology have meant that there is many information of covariate distribution available for model building other than learning data. Therefor, we proposed the construction method for decision trees using these prior information. The performance of the method was investigated through simulations.

Tomohiro Shinozaki

“Statistical causal inference using epidemiologic and clinical data”

In this research project, we are conducting theoretical studies on the identification of statistical models based on the counterfactual potential outcome model to uniformly handle not only clinical trial data but also observational study data without experimental interventions. Specifically, we are interested in statistical inference theory for the optimal treatment regimes, which involves selecting treatment policies tailored to individual patients, particularly adaptive treatment selection based on clinical progression.

Wanwan Zheng

“Study on square packing problem”

Given a set of squares and a strip with bounded width and infinite height, we consider a square strip packaging problem, which we call the square independent packing problem (SIPP), to minimize the strip height so that all the squares are packed into independent cells separated by horizontal and vertical partitions. For the SIPP, we propose a compact representation and prove the problem is NP-hard. We then propose a dynamic programming method that can be extended to a fully polynomial-time approximation scheme (FPTAS). We also propose three mathematical programming formulations based on different solution representations and confirm their performance through computational experiments with a mathematical programming solver.

Shuji Ando

“Study on Models and Measures in Square Contingency Tables”

We proposed some new models having the structure of symmetry or asymmetry, revealed the relation between the proposed and existing models. Additionally, we proposed some measures for analyzing the degree of departure from the model. We showed that the utility of the proposed methods through the data analyses and numerical experiments.

Aki Ishii

“Test for High-Dimensional Correlation Vectors”

We have developed a method for testing high-dimensional correlation vectors for high-dimensional data such as genomic data. Our method can be used as a preliminary test for estimating the correlation structure between genes and gene networks. We have developed a method for high-dimensional data that includes large amounts of noise, which cannot be handled by previous research. The method we have developed has been proven to be highly accurate theoretically, and we have demonstrated the usefulness of the method through numerical experiments and analysis of real data.

Ayaka Yagi

“Study of Test on Variance-Covariance Matrix with Monotone Missing Data”

We obtained research results on the sphericity test of variance-covariance matrices with monotone missing data for a one-sample problem. For this hypothesis testing problem, we give an asymptotic expansion of the distribution function under the null hypothesis. Furthermore, we derive approximate upper percentiles and a modified likelihood ratio test statistic that improves the approximation to the χ^2 distribution. In particular, we have shown via Monte Carlo simulation that the proposed approximate upper percentile has good approximation accuracy to the likelihood ratio test statistic, even when the sample size is small.

Koki Shimizu

“Study on the Application of Eigenvalue Distributions of Random Matrices in Deep Learning”

Over-parameterized deep neural networks (DNNs) often suffer from poor generalization performance. In this study, we discussed the low-rank approximation of DNN weight matrices, which are the sum of a signal and noise matrices, by removing the singular values of the noise matrix. We proposed a metric based on Random Matrix Theory (RMT) to assess the singular value threshold for the decomposition of the weight matrix.

Tomohiro Ohigashi

“Development of a methods for using external data in clinical trials for rare diseases via nonparametric Bayesian methods”

In clinical trials for rare diseases, conducting randomized controlled trials with a sufficient number of participants is difficult. To address this issue, the use of external data has received attention. Although several methods for using external data have been proposed, a standard approach has not yet been established. In this study, nonparametric Bayesian methods are developed that consider potential differences between the populations in external data and the current control data. Additionally, the study aims to address an existing limitation: current methods require strong assumptions when the response variable is time-to-event..

Kento Egashira

“Study on k-means for high dimensional data”

We investigated the asymptotic properties of the k-means within the high-dimensional framework. We derived sufficient conditions under which the probability of the k-means yielding incorrect clustering results converges to zero for high-dimensional data. Based on these theoretical results, we proposed a bias correction to the k-means for high dimensional data.

Tomotaka Momozaki

“Development of fast and scalable Bayesian inference algorithms for massive data.”

In this era of big data, massive data containing more information than previously available can now be easily obtained, but on the other hand, traditional statistical analysis methods cannot withstand the enormous data size and analysis is difficult. Bayesian inference, which can evaluate the uncertainties in the estimation results and provide information necessary for decision-making, is no exception. The aim of this research is to develop a Bayesian inference algorithm that can withstand massive data. We aim to do this by developing statistical models that are easy to handle even with large data sets, and by approximating the models and improving the computational algorithms.

Hikaru Yamaguchi

“Study on Linear Rank Statistics in the Presence of Ties”

In nonparametric rank tests, some theoretical properties are discussed under the assumption of continuity of the population distribution. However, ties may frequently occur in the discretized continuous data because measurement instruments are not arbitrarily precise. In this study, we derived the moment-generating function of a vector of tie-adjusted linear rank statistics and provided a moment-based approximate distribution of a proposed test based on tie-adjusted linear rank statistics. Furthermore, we showed the usefulness of this approximation method through numerical experiments.

Takayuki Shiohama

“Study on statistical analysis on geometric manifold”

We considered statistical analysis of the data that took values on a specific geometric manifold. Such geometric manifolds include a circle, a torus, a cylinder, and a space of their joint probability distributions. In the 2023 academic year, we studied statistical inference for cylindrical distributions and their parameter estimation. We also studied the statistical analysis of stationary time series models whose spectral density has a skew-circular distribution on a circle.

Takahiro Nishiyama

“Study on Statistical Hypothesis Testing Procedures in Diverse Situations”

With the advancement of information technology in recent years, the importance of developing new statistical analysis methods that can handle realistically diverse situations that may arise has increased.

In this study, we aim to develop theories and methodologies for statistical hypothesis testing problems, especially in situations where conventional statistical theories cannot be applied.

Takahiro Nishiyama

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With the advancement of information technology in recent years, the importance of developing new statistical analysis methods that can handle realistically diverse situations that may arise has increased.

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Tamae Kawasaki

“On the tests of normality based on the kurtosis”

We discussed the multivariate kurtosis newly proposed by Miyagawa et al. (2011) based on the two measures of multivariate kurtosis defined by Mardia (1970) and Srivastava (1984). Specifically, we calculated the expected values of multivariate sample kurtosis by assuming the structure of several variance-covariance matrices, with the aim of deriving normalized transformation statistics.

Kazuyuki Koizumi

“Research on data science theory and applications”

In recent years, as data collection and storage have become easier, there has been a growing trend of utilizing previously unavailable data to gain new insights. Accordingly, the field of data science is expected to advance both in theory and application. This research aims to develop and improve theoretical methodologies, as well as to conduct applied studies in several domains, with a particular focus on areas such as sports and law.

Tomoyuki Nakagawa

“Study on Statistical Analysis Methods for Large-Scale and Complex Data”

With the advancement of computing technology, it has become possible to obtain large-scale and complex data. However, there are many situations where existing analytical frameworks cannot be applied. In this study, we addressed various challenges such as model misspecification, high dimensionality, and spatial correlation, and developed a framework for valid statistical inference using divergence and generalized Bayesian Inference. Furthermore, we applied our approach to oceanographic and medical data to verify its effectiveness. Most of these results are currently under review for publication in international academic journals.

Division of Nanocarbon Research

Division of Nanocarbon Research

1. Overview

The Division of Nanocarbon Research is engaged in the elucidation of novel physical properties associated with carbon nanotubes, graphene and related materials. In addition, the division aims to establish new materials science based on the utilization of nanoscale spaces within carbon nanotubes and their interactions with biomolecules.

A defining feature of this division is the close collaboration among specialists in various fields—including theoretical and experimental condensed matter physics, electrical engineering, thermal engineering, and biophysics—all of whom are conducting advanced research on nanocarbons. Through active exchange of information and interdisciplinary cooperation, the division promotes a comprehensive research framework that spans from fundamental studies to applied developments in the field of nanocarbon science.

2. Organization and Facilities

Within the wide range of fields related to nanocarbon, we aim to develop distinctive research mainly in the following areas (Fig. 1).

2. 1. Materials Sciences in Nanospace

We use an individual single-walled carbon nanotube as a well-defined nanospace, and study the interactions between nanotubes and molecules such as water and alcohol by optical spectroscopy, electron microscopy and molecular dynamics simulations. Thereby, we elucidate the structure and phase of the molecules in the nanospace. We also study the interaction between nanotubes and polymers, aiming at application of polymer-nanotube composites.

We regard systems composed of nanotubes with adsobates or defects as extended composites, and study the basic properties by first-principles electronic state calculations and model calculations.

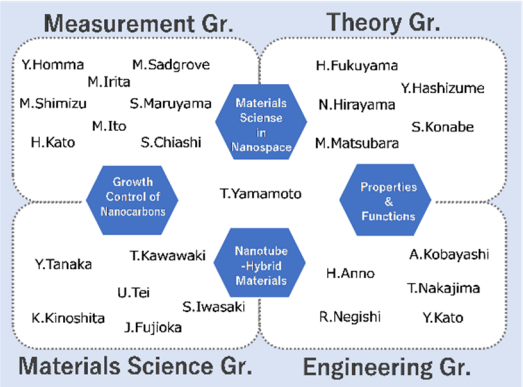

Fig. 1. Configuration of the Division

2. 2. Nanocarbon-Hybrid Materials

We study structural properties of composites composed of nanotubes and biomolecules (DNA, protein). Specifically, we fabricate biodevices with nanotubes functionalized by DNA, and examine whether the structural properties of the biomolecules are retained, and whether the molecular recognition function is retained.

We theoretically investigate the host-guest interactions of the nanotube/biomolecule composites, and clarify the effect on the properties of the composites.

2. 3. Growth Control of Nanocarbons

We develop techniques for precise structural control of nanocarbons based on the various nanotube synthesis techniques such as vertically-aligned growth on silicon and silica substrates and horizontally-

aligned growth on quartz substrate.

We study novel synthesis methods of nanocarbons utilizing arc discharge by changing the discharge ambience, electrode materials, etc. We also study novel methods for graphene synthesis.

2. 4. Properties and Functions

We develop the physics of energy conversion based on nanocarbons and its application. We establish the basic science for nanocarbon-based paper electronics.

3. Activity Reports

3. 1. Measurement Group

Evaluation of the Morphology and Thermoelectric Properties of Carbon Nanotube Thin Films

Buckypapers (BPs) were fabricated using carbon nanotubes (CNTs) synthesized by the e-DIPS and super-growth methods, and their thin-film morphology and thermoelectric properties were evaluated. For the BPs, the optimal composition exhibiting the highest electrical conductivity and Seebeck coefficient was identified by varying the content ratio of CNTs derived from the e-DIPS method (Irita).

Optical Measurement of SWCNT

Papain, a proteolytic enzyme, can reduce oxidized CMC-SWCNTs. In addition, papain is thermally denatured at high temperatures but does not lose its enzymatic activity. We confirmed that even with heat-denatured papain, it can reduce oxidized SWCNTs. In addition, four new different proteolytic enzymes have been added to SWCNTs and evaluated by photoluminescence measurements. (Ito)

Thermoelectric measurement of carbon nanotubes

We have authored a research paper on a technique that utilizes nitrogen-vacancy (NV) centers in nanodiamonds as nanoscale thermometers. This measurements were conducted under atmospheric conditions at room temperature. To broaden the range of experimental conditions, we have developed a new setup incorporating a vacuum chamber capable of low-temperature measurements, equipped with terminals for both electrical and temperature measurements. (Shimizu)

3. 2. Materials Sciense Group

Highly active Pt/CNT catalysts for the oxygen reduction reaction (ORR) were fabricated by introducing carbon defects into single-walled and multi-walled carbon nanotubes (SWCNTs and MWCNTs) via argon plasma etching, followed by platinum sputtering conducted in the same batch without air exposure.

The ORR activity increased with longer etching time in both SWCNT- and MWCNT-supported systems. In particular, the SWCNT-based catalyst exhibited ORR activity surpassing that of the standard catalyst (TEC10E50E, TKK). In addition, the catalyst also demonstrated favorable catalytic performance toward the hydrogen evolution reaction (HER). (S. Iwasaki and Y. Tanaka)

We carried out irradiation experiments on carbon composite fiber reinforced plastic (CFRP) using the Kyoto University infrared free electron laser to investigate the parameters of surface modification. As a result, we found parameters that remove only the epoxy resin from the surface layer without damaging the underlying carbon fiber. In the future, we search for wavelengths for processing each component and construct a processing method that suppresses thermal damage. (Fujioka)

Evaluation of ionic liquid penetration mechanism into nanoporous metal-organic frameworks

Metal–organic frameworks (MOFs), with their highly ordered porous structures and large specific surface areas, have attracted attention for a wide range of applications, including adsorption, separation, catalysis, and energy storage. However, experimental studies on molecular transport within MOFs have been challenging due to unavoidable environmental influences, such as moisture adsorption and crack formation caused by MOF hydrolysis under ambient conditions. In this study, to eliminate the effects of atmospheric moisture, ionic liquids (ILs) were dropped onto the MOF surface, and their penetration behaviour into the MOF interior was observed and evaluated. At room temperature, the influence of the alkyl side-chain length of IL cation molecules was investigated. It was found that as the alkyl chain length increased, ILs no longer penetrated the MOF. Conversely, when shorter side chains were used, penetration was observed; however, in all cases, the time dependence of penetration did not follow the classical capillary action or molecular diffusion model (i.e., $z(t) \propto \sqrt{t}$), but rather showed a linear relationship with time ($z(t) \propto t$). Furthermore, when ILs were intentionally hydrated and the same experiments were conducted, an increase in water content led to enhanced penetration rates, while still maintaining the linear time dependence ($z(t) \propto t$). These results highlight the unique characteristics of IL penetration into MOF nanopores and suggest the necessity of developing a new penetration model to accurately describe this behaviour. (Kinoshita・Zheng)

Moisture-Induced Degradation Mechanism in Metal–Organic Frameworks

Metal–organic frameworks (MOFs) are known to suffer from structural degradation due to the cleavage of metal–ligand bonds induced by water aggregation inside pores. Understanding the interactions between water and MOFs has become an urgent issue. Previously, we have successfully developed MOFs with enhanced durability and moisture resistance by introducing ionic liquids (ILs) into their pores. Near-Edge X-ray Absorption Fine Structure (NEXAFS) experiments were conducted at the Sendai facility to analyse the bonding states of MOFs before and after moisture exposure, as well as after IL incorporation. The results revealed that water molecules inside the pores interact with the coordinatively unsaturated metal sites (open metal sites, OMS) of the MOF, leading to the reduction of the metal centres and the weakening of metal–ligand bonds. Furthermore, it was found the introduced ILs preferentially occupy the OMS, thereby preventing water molecules from accessing the metal sites, and significantly enhancing the MOF's humidity resistance. This study demonstrates that the incorporation of ILs not only prevents moisture-induced degradation of MOFs but also contributes to the improvement of their physicochemical properties and functionalities. (Zheng)

Metal-organic frameworks (MOF) are expected to be used in gas sensors due to their high gas adsorption performance, but their poor electrical conductivity limits their application. In this study, we presented the first successful attempt to contain carbon nanotubes (CNT) into single crystals of $Cu_3(btc)_2$, one of representative MOFs. This approach allowed for the evaluation of physical properties free from grain boundary effects, thereby enabling the investigation of conductivity improvement. The evaluation of physical properties confirmed that CNT can add electrical conductivity to MOF without modifying their pore structure. These results suggest supplying CNT to MOF single crystals can improve electrical conductivity while retaining the inherent gas adsorption properties of the MOF, suggesting the potential for the development of high-speed and highly sensitive sensors. (Kinoshita・Zheng)

In our laboratory, we have succeeded in easily synthesizing Pt nanoclusters with a particle size of about 1 nm in air by reducing platinum (Pt) using polyol reduction and then adding ligands. By adsorbing the obtained Pt nanoclusters onto carbon nanotubes (CNTs), which have excellent durability and conductivity, we have prepared an oxygen reduction reaction (ORR) catalyst that is more active and durable than commercially available catalysts. Furthermore, by using an ORR catalyst in which Pt nanoclusters supported

on a carbon black support are modified with melamine, we have succeeded in further increasing activity and durability. (Kawawaki)

3. 3. Engineering Group

By embedding carbon nanotubes (CNTs) on a polyimide substrate and forming a three-dimensional kirigami structure, we developed a flexible device capable of thermoelectric power generation on both flat and curved surfaces. The device detects thermal anomalies in proportion to the CNTs' thermoelectric output and, with an integrated piezoelectric sensor, successfully achieves battery-free wireless transmission of vibration anomalies. (Nakajima)

We developed a technique to epitaxially grow metal nitride thin films using the sputtering method. By measuring the optical properties, as well as the electron density and mobility of the nitride films, we identified the optimal fabrication conditions for thin films with properties suitable for artificial optoelectronic synapses. Furthermore, devices were fabricated by microfabrication techniques, and the potential application of nitride thin films as artificial optoelectronic synapses was demonstrated.（Kobayashi）

We have studied carrier control in electric double layer transistor (EDLT) thermoelectric devices with semiconducting CNTs as the channel layer. We fabricated an EDLT thermoelectric device with a semi-permanently polarized ionic liquid solid electret as a gate insulating layer on a flexible substrate and confirmed its operation. We also found that p-type CNTs can be converted to n-type by high-temperature vacuum heat treatment. Hybridization of these n-type CNTs with n-type inorganic thermoelectric materials was investigated. (Anno)

We developed an infrared high-temperature furnace operable under a reactive gas (ethanol) environment, and the synthesis of multilayer graphene via a solid-template-based thermal reduction method was investigated. In this study, graphene oxide (GO) sheets were used as the solid template. When thermal reduction was conducted at temperatures exceeding 1400 °C under an ethanol gas environment, a significant improvement in the crystallinity of the resulting graphene was observed. This enhancement in crystallinity was found to be attributable to the formation of additional grown graphene islands on the GO surface, induced by homoepitaxial growth. (Negishi)

We conducted a fundamental experiment on olfactory receptors (artificial olfactory cells) used in "advanced olfactory sensing" to detect illegal drugs by smell. As a material, we used polypyrrole, which exhibits conductive properties, and created organic conductive particles using ZrO_2 particles as a dispersant. This nano-ink was applied to an olfactory receptor chip, and the resistance was measured when ammonia was introduced as an odorant. The results confirmed a certain level of effectiveness as an olfactory sensor. This achievement was presented at The 14th Asian Symposium on Printing Technology. (Yasuo Kato)

3. 4. Theory Group

We derived a formula for the emissivity of transition metal dichalcogenides (TMDs), which are atomically thin materials, and investigated how their thermal radiation properties depend on the density of doped carriers. As a result, we found that thermal radiation mediated by exciton-polarons can occur. This type of radiation has an extremely narrow linewidth compared to blackbody radiation, making it a promising candidate for applications such as thermophotovoltaic power generation. (S. Konabe)

This year, we began studying the temperature dependence of carrier transport properties, such as electrical conductivity, Hall coefficient, and Hall mobility, in n-type doped Mg_2Si. In collaboration with Professor Yasutomo Kajikawa (Shimane University), we found that the experimental data for these properties can be explained using a parabolic band model with an effective mass $m=0.596m_0$ (where m_0 is the free electron

mass) , as obtained from our previous work. We also analysed the temperature dependence of scattering effects from ionized impurities, acoustic phonons, and polar optical phonons, and submitted the results for publication. (Hirayama)

Devices employing novel materials such as carbon nanotubes are being developed by members of this project. Our team has been analyzing signal data obtained from these devices. In this year, we successfully identified and formulated a geometric framework for describing the process of order formation, based on the previously proposed KL divergence method. This approach is currently being applied to the study of time evolution in non-equilibrium processes. (Hashizume)

To optimize the dimensionless thermoelectric figure of merit ZT, we analyzed high-ZT materials GeTe- and Mg_3Sb_2-based compounds. Maximizing ZT requires not only enhancing the power factor but also reducing the thermal conductivity, particularly the lattice thermal conductivity κ_{ph}. However, accurately evaluating κ_{ph} remains challenging. By applying the Sommerfeld–Bethe formula to experimental data, we successfully estimated the lattice thermal conductivity and found that not only the size of the grains but also their shape strongly influences κ_{ph}.. (Matsubara)

4. Challenges and Prospects

The platinum nanocluster supported catalysts prepared in this study using CNTs or CB as supports have an issue in that the particle size increases, especially at high Pt loadings. It is necessary to devise a new type of catalyst support or a new preparation method. (Kawawaki)

Although a prototype of an artificial optoelectronic synapse was fabricated this term, the techniques to control the bandgap and carrier concentration of the thin film have not yet been established, and the desired photoresponse could not be achieved. We will continue to optimize the deposition process with the aim of realizing properties suitable for practical applications. (Kobayashi)

Quantitative evaluation of defect formation at the interface between the carbon support and Pt particles has not been achieved in our gas-phase preparation of Pt/C oxygen reduction reaction (ORR) catalysts.

To elucidate the effect of Pt atoms adsorbed on C defects (referred to as ‘V-site Pt’) on the properties and catalytic activity of Pt particles, it is necessary to quantitatively evaluate 'V-site Pt' using synchrotron radiation in the future. (S. Iwasaki and Y. Tanaka)

To verify whether proteolytic enzymes act on CMC or on SWCNTs, by using different proteolytic enzymes, we will evaluate from chirality dependence and other factors. (Ito)

Optimization of thermoelectric properties of EDLT-type thermoelectric devices with semiconductor CNTs as the channel layer and an electret with fixed ionic liquid polarization as the gate insulating layer will be investigated. Control of gate voltage (electric field strength), optimization of ionic liquid to polymer ratio, thermal stability, etc. will be investigated. In the creation of hybrids of inorganic nanoparticles and CNTs, we will continue to investigate the interaction between inorganic materials and CNTs and its effect on thermoelectric properties by density functional theory calculations using the nonequilibrium Green's function method. (Anno)

In the present study, we demonstrated that highly crystalline graphene layers can grow on graphene oxide (GO) template via van der Waals epitaxy. In fiscal year 2025, we aim to elucidate the formation mechanism of graphene islands by clarifying the growth mode and activation energy for nucleation through controlled driving forces via adjustment of the growth gas pressure. This understanding will serve as a foundation for the development of broadband electronic devices utilizing the linear dispersion of graphene. (Negishi)

A geometric formulation for the time evolution of general non-equilibrium processes has not yet been achieved, and further investigation will be continued. (Hashizume)

This year, we continue to conduct laser processing experiments on carbon composite materials using the wavelength-tunable Kyoto University Infrared Free Electron Laser (KU-FEL), and will conduct processing experiments on carbon fibers in the lower layer of CFRP to suppress thermal damage. At the same time, we plan to elucidate the reaction mechanism by chemical analysis of the generated gas. (Fujioka).

It was demonstrated that liquid penetration into the interior of MOFs does not follow the conventional Washburn law, indicating that the process is governed by a different physical mechanism. The infiltration rate was found to be strongly dependent on the molecular size of the liquid. Moving forward, a systematic evaluation of infiltration behaviour will be conducted by varying parameters such as measurement temperature, the molecular structure of the ionic liquid (IL), and the structure and dimensionality of the MOF. Through this approach, the interactions between MOF nanopores and IL molecules can be further elucidated. (Kinoshita・Zheng)

Although a correlation between moisture-induced degradation of metal–organic frameworks (MOFs) and the weakening of metal–ligand bonds due to interactions between water molecules and metal sites has been suggested, a theoretical understanding of the degradation mechanism remains incomplete. Moving forward, first-principles molecular dynamics simulations based on density functional theory (DFT) will be employed in conjunction with experimental studies to analyse the water adsorption process and to investigate how interactions between ionic liquids (ILs) and MOFs affect structural stability. Furthermore, we plan to evaluate the impact of IL incorporation on the gas adsorption properties of MOFs—specifically, whether the presence of ILs reduces performance, or conversely, whether it enhances functionality. These investigations aim to support the development of performance-optimized MOFs for practical applications. (Zheng)

The dispersion of CNT within the MOF single crystal given by using the present growth method is low, hindering the elucidation of intrinsic physical properties of CNT@MOF single crystals. We will establish a single-crystal synthesis method that enables the fabrication of MOF single crystals with a high degree of CNT dispersion. We will investigate the interactions between CNT and MOF within CNT@MOF single crystals and proceed toward their application to gas sensing devices. (Kinoshita・Zheng)

We will further investigate the relationship between phonon scattering and the morphology of the material.(Matsubara)

This year, we constructed a setup capable of operating under vacuum as well as at both low and high temperatures. Although the setup for electrical and temperature measurements was completed this year, we will re-examine the method of applying microwaves for temperature measurements using diamond NV centers, with the aid of simulations. In addition, we will conduct thermos measurements on carbon nanotubes with various chiralities.(Shimizu)

We will analyse the ionicity and ionisation energy of semiconductor materials. Our previous studies showed that optical phonons significantly affect the transport properties of Mg_2Si. To better understand optical polarons, we will analyse the Fröhlich coupling constant and ionicity by the first-principles methods. (Hirayama)

We plan to advance a demonstration project for monitoring applications through collaboration within the division using either a battery-free anomaly-diagnosis system powered by CNT-based thermoelectric generators or a hybrid version that incorporates a supplemental battery (Nakajima).

The platinum nanocluster supported catalysts prepared in this study using CNTs or CB as supports have an issue in that the particle size increases, especially at high Pt loadings. It is necessary to devise a new type of catalyst support or a new preparation method.(Kawawaki)

5. Conclusion

Researchers from different fields belonging our university, including physics, chemistry, materials, mechanics, data science, and architecture, collaborated to investigate the thermoelectric, catalytic, and filtering effects of nanocarbon materials, and actively engaged in research from basic science to social implementation. In particular, a new form of industry-academia collaboration with ZEON Corporation was started last year and has produced many important results. It is worth mentioning that many of these results have led to patent applications.

Major Research Achievements (FY2024)

Academic Papers

1. Identification of Two-Dimensional Interlayer Excitons and Their Valley Polarization in $MoSe_2/WSe_2$ Heterostructure with h-BN Spacer Layer, H. Kim, H. Wan, Y. Wan, K. Shinokita, K. Watanabe, T. Taniguchi, S. Konabe, K. Matsuda, ACS Nano, 19, 322 (2025) (Peer-reviewed)
2. Exciton-Polaron Thermal Radiation in Two-Dimensional Semiconductors, S. Konabe, Optics Letters, 50, 77, 2024 (Peer-reviewed)
3. An Atomically Precise Pt17 Nanocluster: Their Electronic Structure and High Activity for A Hydrogen Evolution Reaction, K. Oiwa, K. Ikeda, R. Kurosaki, K. Sato, N. Nishi, H. Tachibana, M. A. Haque, T. Kawawaki, K. Iida, Y. Negishi, J. Mater. Chem. A, in press (Peer-reviewed)
4. Ligand-Dependent Intracluster Interactions in Electrochemical CO_2 Reduction Using Cu14 Nanoclusters, Y. Shingyouchi, M. Ogami, S. Biswas, T. Tanaka, M. Kamiyama, K. Ikeda, S. Hossain, Y. Yoshigoe, D. J. Osborn, G. F. Metha, T. Kawawaki, Y. Negishi, Small, 202409910, 2024 (Peer-reviewed)
5. Suppression of Pt Nanocluster Aggregation and Enhanced Oxygen Reduction Activity by Heteroatom Doping of Carbon Nanotubes, M. A. Haque, R. Kurosaki, K. Oiwa, K. Ikeda, K. Sato, N. Nishi, H. Tachibana, T. Kawawaki, Y. Negishi, ACS Appl. Energy Mater. 7, 10137-1-325 (2024) (Peer-reviewed)
6. Near-Infrared Photoluminescence Responses of Single-Walled Carbon Nanotubes Induced by Biomolecules Detected on a Microbead Surface, Y. Tachikawa, M. Ito, M. Irita, T. Harada, and K. Umemura, ACS Omega 9, 44734 (2024) (Peer-reviewed)
7. Near-infrared photoluminescence responses of single-walled carbon nanotubes induced by biomolecules detected on a microbead surface, Yoshiki Tachikawa, Masahiro Ito, Masaru Irita, Takunori Harada, Kazuo Umemura, ACS Omega, 9，44, pp 44734-44740, 2024 (Peer-reviewed)
8. Polypyrrole-ZrO2 hybrid synthesis and adaptability to the olfactory sensor, Kaiki Noma, Yukihiro Tsugita, Yasuo Kato, Shuichi Maeda., The 14th Asian Symposium on Printing Technology in Ho Chi Minh City, Vietnam (ASPT 2024)
9. Infrared free electron laser-irradiated polyleucine does not exert aggregates-induced aversive effects on mouse brain, Mori A, Shiroishi T. Fujioka J, Nakajima T, Mitsui S, Suginoma H, Kakuta Y, Zen H, Nakamura K, Brain Disorders, 14 巻 pp 100137-1~11, 2024 (Peer-reviewed)
10. 圧電性高分子を用いた振動エネルギーハーベスティング，中嶋宇史，日本画像学会誌, 63 巻, pp 168-175, 2024 (in Japanese) (Peer-reviewed)
11. 三元スクッテルダイト $CoGe_{1.5}S_{1.5}$ の電子構造と熱電特性，阿武宏明，山陽小野田市立山口東京理科大学紀要，第 8 号，pp 61–67, 2025 (in Japanese) (Peer-reviewed)
12. nfluence of perturbative intertube interactions on ballistic and quasi-ballistic phonon transports in double-walled carbon nanotubes, T. Shiga, Y. Terada, T. Kodama, S. Chiashi, Int. J. Heat Mass Transfer, 233, 126030 (2024) (Peer-reviewed)
13. Molecular Dynamics of Catalyst-Free Edge Elongation of Boron Nitride Nanotubes Coaxially Grown on Single-Walled Carbon Nanotubes, K. Hisama, K. V. Bets, N. Gupta, R. Yoshikawa, Y. Zheng, S. Wang, M. Liu, R. Xiang, K. Otsuka, S. Chiashi, B. I. Yakobson, S. Maruyama, ACS Nano 18, 31586-31595 (2024) (Peer-reviewed)
14. Multifractality and Hyperuniformity in Quasicrystalline Bose–Hubbard Models with and without Disorder, Masahiro Hori, Takanori Sugimoto, Yoichiro Hashizume, and Takami Tohyama, JOURNAL OF THE PHYSICAL SOCIETY OF JAPAN, 93, 114005, 2024 (Peer-reviewed)

15. 境界誘起型非平衡量子系での流れとエントロピーの関係，鈴木秀則，橋爪洋一郎，日本大学歯学部紀要, 52, 1-10, 2025 (in Japanese) (Peer-reviewed)
16. Sommerfeld–Bethe Analysis of ZT in Inhomogeneous Thermoelectrics, M. Matsubara, T. Yamamoto, and H. Fukuyama, J. Phys. Soc. Jpn., 94, 024601 (2025) (Peer-reviewed)
17. Thermoelectric measurements of nanomaterials by nanodiamond quantum thermometry,Maki Shimizu, Koki Sugimoto, Yasuto, Applied physics express, 9 巻　pp 095001,2024 (Peer-reviewed)
18. Structure and dynamics of adsorbed water on carbon nanotubes: a molecular dynamics simulation, Yuki Maekawa, Yusei Kioka, Kenji Sasaoka, Yoshikazu Homma, and Takahiro Yamamoto, Jpn. J. Appl. Phys. 63, 085002-1-7, 2024 (Peer-reviewed)
19. Ultralow-Temperature Sintering of Titanium Powder by Spark Plasma Sintering Under Cyclic Pressure, N. Manabe, A. S. Suzuki, M. Ninagawa, H. Wakabayashi, N. Hirayama, K. Niinobe, Y. T. Tang, S. Utada, D. G. McCartney, R. C. Reed, and H. Kitagawa, Advanced Engineering Materials 26, 2400965, 2024 (Peer-reviewed)
20. Melt growth of crystalline α-SrSi2 by the vertical Bridgman method and its thermoelectric characteristics, H. Kunioka, S. Iida, K. Kimura, Y. Shioya, Y. Hiraoka, Y. Imai, N. Hirayama, and T. Iida, Journal of Crystal Growth 645, 127838, 2024 (Peer-reviewed)

4 others

Books

1. 表面処理, 分散・複合化技術と産業応用事例, 根岸良太, 神田哲志, 小林慶裕, 第 9 章 第 5 節 (2024 年) (in Japanese)

Invited Lectures

1. 配位子保護金属クラスター表面の理解と光電気化学的触媒反応への応用,川脇徳久,第 18 回分子科学討論会　京都大学吉田キャンパス　2024 年 9 月 (in Japanese)
2. Precise Synthesis of Ligand-Protected Metal Nanoparticles and Nanoclusters for Photoelectrochemical Applications, Tokuhisa KAWAWAKI, International Congress on Pure & Applied Chemistry (ICPAC) Mongolia 2024, Holiday Inn Ulaanbaatar Conference Center, Ulaanbaatar, Mongolia, August, 2024
3. 粒径 1nm 白金ナノクラスターの燃料電池カソード電極触媒としての応用, 川脇徳久, 日本 MRS 水素科学技術連携研究会 2024 年度前期研究会　山梨県立図書館　2024 年 6 月 (in Japanese)
4. バッテリーレス・バッテリー混載型エネルギーハーベスティング異常診断システム, 中嶋宇史, 2024 年度 第 2 回 EHC 総会, 早稲田大学, 2024 (in Japanese)
5. M. Matsubara, Exploring high-performance thermoelectric materials based on linear response theory, Workshop on Recent Theoretical Advances in Thermoelectrics, NIMS, Namiki Site, WPI building (Tsukuba, Japan), 2024/12/11
6. Energy and environmental applications of fullerene nanowhiskers, Kun’ichi Miyazawa and Yumi Tanana, Graphene and Carbon Nanostructure Meetings (GMGCN2024), (2024. 6. 20) WEB

Patents

1. 伊勢健冬, 中嶋宇史, 山添雄介, 圧電ケーブルユニット, 及び検知システム, 特願 2024-158574, 2024 (in Japanese)
2. 伊勢健冬, 中嶋宇史, 山添雄介, 圧電ケーブル, 及び検知システム, 特願 2024-158575, 2024 (in Japanese)

3. 中嶋宇史, 佐藤智浩, センシング装置, 特願 2024-144567, 2024 (in Japanese)
4. 犬塚理奈, 山本貴博, 内田秀樹, 西浦憲, 吸着材および吸着カラム, 特願 2024-150322, 2024 (in Japanese)
5. 小林遵栄, 山本貴博, 内田秀樹, 西浦 憲, 熱電変換素子, 特願 2024-164341, 2024 (in Japanese)

Public Relations

1. 田中優実, “新, 研究室紹介; 東京理科大学 工学部工業化学科 田中研究室”, 日本セラミックス協会誌「セラミックス」,59[10],pp.708-709(2024.10)
2. 山本貴博, Newton 別冊「量子力学 100 年」, (2024 年) (in Japanese)
3. 山本貴博, Newton 6 月号「熱電変換の物理学」, (2024 年) (in Japanese)

Awards

1. Atsushi Kobayashi, Masaru Hori Prize 2025, ISPasma, 2025
2. 本間芳和, 令和６年度産業標準化事業表彰（イノベーション・環境局長表彰）, 経済産業省, 2024 (In Japanese)

Individual Research Topics

Takahiro Yamamoto

"Quantum transport in nanocarbon"

We investigate theoretically and numerically quantum transport in nanocarbons and related materials as well as interaction between nanocarbon and water molecules.

Hidetoshi Fukuyama

"Theory of thermoelectrics of nanocarbon materials"

We investigate theoretically thermoelectric property of nanocarbons using Kubo-Luttinger formula.

Yoshikazu Homma

"Research on physical properties and structural evaluation of nanocarbon materials"

Using scanning electron microscopy (SEM) and spectroscopy, we investigate the structure and physical properties of novel nanocarbon materials. By combining these with the results of molecular dynamics simulations, we will elucidate the interactions between nanocarbon materials and other substances and molecules.

Yumi Tanaka

"Study on the effect of carbon suppots on activity of Pt/carbon-based oxygen reduction catalyst"

Two kinds of Pt/carbon ORR catalysts were prepared by Pt sputtering on g-KB and dg-KB, the former is ketjen black in which a graphite structure had been developed by calcination at 2400°C under He and the latter is the "g-KB" in which the defects were introduced by argon plasma etching treatment, and the ORR activities were compared to investigate the effect of differences in crystallinity of carbon supports on the ORR activity of Pt. As a result, Pt/dg-KB showed higher activity than Pt/g-KB, indicating that the defect introduction into carbon supports with a well-developed graphite structure contributed to the improvement of ORR activity of Pt/C catalyst.

Takashi Nakajima

We develop a scanning thermoelectric response microscope based on current measurement method and clarify the functional properties of CNTs that encompass multilevel nature. We also fabricate thermoelectric power generation devices based on the flexible Kirigami structure and construct an anomaly detection system that can operate without batteries.

Mark Paul Sadgrove

"Study on chiral coupling between nano-optical fibers and SWCNTs"

At Sadgrove lab, single wall carbon nanotubes (SWCNTs) are combined with optical nanofibers of waist diameter ~500 nm. The optical nanofibers have the property of mode chirality – that is, left and right propagating modes in the nanofiber have opposite circular polarizations. Working together with Prof. Homma (TUS) and Prof. Shimizu (Saitama Univ.), the aim of the research is to interface the optical nanofiber mode chirality with the structural chirality of SWCNTs. By achieving this goal, the Sadgrove group plans to make new non-reciprocal optical devices, and new methods of isolating and analyzing single SWCNTs.

Yoichiro Hashizume

“Pioneering technology for processing information obtained from thermoelectric devices”

The fabrication of devices using new materials such as carbon nanotubes is currently conducted by the members of this project. We, therefore, investigate a more efficient analysis of the information obtained by such devices. In particular, it is necessary to develop two methods; the first is the imputation method of missing information caused by signal instability, and the second is security robustness. To meet these needs, we focus on an analysis method using information entropy, called Kullback-Leibler divergence (KL divergence).

Tokushisa Kawawaki

In polymer electrolyte fuel cells, which are attracting attention as a clean power generation system, the oxygen reduction reaction (ORR) occurs at the cathode electrode. This reaction is the rate-limiting step, and a large amount of platinum (Pt) catalysts are currently used. In this study, we aim to prepare a more active ORR catalyst and reduce the amount of Pt used by adsorbing fine Pt nanoclusters on highly conductive carbon supports.

Manaho Matsubara

“Study on optimization of thermoelectric properties of low-dimensional materials”

Using Kubo-Luttinger theory, we will investigate the thermoelectric performance of low-dimensional thermoelectric materials, e.g., carbon nanotubes and graphene, furthermore, we will clarify the optimization conditions for their thermoelectric performance.

Masaru Irita

“Research on thermal properties of single-walled carbon nanotubes and their applications”

We aim to establish a nanoscale thermal control technology by measuring the thermal properties of single-walled carbon nanotubes (SWCNTs) using photoexcitation emission and Raman spectroscopy. In addition, we are working on research and development of optical isolators using SWCNTs and related devices.

Hiroaki Anno

“Research on creation of nanocarbon thermoelectric conversion device materials”

The objective of this study is to develop stable p- and n-type carbon nanotubes (CNTs) for application in thermoelectric conversion devices. Two approaches will be pursued: creation of hybrids consisting of inorganic nanoparticles, CNTs, and organic matrices, and creation of charge-injected CNT thermoelectric devices. The improvement of thermoelectric properties will be advanced by controlling and optimizing inorganic nanoparticles, organic matrix, hybrid structure, electric double-layer transistor structure, and the amount of carrier injection.

Shigeo Maruyama

“Synthesis and application of one-dimensional heterostructures”

One-dimensional heterostructures have been realized using single-walled carbon nanotubes (SWCNTs) as templates, with boron nitride nanotubes and transition metal dichalcogenide nanotubes formed on the outer layers. CVD synthesis of various 1D heterostructures and elucidation of their synthesis mechanism, electronic, optical, thermal, and mechanical properties, and various device applications will be discussed.

Satoshi Konabe

“Theory of Thermal Radiation in Low-Dimensional Nanomaterials”

We theoretically investigate the thermal radiation properties of atomically thin materials such as carbon nanotubes and transition metal dichalcogenides.

Shohei Chiashi

“Fabrication of novel structures of nanocarbon materials and evaluation of their physical properties”

We develop structural control synthesis techniques for nanocarbon materials, including single-walled carbon nanotubes (SWCNTs) and graphene, as well as nanostructuring techniques that combine them with other nanomaterials, such as hexagonal boron nitride (layered structures, junction structures, etc.), and to explore and elucidate their physical properties. We will improve the fabrication techniques for hetero-NTs made of different layers, molecule-encapsulated NTs, and NT thin films made up of these networks and discover new physical properties with the aim of applying them at the nanoscale and microscale.

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Ryota Negishi

“Study on sysnetsis and carrier transport property analysis of multilayer graphene”

We explore a scalable synthesis method of turbostratic multilayer graphene material. To achieve this goal, we develop an ultra-high temperature heating system using an infrared heating furnace. By introducing reactive gas using ethanol and hydrogen gases, we will synthesize highly crystalline of turbostratic multilayer graphene. We will reveal the structural and electrical properties of synthesized multilayer graphene using quantum Hall, angle-resolved photoemission spectroscopy and absorption spectrum.

Hiroki Kato

“3D analysis of nanocarbon composite material”

Three-dimensional (3D) analysis using focused ion beam (FIB) – scanning electron microscope (SEM) will be performed on carbon nanotube composite.

Naomi Hirayama

“Theoretical Analysis of Thermoelectric Carrier Transport at Finite Temperatures”

This study focuses on thermoelectric semiconductors such as Mg_2Si and aims to theoretically analyse thermoelectric properties at finite temperatures. Based on experimental data, we will clarify the effects of various carrier scattering mechanisms involved in the transport processes using first-principles calculations.

Maki Shimizu

“Thermoelectric measurement of carbon nanotubes”

We will develop a method for measuring the thermoelectric properties of a single carbon nanotube using nitrogen-vacancy (NV) centers in diamond, and to clarify its thermoelectric characteristics.

Masahiro Ito

“Study on emission from SWCNT adding polymers.”

The effect of polymers on single-walled carbon nanotubes is evaluated for each chirality using a near-infrared photoluminescence measurement system and a near-infrared microscope.

Jun Fujioka

“Research on Highly Efficient Processing of Carbon Composite Materials”

Carbon composite materials are composed of several materials with different coefficients of thermal expansion (epoxy resin and carbon fiber), and laser processing is not easy. We have been searching for the optimum wavelength for difficult-to-process resins and studying the chemical reactions that occur during processing using the Kyoto University infrared free electron laser, with the aim of achieving highly efficient processing of resins.

Kentaro Kinoshita

“Elucidation of the interaction between metal-organic framework pores and ionic liquids”

A composite material (IL-MOF) in which an ionic liquid (IL) is introduced into the nanopores of a metal-organic framework (MOF) exhibits interesting physical and chemical properties that cannot be achieved with either MOF or IL alone. In order to establish material design guidelines for IL-MOF, we have to clarify the interaction between MOF pores and IL.

Zheng Yumeng

“Elucidation of the Moisture-Induced Degradation Mechanism of MOF and CNT-MOF Interactions for Device Applications”

We elucidate the interaction between metal-organic frameworks (MOFs) and moisture. The mechanism behind the enhanced moisture resistance of MOFs filled with ionic liquids is focused.

“Elucidation of interaction between carbon nanotubes (CNTs) and metal-organic framework (MOF) in CNT@MOF for application to gas sensing devices”

Containing carbon nanotubes (CNTs) into metal-organic framework (MOF) single crystals can add electrical conductivity to MOF. We plan to advance elucidation research on the interaction between CNT and MOF in CNT@MOF for the application of CNT-MOF composites in the development of high-sensitivity sensing devices.

Suguru Iwasaki

“Synthesis of polymorph using anisotropic ion diffusion control”

We plan to synthesize polymorph of inorganic materials based on introduction and extraction of ion species using anisotropic ion diffusion control technique. Polymorph is a family of materials with the same hemical composition but different crystal structure, and the control of polymorph can contribute to develop a new functionality.

Yasuo Kato

“Development of Chemical Olfactory Receptors for Advanced Olfactory Sensing”

Continuing from the previous year, I will once again take on the challenge of developing new devices using nanoscale materials. However, this year, I have decided to shift the research focus toward addressing social issues. Specifically, I will conduct experiments to examine the feasibility of using polypyrrole (PPy)—a type of organic polymer formed through the polymerization of pyrrole—to develop “chemical olfactory receptors” capable of detecting substances such as illegal drugs by their distinctive odors.

Atsushi Kobayashi

“Epitaxial Growth of Novel Functional Transition Metal Nitride Thin Films”

This research promotes the integration of functionalities in semiconductor, superconductor, and ferroelectric thin film materials through material design based on crystal growth. In particular, it focuses on enhancing the quality and functionality of thin film materials that contribute to the development of emerging technologies such as quantum computers, quantum information and communication, power electronics, and next-generation semiconductors for AI computing.

Nano Quantum Information Research Division

Nano Quantum Information Research Division

1. Overview

In the field of quantum information, research toward the realization of quantum computers has been actively advancing around the world in recent years. In our division, we are conducting research in three research areas: superconducting quantum circuits, quantum optics, and quantum information theory. It is expected that the emergence of error-tolerant quantum computers by 2050, and the research division intends to contribute to its realization. Research on superconducting qubits with its good integration potential and operability is currently the most advanced physical system. Physical systems other than superconductivity, such as light, ions, cold atoms are also being actively studied. In our research division, we study quantum system not only with superconducting qubits, but also with optical qubits and spin qubits.

2. Organization and Facilities

The division mainly consists of a superconducting quantum circuit research group, a quantum optics research group, a quantum information research group, and a visiting group.

Since FY2020, the research group for superconducting quantum circuits has been conducting research on the theme of "research and development of bosonic codes using superconducting resonators" in the government funded Moonshot Project. The Superconducting Quantum Circuits Group (Tsai and Yoshihara Laboratory) possesses the following facilities:

Refrigerant-free dilution refrigerator LD250 (Bluefors)
Refrigerant-free dilution refrigerator LD400 (Bluefors)
Vector Network Analyzer 2 units N5231B (Keysight)
Two high-frequency arbitrary waveform generators and real-time observation devices,
M9010A, M9048B, M9023A, M3102A, M3202A (Keysight Technology)
High-speed, high-sampling arbitrary waveform generator, M8195A (Keysight)

The quantum optics research group aims to combine single rare earth atoms with nanofiber optic resonators, and carbon nanotubes to optical fibers. Joint research with the University of Tokyo is currently underway.

The Quantum Information Theory Research Group has traditionally conducted research on quantum information theory, starting from the late Professor Oya. 202 It also hosted an international conference in this field. On the other hand, we are also conducting research to cover the theoretical aspects of superconducting quantum circuits.

3. Activity Reports

3. 1. Superconducting Quantum Circuits Research Group (Tsai, Yoshihara)

We are conducting research aimed at realizing superconducting quantum computers and quantum simulators. Here, one-way quantum computers and gate-model quantum computers are considered. Superconducting qubit possesses a high degree of freedom in the circuit design and ability to local control as well as readout quantum states.

Bosonic code, which is relatively easy to correct errors in quantum computers, protects quantum information from errors by taking advantage of the infinite number of degrees of freedom of the resonator. We are conducting research on Cat Qubit, which realizes Cat code, which is one of the practical bosonic codes, using a car parametric oscillator (KPO) using superconducting circuits. By generating a cat state with a two-dimensional KPO circuit (image1 and 2) and evaluating the fidelity using a quantum tomography method, we succeeded in realizing a universal quantum gate that can operate 1-bit and 2-bit gates.

In the 2-bit circuit, we used the unique properties of KPO to generate an entangled cat state in two ways. The first method is to convert the entangled state (bell state) based on the Fock state to the entangled cat state. In the second method, a $\sqrt{\text{iSWAP}}$ gate is added to two independent cat states to create an entangled cat state.

These results indicate that the planar superconducting KPO circuit successfully developed in this study has the potential to become a new platform of scalable quantum information processing

Al-based Josephson junctions are used in most superconducting quantum computers. However, Al-based Josephson junctions (Al/AlOx/Al) may limit the coherence time of quantum circuits due to the existence of a microscopic two-level system in the tunnel barrier of aluminum oxide. In this context, epitaxial Josephson junctions using NbN/AlN/NbN have been developed. This is promising because of its good crystallinity and resistance to oxidation due to its nitride nature. However, there are few studies of qubits based on NbN/AlN/NbN Josephson junctions. In addition, the relationship between circuit parameters and coherence characteristics has not been investigated.

We have identified circuit parameters and have characterized the coherence properties of an asymmetric SQUID transmon based on NbN/AlN/NbN Josephson junctions (Figure). The sample was fabricated by the National Institute of Information and Communications Technology.

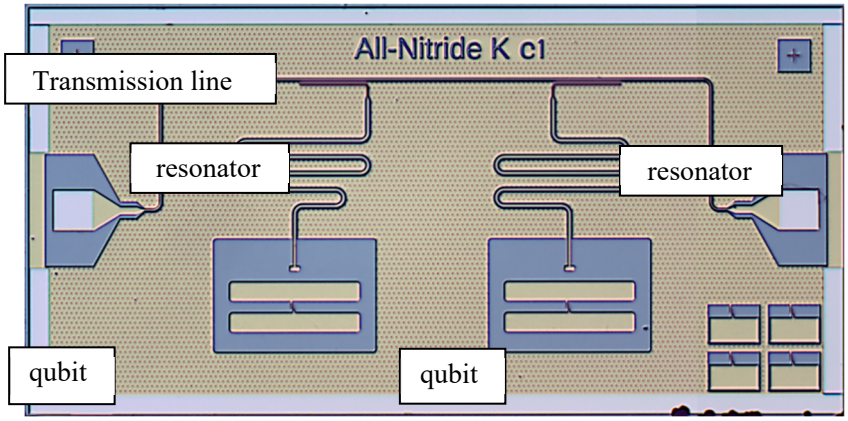


Figure. Laser microscope image of a chip with asymmetric SQUID transmon based on NbN/AlN/NbN Josephson junction. The sample size is 2.5 mm x 5.0 mm.

Using a two-tone spectroscopy, the flux bias dependence of qubit transition frequency is measured. An input-power-dependent two-tone spectroscopy at a half flux quantum bias point is also measured. From the two measurements, circuit parameters such as Josephson energies $E_{Jl}/h = 6.77$ GHz and $E_{Jr}/h = 8.12$ GHz, and the charging energy $E_C/h = 0.111$ GHz are obtained.

We also measured coherence properties. So far, we have measured the energy relaxation time to be T1 = 11.3 ms.

3. 2. Quantum Optics Research Group (Sanaka, Sadgrove)

By applying a quantum encryption key based on single-photon light source technology to quantum cryptography communication, it will be possible to overcome the vulnerabilities (e.g., eavesdropping) of

conventional quantum cryptography communication, which has been implemented in society so far. However, single-photon sources that use crystalline materials such as semiconductors, which are currently being researched and developed, have technical and economic problems in controlling the operating environment (temperature) and in manufacturing and mass production. Therefore, the Optical Quantum Information Group is conducting research on the realization of a "single-photon light source" that can be used at room temperature and the wavelength can be selected using tapered rare-earth doped optical fibers for quantum cryptography, which is a next-generation secure communication system. In this study, we have further developed this mechanism and succeeded in efficiently generating a single photon in the optical fiber and conducting it by selectively exciting a single rare earth atom in the optical fiber from the side of the fiber. This method is a technology that enables the extension of communication distances in quantum cryptography communication using a single photon light source and is the first step toward a large-scale quantum network using a single rare earth atom as a node.

3. 3. Quantum Information Theory Research Group (Watanabe, Iriyama, Hashizume)

In this group, we are conducting research on several of the following subjects:

(1) Research on the formulation of generalized quantum entropy: Quantum information communication theory is the extension of some information quantities such as entropy and mutual entropy formulated in classical systems by Shannon et al. It is a thing. In the formulation of information theory in quantum systems, based on quantum probability theory, quantum channel theory and quantum entropy theory, including quantum coherence determined based on the mathematics of entanglement, are extended, and a foundation is established that correlates them. did research.

(2) Research on the formulation of Quantum Dynamical Mutual Entropy: The commutative channel coding theorem shows the limit of the averaged mutual entropy (transmission rate) obtained from the dynamic entropy from the transmission capacity and provides an important criterion for constructing error-free channels and coding. Extending this theorem to quantum systems is an essential and important issue for rigorous research on communication processes including non-commutativity and coherence in terahertz and next-generation quantum optical communications. We conducted this basic research.

(3) Basic theoretical research and implementation of cryptographic theory that combines security and convenience based on non-commutative algebra, which is the mathematical foundation of quantum information. Furthermore, we construct information security theory with the post-quantum era in mind.

(3-1). Construction of authentication algorithm incorporating secure computation and information distribution structure: Started joint research with companies for commercialization as a platform for secure biometric authentication and non-decryption encryption technology.

(3-2). Construction and implementation of a mathematical framework for Strongly Asymmetric Public Key Agreement. Key sharing is possible with extremely high efficiency without changing the security of the current key sharing method.

(3-3). Formulation of quantum algorithms using adaptive mechanics: Successful quasi-quantum teleportation experiment on classical computer under LOCC, progress toward realization of CNOT logic circuit.

(4) In the field of algebra, various “effective” methods (algorithms) have been devised and play a major role in algebra research.

(4-1). Determination of existence of decoherence-free subspace (DFS): Conventionally, there was no unified method for confirming the existence of DFS. Using the method of this research, it is possible to confirm the presence or absence of DFS for any channel. Furthermore, this method is effective in an algebraic sense, and the presence or absence of DFS can always be confirmed by calculating according to the algorithm.

(5) Evaluation of quantum annealing including finite temperature dissipation: We clarify how much fidelity is maintained by quantum annealing at finite temperature, and what parameters are effective in controlling it. When we have fluctuations at finite temperature, the equilibrium state changes with time. (change of state on a timescale shorter than the equilibration time and longer than the relaxation time). At low temperatures, it does not depend much on the bond with the heat bath, but when the temperature rises, the bond with the heat bath has a strong effect. It is also shown that the fidelity in the final state depends only on the temperature. (Presented at AQC2021).

(6) Development of imaginary-time quantum toolbox (JST PRESTO): A quantum algorithm realizing imaginary time evolution has been proposed for NISQ. In this research, we develop the algorithm further and propose a new method for improving the efficiency of the solution method and implementing full connections.

(7) Indicators for large-scale quantum computers: When a large-scale quantum computer with a large number of qubits is created, an index that characterizes the chip performance of the quantum computer will be required. We proposed one of the indices in our previous work, but there is a limit to the coupling between qubits in real chips. We aim to propose and develop an index that incorporates such constraints.

(8) Artificial intelligence/machine learning and quantum computers: In recent NISQ algorithms, it is necessary to optimize the parameters of quantum gates for the Hilbert space of exponentially wide quantum systems. We will start developing algorithms to do this efficiently using artificial intelligence technology.

4. Challenges and Prospects

Quantum information is a field that is currently being intensively invested in research around the world. It is one of the three basic technologies of the Japan Government Cabinet Office's 'Integrated Innovation Strategy': AI, quantum information, and biotechnology, and is also one of the four pillars of the Department of Physics of the University of Science: space and elementary particles, earth and planets, quantum information, and condensed matter physics. In order to accelerate the progress of this important research field, our division was established in 2020 within the Institute of Research that brings together researchers in the university. Until now, the Tokyo University of Science has been conducting research on superconducting quantum computers under JST CREST (completed in FY2021, total of about 200 million yen) and Cabinet Office Moonshot (total of about 150 million yen until FY2025). In addition, NEDO Next Generation Computing and the Cabinet Office Q-Leap are also collaborating.

Regarding intergroup collaboration within the division, collaborative research is progressing especially between the Superconducting Quantum Circuits Group and the Quantum Information Theory Group. On the other hand, there is a large energy difference between the two physical qubits, superconductivity and light, and there is a limit to research activity that directly fuses them.

Concerning the NbN based superconducting qubits, dephasing time as well as the energy relaxation time should be measured. The coherence measurement away from a half flux quantum bias point should also be

obtained. From the measurements above, a flux noise amplitude can be obtained. Precise measurements of transition frequencies up to 6th excited states are being implemented. From the precise measurement, the uniformity of the epitaxially grown Josephson junction can be evaluated. If necessary, we will design and fabricate new samples

5. Conclusion

Research in this division has progressed smoothly this fiscal year in general. Concerning the superconducting quantum circuits, where research towards the quantum computers is particularly advanced, the following outcomes were achieved: integration of qubits using a pseudo-two-dimensional qubit coupling network that can be planarly packaged; cat states generation with the superconducting Kerr parametric oscillator (KPO) and its fidelity evaluation using quantum tomography, as well as realization of 1-bit gate operation; measurement and reduction of low-frequency noise of KPO oscillation; high-speed initialization of superconducting qubits; extension of the coherence time of superconducting qubits, realization of novel quantum optical circuits using artificial atoms with ultra-strong coupling to resonators.

Qubits based on epitaxial Josephson junctions of NbN/AlN/NbN, which are highly resistant to oxidation and have excellent crystallinity. This year, we identified the sample parameters and performed some of the coherence property measurements. In the future, we will further advance the coherence property measurements and evaluate the sources of fluctuation in qubits using Josephson junctions of NbN/AlN/NbN. We will also evaluate the uniformity of epitaxial Josephson junctions and verify their usefulness as qubit materials.

Although the development of the field of quantum information is what the government is paying particular interest to, there is a serious shortage of domestic research personnel. In particular, the shortage of researchers who can handle experiments is one of the major obstacles to the progress of quantum computer research in Japan. As a research organization within an educational institution, we also focus on human resource development in the division.

Research Achievements (FY2024)

Academic Papers

1. Probing fast quantum circuit refrigeration in the quantum regime, Shuji Nakamura, Teruaki Yoshioka, Sergei Lemziakov, Dmitrii Lvov, Hiroto Mukai, Akiyoshi Tomonaga, Shintaro Takada, Yuma Okazaki, Nobu-Hisa Kaneko, Jukka Pekola, and Jaw-Shen Tsai, Phys. Rev. Applied 23, L011003 (2025) (Peer-reviewed)
2. Entangling Schrödinger's cat states by bridging discrete- and continuous-variable encoding, Daisuke Hoshi, Toshiaki Nagase, Sangil Kwon, Daisuke Iyama, Takahiko Kamiya, Shiori Fujii, Hiroto Mukai, Shahnawaz Ahmed, Anton Frisk Kockum, Shohei Watabe, Fumiki Yoshihara, Jaw-Shen Tsai, Nature Communications | (2025) 16:1309 (Peer-reviewed)
3. A Study of Noise Effect in Feedback control with White Noise Analysis, Taihei Takahashi and Noboru Watanabe, Open Systems and Information Dynamics, Vol. 31, No. 2 (2024) 2450010-2450022(Peer-reviewed)
4. Multifractality and Hyperuniformity in Quasicrystal line Bose–Hubbard Models with and without Disorder, Masahiro Hori, Takanori Sugimoto, Yoichiro Hashizume, and Takami Tohyama, JOURNAL OF THE PHYSICAL SOCIETY OF JAPAN, 93, 114005, 2024(Peer-reviewed)
5. 境界誘起型非平衡量子系での流れとエントロピーの関係, 鈴木秀則, 橋爪洋一郎, 日本大学歯学部紀要, 52, 1-10, 2025 (in Japanese) (Peer-reviewed)

Invited Lectures

1. Quantum Computer & Superconducting Qubit, Jaw-Shen Tsai, KOR-TWN-JPAN Trilateral Technology Dialogue on Semiconductor, AI, & Energy, Seoul National University Jul.4-6, 2024, S. Korea
2. Superconducting Kerr Parametric Oscillators based Bosonic Qubit - A Practical Quantum Information Processing Platform, Jaw-Shen Tsai, QUEST 2024, Kyushu University, Sep.9-11, 2024, Kyushu
3. A novel quantum computing platform: superconducting bosonic quantum system, Jaw-Shen Tsai, The Fifth International Conference on Materials Science and Engineering, Materials Oceania 2024, Sep. 23-26, 2024, Thailand
4. The promise of quantum- Developments of superconducting quantum circuits (keynote speech), Jaw-Shen Tsai, Quantum Taiwan 2024, Le Méridien-Taipei hotel, Oct. 16, 2024, Taiwan
5. Cat state entanglement generation with superconducting Kerr parametric oscillators, Jaw-Shen Tsai, QP45&QBIC2025 International Joint Workshop, TUS Noda Campus, Mar.6, 2025, Chiba
6. Superconducting Kerr Parametric Oscillators based BosonicQubit – A practical Quantum Information Processing Platform, Jaw-Shen Tsai, 2025 年第 72 回応用物理学会春季学術講演会, 東京理科大学野田キャンパス, Mar. 14-17, 2025, 千葉
7. On Entropies for Quantum Dynamical Systems, Noboru Watanabe, 44th International Conference: Quantum Probability and Infinite Dimensional Analysis, Bellavista Relax Hotel, Levico Terme, Italy, May 12-17, 2024
8. Note on Entropies for Quantum Dynamical Systems, Noboru Watanabe, Quantum Information and Probability:from foundations to engineering (QIP24) conference, Linneaus University, Vaxjo, Sweden, Jun. 11-16, 2024
9. On Entropies for the quantum dynamical systems, Noboru Watanabe, 55 Symposium on Mathematical Physics, Nicolaus Copernicus University, Jun. 21-22, 2024

10. Note on Quantum Entropies for the Compound Quantum Channel, Noboru Watanabe, The International Joint Workshop of QP45&QBIC2025 organized by Nano Quantum Information Research Division(Real and a liitle Online), Tokyo University of Science, Noda, Japan, Mar. 4-8, 2025
11. Fiber-confined single-photon source using a single rare-earth ion, Kaito Shimizu, Tomo Osada, and Kaoru Sanaka, Proc. SPIE 13360, Physics and Simulation of Optoelectronic Devices XXXIII, 133600I, (19 March 2025);
12. Single-photon emitter using a rare-earth atom confined in optical fiber, Kaoru Sanaka, Invited talk at Quantum Innovation 2024, The International Symposium on Quantum Science, Technology and Innovation, Tokyo, Japan, Oct. 2024

International Conferences Hosting

International Joint Workshop of QP45 & QBIC2025

From Tuesday, March 4, 2025, to Saturday, March 8, 2025, the International Joint Workshop of QP45 & QBIC 2025 was held in person and partly online, hosted by Tokyo University of Science and the Nano Quantum Information Research Division. This international conference was mainly held face-to-face, and the opening address was given by Dr. Hiroshi Nishihara, Director of the Research Institute. 17 researchers from overseas, 12 researchers from outside the university, 5 researchers from the Nano Quantum Information Research Division, and 3 researchers from the University of Science gave invited lectures, and 1 overseas researcher, 3 researchers from this research division, and 12 poster lectures were given by researchers from the University of Science.

Website: https://sites.google.com/view/qp45-qbic2025/top-page?authuser=0

Symposium Hosting

Interdisciplinary Quantum Roundtable, an Interdisciplinary Exchange Symposium on Quantum Technology

Date: December 5, 2024

Purpose: To create a forum for discussions centered on researchers in the field in order to solve the problems faced by various quantum fields from a broader perspective and with a variety of technologies.

Invited Talk: Prof. Shigeki Yoshikawa (Tokyo University of Science); Prof. Toshihiko Sasaki (The University of Tokyo); Dr. Eidai Asai (National Institute of Advanced Industrial Science and Technology); Prof. Keinari Shibata (University of Tsukuba); Prof. Fumihiro Tomona (National Institute of Advanced Industrial Science and Technology)

Lectures: 11

Number of participants: 61

Sponsorship of International Conferences

1. Junichi Sone (Visiting Professor), 17th Nanotech Association Conference、2025.1.30
2. Junichi Sone (Visiting Professor), ANF Workshop on Nanotech & Deeptech Commercialisation, 2025.1.30

Individual Research Topics

Jaw-Shen Tsai

A method called Bozonic code, which is relatively easy to correct errors in quantum computers, protects quantum information from errors by taking advantage of the infinite degrees of freedom of the resonator. We are conducting research on Cat Qubit, which realizes Cat code, which is one of the practical bosonic codes, using a car parametric oscillator (KPO) using superconducting circuits. We generated a cat state with a two-dimensional KPO circuit (image1 and 2), evaluated the fidelity using a quantum tomography method, and succeeded in realizing a universal quantum gate that can operate 1-bit and 2-bit gates.

We have shown that it is possible to convert the Fock state to the cat state on a one-to-one basis with KPO, and that quantum coherence is preserved in this process. In addition to quantum coherence, the other element that makes quantum information powerful is entanglement. We showed that the entangled Bell-Fock state is converted one-to-one to the entangled cat state (Bell-Cat) using two KPOs.

Fumiki Yoshihara

While dispersive readout is commonly used among various readout methods, cross-resonance readout method, which is expected to be faster with higher-fidelity, attracted more attention, recently. In most of the study on cross-resonance readout methods, transmon is used. On the other hand, flux qubits are less common but have higher anharmonicity and expected to be readout faster and with high-fidelity. We study cross-resonance readout method for flux qubits. In this study, cross-resonance readout method showed higher fidelity. As a future work, we will implement single-shot readout to compare fidelity of dispersive readout method and cross-resonance readout method.

Kaoru Sanaka

We succeeded in stably generating a single-photon source at room temperature by using a single-photon light source with rare-earth doped optical fiber. Single-photon generation at near-infrared wavelengths was achieved with two types of rare earth atoms, Ytterbium and Neodymium, and two academic papers were published on the characteristics of each single-photon light source. In the future, we try to demonstrate that single-photon generation is similarly possible at fiber-optic communication wavelengths using Erbium. We also try to manipulate single-photon generation time with pulsed laser pumped light sources, and enhancement of single-photon emission by resonator effects.

Mark Sadgrove

We published two papers relating to single photon generation. In the first paper, we demonstrated the simultaneous manipulation of quantum dots and gold nanoparticles using an optical nanofiber. In the second paper, we numerically investigated the relation between Purcell enhancement and photonic loss for a quantum dot coupled to a plasmonic cavity.

Noboru Watanabe

"Study of noise effects in feedback control using white noise analysis": It is well known that in proportional-integral-derivative (PID) control, the choice of how to deal with noise is an important issue, and various methods have been proposed. However, a similar method for determining the response to noise has not been studied in probability theory. In this paper, we propose a new method called the "weak form" and use this method to perform a probabilistic analysis of the filtered derivative. The method discussed in this paper is effective in cases other than feedback control.

"Research on quantum communication processes and their complexity": In this research, (1) we investigated the complexity of dynamical systems through quantum communication processes using mean entropy and mean co-entropy introduced by Ohya's Compleity. Furthermore, (2) using the KOW dynamical entropy defined for more general systems including AOW and AF, the complexity of dynamical systems through quantum communication processes given as conjugates of fully positive maps is I did research to find out.

Yoichiro Hashizume

In this year, we extended the space defined by the Fisher information metric, which is well known in information geometry. Specifically, we introduced a pseudo-Fisher metric in which the parameters defining the space include both an order parameter and time. Using this pseudo-Fisher metric, we formulated a method to describe relaxation processes in non-equilibrium systems from an informational perspective. Furthermore, we applied this method to a transition phenomenon involving a shift from one stable state to another and demonstrated that the curvature of the space develops significantly negative values near the onset time. Extending this approach to general non-equilibrium processes remains a future challenge.

Parallel Brain Interaction Sensing Division

Parallel Brain Interaction Sensing Division

1. Overview

Neuroscience (brain science) is a field of life science that is rapidly developing in the 21st century. The field is attracting attention from society and industry because the maintenance of brain health is expected to improve the quality of life in a super-aging society, and the application of information processing mechanisms in the brain lead to the creation of innovative technologies. In recent years, most things have been connected to the Internet (IoT: Internet of Things), and wearable devices such as smartwatches have made it possible for humans to connect to the Internet before even, they realize it (IoB: Internet of Bodies). It is easy to imagine that the next era will happen, when the human mind will be connected to the Internet (IoM: Internet of Minds). This is indeed the beginning of the era of the Internet of Brains. This division will establish a multidisciplinary and interdisciplinary research and development platform by concentrating the multidimensional and multiaxial expertise and information on the brain and neural information/systems with related researchers in/outside of the university. We aim to create an innovative academic field of brain science, "Parallel Brain," originating from Tokyo University of Science in preparation for the coming age of the Internet of the Brain.

2. Organization and Facilities

We propose technology for sensing and reproducing biological information based on the knowledge of brain research by synchronous (parallel) measurement of the brains of multiple individuals using brain research methods for mice and humans, which became our original interdisciplinary brain research field. By utilizing elucidation and support of the mechanisms of group formation and symbiosis in online space, as well as the common sensing technology in both mouse and human experiments, we aim to describe the interaction between multiple brains common to social animals using through mathematical models and to build a theoretical background. This division consists of three groups and seeks to produce emergent results through synergistic effects among these groups.

Animal Experiment Group (Mouse / Human)

This group conducts multidimensional research on brain health and diseases focusing on cognition (depression characterized by pessimistic cognition, senile dementia with impaired cognition and memory functions, autism with impaired social cognition and communication, etc.), from molecular and neural circuits to animal models, elucidates related mechanisms, and creates seeds for improvement drugs and diagnostic agents.

Sensing Group

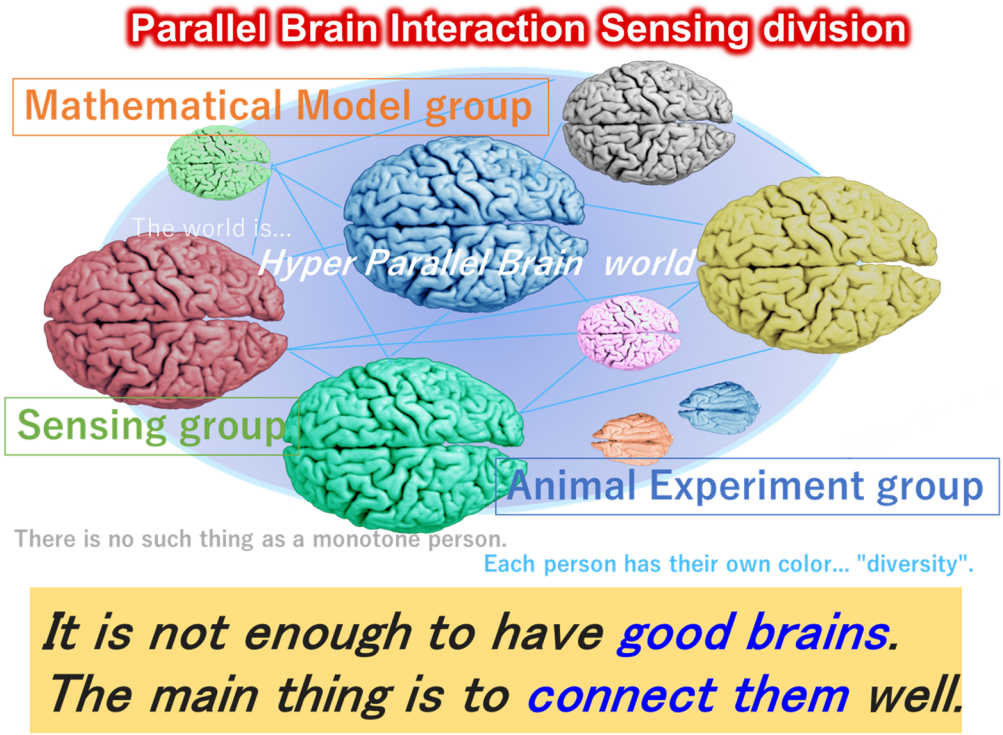
The Sensing Group conducts multidimensional research on the analysis and evaluation of brain dysfunction concerning personality traits focusing on gaze behavior and physiological indicators in developmental disorders, etc., and aims to create related measurement technologies and assistive devices.

Mathematical Model Group

The Mathematical Modeling Group conducts multidimensional studies on functional brain imaging, cognitive psychology experiments, brain-type algorithms, etc., about brain information processing with a focus on human visual perception. We aim to elucidate brain information processing systems and to develop models and theories.

The division consists of 18 researchers in interdisciplinary neuroscience-related fields. Fifteen researchers belong to the Faculty of Science and Technology (Hiroshi Takemura, Takeo Ushijima, Takahiko Yamamoto, Akari Hagiwara, Takumi Asakura, and Masataka Yamamoto), the Faculty of Pharmaceutical Sciences (Akiyoshi Saitoh and Daisuke Yamada), the Research Institute for Biomedical Sciences (Takeshi Nakamura and Shingo Koinuma), the Faculty of Engineering (Osamu Sakata and Takuya Hashimoto), the Faculty of Advanced Engineering (Eri Segi-Nishida and Kanzo Suzuki), and the Institute of Arts and Sciences (Hiroko Ichikawa). The others are three visiting researchers: Ryohei Hasegawa, Toshihiro Takamatsu (National Institute of Advanced Industrial Science and Technology (AIST)) and Asami Oguro-Ando (The University of Exeter Medical School)

We are mainly engaged in cooperative research using the unique talents and strengths of each member. The following is a list of collaborative research projects that transcend the boundaries of each specialized field, which are only possible in this division.



3. Activity Reports

Since the establishment of the division, we have started various collaborative research that transcends the boundaries of each group, which was possible only in this division. The part of activities of the division in FY2024 is the following.

3. 1. Research Collaborations beyond Groups

3. 1. 1. Elucidation of Brain Functions That Regulate Social Behavior 'Evaluation of Social Behavior and Brain Developmental Changes in a Human Chromosome Deletion Disease Model of Autism' (Segi-Nishida [TUS] / Oguro-Ando [Univ. of Exeter])

This study focuses on a human chromosomal deletion syndrome involving the loss of three genes located in the 3p26.3 region of chromosome 3. This region contains CHL1, CNTN4, and CNTN6, all of which encode

neural cell adhesion molecules and have been reported as risk factors for autism. Using a triple-knockout mouse model (3PKO mice) provided by Dr. Oguro, we previously observed reduced social behavior along with attenuated anxiety-like behavior. Histological analyses also revealed morphological abnormalities in the hippocampus. In fiscal year 2024, we examined the structure of the cerebral cortex and the composition of neuronal cell types. In 7-week-old mice, the thickness of the somatosensory cortex was significantly reduced in 3PKO mice. Specifically, the number of excitatory neuron marker-positive cells in the upper cortical layers (layers II–IV) was significantly decreased, while the number of inhibitory neuron marker-positive cells was increased. In the hippocampal dentate gyrus, the number of FosB-positive cells, a marker of neuronal activity, was significantly reduced.

3. 1. 2. Physiological Changes due to Pleasant Emotional Experiences and Positive Perception of Other People's Facial Expressions (Ichikawa, Oguro-Ando)

Laughing has a positive effect on health (Martin, 2002, for review). Laughing increases heart rate (Kop et al., 2011) and sweating (Guerra et al., 2012; Salimpoor et al., 2009) and facial muscle activity (Fiacconi & Owen, 2015). 2024 examined the following two aspects.

(1) whether laughing makes people perceive other people's facial expressions as more positive: It is known that people in a positive emotional state perceive other people's facial expressions as similar to their own emotional state, i.e., as positive, which is known as mood congruency; (2) whether laughing makes people perceive other people's facial expressions as more positive, which is known as mood congruency. We investigated whether participants in a study would be more likely to perceive other people's facial expressions as pleasant when they watched a comedy video, compared to when they watched a weather forecast. The results showed that the participants felt more pleasant emotions after watching the comedy video, and they may also perceive other people's facial expressions as pleasant. The results are being prepared for submission to an international journal. Currently, a project is underway to conduct the same experiment in the U.K. and compare the results internationally.

(2) Are physiological changes associated with the subjective experience of “fun” that occurs when laughing: In studies conducted up to FY2023, co-occurrence of subjective experience and physiological changes was observed, but no quantitative correlation was found. We attributed this to the study participants' failure to conform to their preferred humor style, and in FY2024 we examined this by having participants watch a comedy video that conformed to their humor style. Participants were asked to rate the video on a 5-point scale of subjective funniness at the point where they found the video funny. In addition, physiological indices (facial electromyography, cutaneous electric response produced by palm sweating, and heart rate) of the participants were measured during the viewing. The results showed that the orbicularis oculus muscle was active at the timing when the participants subjectively found it interesting, and the amount of activity correlated with the subjective intensity of the interestingness. In the future, we will examine the effects of subjective enjoyment on the body by measuring cardiovascular responses.

3. 1. 3. Biomechanical Analysis of Age-Dependent Gait Deficiency in Mice Deficient in Cerebellar Neural Transmission (Hagiwara, Takemura and Y. Yamamoto)

The cerebellum is important for balance control in locomotion, and plastic changes in neurotransmission have revealed the mechanism of motor learning. However, the involvement of the cerebellum in the decline in gait function due to aging and frailty and its neural mechanisms remain largely unknown. To establish the appropriate treatment and rehabilitation methods, we investigated newly developed conditional knockout

(cKO) mice, in which a specific deletion of LKB1, a phosphatase of the AMPK family involved in cell metabolism and morphogenesis, is observed in the cerebellar granule. Hagiwara et al. have found the age-dependent gait defect in this mouse.

The Rotarod test evaluates the motor coordination by measuring how long mice can stay on a rotating rod. However, this method does not provide detailed posture-related indicators such as balance maintenance. To address this, we developed the gait analysis system from freely moving mice using a video-based machine learning technique. With this system, we found that LKB1 cKO mice showed no significant differences in gait parameters such as stride length, suggesting that their coordination deficits likely arise from cerebellar dysfunction. We are currently conducting morphological analyses of age-dependent changes in the cerebellum and preparing to publish our findings in an international scientific journal.

3. 1. 4. Evaluation of the Neural Basis of Stress Sensitivity in Synaptic Protein-Deficient Mice (Hagiwara, Saitoh, Yamada, Takemura, and Y. Yamamoto)

People are exposed to various physical and mental stresses from the environment, and the recent increase in complexity of social structure is believed to be a factor that causes organic and functional changes in the brain, increasing the incidence of mental disorders. In other words, understanding the neural basis is essential to solve stress-related mental problems. At the site of neuronal transmission, called the synapse, information is transmitted through transmitters, and various proteins modify synaptic functions in a plastic way. In mice lacking the presynaptic protein CAST, Hagiwara has shown neglect-like maternal behavior, suggesting that stress sensitivity during pregnancy is involved (Hagiwara et al., Scientific Reports, 2020). Therefore, we will examine the sensitivity of CAST-deficient mice to various types of stress and elucidate the neural mechanisms associated with stress sensitivity.

First, due to concerns about the low reproducibility of the tail suspension test—a method used to assess depression-like behavior—stemming from experimenter-dependent criteria, we developed an automated system that measures immobility time using a deep learning technique (H. Oikawa, D. Kobayashi, M. Yamamoto, A. Hagiwara, H. Takemura, *Immobility Recognition System in Tail Suspension Test Using Single Camera and Deep Learning*, IEEE Systems, Man, and Cybernetics Magazine, 2024). Using this system, we found that CAST-deficient (KO) mice exhibited increased immobility time, indicating depression-like behavior. Furthermore, administration of an antidepressant to the KO mice showed significantly reduced immobility time. This work aims to identify the underlying transcription factors and brain regions to further elucidate the mechanisms involved.

3. 1. 4. Analysis of Jakmip1-Deficient Mice, a Mouse Model for Autism (Saitoh, Oguro-Ando, Hagiwara, and Yamada)

Autism spectrum disorder (ASD) is a highly heritable developmental disorder characterized by communication disorders and patterning of behavior. Oguro identified JAKMIP1 as a factor down-regulated in Fragile X syndrome and 15q duplication syndrome, the most common syndrome among ASD. Furthermore, the analysis of RNA sequence of JAKMIP1-deficient mice suggests that JAKMIP1 is involved in the regulation of cytokine signaling, and a more detailed analysis will be performed. This research was selected for funding by the Daiichi Sankyo TaNeDS program for 2022. Oguro and Hagiwara conduct morphological analyses, focusing on aspects such as the cortical layer structure in the knockout mice. Meanwhile, Yamada, Saito, and a graduate student from the Oguro lab will investigate neuronal transmission using the patch-clamp technique. In addition, Saito, Yamada, and Hagiwara will assess behavioral deficits and the pharmacological effects of various drugs in the deficient mice.

3. 1. 5. DNA Methylation Analysis in Various Mouse Models (Oguro-Ando, Segi-Nishida, Saitoh, Hagiwara, and Yamada)

Neuronal circuits change in various ways depending on the environment, and neuronal activities undergo epigenetic changes that regulate gene expression. The development of transcriptome technology has been under intense competition in recent years, and the earliest introduction of novel technology is necessary for the effective development of research. The University of Exeter, where Oguro belongs, has a biomedical informatics center funded by the Wellcome Trust and equipped with the necessary facilities to carry out research at a high level. In this study, Segi, Hagiwara, and Saitoh & Yamada will collaborate with Oguro to conduct a comprehensive analysis of DNA methylation in order to clarify the interaction between neural activity and gene expression in various genetically engineered mice and disease model mice. In addition, Professor Jonathan Mill, a leader in epigenetic research, and his colleagues have mapped regulatory genomic variation in human psychiatric disorders (Washer SJ, et al., 2022). In this study, Segi, Hagiwara, Saito and Yamada, respectively, will collaborate with Oguro to conduct a comprehensive analysis of DNA methylation, aiming to clarify the relationship between neural activity and gene expression across various genetically modified mice and disease models. In particular, the project led by Segi with Hagiwara as co-investigator, has been supported by a grant from the Tokyo University of Science Female Researchers Fund. The project will be further developed to elucidate the molecular and neural mechanisms of psychiatric disorders, with a focus on epigenomic modifications.

3. 1. 6. Research on Causality Analysis Technology among Heterogeneous Biosignals Aiming at Visualization of Brain-Gut Interaction Phenomena (O.Sakata)

When the mind suffers, the gastrointestinal condition tends to deteriorate; conversely, when gastrointestinal health declines, it negatively affects mental well-being, creating a vicious cycle. This phenomenon is known as the brain-gut interaction. Although its detailed mechanisms remain unclear, we are empirically well aware of its existence. This is not a condition that suddenly causes severe symptoms, but rather one that gradually worsens from a healthy state. Early detection of this vicious cycle enables timely intervention and can prevent serious progression.

This research focuses on developing techniques to quantitatively evaluate the initiation and persistence of brain-gut interactions through causal analysis among biosignals obtained from different organs—namely, signals originating from the nervous system, the cardiovascular system, and the digestive tract—all of which represent different physical quantities.

This project was newly adopted as a Grant-in-Aid for Scientific Research (KAKENHI) initiative starting in FY2023 and has now completed its second year. During this time, we have improved the evaluation technology of small intestinal peristaltic activity—which serves as the target signal for causal analysis with neural information (mainly EEG)—from both software and hardware perspectives.

Specifically, in terms of long-term continuous bowel sound monitoring technology, we advanced research on mathematical modeling techniques for classifying and predicting changes in bowel sound occurrence frequency, and we developed a new sensing device system for wearable bowel sound acquisition.

This study will continue into the third year and beyond.

3. 2. Public Events

3. 2. 1. Third Public Symposium "Sensing the Future: Exploring the Deep Sea of Brain Science and Aging"

- **Saturday, December 14, 2024 9:30-17:30**
- **Tokyo University of Science, Noda Campus Lecture Building K401**

- **Four invited lectures from academic researchers and industrial researchers, two invited lectures from researchers in the companies, and 58 student posters.**
- **Participants: 104(including 13 general participants)**

It was a great success with lectures and related information provided by researchers active in brain research fields from the basics to the latest hot topics, as well as an exchange of information on the latest research results in the laboratories of the division members and personal exchanges.

3. 2. 2. Parallel Brain Workshops and Seminars

We held parallel brain workshops and seminars by inviting nine great lecturers (3 of whom are international researchers) who are conducting cutting-edge research in their respective fields in JY2024. Since the members of this division have a wide range of specialties, the specialties of the speakers are also different, but each talk is connected to brain research, and it is a very meaningful meeting that leads not only to the studies but also to the opportunities of the human exchange for the division members.

4. Challenges and Prospects

This division is composed of interdisciplinary researchers who specialize in multiple fields and different fields inside and outside the university to promote fusion-type collaboration and joint research. By bringing together the wisdom and technical capabilities of multiple fields and different fields, we will pioneer creative basic research and applied research that is unique to TUS with the brain at the core and integrate multiple fields and different fields. We will promote new joint research that started from the establishment of the division, gather the wisdom and power of science and engineering, expand the cutting-edge technology of the sensing team, and apply new analysis methods and measurement technologies to animal and human measurement experiments. We will conduct 'Parallel Brain' research unique to TUS. In addition, we will strengthen cooperation with researchers outside TUS through symposiums, workshops, and seminars, and we will actively carry out publicity and lobbying activities to acquire large-scale grants. Furthermore, through the above activities, we will convey the joy of interdisciplinary collaborative research not only to faculty members, but also to students, and strive to nurture young people who will support the field of brain science in the future.

5. Conclusion

To develop brain research unique to TUS, this division integrates the promotion of collaborative research and original individual research, and develops innovative academic fields originating from TUS, such as 'Connecting Brain' and 'Parallel Brain'. We will continue to work to build this by pursuing the interdisciplinary comprehensive strength and synergistic effects of science and engineering and collaborating with clinical institutions such as medical schools and hospitals. We will further enhance and develop the research base of brain science and neuroscience within TUS, and develop the next generation of human resources. We also practice education for training. Despite being only two years old, the results of the division's activities are gradually taking shape, such as the publication of papers on the results of collaborative research and the acquisition of budgets for newly created collaborative research.

Major Research Achievements (FY2024)

Academic Papers

1. Interactive segmentation with curve-based template deformation for spatiotemporal computed tomography of swallowing motion, Y. Kimura, T. Ijiri, Y. Inamoto, T. Hashimoto, Y. Michiwaki, PLOS ONE, 19(10): e0309379, 2024 (Peer-reviewed)
2. Role of desmoplakin in supporting neuronal activity, neurogenic processes, and emotional-related behaviors in the dentate gyrus, Otsubo K, Sakashita N, Nishimoto Y, Sato Y, Tsutsui T, Kobayashi K, Suzuki K, Segi-Nishida E, Front. Neurosci.,18:1418058, 2024 (Peer-reviewed)
3. Effect of chronic corticosterone administration on acute stress-mediated gene expression in the cortex and hippocampus of male mice, Shiraki H, Segi-Nishida E, Suzuki K, Biochem. Biophys. Res. Commun., 762:151729, 2025 (Peer-reviewed)
4. Production of Adeno-Associated Virus Vector Serotype rh.10 and Optimization of Its Purification via Chloroform Extraction, Tamura N, Suzuki K, Shiraki H, Waguri I, Segi-Nishida E, Biol. Pharm. Bull., 48:355-362., 2025 (Peer-reviewed)
5. Immediate Effect of Wearable Balance Training Device on Muscle Co-contraction and Postural Control During Standing, M. Yamamoto, K. Shimatani, ME. Hahn, and H. Takemura, IEEE Trans Neural Syst Rehabil Eng., vol. 32, pp. 2230-2238, 2024. (Peer-reviewed)
6. Epoch Segmentation Method for Mathmatical Modeling of "Temporal Change of Occurrence Frequency of Bowel Sounds", Koki Tozawa, Osamu Sakata, Proc. 55th Int. Sympo. On Stochastic Theory and Its App., pp.80-82, 2024. (Peer-reviewed)
7. Performande evaluation of wearable long-term intestinal sound measurement device using machine learing, Daichi Yato, Osamu Sakata, Proc. 55th Int. Sympo. On Stochastic Theory and Its App., pp.83-86, 2024. (Peer-reviewed)
8. Subjective effects of broadband water sounds with inaudible high-frequency components. Scientific Reports, Asakura, T. (2024). 14(1), 1-12. (Peer-reviewed)
9. Cross-modal feedback of tactile and auditory stimuli for cyclists in noisy environments, Uemura, R., Asakura, T. (2024). Sensors and Actuators A: Physical, 380, 116031. (Peer-reviewed)
10. Interaction effect of reproducing spatialized human-induced and environmental sounds from nearby sources on the social Simon effect, Asakura, T. (2025). Applied Acoustics, 228, 110343. (Peer-reviewed)
11. TC10 on endosomes regulates the local balance between stability and dynamics through PAK2-JNK pathway and promotes axon outgrowth, Shingo Koinuma, Misa Miyaji, Suzuka Akiyama, Yasuyuki Ito, Hiroshi Takemura, Naoyuki Wada, Michihiro Igarashi, Takeshi Nakamura. J Cell Sci, 138 (4) doi.org/10.1242/jcs.263636. 2025. (Peer-reviewed)
12. Rab39B, associated with early-onset familial PD, is transiently activated prior to lysosome-lysosome fusion in Neuro2A cells, Ena Furusawa, Shingo Koinuma, Yutaro Hazama, Misa Miyaji, Naoyuki Wada, Mitsunori Fukuda, Takeshi Nakamura. submitted to Genes Cells. 2025(Peer-reviewed)

Books

1. Brain Science review 2025, Adtree, Brain Science Foundation, Nobutaka Hirokawa, Takehiko Bandou, Kanzo Suzuki, Study on the mechanism of antidepressant effect of ketamine, pp157-170

Invited Lectures

1. From the Nanoscale to Synapses: A Neuroscience Career and Challenges for the Next Generation, Akari Hagiwara, 34th Annual Meeting of Young Researchers in Neurobehavioral Pharmacology – Symposium for Next Generation Researchers, Ochanomizu University, March 2025
2. Structural Analysis of Synaptic Remodeling in Neurodegeneration Using Advanced Electron Microscopy Techniques, Akari Hagiwara, APPW2025, Joint Symposium on “Frontiers in Neuroimaging” by the Anatomical and Microscopy Societies, Makuhari Messe, March 2025

Public Relations

1. Akari Hagiwara, Lecture titled "The Brain, Nerves, and Synaptic Transmission" at the 4th Science Day, Keisen Jogakuen Junior High School, March 7, 2025

Awards

1. Asuka Shindo Moka Tsuchiya, Asami Oguro-Ando, Mako Saruta, Karin Hosoya, Eri Segi-Nishida, The 151th Annual meeting of the Japanese Pharmacological Society Kantobukai, Hoshi University, 2025, Young Investigator Award (Student)
2. Rino Kashiwabara, Haruka Suzuki, Eri Segi-Nishida, APPW2025 Joint Conference, Makuhari Messe, 2025, Physiological Reports/Guraduate Student Presentation Award (Student)
3. Mako Saruta, Asuka Shindo, Moka Tsuchiya, Karin Hosoya, Asami Oguro, Eri Segi, APPW2025 Joint Conference, Makuhari Messe, 2025, Undergraduate Poster Award (Student)

Individual Research Topics

Hiroshi Takemura

“Research on 3D gait measurement of mice”

In this research, the combined measurement method of RGB-D video shooting from below and body part tracking by deep learning and transparent running wheel is proposed for measuring three-dimensional limb movements. And we developed the transparent running wheel system for three-dimensional mice gait analysis. As a result, the proposed method and system can measure the 3D gait of a mouse with sufficient accuracy by improving the accuracy of existing limb tracking methods. In the future, we will construct a model that enables the prediction of more diverse mouse behaviors.

Takeshi Nakamura and Shingo Koinuma

“Analysis of Rab39, a risk factor for multiple psychiatric and neurological disorders”

Rab39B, which is highly expressed in neural tissues, is a risk factor for intellectual developmental failure, autism, juvenile Parkinson's disease, etc. Multiple molecular functions in the intracellular transport system are assumed to correspond to these diverse pathologies and are being analyzed. On the other hand, considering that membrane transport is a collection of local events that fluctuate in space and time, there are certain limitations in accurately understanding the molecular functions and regulatory mechanisms of Rab39B using only biochemical methods to uniformly solubilize cells or analysis using mutants. Therefore, we have developed a FRET biosensor that can visualize Rab39B activity and created a highly sensitive Rab39B sensor with a dynamic range of 101% (results up to last fiscal year). This year, we investigated changes in Rab39B activity on lysosomes during the process of lysosome fusion by confocal FRET imaging using this Rab39B sensor. Previous analyses have shown that Rab39B-positive vesicles in Neuro2A cells are 40% lysosomes, 40% recycling endosomes, and 20% late endosomes. In Neuro2A cells in the presence of Lysotracker, we performed time-lapse FRET imaging at 1 min intervals using confocal microscopy to capture the fusion process of lysosomes with each other. Rab39B activity tended to increase from 1 min before fusion to 1 min after fusion. The increase from 1 minute before fusion to the time of fusion was statistically significant ($p<0.05$). In addition, in the previous year's analysis, we used Rab39B-deficient Neuron2A cells to determine whether there are differences in the intracellular distribution and pH of lysosomes between the parental strain and the Rab39B-deficient Neuron2A cells, and obtained the following results. (i) We expressed mRFP-LAMP1, a lysosomal/late endosomal marker, in the parental and Rab39B-deficient strains and classified the cells into two groups: those in which LAMP1-positive vesicles cluster around the nucleus and those in which they are scattered around the cell periphery. In the wild-type strain, 55% of the cells had LAMP1-positive vesicles clustered around the nucleus, whereas this percentage decreased to 15% in the Rab39B-deficient strain ($p<0.001$). (ii) Image analysis of the parental and Rab39B-deficient strains stained with Lysotracker showed that the fluorescence intensity, which reflects the pH of the lysosomal lumen, was reduced in the Rab39B-deficient strain to almost half that of the parental strain (pH was increased; $p<0.05$). These results suggest that Rab39B acts to enhance degradation in lysosomes through accumulation around the nucleus and acidification of the lumen; a recent report that Vps41, one of the components of the HOPS tethered complex, binds to Rab39B and In light of previous studies, we are considering the possibility that Rab39B may act in fusion through lysosomal tethering.

Eri Segi-Nishida and Kanzo Suzuki

“Research on emotional responses focusing on hippocampal functions”

This study focuses on stress-induced depressive states and antidepressant effects by examining functional changes in the hippocampus, aiming to clarify which molecular mechanisms influence emotional regulation and what specific changes occur in the hippocampus during these processes. In the 2024, we investigated how prolonged glucocorticoid exposure alters the brain’s sensitivity to inflammation in response to acute stress. Chronic administration of corticosterone (CORT) alone significantly increased the expression of glucocorticoid-responsive genes Fkbp5 and Sgk1 across multiple brain regions, including the hippocampus. When we examined the induction of proinflammatory cytokine genes (IL-1β and TNFα), neither acute restraint stress alone nor chronic CORT treatment alone induced significant expression changes. However, in mice subjected to chronic CORT treatment, acute stress markedly enhanced the expression of both IL-1β and TNFα. These findings indicate that under chronic glucocorticoid exposure, stress load exacerbates neuroinflammatory responses. Such heightened responses may contribute to the excessive inflammation observed in certain psychiatric disorders.

Akiyoshi Saitoh

“Emotional behavior analysis in stress-induced ultrasonic vocalization”

In this study, we found that mice exposed to a specific stress exposure (cold + restraint stress) vocalize ultrasonic sounds in the 20 kHz band. This negative emotion-induced ultrasound was suppressed by anxiolytic drugs and was not altered by other antipsychotics or antidepressants, suggesting that it indicates a state of anxiety.

Daisuke Yamada

“Research on the mechanism of stress-induced alteration of the brain-gut axis”

Negative emotions such as depression, anxiety, and fear are known to be influenced not only by the brain, but also by the intercommunication between the brain and peripheral organs, often referred to as the brain-gut axis. This study aims to elucidate how stress affects the autonomic nervous system and neural circuits of the brain, which are considered crucial on the brain-gut axis. In FY2023, we demonstrated that the diarrheal symptoms exhibited by animals subjected to vicarious social defeat stress were alleviated by the administration of an opioid delta receptor agonist.

Hiroko Ichikawa

“Psychological Perspective on Interaction Between Individual”

In collaboration with other researchers in this division, we will examine the mechanism of interactions between individuals based on psychological findings. Together with Takemura, Yamamoto and colleagues, we will examine the relationship between the perception of approaching pedestrians and the physical reaction to avoid collisions, using university students with autistic characteristics as research subjects. With Saitoh, Yamada, Asakura and colleagues, we will examine the effects on the organism of listening to music containing ultrasonic components that exceed the range of human hearing. Together with visiting researcher Oguro, we will examine the effects of experiencing pleasant emotions such as comedy on the perception of other people’s facial expressions.

Takeo Ushijima

“Analytical research on various mathematical models”

This research aims to elucidate various properties of solutions of mathematical models described by differential equations for various phenomena. In FY2021, we studied the properties of special solutions called traveling wave solutions, which are necessary to investigate the properties of the explosion solutions of mathematical models for interfacial phenomena, and found that their properties change significantly depending on the parameters included in the model. The results show that the properties of the traveling wave solution vary significantly depending on the parameters included in the model.

Takahiko Yamamoto

“Investigation of the effects of AC magnetic fields on the human body”

Although electromagnetic waves are used in all aspects of modern life, the effects of electromagnetic waves on the human body are still largely unknown. In this study, we investigate the effects of AC magnetic fields of several hundred kHz, which are used for noncontact power transmission, on the behavior of small laboratory animals. As a result, a significant difference in locomotion was observed between the groups exposed to the magnetic field and those not exposed to the magnetic field, indicating that exposure to the magnetic field has some effects on the organisms.

Takumi Asakura

“Relationship between subjective and biological responses to pleasant and unpleasant sounds”

This study examined the relationship between subjective and biological responses to two contrasting acoustic stimuli, a murmuring river and white noise. Compared to murmuring sound, the EEG energy in the alpha region and the change in SD2/SD1, a heart rate-related index, was significantly lower when white noise was presented, suggesting the influence of the pleasantness/unpleasantness of the presented sound. On the other hand, a detailed clustering analysis revealed that EEG energy in the alpha region decreased in the case of subjects who perceived the murmuring of a river as "powerful" rather than "beautiful," even though it was presented as a pleasant sound, suggesting that biological responses to exposure to sound may be influenced by the impression of different sounds depending on the individual. This suggests the possibility that biological responses to exposure to sound may be affected by the impression of sound that differs from one individual to another.

Masataka Yamamoto

“Human enhancement through rehabilitation”

This study proposes ankle-foot assist device selection support system to assist stroke patients and investigates the interaction between therapists and patients during gait training. Proposed model for the selection support system achieved sufficient accuracy for selecting magnitude of assist from the gait data of stroke patients. Moreover, we proposed a method to easily assess the severity of gait function in stroke patients using an RGB camera and confirmed that scoring can be performed with sufficient accuracy. Future works will clarify the interaction between the therapist and the patient during gait training.

Osamu Sakata

“Causal analysis of heterogeneous biological signals”

The human body generates various types of biological signals and information, many of which can be measured. For each biological signal, technologies for deciphering, analyzing, and processing them have been developed mainly for medical use, and their utilization in non-medical fields has also been progressing. However, the use of each biosignal alone or in combination with multiple biosignals has been limited, and the technology to objectively analyze the relationship between different biosignals and biosignals has not yet been developed, even though the signals and information are obtained from a single human body. In this study, we will focus on the causality between different biological signals and information obtained from a single human body, and we will work on the development of technology for quantitative analysis and visualization of this causality.

Takuya Hashimoto

“Robot simulator”

This project aims to reproduce gestures and behaviors that are difficult to control in humans by using robots that closely resemble humans (android robots) and to evaluate the impressions and influences that these behaviors have on others. Currently, we are developing a simulated patient robot (SP robot) for medical interview training to reproduce patient-like behaviors. In the future, we will investigate methods to quantify the physician's non-verbal behavior and speech information during a simulated medical interview using the SP robot and develop a method to quantify the physician's interviewing skills.

Akari Hagiwara

“Analysis of neural networks and brain functions based on synaptic transmission”

Morphological analysis of neural circuits for various information processing in the brain. In particular, the sites of information transmission, called synapses, would be essential to reveal the neural mechanisms of brain functions and psychiatric and neurological disorders. The recently developed mouse has the potential to serve as a model mouse for analyzing the decline in gait function and will be integrated with biomechanics research to develop the mechanism of gait disorders and appropriate rehabilitation methods.

Ryohei Hasegawa

“Brain training system using EEG for competitive competitions”

We are developing a hands-free brain training system that utilizes “EEG switches” by immediately detecting event-related potentials, which are supratentorial EEG components that reflect momentary increases in attendance. We are aiming for further advancement of this system by confirming that a competitive game (b-sport) can be conducted between subjects of different generations, in which multiple people try this system simultaneously to see how quickly and accurately they can select robotic movements.

Division of Composite Materials Engineering

Division of Composite Materials Engineering

1. Overview

The Division of Composite Materials Engineering conducts research on lightweight and high-strength composite materials used in aerospace equipment from material to structure. The goal of the division is to promote rapid technological development through cooperation among experts in specialized fields such as materials science, processing, fracture mechanics, and numerical simulation. Specific themes include new methods for predicting composite degradation, 3D printing of composite materials (Fig.1), and composite ropes, among others. In addition, we regularly hold research meetings on composite materials engineering to create opportunities for collaboration among the members of the division and to foster young researchers. In the future, the division aims to form a research and development center that will utilize the results of basic research at the university, deepen cooperation with industry, and promote the development of applications.

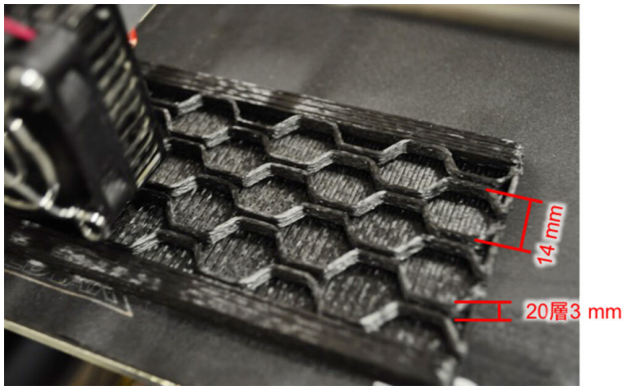


Fig. 1. Composite 3D printing for automated processing

2. Organization and Facilities

This division consists of 12 faculty members in the following three fields: chemistry, materials, and mechanics. The unique feature of this division is that the faculty members in these three fields cooperate with each other to conduct research on composite materials from materials to structures in an integrated manner. In addition, the division shares the use of laboratories in the Noda 10 Building (Fig. 2).

Name	Job Title	Affiliation
Ryosuke MATSUZAKI	Director / Professor	Department of Mechanical and Aerospace Engineering, Faculty of Science and Technology
Shinji OGIHARA	Vice Director / Professor	Department of Mechanical and Aerospace Engineering, Faculty of Science and Technology
Jun KOYANAGI	Professor	Department of Materials Science and Technology,Faculty of Advanced Engineering
Koji ARIMITSU	Professor	Department of Pure and Applied Chemistry,Faculty of Science and Technology
Hiroshi OKADA	Professor	Department of Mechanical and Aerospace Engineering, Faculty of Science and Technology
Akiyuki TAKAHASHI	Professor	Department of Mechanical and Aerospace Engineering, Faculty of Science and Technology
Yasuo KOGO	Professor	Department of Materials Science and Technology,Faculty of Advanced Engineering
Ryo INOUE	Associate Professor	Department of Mechanical Engineering, Faculty of Engineering
Yutaro ARAI	Junior Associate Professor	Department of Materials Science and Technology,Faculty of Advanced Engineering
Fikry MOHAMMAD	Assistant Professor	Department of Mechanical and Aerospace Engineering, Faculty of Science and Technology
Yutaka OYA	Assistant Professor	Department of Materials Science and Technology,Faculty of Advanced Engineering

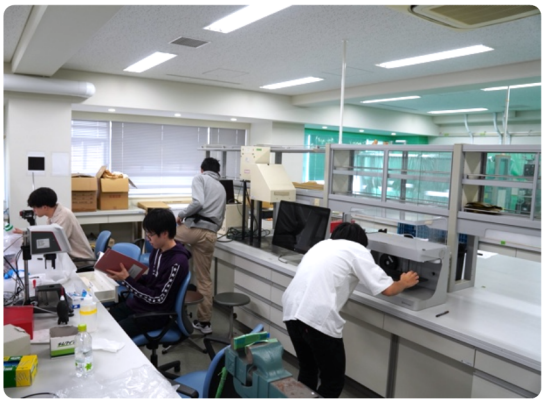


Fig. 2. Shared laboratory of the division (Noda Bldg. No. 10)

3. Activity Reports

As a result of many years of dedicated research and educational activities, the department has successfully secured a large-scale external research grant since fiscal year 2022. Specifically, under the JST Moonshot R&D Program (Full-Scale Research), Tokyo University of Science has been allocated a total of 138 million yen in direct funding over the period from FY2022 to FY2026. The project is titled “Elucidation of Fatigue Degradation Mechanisms and Development of a Residual Life Estimation Method for CFRP”, led by Professor Arai of Nagoya University, with Professor Koyanagi of Tokyo University of Science serving as the lead collaborator for the university. In addition, active collaborative research is being conducted within the department on topics such as strength estimation of CFRP ropes and 3D printing technologies for composite materials. A number of co-authored papers have been published as a result of these collaborative efforts.

The department also regularly hosts the Composite Materials Engineering Seminar, which features lectures by leading researchers in related fields and technical visits to relevant industries. These events serve as a platform for sharing the latest research trends and promoting academic exchange. Furthermore, the

department actively co-hosts seminars with related academic societies and research groups, thereby fostering broad interdisciplinary collaboration beyond the scope of the department itself. Through site visits and the organization of academic events, the department continues to attract interest from students and early-career researchers, contributing to the development of the next generation of scientists and engineers.

Composite Materials Engineering Seminar

- **25th Seminar (October 25, 2024)**
  Technical Visit: SUBARU Corporation, Aerospace Company, Utsunomiya Plant

- **26th Seminar (November 25, 2024)**
  Co-hosted with the Damage Study Group, Japan Society for Composite Materials

- **27th Seminar (March 7, 2025)**
  Co-hosted with the Subcommittee on Yarn Mechanics
  — Keynote Lecture: Koichi Goda (Yamaguchi University), “Strength Reliability of Fiber-Reinforced Composites”
  — Talk: Ryosuke Matsuzaki (Tokyo University of Science), “Overview of the Composite Materials Engineering Division at TUS”

Co-hosted Event

- Research Group on Next-Generation Heat-Resistant Composites and Coatings
  Date: October 29, 2024
  Venue: TKP Tokyo Station Conference Center

4. Challenges and Prospects

At present, one of the major challenges lies in the continued support and development of doctoral students, as well as in providing master’s students with guidance for pursuing careers in related fields. Going forward, the department aims to strengthen its support for postdoctoral researchers and doctoral students by leveraging large-scale project funding, thereby enhancing efforts to nurture the next generation of researchers. Through these initiatives, the department seeks to further advance its research capabilities and expertise, contributing to the sustainable development of the composite materials engineering field.

5. Conclusion

The Composite Materials Engineering Division continuously organizes research seminars to share the latest research findings and trends, thereby reinforcing internal collaboration and supporting the development of young researchers. By hosting academic conferences and workshops, the department promotes engagement with external researchers and industry professionals, fostering industry-academia collaboration on specific themes and accelerating the social implementation of research outcomes. Through these ongoing efforts, the department aims to advance the field of composite materials engineering and achieve sustainable societal contributions based on the application of its research achievements.

Major Research Achievements (FY2024)

Academic Papers

1. 後加工による CFRP シングルラップ接合強度向上に関する数値シミュレーション, 小柳 潤, 中藏鮎子, 高村円璃, 武田真一, 森本哲也, 日本複合材料学会誌, Vol. 50 (2024), pp. 171-176 (in Japanese) (Peer-reviewed)
2. Atomic thermal fluctuation reduction method for robust local lattice structure identification in finite-temperature molecular dynamics, Atsuo Hirano, Yosuke Tsunemoto and Akiyuki Takahashi, Modeling and Simulation in Materials Science and Engineering, Vol. 32 (2024), 065018, doi: 10.1088/1361-651X/ad5dd4 (Peer-reviewed)
3. Stress field and interaction forces between dislocations and precipitate distributions, A. Takahashi, T. Kasuya, N.M. Ghoniem, International Journal for Numerical Methods in Engineering, Vol. 125, (2024), e7468, doi: 10.1002/nme.7468 (Peer-reviewed)
4. Material design using calculation phase diagram for refractory high-entropy ceramic matrix composites, Yutaro Arai, Manami Saito, Akane Samizo, Ryo Inoue, Keishi Nishio, Yasuo Kogo, Int. J. Appl. Ceram. Technol. 2024; 21: 2702–2711. https://doi.org/10.1111/ijac.14688 (Peer-reviewed)
5. Evolution of microstructure and sintering of tape-cat alumina laminates observed by synchrotron X-ray multi scale tomography, G. Okuma, R. Usukawa, T. Osada, M. Iguchi, T. Kohata, N. Kondo, H. Nakajima, T. Okazaki, S. Machida, Y. Arai, R. Inoue, H. Kakisawa, K. Shimoda, A. Takeuchi, M. Uesugi, F. Wakai, Cream. Inter., 50, 19, Part C, 37402-411 https://doi.org/10.1016/j.ceramint.2024.04.09 (Peer-reviewed)
6. Thermodynamic Analysis on Complex Oxides Formed by Aerodynamic Heating for Ultrahigh-Temperature Ceramic Matrix Composites, Mizuki Tsuganezawa, Yutaro Arai, Ryo Inoue, J. Compos. Sci. 2025, 9(2), 87; https://doi.org/10.3390/jcs9020087 (Peer-reviewed)
7. Damage behavior in unidirectional CFRP laminates with ply discontinuity, M. J. Mohammad Fikry, Yutaro Arai, Ryo Inoue, Vladimir Vinogradov, KT Tan, Shinji Ogihara, Applied Composite Materials (2025), Advance online publication (Peer-reviewed)
8. Inhibition of interlaminar damage in CFRP laminates by inserting non-woven carbon fiber interlaminar reinforced tissue, M. J. Mohammad Fikry, Nobuo Terashi, Koji Koizumi, Shinji Ogihara, Advanced Composite Materials (2025), Advance online publication (Peer-reviewed)
9. Redefined three-dimensional J-integral as finite strain elastic-plastic crack parameter (Energy release rate and contribution of weakly singular terms), Hiroshi Okada, Takahiko Gouda, Koichiro Arai, Theoretical and Applied Fracture Mechanics, Volume 130, 2024, 104310, https://doi.org/10.1016/j.tafmec.2024.104310 (Peer-reviewed)
10. A benchmark elastic–plastic finite element analysis of plate with a surface crack under tensile load for the development of the reference stress method, Satoyuki Tanaka, Thin Thin Htut, Hiroshi Okada, Takahiko Gouda, Yuta Tonbe, Takumi Nagano, International Journal of Pressure Vessels and Piping, Volume 209, 2024, 105182, https://doi.org/10.1016/j.ijpvp.2024.105182 (Peer-reviewed)
11. A method of overlaying models of isogeometric analysis (IGA) for modeling localized features of structure and its accuracy, Yuhi Tsuchiyama, Yusuke Sunaoka, Hiroshi Okada, Yuto Otoguro, Mechanical Engineering Journal, Vol. 11, Article ID 24-00173, 2024, Online ISSN 2187-9745, https://doi.org/10.1299/mej.24-00173 (Peer-reviewed)

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13. High-throughput in-situ mechanical evaluation and parameter optimization for 3D printing of continuous carbon fiber composites, Yuichiro Yuge, Ryosuke Matsuzaki, Composites Part C, 15 (2024.10), 100536 (Peer-reviewed)
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16. Thermal curing of epoxy resins at lower temperature using 4-(methylamino)pyridine derivatives as novel thermal latent curing agents, Daisuke Aoki, Shigemasa Dogoshi, Yukai Ito, Koji Arimitsu, J. Polym. Sci., 2024, 62, 4406-4415 (Peer-reviewed)
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Books

1. Durability of Carbon Fiber Reinforced Plastics, Jun Koyanagi, CRC Press, Taylor & Francis Group (2024)
2. Design of refractory high entropy alloys for extreme environment by using CALPHAD, Yuki Komiya, Yasuo Kogo, Yutaro Arai, MRS Advances, 9 (2024) 815–821
3. Experimental and analytical evaluation of an aerospace thermal protection system: Carbon monolith ablator, Rina Ono, Kenjiro Tsukamoto, Yutaro Arai, Yasuo Kogo, MRS Advances, 9 (2024) 822–829

Public Relations

1. 有光晃二, 西野 孝, 辻井敬亘, 扇澤敏明, 材料系 4 学会トップ座談会 コラボレーションで新たな可能性拓く, 化学工業日報, (2024 年 11 月 6 日)(in Japanese)

Award

1. 井上 遼, 学校法人東京理科大学 優秀研究者奨励賞(2024 年 3 月 27 日) (in Japanese)

Individual Research Topics

Jun Koyanagi

"Numerical Simulations on the Mechanical Properties of Composite Materials"

Focusing primarily on carbon fiber reinforced plastics (CFRP), research is being conducted to improve mechanical properties through finite element analysis and molecular dynamics simulations. The goal is to achieve higher strength, longer service life, and the development of new composite materials. In recent years, a comprehensive durability evaluation method based on entropy has been established to detect damage and degradation, and to estimate residual strength and service life, with the aim of promoting sustainable manufacturing.

Shinji Ogihara

"Microscopic Damage Behavior in Fiber-Reinforced Composites"

This research experimentally investigates the initiation and propagation of microscopic damage under various loading conditions, focusing on laminated fiber-reinforced composites. The effects of such damage on the mechanical properties of the materials were evaluated, and the experimental results were compared with predictions from finite element analysis and damage mechanics models to assess their validity. The research laid the foundation for applying these methods to more complex material systems, contributing to structural health monitoring of composites in service.

Ryosuke Matsuzaki

"Research on 3D Printing of Composite Materials"

This research aims to develop high-strength and high-stiffness components for automotive and aerospace applications using 3D printing of continuous carbon fiber-reinforced polymer composites. In the past year, experimental demonstrations were conducted on improving curvature printability using twisted fibers and printing microstructures using carbon nanotube fibers. Additionally, research was conducted on improving print accuracy through the use of machine learning.

Ryo Inoue

"Development and Characterization of Heat-Resistant Composites"

This research focuses on developing novel composite materials that can withstand environments exceeding 1000°C, such as jet engine components. Efforts include developing new manufacturing methods using heat-resistant fibers and ceramic matrices (e.g., via 3D printing), simulating manufacturing processes, establishing high-temperature measurement techniques, and evaluating material performance under simulated service environments.

Hiroshi Okada

"Advances in Nonlinear Computational Fracture Mechanics"

This research proposes and applies a redefined J-integral suitable for analyzing three-dimensional crack propagation under elastoplastic deformation in heterogeneous materials with residual stress, within a finite deformation framework. Further work involves improving the accuracy and efficiency of 3D fracture mechanics analysis using multi-patch isogeometric analysis.

Akiyuki Takahashi

“Dislocation Dynamics Analysis of Microscopic Structures and Mechanical Properties of Materials”

A simulation method was developed to model dislocation–precipitate interactions using analytical solutions for the elastic stress fields generated by precipitates. This method enables the numerical analysis of model alloys with realistic precipitation densities. Additionally, efforts are underway to perform dislocation dynamics simulations to elucidate the effects of precipitates and specimen dimensions in alloy micro-pillar tests.

Yasuo Kogo

“Fabrication and Mechanical Characterization of Particle-Dispersed Porous Carbon Composites”

We established a material process for ZrO_2 particle dispersed porous carbon composites with 3D networked structures (hereafter denoted as ZCM). Uniform dispersion of particles up to ~9 vol% was observed and 3D networked structures without containing particles was maintained. The compressive strength of composites decreased compared to it without particles. However, the compressive strength of composites is similar to it for conventional porous carbon materials. The ablation behavior of ZCM as a component of thermal protection system for re-entry vehicles will be evaluated.

Yutaro Arai

“Fabrication and Ablation Behavior of Heat-Resistant Multi-Element Ceramic Matrix Composites via High-Entropy Alloy Infiltration”

A high-entropy alloy composition with a melting point around 1700°C was designed using computational thermodynamics. By infiltrating this alloy into porous carbon fiber reinforced carbon (C/C) and inducing a reaction, a novel heat-resistant multi-element ceramic matrix composite (RMECMC) was fabricated. Upon exposure to an oxidizing atmosphere at approximately 2000°C, the RMECMC showed a thickness loss rate of about 5%, which is an improvement over the base C/C material.

Koji Arimitsu

“Photo and thermal curing of epoxy resins using latent curing agents”

We developed a photobase generator that generates an organic superbase, and investigated photoanionic adhesion of epoxy-thiol systems, and succeeded in photoadhesion of copper substrates that do not transmit light. We also developed a thermal latent curing agent that generates aminopyridine, which does not react with epoxy resin at room temperature and succeeded in curing epoxy resin with high efficiency by heating at 80-100℃.

Mohammad Fikry

“Interlaminar Toughening of CFRP Laminates Using Interleaving Layers”

CFRP laminates typically exhibit excellent in-plane properties but poor out-of-plane characteristics such as interlaminar toughness. This study aims to enhance interlaminar fracture toughness and suppress delamination by inserting interleaving layers—such as carbon fiber nonwoven fabrics, cellulose nanofiber-reinforced resins, or polyamide mesh—between the laminate layers. Targeting complex laminates with resin-rich pockets at fiber discontinuities, localized interleaving was applied and was found to effectively suppress damage initiation.

Division of Aging Biology

Division of Aging Biology

1. Overview

Aging is a phenomenon that is regulated and influenced by various external factors, including environment, stress, and lifestyle. Our division focuses on lipids, water-soluble metabolites, the epigenome, mitochondrial function, and immune function, all of which undergo dynamic changes in response to external stimuli. We aim to elucidate the fundamental principles of aging and acquire knowledge that will contribute to the development of preventive and interventional strategies against aging. Given the broad range of research fields required to achieve this goal, our division brings together outstanding researchers from diverse disciplines within the Faculty of Science and Technology, the Faculty of Pharmaceutical Sciences, and the Research Institute for Biomedical Sciences. In addition, we collaborate with leading external researchers in aging biology, leveraging Tokyo University of Science's unique interdisciplinary approach to drive cutting-edge aging research.

2. Organization and Facilities

The Division of Aging Biology research primarily consists of four research groups: the Lipids and Water-Soluble Metabolites Group, the Epigenome Group, the Mitochondrial Function Group, and the Immune Function Group. In addition to these core groups, we collaborate with outstanding researchers specializing in bone, neurobiology, respiratory systems, tumors, and primate aging models to promote comprehensive aging research from multiple perspectives. Furthermore, we have established an RNA-seq Analysis Support Center within the division to assist members with transcriptome analysis.

3. Activity Reports

3. 1. Lipids and Water-Soluble Metabolites Group

The Nakamura Laboratory has created genetically modified mice with lacking or overexpressing enzymes involved in the metabolism of phosphoinositides which are expected to play a role in the regulation of cellular senescence. Additionally, the laboratory has discovered a novel phospholipase C that is anticipated to be involved in cellular senescence.

The Higashi Laboratory has found that polyamines regulate the protein synthesis of the translation initiation factor eIF5A2 (eIF5A2) which is required for cancer cell growth. In addition, the laboratory has constructed a luciferase assay system to identify eIF5A2-specific inhibitors using a drug library.

The Takehiko Sasaki Laboratory analyzed age-related variations in bioactive phospholipids, specifically phosphoinositides (PIPs), by applying their proprietary technique—PRMC-MS (phosphoinositide regioisomer measurement by chiral column chromatography and mass spectrometry)—to mouse tissue samples. In addition, the team established analytical systems capable of quantifying anxiety-like, depression-like behaviors, and memory functions using video tracking software (Any-maze). Furthermore, by combining forelimb grip strength measurements with treadmill exercise tolerance testing, they developed a highly accurate system to assess age-related declines in motor function.

The Atsuo Sasaki Laboratory has been investigating a novel mechanism of aging regulation mediated by GTP-sensing functionality. Recent findings suggest that the activity of certain GTP-associated molecules fluctuates during the aging process, influencing aging progression at both the cellular and organismal levels.

Building on these insights, the laboratory employs biochemical, molecular biological, and cell biological approaches to elucidate how the GTP-sensing system is linked to the regulation of downstream degradative pathways. The team has also developed and characterized novel inhibitors targeting this pathway, and has published related findings in *The FEBS Journal*. Moving forward, the research will extend from cellular analyses to investigations at the organismal level to further clarify the regulatory mechanisms of aging.

3. 2. Epigenome Group

The Maezawa Laboratory performed scATAC-seq analysis using aged mouse testes, leading to the identification of age-associated chromatin structural alterations at specific differentiation stages of male germ cells. Future work will focus on characterizing the epigenetic modifications within these altered regions and elucidating the underlying regulatory mechanisms. In addition, metabolomic analysis was conducted on germ cells at representative stages of differentiation, revealing age-related metabolic alterations. Ongoing studies aim to clarify the relationship between metabolic reprogramming and epigenomic changes during aging.

The Hayano Laboratory is investigating age induction driven by epigenetic changes using the ICE (inducible changes to the epigenome) mouse model. Currently, we are focusing on the Wnt-β-catenin pathway and the Rho-GTPase pathway, which are affected by epigenetic alterations induced by DNA damage in ICE mice, and have identified novel small-molecule compounds. These compounds are believed to improve cognitive function and muscle strength in aged mice, as well as regulate the differentiation of mesenchymal cells. Moving forward, we aim to further elucidate the molecular mechanisms underlying epigenetically induced aging and to develop novel therapeutic strategies targeting epigenetic modifications.

3. 3. Mitochondrial Function Group

The Higami Laboratory has independently generated tissue-specific knockout mice for mitochondrial peptidases involved in protein maturation and obesity and aging-induced factors that increase in adipose tissue, and has investigated that phenotypes associated with ageing and obesity.

The Kobayashi Laboratory aimed to elucidate the role of mitochondrial protein maturation process in aging and senescence, and analyzed the expression and activity of mitochondrial signal peptidases involved in this process in tissues of the aging and caloric restriction animals.

The Yanagi Laboratory recently published a paper in Nature Communications (2025, Volume 16, Article number 1508) reporting that RMDN3 (also known as PTPIP51) regulates the transfer of lipid radicals from mitochondria to the endoplasmic reticulum at contact sites between the two organelles. Phosphorylation of RMDN3 enhances its interaction with the ER protein VAPB, facilitating this transfer and thereby reducing mitochondrial oxidative stress. These findings reveal a novel protective mechanism of organelle contact that helps maintain mitochondrial health.

3. 4. Immune Function Group

The Ikawa Laboratory worked on generating induced Leukocyte Stem (iLS) cells from hematopoietic stem cells (HSCs) in bone marrow of aged mice to determine the relationship between HSC aging and leukemogenesis. They also developed a method to generate chimeric antigen receptor (CAR)-NK cells against various antigens, which may lead to a novel senolytics in the future.

The Yoshimura Laboratory previously discovered that the nuclear receptor NR4a plays a crucial role in the dysfunctional state known as "exhaustion" of T cells, which is associated with aging and cancer. The laboratory aims to verify whether the loss or inhibition of NR4a in mouse and human T cells can delay immune aging. Concurrently, the effects on aging-related disease models such as cancer, dementia, and fatty liver disease will also be investigated.

The Haeno Laboratory have advanced the construction and analysis of a mathematical model related to clonal hematopoiesis, and found that clonal hematopoiesis is promoted by factors such as age, stem cell division rate, mutation rate, the degree of fitness increase due to mutations, and the number of hematopoietic stem cells. Additionally, in collaboration with Associate Professor Koichi Takahashi from MD Anderson Cancer Center, we conducted an analysis using mutation accumulation data of hematopoietic stem cell populations in cases of myeloma treatment. Our co-authored paper has been accepted by Nature Genetics.

4. Challenges and Prospects

Research is being actively pursued within each research group and on individual research topics. However, as this is the first year since the establishment of the division, many efforts are still ongoing, including the identification of aging regulatory factors and the analysis of the mechanisms by which target factors control aging. Moving forward, we aim to further advance the identification of aging control factors as potential intervention targets and to deepen our understanding of the molecular mechanisms underlying aging regulation.

5. Conclusion

In the first year since the establishment of this department, we have made steady progress in laying the groundwork for our research goals. These include establishing essential experimental systems and developing model animals and cell lines. Our aim is to elucidate the fundamental principles and underlying mechanisms of aging through approaches unique to Tokyo University of Science, and to generate insights that will contribute to the development of preventive and interventional strategies against aging. We are also committed to fostering this department as a platform for collaborative research, information exchange, and technological interaction with aging biology researchers both in Japan and internationally.

Major Research Achievements (FY2024)

Academic Papers

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Books

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2. カロリー制限下における SREBP-1c の発現制御機構と白色脂肪組織の代謝リプログラミング, 野崎優香, 水之江雄平, 樋上賀一, 週刊医学のあゆみ特集「脂質制御因子 SREBP の新展開」, 291 (11), 1028-1032, 2024 (in Japanese)
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8. 免疫アレルギー領域のスタートアップの最新動向調査研究 2022 日米欧のアレルギー投資国際比較, 足立剛也, 早野元詞, 伊藤靖典, 猪俣武範, 小川 靖, 貝沼圭吾, 神尾敬子, 倉島洋介, 桑原 優, 坂下雅文, 佐藤さくら, 富田康裕, 中島沙恵子, 二村昌樹, 正木克宜, 玉利真由美, 海老澤元宏, 森田英明, アレルギー, 2024 年 73 巻 3 号 p. 268-278 (in Japanese)
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Invited Lectures

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2. NR4a 阻害剤の開発に向けて, 吉村昭彦, 第 2 回シーズ・ニーズワークショップ 2025 年 1 月 24 日（東京都品川区）(in Japanese)
3. サイトカインを中心とした免疫寛容と抗腫瘍免疫の分子機構, 吉村昭彦, 三風会セミナー、2025 年 1 月 17 日（熊本県菊池市）(in Japanese)
4. 免疫を制御する仕組みとがん免疫療法, 吉村昭彦, 第 169 回サイテックサロン, 2025 年 1 月 11 日（東京都目黒区）(in Japanese)

5. 脳梗塞における免疫応答 CVMW202 4 心血管代謝週間「特別講演 3」, 吉村昭彦, 2024 年 12 月 8 日（東京都千代田区）(in Japanese)
6. サイトカインのシグナル制御と免疫寛容, 吉村昭彦, 第 15 回日本炎症性腸疾患学会学術集会 会長セッション 2024 年 11 月 15 日（東京都品川区）(in Japanese)
7. がん、脳疾患、老化に挑む免疫研究の最前線, 吉村昭彦, 第 97 回日本生化学会モーニングセミナー, 2024 年 11 月 6 日（横浜市）(in Japanese)
8. NR4a Play Central for Immune Tolerance and Anti-tumor Immunity, Akihiko Yoshimura, FIMSA 2024, 2024 年 10 月 24 日 (Taipei)
9. Ras-ERK 経路の抑制分子 SPRED の変異と疾患, 吉村昭彦, 第 14 回シグナルネットワーク研究会 2024, 2024 年 10 月 18 日（沖縄県国頭郡）(in Japanese)
10. サイトカインシグナルと免疫寛容, 吉村昭彦, 第 14 回 「よく分かる」免疫学講座, 2024 年 10 月 18 日（岡山市）(in Japanese)
11. 免疫寛容の分子機構と NR4a, 吉村昭彦, 日本免疫学会サマースクール in 湘南 2024 年 8 月 4 日 (神奈川県三浦郡湘南国際村センター）(in Japanese)
12. 研究費獲得に向けて- 私の経験から -, 吉村昭彦, 慶應義塾大学薬学部研究費獲得講習会 2024 年 8 月 5 日（東京都港区）(in Japanese)
13. NR4a transcription factor regulates exhaustion and stemness of intratumoral memory T cells, Akihiko Yoshimura, 第一回日本サイトカイン学会（札幌市）
14. 脳梗塞における炎症性サイトカインと制御性 T 細胞の意義, 吉村昭彦, 第 24 回日本分子脳神経外科学会 2024 年 7 月 20 日 （佐賀市）(in Japanese)
15. がん、脳疾患、老化に挑む免疫研究の最前線, 吉村昭彦, 第 32 回千葉大学大学院薬学研究院宮木高明記念講演会 2024 年 7 月 6 日(千葉市) (in Japanese)
16. 免疫老化と個体の老化, 吉村昭彦, 東京理科大学老化生物学研究部門キックオフシンポジウム 2024 年 6 月 28 日(野田市) (in Japanese)
17. 自己免疫疾患はなぜ起きるのか?, 吉村昭彦, NPO 法人筋無力症患者会特別講演 2024 年 4 月 20 日(zoom 講演) (in Japanese)
18. 血液前駆細胞を用いた再生・細胞療法の開発, 伊川友活, 東京理科大学老化生物学研究部門キックオフシンポジウム 2024 年 6 月 28 日 (in Japanese)
19. がん細胞の増殖に関与するポリアミン制御遺伝子の同定, 東 恭平, 日本農芸化学会 2025 年度札幌大会 シンポジウム (社会実装に近づくポリアミン研究), 札幌, 2025 (in Japanese)
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22. ミトコンドリアプロテオスタシスを起因としたカロリー制限による寿命延長効果, 野崎優香, 水之江雄平, 小林正樹, 樋上賀一, 第 47 回日本分子生物学会年会シンポジウム「Nutri-aging が制御するジェロサイエンス研究」, 福岡, 2024 (in Japanese)
23. 葉酸欠乏による父性エピゲノムの変容機構, 前澤 創, 第 47 回日本分子生物学会年会, 福岡, 2024 (in Japanese)
24. 命をつなぐ配偶子エピゲノム – その形成機構や揺らぎについて, 前澤 創, 環境エピゲノミクス研究会（EEG）2024 春季ネットシンポジウム, オンライン, 2024 (in Japanese)
25. Mechanisms of rotary ATPases, 政池知子, 21st Congress of International Union of Pure and Applied Biophysics 2024 (IUPAB2024) in collaboration with the 62nd Annual Meeting of the Biophysical Society of Japan, 京都, 2024

26. がん形成過程の数理情報解析研究, 波江野洋, 第 56 回日本動脈硬化学会総会・学術集会　シンポジウム「生命現象への数理学的アプローチ」, 神戸, 2024 (in Japanese)
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29. Computational Simulation of Tumor Evolution Based on Omics Data, 波江野洋, 6th International Bio-Medical Interface Symposium 2025(IBMI 2025),台北,2025
30. 老化, がん, 性分化疾患でのホスホイノシタイド変容, 佐々木雄彦, 生体膜国際研究拠点形成セミナー, 2024 年 1 月 30 日, 神戸大学 (in Japanese)
31. ホスホイノシタイド群の病態生理機能と分子解剖, 佐々木雄彦, ChemBio ハイブリッドレクチャー, 2024 年 10 月 1 日, 東京大学 (in Japanese)
32. Decoding the evolving role of GTP energetics in bioregulation, 佐々木敦朗, 國立清華大學 生命科學暨醫學院（台湾） 2024 年 12 月 6 日（台湾）
33. GTP 代謝と生命のダイナミズム：生体と疾患制御への新視点, 佐々木敦朗, 同志社大学 2024 年 11 月 19 日（京都市）(in Japanese)
34. 第 3 回 GTP ハッカソン オーガナイザー兼講演, 佐々木敦朗, 2024 年 11 月 17 日（静岡市）(in Japanese)
35. GTP 代謝と生命のダイナミズム：生体と疾患制御への新視点+ 豊かにキャリアを歩むために大事にしていること, 佐々木敦朗, 琉球大学熱帯生物圏研究センター 2024 年 11 月 14 日（沖縄県）(in Japanese)
36. Investigating the GTP Energetics, 佐々木敦朗, 沖縄科学技術大学院大学（OIST） 2024 年 11 月 13 日（沖縄県）(in Japanese)
37. シンポジウム:GTP シンフォニー：生理条件で探る代謝生化学と疾病解明, 佐々木敦朗, 第 97 回日本生化学会大会 2024 年 11 月 7 日（横浜市）(in Japanese)
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40. GTP 代謝と生命のダイナミズム：生体と疾患制御への新視点, 佐々木敦朗, 大分大学 2024 年 7 月 30 日（大分市）(in Japanese)
41. Opening Remarks 2024 Spring GTP ワークショップ, 佐々木敦朗, 2024 年 3 月 3 日（東京大学）(in Japanese)
42. Wnt activation disturbs cell competition and causes diffuse invasion of transformed cells through NF-kB-MMP21 pathway, 昆 俊亮, 第９６回日本組織培養学会, ２０２４年６月２７日
43. がん細胞が産生した際の生体内反応を観察するマウスモデルの作出と解析, 昆 俊亮, 小動物インビボイメージング会, ２０２４年９月７日 (in Japanese)
44. 細胞膜リン脂質の変容と細胞老化の関連, 中村由和, 金丸佳織, 第 66 回日本老年医学会学術大会　2024 年 6 月 14 日（名古屋）(in Japanese)
45. エピゲノム情報による後天的老化制御, 早野元詞, 第 77 回日本酸化ストレス学会・第 23 回日本 NO 学会合同学術集会, 神奈川歯科大学, 神奈川, 2024/5/17 (in Japanese)
46. 老化のタイミングおよび速度を決定するエピゲノム制御と、その可逆性, 早野元詞, 第 97 回日本整形外科学会学術総会 人生 100 年時代講演 1, 福岡国際会議場, 福岡 , 2024/5/24 (in Japanese)

47. 非視覚光受容体 OPN5 による脳機能制御, 早野元詞, 第 24 回日本抗加齢医学会総会, 熊本城ホール, 熊本, 2024/6/1 (in Japanese)
48. DNA 損傷依存的エピゲノム情報の喪失による老化制御, 早野元詞, 第 24 回日本抗加齢医学会総会, 熊本城ホール, 熊本, 2024/6/2 (in Japanese)
49. 後天的老化制御の分子理解, 早野元詞, ABiSS2024, あかん遊久の里 鶴雅, 北海道, 2024/9/16-18 (in Japanese)
50. The changes in epigenome identity by DNA damage regulates aging, Motoshi Hayano, A3 Foresight Meeting in Daejeon, Daejeon, Korea, 7 Mar 2025
51. DNA 損傷によるエピゲノム変動を介した老化制御, 早野元詞, 第 24 回日本再生医療学会総会, パシフィコ横浜, 神奈川, 2025/3/20-22 (in Japanese)

Patents

1. 出願番号：PCT/JP2024/ 27781
   発明者：伊川友活, 重廣 司, 春山宗忠
   発明の名称：免疫細胞の製造方法
   出願人：東京理科大学, 第一三共株式会社
   出願日：2024 年 8 月 2 日 (in Japanese)
2. 出願番号：PCT/JP2024/032131
   発明者：柳 茂, 他１２名
   発明の名称：ベルベルビン関連化合物
   出願人：株式会社マイトジェニック
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2. 早田匡芳, 日本組織培養学会 第 96 回大会において本学大学院生らが English Presentation Award を受賞, 東京理科大学プレスリリース 2024 年 7 月 25 日。
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12. 早野元詞, エイジング革命 250 歳まで人が生きる日, 朝日新聞出版, 2024 年 5 月 13 日
13. 早野元詞, アンチエイジングとは別物…「50 歳の人が治療で 30 歳に」老化のリセット・スイッチを手に入れた近未来の寿命, PRESIDENT Online, 2024 年 5 月 13 日
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18. 早野元詞, 老化って予防しかできないの？→実は「治療」可能な日が近づいていた！, DIAMOND online, 2024 年 7 月 27 日
19. 早野元詞, エイジングのメカニズムを解明し, 社会実装につなげる, Top Researchers, 2024 年 8 月 6 日
20. 早野元詞, 「若返り」技術, 手にできる日は？, 毎日新聞, 2024 年 8 月 14 日
21. 早野元詞, 老化にいどむ最先端研究と未来の人体　不死のサイエンス, 科学雑誌 Newton, 2024 年 10 月 25 日
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23. 早野元詞, 【真実】老化は遺伝子が 2 割, 生活習慣が 8 割, News Picks, 2024 年 11 月 11 日
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27. 早野元詞, 【老化の鍵】遺伝子の ON・OFF スイッチはハックできる, News Picks, 2024 年 11 月 15 日
28. 早野元詞, 【3.7 兆円】老化細胞, 遺伝子治療, 若返り…老化研究を巡るロンジェビティ産業の相克, News Picks, 2024 年 11 月 15 日
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1. 野崎優香, 第 23 回日本ミトコンドリア学会年会, 口頭発表優秀賞, 2024
2. 福王智康, 野崎優香, 水之江雄平, 小林正樹, 樋上賀一, 第 47 回日本基礎老化学会　奨励賞. 2024
3. 野崎優香, 第 17 回資生堂女性研究者サイエンスグラント, 株式会社資生堂, 2024
4. 高橋 秀, 上林悠人, 田中信清, 中江 進, 池上浩司, 政池知子, 優秀ポスター賞 (医学・生物科学), 日本顕微鏡学会・第 80 回学術講演会, 2024
5. 金丸佳織, 第 47 回日本基礎老化学会, 奨励賞, 2024
6. 早野元詞, 2024 年日本抗加齢医学会, 研究奨励賞, 2024 年 6 月

Individual Research Topics

Yoshikazu Nakamura, Kaori Kanemaru

“Elucidating the Role of Phospholipids in the Regulation of Aging”

Twelve factors that define aging have been reported as the Hallmarks of Aging; however, lipid-related factors are not included, and the role of lipids in aging regulation remains largely unexplored. This study aims to identify phospholipids and their metabolizing enzymes involved in aging regulation and to explore their potential as targets for suppressing cellular, tissue, and organismal aging.

Yoshikazu Higami, Yuka Nozaki, Yuhei Mizunoe

“Effect of mitochondrial quality on aging in white adipose tissue”

In recent years, white adipose tissue is known to be an endocrine tissue that is important for the metabolism of individual.We have previously identified several mitochondrial quality-related proteins whose expression in white adipose tissue changes in response to metabolic improvement, obesity and ageing. In this study, to elucidate the function of mitochondrial factor in l metabolism and ageing using genetically engineered mice model.

So Maezawawa

“Elucidating the Mechanisms of Age-Associated Alterations in the Paternal Epigenome”

While the genome is stable throughout its lifetime, the epigenome is subject to dynamic alterations across the lifespan. In sperm, age-related epigenetic alterations have been implicated not only in the decline of sperm quality but also in the acceleration of aging phenotypes in offspring. However, the molecular mechanisms by which these paternal epigenomic changes are established during spermatogenesis remain largely unknown. This study aims to elucidate the underlying mechanisms of age-associated epigenetic remodeling in the paternal germline, with a particular focus on changes in intracellular metabolic states and epigenetic regulation. Furthermore, we seek to explore whether modulation of the nutritional environment can prevent or reverse these epigenetic alterations, thereby offering potential strategies for mitigating their transgenerational effects.

Tomokatsu Ikawa

“Elucidation of relationship between clonal hematopoiesis and leukemia development”

Clonal hematopoiesis of indeterminate potential (CHIP) arises from age-associated acquired mutations in hematopoietic progenitors, which display clonal expansion and produce phenotypically altered leukocytes. CHIP is associated with an increased risk of blood cancers, such as acute myeloid leukemia. This study focuses on the mechanisms how CHIP induces the development of leukemia with aging.

Shunsuke Kon

“The functional significance of cellular senescence in cancer malignancy”

Dual nature of senescence, tumor-suppressive and promotive, complicates our understanding of its physiological relevance in cancer. In this study, using an intestinal *de novo* cancer mouse model, we investigate how induction of cellular senescence affects invasiveness and malignant potential of cancer cells.

Mahito Sadaie

“Identification of Cellular Senescence Inducers Using Changes in Nuclear Morphology as Indicators and Elucidation of Their Mechanism of Action”

Cellular senescence is a phenomenon where cells undergo permanent growth arrest in response to stress, accompanied by characteristic changes in nuclear morphology. This study aims to identify compounds that induce cellular senescence by using these morphological changes as indicators and to elucidate the molecular mechanisms underlying senescence induction. Furthermore, we will investigate whether the identified senescence inducers can induce senescence in cancer cells and explore their potential applications in cancer therapy. This research may lead to the discovery of previously unknown stressors and senescence-associated genes involved in the induction of cellular senescence.

Hiroshi Haeno, Kouichi Saeki

“Elucidation of the mechanisms of clonal hematopoiesis using mathematical analysis”

As individuals age, specific genetic mutations such as DNMT3A and RUNX1 accumulate in the population of hematopoietic stem cells and spread within the hematopoietic tissue. This phenomenon is known as “clonal hematopoiesis”, and it is associated with an increased risk of cancer and cardiovascular diseases. Our group aims to elucidate the mechanisms of clonal hematopoiesis using mathematical analysis through a stochastic process called the Moran process.

Tadayoshi Hayata, Yukihiro Kohara

“Exploration of New Therapeutic Molecular Targets and Elucidation of Pathophysiology for Age-related Musculoskeletal Diseases”

Extending healthy life expectancy is a global challenge, and the prevention and treatment of age-related musculoskeletal diseases such as osteoporosis and sarcopenia are considered urgent priorities. This research aims to identify new therapeutic molecular targets for these diseases while using gene-modified mice to gain deeper insights into their pathophysiology. Through this study, it is expected to lead to the development of sustainable treatments that enable older adults to live healthier and more fulfilling lives.

Kyouhei Higashi, Masahiro Komeno

“Functions of spermidine and eukaryotic translation factor eIF5A in cancer cell proliferation and invasion”

Long-term oral administration of spermidine (SPD) induces autophagy, resulting in the activation of aged cell functions. For this reason, SPD has attracted attention as a geroprotector. However, SPD is also involved in cancer malignancy; therefore, it is necessary to clarify the role of SPD in cancer cell proliferation in more detail. In this study, we amied to demonstrate that eIF5A2, which is hypusinated using SPD as a substrate, plays an important role in cancer-specific proliferation and explore its inhibitors.

Teiichi Furuichi

“Exocytosis of biologically active substances and cellular senescence”

Humans digest ingested food into small molecules and absorb them into cells to perform energy metabolism, thereby maintaining dynamic and orderly cellular structure and function. The pancreas has acinar cells that secrete digestive enzymes to break down nutrients and β cells that secrete insulin for nutrient absorption, playing a crucial role in the strategy to secure the energy and materials essential for cellular activity throughout the body. In this study, starting from molecules involved in exocytosis regulation, we will elucidate the molecular mechanisms of secretion decline/insufficiency, pancreatic cell degeneration, and inflammation onset associated with aging and lifestyle, and consider the impact on cellular senescence throughout the body. We will also conduct research from the perspective of exocytosis in the nervous system.

Tomoko Masaike

“The influence of ageing on mucociliary clearance”

Mucociliary clearance plays an important role in generation of fluid flow in different parts of the body. In this study, we focus on the effects of ageing on the airway. Beating patterns of epithelial cilia in the trachea of mice are observed using 3D tracking microscopy. With this method, we can quantify not only frequency of beating but also speed of effective/recovery strokes and changes in asymmetry of the waveform. Meanwhile, generated fluid flow was also measured through traslocation of microbeads. Applying these analyses to assessing the effects of ageing, we hope to obtain insights into prevention of diseases such as pneumonia, which is often critical to elderly people.

Akihiko Yoshimura

“Elucidating the role of NR4a in T cell exhaustion and aging”

The Yoshimura Laboratory previously discovered that the nuclear receptor NR4a plays a crucial role in the dysfunctional state known as “exhaustion” of T cells, which is associated with aging and cancer. We aim to verify whether the loss or inhibition of NR4a in mouse and human T cells can delay immune aging. Concurrently, the effects on aging-related disease models such as cancer, dementia, and fatty liver disease will also be investigated.

Naoyuki Wada

“Analysis of Maturation, Regeneration, and Aging of Zebrafish Skeletal Tissue”

We will conduct research using zebrafish as a model for the growth, maintenance, and aging of the human skeleton. We will investigate the formation and maintenance of the median skeleton, including the vertebrae and the fin rays that form the median fin, focusing on the various stages of development (morphogenesis), growth, and regeneration in fish.

Masaki Kobayashi

“Involvement of Mitochondrial Protein Maturation Process in the Regulation of Aging”

Mitochondrial dysfuntion is widely accepted as a hallmark of aging, but its details remain elusive due to extreme diversity of mitochondrial regulation. This study focuses on mitochondrial protein maturation process and aims to elucidate a novel mechanism in the regulation of aging by demonstarating the involvement of mitochondrial signal peptidases in aging.

Atsuo Sasaki

“Elucidating Aging Regulation Mechanisms via GTP Systems”

Recent findings suggest that fluctuations in GTP-sensing mechanisms influence aging at both the cellular and organismal levels. Our research aims to uncover fundamental principles underlying aging regulation mediated by GTP sensing. We employ biochemical, molecular biological, and cell biological approaches to investigate the connection between GTP sensing and the regulation of cellular degradative pathways. In addition, we are developing novel inhibitors targeting this pathway. Ultimately, we seek to extend these insights to organismal models and explore potential strategies for aging intervention.

Takehiko Sasaki

“Elucidating the Physiological Role of Phosphoinositide Metabolism in Aging”

Our laboratory focuses on age-related alterations in the phosphoinositide (PIPs) profile, particularly how changes in distinct PIPs species influence intracellular signaling and organelle function. Utilizing our proprietary LC-MS/MS technique, we aim to comprehensively characterize PIPs species and elucidate mechanisms underlying aging-associated metabolic reprogramming. Furthermore, we are investigating how shifts in the PIPs profile affect cancer progression, reproductive capacity, cognitive performance, and motor function, with the ultimate goal of identifying novel therapeutic targets for the prevention and treatment of aging-related diseases.

Motoshi Hayano

“Molecular mechanisms of epigenetically regulated aging”

There is considerable individual variability in the rate of aging, and it is estimated that more than 85% of health and lifespan is determined by environmental factors, such as stress-induced DNA damage. In 2023, we demonstrated that postnatal DNA damage, even without accompanying genomic mutations, induces long-term epigenetic alterations sufficient to drive aging-related phenotypes, including those affecting the brain and muscles, using a novel aging mouse model known as the ICE (Inducible Changes to the Epigenome) mouse. In this project, we focus on the impact of postnatal DNA damage stress and investigate the molecular mechanisms underlying epigenetic changes and the initiation of aging by dividing the process into two distinct phases: (1) the “prime phase,” in which epigenetic regulation is mediated by the ATM/ATR pathways involved in DNA damage response and repair, and (2) the "memory phase," in which epigenetic information, such as DNA methylation changes mediated by Tet1, becomes fixed and controls cellular function through gene expression modulation.

Shigeru Yanagi

“Regulation of Organelle Contact and Aging-Related Mitochondrial Function”

Professor Shigeru Yanagi's research focuses on maintaining mitochondrial function during aging, with particular attention to the mitochondrial ubiquitin ligase MITOL and its role in regulating contact between the endoplasmic reticulum and mitochondria. Mitochondria not only produce energy but also maintain cellular homeostasis through interactions with other organelles. The Yanagi laboratory studies how MITOL controls inter-organelle communication and mitochondrial quality control, such as mitophagy, to preserve cellular function. This research also aims to identify novel drug targets for mitochondria-targeted therapeutics to prevent or treat aging-related diseases.

Research & Development Platform for Functional Green Building Materials

Research & Development Platform for Functional Green Building Materials

1. Overview

This project focuses on the research and development of high-functional materials and construction methods that contribute to CO_2 emission reduction for non-structural building components, such as exterior materials, interior materials, entrance components, and foundation materials. We aim to achieve environmentally conscious buildings with zero greenhouse gas emissions by 2050. Within this project, we are developing a system to evaluate CO_2 emissions across the entire life cycle of these components.

As society's decarbonization efforts accelerate, reducing the environmental impact of buildings has become essential. Non-structural components are estimated to contribute over 20% of "Embodied Carbon," which includes CO_2 emissions from the production, processing, transportation, installation, and disposal phases of construction materials. Additionally, these components play a crucial role in the building's functionality and contribute significantly to "Operational Carbon," the CO_2 emissions during the building's operational phase. Therefore, achieving the optimal balance between CO_2 reduction and functional enhancement in "Whole Life Carbon" (WLC) is vital.

Therefore, this project will advance the research and development of materials and construction methods that highly balance environmental performance and functionality for exterior materials, interior materials, openings, and substrates, significantly impacting WLC. Additionally, the research and development aimed at enhancing the functionality and performance of interior and exterior materials will contribute to resource conservation and recycling, thereby fostering a nature-positive approach.

2. Organization and Facilities

In implementing this project, Tokyo University of Science will establish a collaborative research framework primarily involving the Department of Architecture within the Faculty of Science and Technology, in conjunction with faculty members from the Department of Advanced Chemistry, the Department of Management Systems Engineering, and the Graduate School's International Fire Science program. This interdisciplinary approach will drive the university-industry collaboration as a comprehensive open innovation project, creating pioneering examples in various interdisciplinary fields and leading efforts for environmental sustainability in the construction industry.

For the fiscal year 2024, in addition to existing facilities, we have introduced vacuum pressure impregnation equipment and temperature and humidity stability chamber to enhance the performance evaluation system for building materials.

Faculty of Science and Technology	
Department of Architecture	Professor Manabu KANEMATSU
Department of Pure and Applied Chemistry	Professor Takahiro GUNJI
Department of Industrial and Systems Engineering	Associate Professor Seiichi YASUI
Department of Architecture	Associate Professor Kozo TAKASE
Graduate School of Science and Technology	
Department of Global Fire Science and Technology	Professor Yoshifumi OMIYA

Xenon arc Weathering Testing Machine

Cone calorimeter Testing Machine

Vacuum Pressure Impregnation Equipment

Temperature and Humidity Stability Chamber

Photo 1. Main facilities

3. Activity Reports

3. 1. CO_2 Reduction Strategies Working Group (WG0) M. Kanematsu, S. Yasui

In WG0, we aim to contribute to formulating CO_2 reduction strategies by establishing various performance evaluation methods, including environmental performance, for interior and exterior materials in environmentally conscious buildings and by identifying the priorities and improvement effects of challenges in material development. In fiscal year 2024, we conducted the following activities and provided support for LCA accounting for each working group.

- ✓ Calculation of $LCCO_2$ for standard office buildings
- ✓ Examination of the priority of evaluation items for environmentally conscious buildings
- ✓ Examination of multi-objective optimization for environmentally conscious building

3. 2. Exterior Materials Working Group (WG1) M. Kanematsu

WG1 aims to develop new exterior materials for concrete substrates. We are advancing technologies for directly printing coating films onto concrete substrates and finishing the concrete surface with a glass layer. To ensure these materials are suitable for exterior use, we investigate substrate treatment methods to achieve adequate weather resistance. Furthermore, we are conducting performance evaluations based on exposure tests and UV-accelerated degradation tests and investigating the degradation mechanisms. In fiscal year 2024, we investigated the thermal effects of laser glazing on the concrete substrate by firing glaze onto concrete surfaces using a laser, and clarified how the firing method influences the performance of the glaze layer.

3. 3. Interior Materials Working Group WG2 (WG2) T. Gunji

Promoting the use of wood in buildings is encouraged as it can fix carbon dioxide (CO_2). While fire-retardant treatment is often required for wooden interior materials, and the leaching of chemicals under certain environmental conditions is a major problem. Additionally, fire-retardant-treated wood is produced by infusing large amounts of chemicals into the wood using significant energy, but the environmental impact is still unknown. WG2 will calculate the $LCCO_2$ of existing fire-retardant-treated wood to clarify its environmental impact. Moreover, to reduce CO_2 emissions, we are developing new fire-retardant treatment

technologies that prevent chemical leaching, contributing to developing environmentally friendly buildings. Specifically, we are working on new fire-retardant treatment techniques that combine impregnation and coating methods. In fiscal year 2024, we synthesized two types of flame retardants and conducted performance evaluation experiments using test specimens made from wood pieces treated via coating and impregnation. The CO_2 emissions associated with the manufacturing process are scheduled to be estimated and validated at the specimen scale in fiscal year 2025 and beyond.

3. 4. Openings Working Group (WG3) K. Takase

In WG3, we focus on openings to realize new openings that significantly contribute to environmentally conscious buildings. This involves evaluating openings' WLC, considering CO_2 emissions during material production, transportation, and installation phases (upfront carbon), and their performance during use. Generally, office buildings have high energy consumption for air conditioning. Therefore, we focused on office buildings with curtain walls, which are expected to be affected by differences in the thermal performance of the building envelope and conducted studies to estimate the $LCCO_2$. In fiscal year 2024, including the above activities, we carried out investigations toward the development of new opening components, conducted mock-up experiments, and identified differences in thermal performance values through two-dimensional steady-state heat transfer simulations.

3. 5. Substrate Working Group (WG4) Y. Omiya

WG4 is advancing surveys on the current status of $LCCO_2$ and LCA evaluations related to fireproof coating work, aiming to achieve substrate materials that contribute to environmentally conscious construction. Efforts include understanding initiatives such as decarbonization, CO_2 reduction, and achieving carbon neutrality in fireproof coating operations, as well as grasping examples of initiatives such as research on $LCCO_2$ and LCA evaluations. In fiscal year 2024, we assessed the status of $LCCO_2$ evaluations for fireproof coatings and reviewed the progress of technical discussions with relevant manufacturers.

Major Research Achievements (FY2024)

Academic Papers

1. 大塚慶人, 高瀬幸造, 松尾隆士, 二川眞一郎, 赤羽根駿之介, 木・再生アルミ複合カー テンウォールの開発と LCCO2 評価, 日本建築学会技術報告, 2025.6 (in Japanese) (Peer-reviewed)
2. 清村俊介, 辻埜真人, 竹本喜昭, 赤羽根駿之介, 堀合航太, 金 準鎬, 兼松 学, レーザによるコンクリート表面への施釉方法の開発, 月刊リフォーム, 2025.3 (in Japanese)
3. 橋本章吾, 山本一樹, 郡司天博, 稲藁灰を用いるシラトランの合成とその難燃剤としての性質, 日本化学会第 105 春季年会, 2025.3 (in Japanese)
4. 森 一希, 山本一樹, 郡司天博, ポリボロシロキサンの合成とその木材難燃剤としての性質, 日本化学会第 105 春季年会, 2025.3 (in Japanese)
5. 寺本有花, 山本一樹, 郡司天博, シラトランの合成とその木材難燃化剤としての性質, 日本化学会第 105 春季年会, 2025.3 (in Japanese)
6. 飯島真尋, 山本一樹, 郡司天博, ポリホスファシロキサンの合成とその難燃剤としての評価, 日本化学会第 105 春季年会, 2025.3 (in Japanese)
7. 倉原菜々, SSG 構法を用いた木・再生アルミを使用する高熱性能カーテンウォールの LCCO2 評価, 東京理科大学 創域理工学部 建築学科 卒業論文, 2025.2 (in Japanese)
8. 寺本有花, 山本一樹, 郡司天博, 木材難燃化剤としてのシラトランの合成と応用, 第 43 回 無機高分子研究討論会, 2024.11 (in Japanese)
9. 森 一希, 山本一樹, 郡司天博, ボロシリケート木材難燃剤 第 43 回 無機高分子研究討論会, 2024.11 (in Japanese)
10. 清村俊介, 辻埜真人, 竹本喜昭, 赤羽根駿之介, 堀合航太, 金 準鎬, 兼松 学, コンクリートへの新しい仕上技術の開発, ～レーザによるコンクリート表面への施釉方法～, 日本建築仕上学会, 2024.10 (in Japanese)
11. 堀合航太, 清村俊介, 辻埜真人, 竹本喜昭, 金 準鎬, 兼松 学, コンクリートへの新しい仕上技術の開発, ～UV プリンタによって成膜したプリンティング層の耐候性評価～, 日本建築仕上学会, 2024.10 (in Japanese)
12. 大塚慶人, 高瀬幸造, 松尾隆士, 二川眞一郎, 赤羽根駿之介, 堀川潤也, 藤原直樹, 増田信哉, エンボディードカーボン算定ツールと熱負荷シミュレーションによる木・再生アルミ複合カーテンウォールの LCCO2 評価　その１：中規模オフィスビルを対象とした検討, 空気調和・衛生工学大会学術講演論文集, 2024.9 (in Japanese)
13. 大塚慶人, 高瀬幸造, 松尾隆士, 二川眞一郎, 赤羽根駿之介, 堀川潤也, 藤原直樹, 増田信哉, エンボディードカーボン算定ツールと熱負荷シミュレーションによる木・再生アルミ複合カーテンウォールの LCCO2 評価　その１：中規模オフィスビルを対象とした検討, 空気調和・衛生工学大会学術講演論文集, 2024.9 (in Japanese)
14. 大塚慶人, 高瀬幸造, 松尾隆士, 二川眞一郎, 赤羽根駿之介, 堀川潤也, 藤原直樹, 増田信哉, 木・再生アルミを使用した高熱性能カーテンウォールの LCCO2 評価　その１：中規模オフィスビルを対象とした検討, 日本建築学会大会学術講演梗概集, 2024.8 (in Japanese)
15. 大塚 慶人, 高瀬 幸造, 松尾 隆士, 二川 眞一郎, 赤羽根 駿之介, 堀川 潤也, 藤原 直樹, 増田 信哉, 木・再生アルミを使用した高熱性能カーテンウォールの LCCO2 評価　その１：中規模オフィスビルを対象とした検討, 日本建築学会大会学術講演梗概集, 2024.8 (in Japanese)
16. 堀合 航太, レーザ焼成釉薬仕上技術に関する基礎的研究, 東京理科大学 創域理工学系研究科建築学専攻　修士論文, 2025.2 (in Japanese)
17. ハン イツナン, 廃ガラスを利用したレーザ焼成釉薬仕上げ技術に関する基礎的研究, 東京理科大学 創域理工学部 建築学科 卒業論文, 2025.2 (in Japanese)

Patents

1. Application Number: 2024-146489 (Unpublished Application)
2. Application Number: 2024-139929 (Unpublished Application)
3. Application Number: 2024-177076 (Unpublished Application)
4. Application Number: 2024-177369 (Unpublished Application)

Two additional applications currently in preparation

Public Relations

1. Nikkei MJ, “Unlimited Color and Design on Concrete”, December 23, 2024
2. Nikkei Online Edition, “Shimizu Corporation Achieves Unlimited Color and Design on Concrete at Low Cost”, January 12, 2025

Research Achievements by Researcher

Hiroshi Nishihara ----------

Academic Papers

1. Face-on-oriented formation of bis(diimino)metal coordination nanosheets on gold electrodes by electrochemical oxidation. Hiroaki Maeda, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Kazuhito Tsukagoshi, Hiroshi Nishihara, New J. Chem., 2024, 48, 6081-6087 (Front Cover) (Peer-reviewed)
2. Spontaneous-Spin-Polarized 2D π-d Conjugated Frameworks Towards Enhanced Oxygen Evolution Kinetics. Won Seok Lee, Hiroaki Maeda, Yen-Ting Kuo, Koki Muraoka, Naoya Fukui, Kenji Takada, Sono Sasaki, Hiroyasu Masunaga, Akira Nakayama, Hong-Kang Tian, Hiroshi Nishihara, Ken Sakaushi, Small, 2024, 20, 2401987 (Peer-reviewed)
3. Bis(diimino)nickel Coordination Nanosheets Modified with Triptycene Moieties for Facile Exfoliation and Enhanced Hydrogen Evolution Catalytic Activity. Hiroaki Maeda, Yuta Sudo, Sayoko Nagashima, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Hiroshi Nishihara, ACS Appl. Nano Mater., 2024, 7, 13775-13784 (Peer-reviewed)
4. Modulation between capacitor and conductor for a redox-active 2D bis(terpyridine)cobalt(II) nanosheet via anion-exchange. Kenji Takada, Miyu Ito, Naoya Fukui, Hiroshi Nishihara, Commun. Chem., 2024, 7, 186 (Featured Image) (Peer-reviewed)
5. Electrically Conductive Multivariate Coordination Nanosheets. Kenji Takada, Hiroaki Maeda, Naoya Fukui, Hiroshi Nishihara, Coord. Chem. Res., 2025, 1, 100006 (Peer-reviewed)
6. Synthesis of Bis(diimino)palladium Nanosheets as Highly Active Electrocatalysts for Hydrogen Evolution, Hiroaki Maeda, Eunice Jia Han Phua, Yuta Sudo, Sayoko Nagashima, Wentai Chen, Mayumi Fujino, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Kazuhito Tsukagoshi, Hiroshi Nishihara, Chem. Eur. J., 2025, 31, e202403082 (Cover Feature) (Peer-reviewed)
7. Discrete coordination nanochains based on photoluminescent dyes reveal intrachain exciton migration dynamics. Ryojun Toyoda, Naoya Fukui, Haru Taniguchi, Hiroaki Uratani, Joe Komeda, Yuta Chiba, Hikaru Takaya, Hiroshi Nishihara, Ryota Sakamoto, Nature Commun., 2025, 16, 1367 (Peer-reviewed)

Invited Lectures

1. 配位ナノシート －電子機能性二次元高分子錯体, 西原 寛, 日本セラミックス協会第 37 回秋季シンポジウム, 名古屋, 2024/9/11 (in Japanese)
2. Coordination Nanosheets − Electro-functional 2D Polymers of Metal Complexes, Hiroshi Nishihara, PRiME2024, Hawaii, USA, 2024/10/7

Public Relations

1. 福居直哉, 西原 寛, 光が流れるナノチェーンを開発し機構も解明　―究極の微小・超高速・省エネルギーデバイスの実現に期待―, 東京理科大学プレスリリース, 2025/2/7 (in Japanese)
2. Hiroaki Maeda, Hiroshi Nishihara. Breakthrough in Clean Energy: Palladium Nanosheets Pave Way for Affordable Hydrogen, Media Relations, Tokyo University of Science, 2025/2/7

Takahira Aoki ----------

Academic Papers

1. PPS および CF/PPS の結晶化挙動に関する実験的・解析的研究, 加藤雅也, 樋口 諒, 大矢豊大, 大島草太, 水口 周, 横関智弘, 青木隆平, 日本複合材料学会誌, Vol.50, No.1, pp8-18, 2024 (in Japanese) (Peer-reviewed)
2. Whipping motion of airplane composite fan blades due to bird strike, Sho Kajihara, Ryo Higuchi, Takahira Aoki, Shinya Fukushige, Advanced Composite Materials, Vol. 33, No.4, pp581-602, 2024 (Peer-reviewed)

Books

1. 軽量構造力学（航空宇宙工学テキストシリーズ）, 青木隆平, 廣瀬康夫, 吉村彰記, 丸善, 2024 (in Japanese)

Awards

1. 鈴木雄士, 青木隆平, 第33回日本航空宇宙学会賞論文賞, 日本航空宇宙学会, 2024年4月19日 (In Japanese)

Mitsuhiko Shionoya ----------

Academic Papers

1. Single-gold etching at the hypercarbon atom of C-centred hexagold(I) clusters protected by chiral N-heterocyclic carbenes, X.-L. Pei, P. Zhao, H. Ube, Z. Lei, M. Ehara, M. Shionoya, Nat. Commun. 15, 5024 (2024) (Peer-reviewed)
2. Enzymatic synthesis of ligand-bearing oligonucleotides for the development of metal-responsive DNA materials, Y. Takezawa, M. Shionoya, Org. Biomol. Chem. 22, 7259–7270 (2024) (Peer-reviewed)
3. Oral microsphere formulation of M2 macrophage-mimetic Janus nanomotor for targeted therapy of ulcerative colitis, R. Luo, J. Liu, Q. Cheng, M. Shionoya, C. Gao, R. Wang, Sci. Adv. 10, eado6798 (2024) (Peer-reviewed)
4. Porous Supramolecular Crystalline Probe that Detects Non-Covalent Interactions Involved in Molecular Recognition of Furanic Compounds, S. Tashiro, K. Kuwabara, M. Shionoya, Small 20, 2405507 (2024) (Peer-reviewed)
5. Intricate Low-Symmetry Ag_6L_4 Capsules Formed by Anion-Templated Self-Assembly of the Stereoisomers of an Unsymmetric Ligand, S. Tashiro, Y. Yamada, L. A. Kringe, Y. Okajima, M. Shionoya, J. Am. Chem. Soc. 146, 34501–34509 (2024) (Peer-reviewed)

Invited Lectures

1. Nucleic Acid Chemistry based on Metal-Mediated Base Pairing, Mitsuhiko Shionoya, French-Japanese Symposium on BioInorganic Chemistry, Marseille, 2024
2. Bio-inspired Molecular Design and Functionalization of Supramolecular Architectures, Mitsuhiko Shionoya, The 1st RIST International Symposium “Chemistry and Physics of Coordination Nanosheet”, Tokyo, 2024
3. 生命分子を結合から眺める – 結合特性から機能創成へ –, 塩谷光彦, 総合研究院フォーラム, 千葉, 2024 (in Japanese)
4. 生命分子を結合から眺める – 配位結合で塩基対を形成する人工 DNA –, 塩谷光彦, 核酸医薬研究センター／再生医療を加速する超細胞・DOS 開発研究部門合同第 1 回シンポジウム, 東京, 2024 (in Japanese)
5. 生命分子を結合から眺める – 結合特性から機能創成へ –, 塩谷光彦, 生物無機化学シンポジウム 2025, 大阪, 2025 (in Japanese)

Ichiro Hagiwara ----------

Academic Papers

1. 避難経路上にあるセキュリティ対策に関する研究　その 1　被験者による非常錠の解錠実験, 萩原一郎, 古川容子, 日本建築学会学術講演梗概集（防火）, pp97-98,2024 (in Japanese)
2. 避難経路上にあるセキュリティ対策に関する研究　その 2　被験者アンケートからみる解錠の容易性, 古川容子, 萩原一郎, 日本建築学会学術講演梗概集（防火）, pp99-100,2024 (in Japanese)

Tomohiko Hayakawa ----------

Academic Papers

1. Motion-Blur Compensation Method Using a Transparent Hexagonal Prism, Tomohiko Hayakawa, Ayako Mino, Yuka Hiruma, and Masatoshi Ishikawa, International Symposium on System Integration (SII2025), pp.159-160, 2025 (Peer-reviewed)
2. Assist System to Speed up Object Grasping by Reading Human Intention on a Desk, 早川智彦, 蛭間友香, 妹尾 拓, 黄 守仁, 石川正俊, SI2024, 25th System Integration Division Conference, 講演会論文集, pp. 2482-2483, 2024 (in Japanese)
3. Object Grasping Assist System with Reading Human Intention and Predicting Object Position, Tomohiko Hayakawa, The 11th International Conference on Automation, Robotics and Applications (ICARA 2025), 2025 (Peer-reviewed)

4. 岩﨑健一郎, 早川智彦, 石川正俊: 高速カメラを用いた接地直後の背屈筋収縮の推定手法, 第 2 回スポーツ情報学研究発表会(北見, 2024. 11.1), 映像情報メディア学会技術報告, Vol. 48. No. 36 SIP2024-12, 2024 (in Japanese)
5. 3D Measurement Method Using Stereo Matching Of 2D Images Taken by Infrastructure Monitoring Systems, Tomohiko Hayakawa, Yushi Moko, Yuka Hiruma, Yoshimasa Onishi, Masatoshi Ishikawa, IALCCE LCM Workshop 2024 (Peer-reviewed)
6. 回転六角柱によるモーションブラー補償システム, 早川智彦, 三野綾子, 蛭間友香, 石川正俊, 第 42 回日本ロボット学会学術講演会 (RSJ2024) 予稿集, 1A5-04, 2024 (in Japanese)
7. Vehicle Self-Position Estimation Using Lighting Recognition in Expressway Tunnel for Visual Inspection Flow, Yushi Moko, Yuka Hiruma, Tomohiko Hayakawa, Yushan Ke, Yoshimasa Onishi, Masatoshi Ishikawa, J. Robot. Mechatron., Vol.36 No.3, pp. 746-757, 2024 (Peer-reviewed)

Invited Lectures
1. User Performance Based on the Effects of Low Video Latency, Tomohiko Hayakawa, 6th International Bio-Medical Interface Symposium 2025 (IBMI 2025)
2. Measurement of Tolerance Limits for Video Latency Using High-speed Cameras and High-speed Projectors, Tomohiko Hayakawa, International Display Workshops (IDW 2024), PRJ1-3, pp.896-898, 2024

Awards
1. 宮下令央, 末石智大, 田畑智志, 早川智彦, 石川正俊, 電子情報通信学会通信ソサイエティ論文賞（和文マガジン論文賞）, 電子情報通信学会, 2024 (in Japanese)

Leo Miyashita ----------

Academic Papers
1. Simultaneous High-speed Depth Measurement and Video Presentation using a Video-rate Projector, Leo Miyashita, Masatoshi Ishikawa, International Conference Cybernetics & Informatics (K&I2025), pp. 1-6, 2025 (Peer-reviewed)
2. Hierarchical ArUco Marker Array for Coarse-to-Fine Localization in XR applications, Leo Miyashita, Satoshi Tabata, Masatoshi Ishikawa, IEEE International Conference on Artificial Intelligence & eXtended and Virtual Reality (AIxVR2025), pp. 209-212, 2025 (Peer-reviewed)
3. Hierarchical Robust Tracking System for High Spatio-temporal Resolution Vision, Leo Miyashita, Masatoshi Ishikawa, International Symposium on System Integration (SII2025), pp.811-816, 2025 (Peer-reviewed)

Invited Lectures
1. Dynamic Projection Mapping Technologies Pioneered by High-speed Vision, Leo Miyashita, Tomohiro Sueishi, Satoshi Tabata, Tomohiko Hayakawa, Masatoshi Ishikawa, The 5th International Conference on Emerging Technologies for Communications (ICETC 2024), Kitakyushu, Japan, 2024
2. 動的デジタルツイン計測とダイナミックプロジェクションマッピング, 宮下令央, 第 33 回レーザーディスプレイ技術研究会, 宇都宮, 2024 (In Japanese)
3. Dynamic Projection Mapping Based on High-speed Sensing and Display, Leo Miyashita, International Meeting on Information Display (IMID 2024), Jeju, Korea, 2024

Awards
1. 宮下令央, 末石智大, 田畑智志, 早川智彦, 石川正俊, 電子情報通信学会通信ソサイエティ論文賞（和文マガジン論文賞）, 電子情報通信学会, 2024 (In Japanese)

Masaru Irita ----------

Academic Papers

1. Evaluation of Fiber Volume Fraction, Orientation and in-Situ Damage Initiation Observation of Discontinuous Fiber-Reinforced CFRTP, M. MJ, M. IRITA, S. OGIHARA, and M. ARAI, Mater. Syst. 42, 49 (2025) (Peer-reviewed)
2. Near-Infrared Photoluminescence Responses of Single-Walled Carbon Nanotubes Induced by Biomolecules Detected on a Microbead Surface, Y. Tachikawa, M. Ito, M. Irita, T. Harada, and K. Umemura, ACS Omega 9, 44734 (2024) (Peer-reviewed)

Hitoshi Ube ----------

Academic Papers

1. Single-gold etching at the hypercarbon atom of C-centred hexagold(I) clusters protected by chiral N-heterocyclic carbenes, Xiao-Li Pei, Pei Zhao, Hitoshi Ube, Zhen Lei, Masahiro Ehara, Mitsuhiko Shionoya, Nature Communications, Vol.15, 5024, 2024 (Peer-reviewed)

Shouren Huang ----------

Academic Papers

1. Utilizing High-Speed 3D Vision for a Commercial Robotic Arm: Direct Integration and the Dynamic Compensation Approach, Shouren Huang, Wenhe Wang, Leo Miyashita, Kenichi Murakami, Yuji Yamakawa, Masatoshi Ishikawa, Journal of Robotics and Mechatronics, Vol.37 No.2, pp. 424–433, (2025) (Peer-reviewed)
2. Dynamic SpectraFormer for Ultra-High Resolution Underwater Image Enhancement, Zhiqiang Hu, Tao Yu, Shouren Huang, Masatoshi Ishikawa, 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (Abu Dhabi, UAE, 2024.10.17)/Proceedings, pp. 8633–8640 (2025) (Peer-reviewed)
3. Object Grasping Assist System with Reading Human Intention and Predicting Object Position, Tomohiko Hayakawa, Tomohiro Sueishi, Yuka Hiruma, Himari Tochioka, Taku Senoo, Shouren Huang, Masatoshi Ishikawa, The 11th International Conference on Automation, Robotics and Applications (ICARA 2025) (Zagreb, Croatia, 2025.2.14) (2025) (Peer-reviewed)
4. Perceptual Anchoring for Gaze-tracking Wearables and Robot-mounted Sensors, Sune Lundø Sørensen, Shouren Huang, Yongpeng Cao, Mikkel Baun Kjærgaard, The 21st International Conference on Ubiquitous Robots (UR2024) (New York, USA, 2024.06.25)/Proceedings, pp. 71–76 (2025) (Peer-reviewed)
5. 上腕の一自由度回転運動に向けた高速ビジョンに基づく電気刺激フィードバック制御の実現および性能検討, 川脇優輝, 黄 守仁, 山川雄司, 石川正俊, 第25回計測自動制御学会システムインテグレーション部門講演会 (SI2024) (岩手, 2024.12.19), 講演会論文集, pp. 2795–2799 (in Japanese)
6. 高速 3D ビジョンとロボットアームの統合：フィードバックレートによる性能検討, 王 文鶴, 黄 守仁, 宮下令央, 村上健一, 山川雄司, 石川正俊, 第 24 回計測自動制御学会 システムインテグレーション部門講演会 (SI2024) (岩手, 2024.12.16), 講演論文集, pp. 780–782 (in Japanese)
7. 机上における人の動作意図読み取りによる物体把持高速化アシストシステム, 早川智彦, 蛭間友香, 妹尾 拓, 黄 守仁, 石川正俊, 第 25 回計測自動制御学会システムインテグレーション部門講演会 (SI2024) (岩手, 2024.12.19), 講演会論文集, pp. 2482–2483 (in Japanese)

Invited Lectures

3. 次世代生産システムに向けた知能ロボットの検討：高速ビジョンの役割, 黄 守仁, JST/WINDS 公開特別シンポジウム「高速ビジョンによる多次元デジタルツイン計測と再構築」, 東京, 2024 (in Japanese)

Tomohiro Sueishi ----------

Academic Papers

1. Object Grasping Assist System with Reading Human Intention and Predicting Object Position, Tomohiko Hayakawa, Tomohiro Sueishi, Yuka Hiruma, Himari Tochioka, Taku Senoo, Shouren Huang, Masatoshi Ishikawa, The 11th International Conference on Automation, Robotics and Applications (ICARA2025), 2025 (Peer-reviewed)
2. High-speed Spin Measurement System for Dotted Table Tennis Ball Using Single-frame M-sequence Multi-exposures, Tomohiro Sueishi, Himari Tochioka, Masatoshi Ishikawa, SICE Journal of Control, Measurement, and System Integration, Vol. 18, Issue 1, pp.1-11, 2025 (Peer-reviewed)
3. Image-based Response Measurement of Liquid Lens and Iterative Calibration of Scanning Focus Tracking for Dynamic Iris Authentication, Tomohiro Sueishi, Keiko Yokoyama, Shoji Yachida, Masatoshi Ishikawa, 2025 IEEE/SICE International Symposium on System Integration (SII2025), pp.1016-1021, 2025 (Peer-reviewed)
4. Toward Micro Eye Movement Detection in Practice: Stand-alone Eye Tracker with High Resolution and Wide Measurement Range, Keiko Yokoyama, Tomohiro Sueishi, Michiaki Inoue, Shoji Yachida, Toshinori Hosoi, Masatoshi Ishikawa, 2024 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS2024), pp. 10633-10640, 2024 (Peer-reviewed)
5. 気管軟化症診断定量化に向けた気管内心原性振動の高速画像計測手法, 末石智大, 古村 眞, 石川正俊, 生体医工学シンポジウム 2024, p.82, C-17, 2024 (in Japanese)
6. High-speed Spin Measurement Method for Dotted Table Tennis Ball Using Structured Light of M-sequence Flickering Pattern, Tomohiro Sueishi, Himari Tochioka, Masatoshi Ishikawa, SICE Festival 2024 with Annual Conference (SICE FES 2024), pp.1188-1193, 2024 (Peer-reviewed)
7. High-speed Tip Position Estimation of Tracheal Endoscope Probe with Ring-shaped Optical Markers, Tomohiro Sueishi, Makoto Komura, Masatoshi Ishikawa, The 46th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC2024), Poster ID.118374, 2024 (Peer-reviewed)
8. High-speed Image-based Measurement Method of Tracheal Cardiac-induced Pulse Transit Time, Tomohiro Sueishi, Makoto Komura, Masatoshi Ishikawa, The 46th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC2024), Poster ID.118373, 2024 (Peer-reviewed)
9. Apollon Mark: Bounce Mark Visualization System for Ball Sports Judgement Using Prediction-based Preceding Mirror Control, Himari Tochioka, Tomohiro Sueishi, Masatoshi Ishikawa, SICE Journal of Control, Measurement, and System Integration, Vol. 17, Issue 1, pp.164-175, 2024 (Peer-reviewed)

Invited Lectures

1. Dynamic Projection Mapping Technologies Pioneered by High-speed Vision, Leo Miyashita, Tomohiro Sueishi, Satoshi Tabata, Tomohiko Hayakawa, Masatoshi Ishikawa, 2024 International Conference on Emerging Technologies for Communications (ICETC2024), IS4-03, Fukuoka, 2024

Awards

1. 宮下令央, 末石智大, 田畑智志, 早川智彦, 石川正俊, マガジン論文賞, 電子情報通信学会通信ソサイエティ, 2024 (In Japanese)

Masashi Nojima ----------

Academic Papers

1. Learning to Cultivate Imagination through CONNECTEDkind -Suggestions from an Electroencephalogram Analysis-, YAMASHITA Kyohei, NAGATA Yoshiyuki, MORI Ayaka, MUZUSHIMA Naoki, NOJIMA Masashi, Japanese Association of Art Education, ISSN:0917-771X, 45, p231-243 (2024)

Awards

1. Masashi Nojima, Foundation of new material information for Promotion of Science, 2024
   “Characterizations of local stress properties on CFRPs by an FIB micro-sampling method”

Hiroaki Maeda ----------

Academic Papers

1. Electrically conductive multivariate coordination nanosheets, Kenji Takada, Hiroaki Maeda, Naoya Fukui, Hiroshi Nishihara, Coordination Chemistry Research, Vol.1, 100006, 2025 (Peer-reviewed)
2. Synthesis of Bis(diimino)palladium Nanosheets as Highly Active Electrocatalysts for Hydrogen Evolution, Hiroaki Maeda, Eunice Jia Han Phua, Yuta Sudo, Sayoko Nagashima, Wentai Chen, Mayumi Fujino, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Kazuhito Tsukagoshi, Hiroshi Nishihara, Chemitry – A European Journal, Vol.31, No.6, e202403082, 2025 (Peer-reviewed)
3. Bis(diimino)nickel Coordination Nanosheets Modified with Triptycene Moieties for Facile Exfoliation and Enhanced Hydrogen Evolution Catalytic Activity, Hiroaki Maeda, Yuta Sudo, Sayoko Nagashima, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Hiroshi Nishihara, ACS Applied Nano Materials, Vol.7, No.11, pp 13775-13784, 2024 (Peer-reviewed)
4. Spontaneous-Spin-Polarized 2D π-d Conjugated Frameworks Towards Enhanced Oxygen Evolution Kinetics, Won Seok Lee, Hiroaki Maeda, Yen-Ting Kuo, Koki Muraoka, Naoya Fukui, Kenji Takada, Sono Sasaki, Hiroyasu Masunaga, Akira Nakayama, Hong-Kang Tian, Hiroshi Nishihara, Ken Sakaushi, Small, Vol.20, No.40, 2401987, 2024 (Peer-reviewed)

Books

1. "Functional Macromolecular Complexes" Chapter 6: Two-dimensional Polymer Complexes: Coordination Nanosheets, Hiroaki Maeda, Hiroshi Nishihara, Royal Society of Chemistry, pp 114-128, 2024

Public Relations

1. Hiroaki Maeda, Hiroshi Nishihara, Nanosheet catalysts for affordable hydrogen fuel production, Advanced Science News, 2024
2. 前田啓明, 西原 寛, 優れた性能を示す電極触媒を簡便に作製する手法を開発 ～少ない貴金属で白金触媒と同等の性能、水素社会の実現に貢献～, 東京理科大学プレスリリース, 2024 (In Japanese)
3. Hiroaki Maeda, Hiroshi Nishihara, Breakthrough in Clean Energy: Palladium Nanosheets Pave Way for Affordable Hydrogen, Tokyo University of Science Press Release, 2024

Awards

1. Hiroaki Maeda, Eunice Jia Han Phua, Yuta Sudo, Sayoko Nagashima, Wentai Chen, Mayumi Fujino, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Kazuhito Tsukagoshi, Hiroshi Nishihara, Selected as Cover Feature of Chemistry – A European Journal Vol.31, No.6, 2025
2. Hiroaki Maeda, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Kazuhito Tsukagoshi, Hiroshi Nishihara, Selected as Front Cover of New Journal of Chemistry Vol.48, No.14, 2024

Kenji Takada ----------

Academic Papers

1. Electrically Conductive Multivariate Coordination Nanosheets, Kenji Takada, Hiroaki Maeda, Naoya Fukui, Hiroshi Nishihara, Coordination Chemistry Research, Vol. 1, 100006, 2025 (Peer-reviewed)
2. Synthesis of Bis(diimino)palladium Nanosheets as Highly Active Electrocatalysts for Hydrogen Evolution, Hiroaki Maeda, Eunice Jia Han Phua, Yuta Sudo, Sayoko Nagashima, Wentai Chen, Mayumi Fujino, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Kazuhito Tsukagoshi, Hiroshi Nishihara, Chemistry – European Journal, Vol. 31, e202403082, 2025 (Peer-reviewed)
3. Modulation between capacitor and conductor for a redox-active 2D bis(terpyridine)cobalt(II) nanosheet via anion-exchange, Kenji Takada, Miyu Ito, Naoya Fukui, Hiroshi Nishihara, Communications Chemistry, Vol. 7, 186, 2024 (Peer-reviewed)
4. Bis(diimino)nickel Coordination Nanosheets Modified with Triptycene Moieties for Facile Exfoliation and Enhanced Hydrogen Evolution Catalytic Activity, Hiroaki Maeda, Yuta Sudo, Sayoko Nagashima, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Hiroshi Nishihara, ACS Applied Nano Materials, Vol. 7, pp. 13775-13784, 2024 (Peer-reviewed)

5. Spontaneous-Spin-Polarized 2D π-d Conjugated Frameworks Towards Enhanced Oxygen Evolution Kinetics, Won Seok Lee, Hiroaki Maeda, Yen-Ting Kuo, Koki Muraoka, Naoya Fukui, Kenji Takada, Sono Sasaki, Hiroyasu Masunaga, Akira Nakayama, Hong-Kang Tian, Hiroshi Nishihara, Ken Sakaushi, Small, Vol. 20, 2401987, 2024 (Peer-reviewed)

Satoshi Tabata ----------

Academic Papers

1. High-speed all-in-focus 3D imaging method based on liquid lens focus scanning, Huayu Cheng, Lihui Wang, Satoshi Tabata, Yuan He, Yan Hu, Jiang Liu, and Zhiwei Mou, Applied Optics, Vol.63, Issue 21, pp.5602-5610, 2024 (Peer-reviewed)
2. 小型高速三次元スキャナの開発, 田畑智志, 石川正俊, 渡辺義浩, 画像ラボ, 解説論文, Vol.35, No.9, pp.13-18, 2024 (In Japanese)
3. 液体レンズを用いた高速焦点追従投影システム, 王 立輝, 田畑智志, 徐 鴻金, 胡 云普, 渡辺義浩, 石川正俊:, 光学, 解説論文, 53 巻, 第 6 号, p.234, 2024 (In Japanese)
4. Hierarchical ArUco Marker Array for Coarse-to-Fine Localization in XR applications, Leo Miyashita, Satoshi Tabata and Masatoshi Ishikawa, IEEE International Conference on Artificial Intelligence & eXtended and Virtual Reality (AIxVR2025), pp.209-212, 2025 (Peer-reviewed)
5. 可変焦点光学系キャリブレーションのためのジーメンススターサークルグリッドの検討, 田畑智志, 石川正俊, 第 42 回日本ロボット学会学術講演会(RSJ2024)予稿集, 3A3-03, 2024 (Peer-reviewed)

Invited Lectures

1. Leo Miyashita, Tomohiro Sueishi, Satoshi Tabata, Tomohiko Hayakawa, Masatoshi Ishikawa: Dynamic Projection Mapping Technologies Pioneered by High-speed Vision, International Conference on Emerging Technologies for Communications (ICETC 2024), Kitakyushu, Japan, 2024

Awards

1. 宮下令央, 末石智大, 田畑智志, 早川智彦, 石川正俊, 電子情報通信学会通信ソサイエティ論文賞（和文マガジン論文賞）, 電子情報通信学会, 2024 (In Japanese)

Naoya Fukui ----------

Academic Papers

1. Discrete coordination nanochains based on photoluminescent dyes reveal intrachain exciton migration dynamics, Ryojun Toyoda, Naoya Fukui, Haru Taniguchi, Hiroaki Uratani, Joe Komeda, Yuta Chiba, Hikaru Takaya, Hiroshi Nishihara, Ryota Sakamoto, Nature Commun., 16, 1367, 2025 (Peer-reviewed)
2. Synthesis of Bis(diimino)palladium Nanosheets as Highly Active Electrocatalysts for Hydrogen Evolution, Hiroaki Maeda, Eunice Jia Han Phua, Yuta Sudo, Sayoko Nagashima, Wentai Chen, Mayumi Fujino, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Kazuhito Tsukagoshi, Hiroshi Nishihara, Chem. Eur. J., 31, e202403082, 2025 (Peer-reviewed)
3. Electrically Conductive Multivariate Coordination Nanosheets, Kenji Takada, Hiroaki Maeda, Naoya Fukui, Hiroshi Nishihara, Coord. Chem. Res., 1, 100006, 2025 (Peer-reviewed)
4. Modulation between capacitor and conductor for a redox-active 2D bis(terpyridine)cobalt(II) nanosheet via anion-exchange, Kenji Takada, Miyu Ito, Naoya Fukui, Hiroshi Nishihara, Commun. Chem., 7, 186, 2024 (Peer-reviewed)
5. Bis(diimino)nickel Coordination Nanosheets Modified with Triptycene Moieties for Facile Exfoliation and Enhanced Hydrogen Evolution Catalytic Activity, Hiroaki Maeda, Yuta Sudo, Sayoko Nagashima, Kenji Takada, Naoya Fukui, Hiroyasu Masunaga, Sono Sasaki, Hiroshi Nishihara, ACS Appl. Nano Mater., 7, 13775-13784, 2024 (Peer-reviewed)
6. Spontaneous-Spin-Polarized 2D π-d Conjugated Frameworks Towards Enhanced Oxygen Evolution Kinetics, Won Seok Lee, Hiroaki Maeda, Yen-Ting Kuo, Koki Muraoka, Naoya Fukui, Kenji Takada, Sono Sasaki, Hiroyasu Masunaga, Akira Nakayama, Hong-Kang Tian, Hiroshi Nishihara, Ken Sakaushi, Small, 20, 2401987, 2024 (Peer-reviewed)

Xiaoli Pei ----------

Academic Papers

1. Single-gold etching at the hypercarbon atom of *C*-centred hexagold(I) clusters protected by chiral *N*-heterocyclic carbenes, Xiao-Li Pei, Pei Zhao, Hitoshi Ube, Zhen Lei, Masahiro Ehara, Mitsuhiko Shionoya, Nature Communications, Vol.15, 5024, 2024 (Peer-reviewed)

Takahiro Yamazaki ----------

Academic Papers

1. Efficient Discovery of Large Magnetic Anisotropy with Thermodynamically Stable Materials via Multi-Objective Bayesian Optimization, K. Nakamura, D. Furuya, Y. Miura, T. Yamazaki, A.L. Foggiatto, Y. Iwasaki, M. Kotsugi, STEM:M, accepted (24 Mar 2025) (Peer-reviewed)
2. Iron Loss Analysis in Soft Magnetic Materials via Maxwell Equations-Coupled Multiscale Micromagnetic Simulations, Y. Shima, T. Yamazaki, A.L. Foggiatto, C. Mitsumata, M. Kotsugi, Journal of Applied Physics, accepted (06 Mar 2025) (Peer-reviewed)
3. Uncovering the Origin of Magnetic Moment Enhancement in Fe–Co–Ir Alloys via High-Throughput XMCD, T. Yamazaki, T. Kawasaki, A.L. Foggiatto, R. Toyama, Y. Sakuraba, Y. Igarashi, C. Mitsumata, Y. Iwasaki, M. Kotsugi, Physical Review Materials, 9, 034408 (2025) (Peer-reviewed)
4. Tuning Magnetic Properties by Microstructure Control of Nanocrystalline Thin Films for Compact Vibration Energy Harvesters, K. Sano, T. Yamazaki, Y. Nakamura, M. Ohtake, C. Oka, J. Sakurai, S. Hata, IEICE Electronics Express, 21, 1 (2025), pp. 1–6 (Peer-reviewed)
5. Autonomous Search for Half-Metallic Materials with B2 Structure, Y. Iwasaki, R. Toyama, T. Yamazaki, Y. Igarashi, M. Kotsugi, Y. Sakuraba, STAM:M, 4, 1 (2024), 2403966 (Peer-reviewed)
6. Effect of Noise on Accuracy of Grain Size Evaluation by Magnetic Barkhausen Noise Analysis, K. Omae, T. Yamazaki, K. Sano, C. Oka, J. Sakurai, S. Hata, International Journal of Automation Technology, 18, 4 (2024), pp. 528–536 (Peer-reviewed)
7. Prototype of Parallel Plate Type Fast Atom Beam Source and Its Improvement of Irradiation Characteristics, T. Kato, R. Morisaki, T. Yamazaki, C. Oka, J. Sakurai, S. Hata, International Journal of Automation Technology, 18, 4 (2024), pp. 513–520 (Peer-reviewed)
8. Quantification of the Coercivity Factor in Soft Magnetic Materials at Different Frequencies Using Topological Data Analysis, R. Nagaoka, K. Masuzawa, A.L. Foggiatto, T. Yamazaki, I. Obayashi, Y. Hiraoka, C. Mitsumata, M. Kotsugi, IEEE Transactions on Magnetics, 60, 9 (2024), 4000305 (Peer-reviewed)
9. Analysis of the Excess Loss in High-Frequency Magnetization Process Through Machine Learning and Topological Data Analysis, A.L. Foggiatto, R. Nagaoka, M. Taniwaki, T. Yamazaki, T. Ogasawara, I. Obayashi, Y. Hiraoka, C. Mitsumata, M. Kotsugi, IEEE Transactions on Magnetics, 60, 9 (2024), 700130 (Peer-reviewed)

Invited Lectures

1. ハーフメタルホイスラー合金の XMCD 測定と機械学習を活用したスペクトル解析, 山崎貴大, 杉田涼介, 小嗣真人, 磁気記録・情報ストレージ研究会（MRIS）, 名古屋大学 (MRIS, IEE-MAG), 2025 年 3 月 7 日, 名古屋
2. Machine Learning Assisted XMCD Spectra Analysis in High Spin-Polarized Co2MnGaxGe1-x Heusler Alloys, T. Yamazaki, 2nd NSF Global Center Meeting, Morito memorial hall, Tokyo, Japan, Dec 20, 2024, Tokyo
3. 磁気バルクハウゼンノイズ(MBN)測定による軟磁性体中の磁壁ダイナミクスの解析, 田丸慎吾, 山崎貴大, 日本金属学会第 2 分野主催「情報・デバイス」と「材料」研究会 2024 年 11 月 8 日, 仙台

Public Relations

1．イリジウム添加による鉄-コバルト合金の磁気特性の増強メカニズムを解明～放射光計測と高品質薄膜技術で磁性材料の精密評価を実現～, 山崎貴大, 河崎崇広, 小嗣真人, 岩崎悠真, 桜庭裕弥, 河村直己, 大河内拓雄, 東京理科大学, 高輝度光科学研究センター, 兵庫県立大学, 日経新聞, 朝日デジタル他, 2025 年 3 月 13 日

Shinichi Kumakura ----------

Academic Papers

1. Electrode performance of P'2-$Na_{2/3}[Mn_{1-x}Sc_x]O_2$ in sodium batteries, K. Moriya, S. Kumakura, E. J. Kim, R. Tatara, S. Komaba, Electrochemistry Communications, 174, 107891, 2025 (Peer-reviewed)

Patents

1. 駒場慎一, 熊倉真一, 守谷洸大, 鳥海 翔, 国内優先出願,酸素吸蔵材料及び酸素吸蔵材料の製造方法, 特願 2025-28419,2025

Daiki Usukura ----------

Academic Papers

1. Brefeldin A and M-COPA block the export of RTKs from the endoplasmic reticulum via simultaneous inactivation of ARF1, ARF4, and ARF5, Miyuki Natsume, Mariko Niwa, Sho Ichikawa, Takuma Okamoto, Hisazumi Tsutsui, Daiki Usukura, Takatsugu Murata, Ryo Abe, Motoyuki Shimonaka, Toshirou Nishida, Isamu Shiina, Yuuki Obata, Journal of Biological Chemistry, Vol. 300, Issue 6, pp 107327, 2024 (Peer-reviewed)

Yushi Moko ----------

Academic Papers

1. Vehicle Self-Position Estimation Using Lighting Recognition in Expressway Tunnel for Visual Inspection Flow, Yushi Moko, Yuka Hiruma, Tomohiko Hayakawa, Yushan Ke, Yoshimasa Onishi, Masatoshi Ishikawa, Journal of Robotics and Mechatronics, Vol.36, No.3, pp 746-757, 2024 (Peer-reviewed)
2. 3D Measurement Method Using Stereo Matching Of 2D Images Taken by Infrastructure Monitoring Systems, Tomohiko Hayakawa, Yushi Moko, Yuka Hiruma, Yoshimasa Onishi, Masatoshi Ishikawa, IALCCE LCM Workshop 2024 (Ijmuiden, Netherlands) Proceedings in printing (Peer-reviewed)

Report of Research Institute for Science and Technology Forum

Report of “Research Institute for Science and Technology Forum 2024” (11/25)

On November 25 (Mon), 2024, Research Institute for Science and Technology Forum 2024 — Aiming Only at TUS was held in a hybrid type of face-to-face and online. The event was held in a great success with 151 participants (69 participants in the venue and 82 participants online).

In the forum, research centers and research divisions in the areas of "Fundamentals," "Functional Materials," "Bio and Pharmacy," and "Information and Societal," gave oral presentations on the most recent research trend or topic for each research group. A poster session by research divisions was also held.

During the Q&A session, many researchers engaged in lively discussions, making it a meaningful forum in which we can look forward to the future development of our university's unique research activities that go beyond the framework of Research Centers and Research Divisions.

[Program]

1. **Opening Remarks**
   Masatoshi Ishikawa (President, Tokyo University of Science)
2. **Overview of the Research Institute for Science and Technology (RIST)**
   Hiroshi Nishihara (Director, Research Institute for Science and Technology)

Oral Presentations of Research Centers and Research Divisions

[Bio and Pharmacy]

3. **Division of Biological Environment Innovation**
   Gen-ichiro Arimura (Professor, Department of Biological Science and Technology, Faculty of Advanced Engineering)
4. **Nucleic Acid Drug Discovery Center**
   Takeshi Wada (Professor, Department of Medicinal and Life Sciences, Faculty of Pharmaceutical Sciences)
5. **Research Center for Drug Discovery and Applied Sciences**
   Isamu Shiina (Professor, Department of Applied Chemistry, Faculty of Science Division I)

[Information and Societal 1]

6. **Medical Data Science**
   Kazunori Akimoto (Professor, Department of Medicinal and Life Sciences, Faculty of Pharmaceutical Sciences)
7. **Research Center for Multi-Hazard Urban Disaster Prevention**
   Yasuo Nihei (Professor, Department of Civil Engineering, Faculty of Science and Technology)
8. **Center for Fire Science and Technology / Research Center for Fire Safety Science**
   Masayuki Mizuno (Professor, Department of Global Fire Science and Technology, Department of Global Fire Science and Technology)

[RIST]

9. **Research Institute for Science and Technology**
   Mitsuhiko Shionoya (Professor, Research Institute for Science and Technology)

[Information and Societal 2]

10. Division of Smart Healthcare Engineering

Takahiko Yamamoto (Associate Professor, Department of Electrical Engineering, Faculty of Science and Technology)

11. Statistical Science Research Division

Tomohiro Shinozaki (Junior Associate Professor, Department of Information and Computer Technology, Faculty of Engineering)

12. Research Center for Space System Innovation [SSI]

Shinichi Kimura (Professor, Department of Electrical Engineering, Faculty of Science and Technology)

[Fundamentals]

13. Research Alliance for Mathematical Analysis

Keiichi Kato (Professor, Department of Mathematics, Faculty of Science Division I)

14. Division of Nano-quantum Information Science and Technology

Kwon Sangil (Project Fellow, Research Institute for Science and Technology)

[Functional Materials]

15. Renewable Energy Science & Technology Research Division

Mutsumi Sugiyama (Professor, Department of Electrical Engineering, Faculty of Science and Technology)

16. Carbon Value Research Center

Akihiko Kudo (Professor, Department of Applied Chemistry, Faculty of Science Division I)

17. Water Frontier Research Center (WaTUS)

Masahiro Motosuke (Professor, Department of Mechanical Engineering, Faculty of Engineering)

18. Closing Remarks

Yasuo Kogo (Director, Organization for Research Promotion)

19. Poster presentations of 11 Research Divisions

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