ANNUAL REPORT No. 40

Research Institute for Science and Technology

April, 2022 – March, 2023

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 fiscal 2022 (from April 2022 to March 2023).

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 FY2022, Research Division of Medical Date Sciences and Research Division for Smart Healthcare Systems were newly installed. In addition, on June 1, 2022, as a co-creation project, a new "Research & Development Platform of Function Green Building Materials" was established in collaboration with Shimizu Corporation, and joint research in industry-academia collaborations has begun. As a result, Research Institute for Science and Technology consisted of three Research Centers, 22 Research Divisions one Joint Usage/Research Center, and two Open Innovation Projects at the end of FY2022.

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, 2023

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

Contents

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 (RIST) was originally General Research Institute, which was established on January 21, 1981. General Research Institute has been active as the university's only cross-disciplinary comprehensive research organization, and has accumulated many achievements. In the 25 years up to 2005, 17 research departments were established, and the university has 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.

On April 1, 2015, with the reorganization into Organization for Research Advancement with the aim of enhancing the research promotion system, General Research Institution was reorganized into Research Institute for Science and Technology.

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

Research Institute for Science and Technology consists of Research Centers, Joint Usage/Research Center, Research Hubs, Research Divisions, and the Open Innovation Projects.

Research Reports by
Research Center/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)

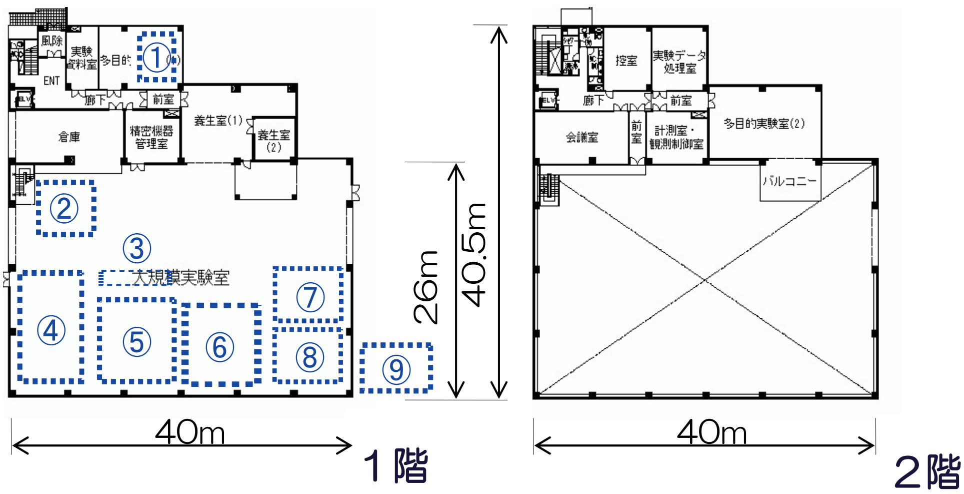

Fig. 3. Floor plans and facilities/equipment of the Fire Research and Test Laboratory.

(i) ⑥Multi-purpose horizontal loading furnace

(ii) ⑧Large-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 smoke flow and fire whirls are reported.

Experimental studies on smoke flow have been carried out on the effectiveness of smoke exhausting method by using elevator shafts. In the case of fires in high-rise buildings, efficient and continuous smoke control/exhausting outside the building over a long period of time is required to prolong evacuation and to support firefighters. This study focuses on smoke tower systems that can exhaust smoke to the outdoors not only in the early stages of a fire but also during a fully-developed fire due to the buoyancy of the smoke, especially utilizing elevator shafts that are not in use during a fire. Furthermore, this study aims to establish a more efficient smoke control system by introducing a new smoke control method to the existing smoke control system. Specifically, the method utilizes an electric field. First, we started by using the model shown in Fig. 4 to understand the state of electrification of smoke particles generated by combustion.

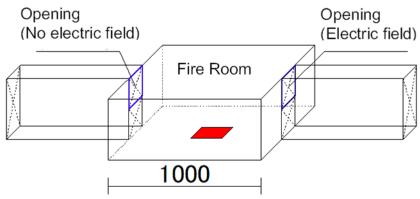

Fig. 4. Experimental Setup on Smoke flow.

As to the fire-whirl research, experiments were conducted to understand the formation mechanisms in urban and wildland fires. Fire whirls are tornado-like flows generated near fire areas. Once generated, the rate of fire spread tends to increase owing to an increase in radiant heat flux and the enhanced firebrand showers. Fire whirls are believed to be formed by the interaction between the buoyancy upward flows from a fire and a natural wind. Therefore, open-field experiments were conducted to understand the effects of natural wind, as shown in Photo 2. Differences between conditions that tend to fire-whirl formation and those that do not were analyzed by comparing measured wind data. Furthermore, numerical simulations using FDS were conducted to reproduce experimental observations.

Photo 2. Fire whirl experiment.

3.2. Area of Evacuation and Human Behavior

This area covers not only evacuation safety during fires, but also occupational safety of firefighters at fire sites. Here, we introduce the results of our research on the following two points.

(Occupational Safety of Firefighters) Firefighters are exposed to various risks on a daily routine as they respond to fires and other severe disaster situations. The results of the study in FY2022 were as follows: (1) measurement of mental and physical workload of firefighters using a wearable device and (2) measurement of heat acclimatization response for developing countermeasures against heat stroke. And we established a method to estimate the physical and mental workload of firefighters in the field using only non-invasive methods, such as wearable devices and saliva analysis (Photo 3). Furthermore, in project (2), we were able to clarify the daily dehydration state of firefighters and behavioral characteristics associated with high risk of heat stroke based on the measurement of changes in the heat acclimatization response over time.

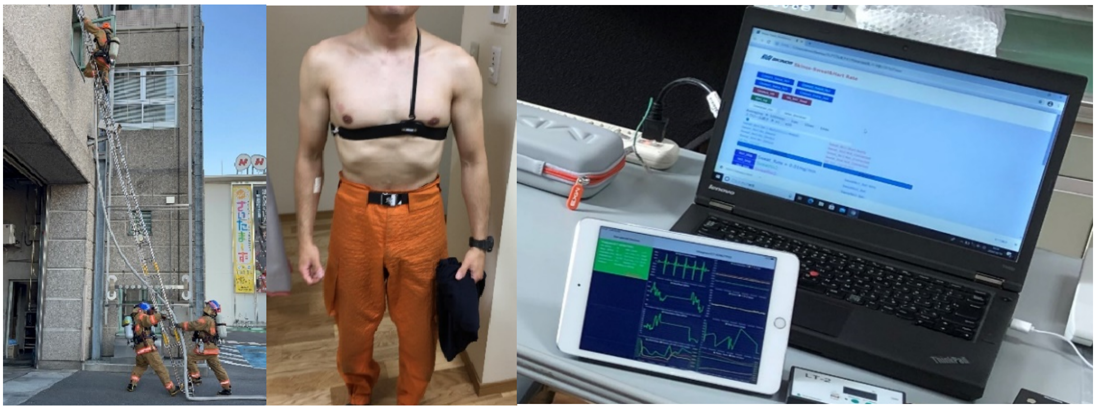

Photo 3. Measurement Physiological markers are monitored by a wearable device (middle) during actual training (left) to measure the training load (right).

(Basic research on indoor evacuation guidance using drones) In recent years, drones have been used in various situations in the field of disaster prevention, and as one of them, the use of drones for indoor evacuation guidance in the event of a fire in a high-rise building or an underground mall has begun. However, sufficient studies have not been conducted on the appropriate drone flight speed and altitude for indoor evacuation guidance by drone. Therefore, as basic research on indoor evacuation guidance using drones, the appropriate positional relationship between drones and people during evacuation guidance was examined. Subjects following a drone flying at two speeds (0.5 m/s, 1.0 m/s) and four flight altitudes (1.5 m, 2.0 m, 2.5 m, 3.0 m) on straight and hooked paths were analyzed for walking dynamics (Fig. 5). The relative distance between the drone and the subject was maintained at the initial value at 1.5 m and 2.0 m altitude for both straight and hooked paths. However, at altitudes of 2.5 m and 3.0 m, the distances between them could not maintain their initial values, and the difference in values increased with movement. The distance was greater with a velocity of 1.0 m/s than with a velocity of 0.5 m/s. In the future, it is necessary to conduct a study with an increased number of subjects.

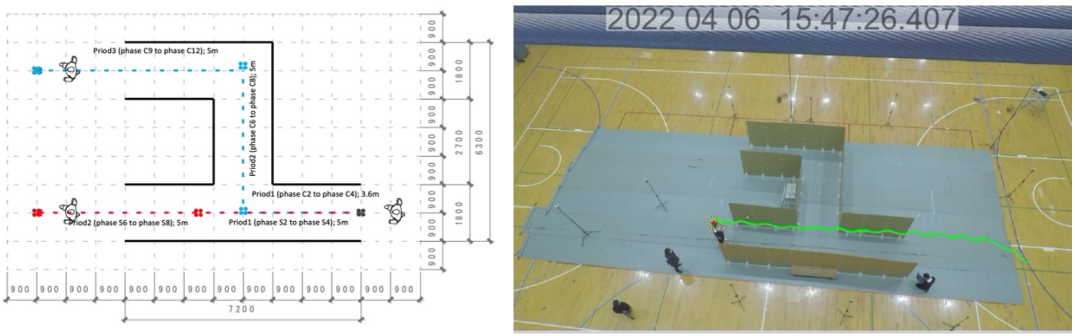

Fig. 5. Experiment Setup – Plan View.

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

The fire safety of building components and frames, as well as the fire safety of materials used for interior finishes, fixtures, and furniture have been the primary focus in this area. In FY2022, we continued our previous work by analyzing the fire behavior of fire-protected steel columns using a finite element analysis method, with experimental results from several cases used as a benchmark. In particular, we investigated a finite element analysis method that considers high-temperature creep of steel for columns with higher strength (700 MPa tensile strength) or higher yield points (400 MPa and 500 MPa yield points) compared to ordinary steel (yield point of 325 MPa or lower and tensile strength of 490 MPa or lower). These steel grades were developed by Japanese steel manufacturers for advanced seismic design, and their fire resistance performance is still unknown. This research theme is unique and made possible by TUS's advanced experimental facilities, analytical capabilities, and collaboration with industry groups.

In terms of material research, we conducted experiments to simulate an entire fire in a compartment under conditions that replicate the type of materials used in the surrounding structure, such as walls, floor, and ceiling. We also accumulated quantitative data on the effective value of the thermal inertia of materials.

Furthermore, we examined methods to evaluate the functional degradation of buildings caused by natural disasters and the recovery time from such degradation. We conducted resilience analysis of buildings with different collapse modes, which will lead to the development of a seismic performance analysis method from the perspective of the resilience of the city as a collection of buildings. This research aims to address the vulnerability of urban functions to natural disasters, as exemplified by the paralysis and confusion of the capital city of Tokyo after an earthquake, which is currently the most socially feared issue in Japan. This theme is a characteristic research area of TUS, which conducts research on safety against multiple hazards, including fire and earthquakes.

3.4. Area of Firefighting, Fire prevention, and Industry Fires

Research is conducted from the viewpoints of "using science and technology to enhance firefighting activities" and "protecting against industrial fires caused by chemical substances."

Photo 4. Vehicle materials.

In the research on mental and physical health management and effective training methods to prevent occupational accidents among firefighters, in cooperation with a fire department, physiological indices are measured during training of firefighters wearing the equipment they will actually use; then, management methods and effective training methods to maintain safety in firefighting activities are formulated. Other studies included: (1) on-site analysis of changes over time in heat acclimatization training for firefighters to reduce the risk of heat stroke during summer; (2) research on the use of drone technology in the field of firefighting disaster prevention; and (3) research on evaluating the capability of fire-suppression agents in light of their environmental impact. In addition, we studied the electrical-breaker behaviors at fire scenes toward determining the fire-starting point in fire investigations. Other studies include modeling building damages using a U-Net convolutional neural network to support activities during forest fires.

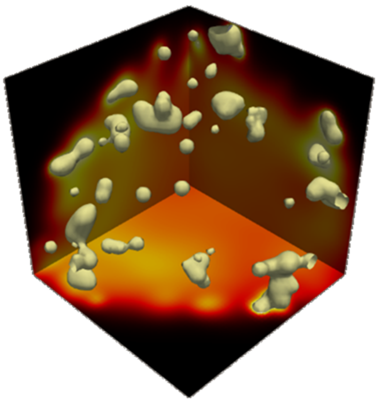

Fig. 6. A dust-explosion simulation.

In the research for protection against industrial fires caused by chemical substances, we aimed to establish methods that can accurately and quantitatively assess the risk of potential fires and explosions. A dust-explosion model that can predict the lower explosion limit was developed (Fig. 6). In addition, from the viewpoint of investigating fire safety measures for trains from the vehicle material (Photo 4), improvements aimed at preventing vehicle fires and developing flame retardants for electrical components were investigated. The use of AI technology for analyzing the "causes and consequences" and the "materials and conditions" of industrial fires was also studied.

4. Challenges and Prospects

Research activities were initiated in four new areas in 2021, reflecting the diversification of fire phenomena in recent years. These days, fires such as gasoline arson, or more specifically, “unexpected fires,” have frequently been occurring, and the current fire prevention measures may not be sufficient to ensure human safety. These circumstances forced us to initiate research activities in a new, updated framework. Research is conducted by first analyzing characteristic fire phenomena and then identifying and discussing issues in each area. Such efforts will require time to produce satisfactory outcomes. We will continue to solve common problems through close collaboration among the research areas, which will lead to the reduction of fire damage. In addition, as a “Joint Usage/Collaborative Research Center,” we have conducted many joint research projects. In recent years, however, due in part to the coronavirus pandemic, research activities, especially with overseas partners, have been sluggish. Now that the spread of the new coronavirus has finally come to an end, we will work to bring our overseas joint research activities back to the level they were before the pandemic.

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. In recognition of 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. However, 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.

In November 2022, a symposium entitled “Preparing for Arson Fires Involving Gasoline Spraying” was held on gasoline arson, an issue in recent years to be addressed. This symposium was held in a hybrid face-to-face and online format, with lectures delivered from two venues in Noda and Kagurazaka. Notably, the Center’s features were fully utilized by delivering lectures with dynamic fire experiments conducted in our Laboratory, which could be observed on-site. At the same time, the online attendees could see them in a highly realistic video format, leading to a deeper understanding of the contents of the lectures. The symposium was a success, with more than 200 participants, both in person and online, and a lively question-and-answer session with participants.

Major Research Achievements (FY 2022)

Academic Papers

1. Damage-resistant performance evaluation of RC columns with wing walls from the viewpoint of functional recovery, Shibata R., Kinugasa H., Mukai T., Choe H., AIJ journal of technology and design, Vol. 29, No.71, pp.168-173, 2023.2 (in Japanese) (Peer-reviewed)
2. COLLAPSE BEHAVIOR EVALUATION OF STEEL FLOOR STRUCTURES WITH UNINSULATED SECONDARY BEAMS UNDER ELEVATED TEMPERATURES IN FIRES, Jiro TAKAGI, Song WANG, Jun KURIHARA, Mamoru KOHNO and Ken MATSUYAMA, J. Struct. Constr. Eng., AIJ, Vol. 87, No. 799, 944-953, Sep., 2022 (in Japanese) (Peer-reviewed)
3. ANALYSIS OF CREEP BEHAVIOR OF HIGH YIELD POINT STEELS YP400, YP500 COLUMNS AT ELEVATED TEMPERATURES, Quoc Tuan PHAN, Mamoru KOHNO, Steel Construction Engineering, Vol. 29, pp. 57-68, 2022 (Peer-reviewed)
4. Modeling of Creep Behavior of High Strength Steel H-SA700 Columns at Elevated Temperature, Quoc Tuan Phan, Mamoru Kohno, Yukio Murakami, Hoang Long Nguyen, International Journal for Fire Science and Technology, Vol. 41, pp. 1-20, 2022 (Peer-reviewed)
5. Effect of circulation on flame heights over liquid fuel pools, X. Ju, M. Mizuno, T. Matsuoka, T. Yamazaki, K. Kuwana, Y. Nakamura, Combustion and Flame, Vol. 246, 112435 (10 pages), 2022 (Peer-reviewed)
6. Determining kinetic parameters of cellulose and lignin pyrolysis by Gaussian process regression (GPR) method, P. Viriya-amornkij, K. Kuwana, Progress in Scale Modeling, an International Journal, Vol. 3, Article 03-01-05 (10 pages), 2022 (Peer-reviewed)
7. Large-scale fire-whirl and forest-fire disasters: awareness, implications, and the need for developing preventative methods, A.D. Ahmad, N.K. Akafuah, J. Forthofer, M. Fuchihata, T. Hirasawa, K. Kuwana, Y. Nakamura, K. Sekimoto, K. Saito, F.A. Williams, Frontiers in Mechanical Engineering, Vol. 9, 1045542 (16 pages), 2023 (Peer-reviewed)
8. NUMERICAL SIMULATION OF THERMAL PLUME ABOVE COMMERCIAL COOKING GAS STOVE USING CFD ANALYSIS (PART 1): TEMPERATURE AND VELOCITY DISTRIBUTIONS OF EXHAUST GAS, AND CAPTURE EFFICIENCY OF EXHAUST HOOD UNDER OPEN FLAME CONDITION, Yuki SHIMANUKI, Takashi KURABUCHI, Takao OSAWA, Yoshihiro TORIUMI, Sihwan LEE, Ami KUDO and Yasuhisa ASAWA, J. Environ. Eng., AIJ, Vol. 87, No. 799, 569-578, Sep., 2022 (in Japanese) (Peer-reviewed)
9. Reproduction of Thermal Plume above Commercial Cooking Gas Stove using CFD Analysis. Takao Osawa, Takashi Kurabuchi, Yoshihiro Toriumi, Sihwan Lee, Yuki Shimanuki, Ami Kudo : Proceedings CLIMA 2022: The 14th REHVA HVAC World Congress, pp. 166-170, (April, 2022) (Peer-reviewed)
10. Fire Retardancy of Fire-retardant-impregnated Wood after Natural Weathering Ⅲ. Fire performance after 10-years exposure, Masayuki Kawarasaki, Ryoichi Hiradate, Yasushi Hirabayashi, Yasuhiro Kawai, Shinich Kikuchi and Yoshifumi Ohmiya, Mokuzai Gakkaishi, Vol. 69, No. 1, pp 30−40 (2023) (in Japanese) (Peer-reviewed)
11. Analysis of Evacuation Behavior in Underground Mall Fire using VR Simulator Influences of Player's Location and Direction at the Start of Evacuation and Composition Ratio of Evacuees with Different Walking Speeds, Toshinari Tanaka, Masayuki Mizuno, Bulletin of Japan Association for Fire Science and Engineering, Vol. 72, No. 1, pp.9-24, 2022.4 (in Japanese) (Peer-reviewed)
12. Questionnaire Survey on Maintenance of Residential Fire Alarms, Masayuki Mizuno, Hiromichi Ebata, Shuji Ito, Yoshiharu Nagawa, Journal of social safety science, No. 42, 10 p, 2023.3 (in Japanese) (Peer-reviewed)
13. Combustion behavior of corrugated cardboard for disaster shelter by combustion calorimeter method, Y. Mizutani, Y. Mochizuki, A. Sakuma, M. Okoshi, K. Matsuyama, Journal of Materials Life Society, Vol. 34, Issue 3, pp. 51-58, 2022 (in Japanese) (Peer-reviewed)

14. Flame-retardancy evaluation of corrugated cardboad beds for disaster shelter and prevention of fire spread with their zoning, Y. Mizutani, Y. Mochizuki, A. Sakuma, M. Okoshi, K. Matsuyama, Journal of Materials Life Society, Vol. 34, Issue 3, pp. 59-65, 2022 (in Japanese) (Peer-reviewed)
15. Similarity of Energy Balance in Mechanically Ventilated Compartment Fires: An insight into the conditions for reduced-scale fire experiments, H. Suto, K. Matsuyama, Y. Hattori, Nuclear Engineering and Technology, Vol. 54, Issue 8, pp. 2898-2914, 2022 (Peer-reviewed)
16. M. Araki and K. Matsuyama, Rapid Measurements of Hydrogen Cyanide Concentration in Combustion Gas via Terahertz Spectroscopy, Current Applied Physics, Vol. 36, pp. 83-87, 2022 (Peer-reviewed)

Books

1. Takashiro Akitsu, Akinori Honda, "Flame-Retardant Polymeric Foams and Materials of Trains", Polymeric Foams: Materials, Technology and Applications, chapter 21, American Chemical Society, in press. (Peer-reviewed).
2. Principles of Fire Preventive Materials - For Protecting Building and Life Safety from Fire with Building Construction and Materials -, Yoshifumi Ohmiya, and 12 others, p74, Architectural Institute of Japan, 2022 (in Japanese)

Invited Lectures

1. 消防活動における熱中症リスク，水野雅之，総合危機管理学会・第 6 回学術集会, 21 May 2022（in Japanese）
2. 火の効用・火の災害，松原美之，野田市防災講演会, 1 Aug., 2022 (in Japanese)
3. Takashiro Akitsu: "Sustainable Nanomaterials of Metals and Safety", World Science Congress ~Science for Society and Sustainable Development~ (2022.8.13) West Bengal, India (Online).
4. Takashiro Akitsu: "Mercury Toxicity from Factory and Fire", GREEN TECHNOLOGY: ISSUES AND CHALLENGES 2022 (2022.9.20) Chaudhary Charan Singh University, Meerut, India (Online).
5. 静電気現象と災害・障害，松原美之，東京安全衛生教育センター, 31 Oct., 2022 (in Japanese)
6. 静電気による液体可燃物の災害と対策，松原美之，静電気学会, 14 Dec., 2022 (in Japanese)

Public Relations

1. 萩原一郎，千日デパート火災から 50 年についてコメント，読売新聞, 2022.5 (in Japanese)
2. 萩原一郎，大阪北新地火災の報告書公表に関するコメント，毎日新聞, 2022.6 (in Japanese)
3. 萩原一郎，熊本大洋デパート火災から 50 年についてコメント，毎日新聞, 2022.12.18 (in Japanese)
4. 萩原一郎，仙台駅前の火災についてインタビュー対応，仙台放送, 2022.12.21 (in Japanese)
5. 萩原一郎，講演「火災時に命を守るための避難計画」，シンポジウム「ガソリン散布を伴う放火火災に備える」，火災科学研究所, 2022.11.25 (in Japanese)

Awards

1. Kazunori Kuwana, JAFSE Award, Japan Association for Fire Science and Engineering, 2022
2. Kazunori Kuwana, Wookyung Kim, Toshio Mogi, Ritsu Dobashi, Best Paper Award, Japan Society for Safety Engineering, 2022
3. Kohei Matsushita, Ai Sekizawa, Masayuki Mizuno, Excellent Paper Award in Fire Science and Disaster Prevention, Fire and Disaster Management Agency, Ministry of Internal Affairs and Communications, 2022
4. Yusuke Ikuma, Shinya Yanagita, Masayuki Mizuno, Yoshifumi Ohmiya, Takahiko Yamamoto, Paper Award of the Japan Institute of Electronics Packaging, Japan Institute of Electronics Packaging, 2022

Individual Research Topics

Takashiro Akitsu

"Flame-retardant polymer foams and materials for trains, and fire accident train surveys"

Both thermosetting and thermoplastic resins are used in foamed plastics such as polyurethane and polystyrene, and advances in nanotechnology have greatly improved the controllability of foaming and molding. These advances include not only packaging-related applications, but also industrial applications such as thermal insulation that depend on structure and physical properties. Regarding the use of foamed plastics as insulation materials for railway vehicles and cushioning materials for seats, the history and examples of railway vehicles (survey on fire accident trains), improvement of flame resistance, and thermal analysis are summarized.

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 properties of fire plume ejected from an opening during a building fire"

Assuming a fully-developed fire in a building, the conditions of combustible materials and architectural conditions (eaves, balconies) are used as parameters, and research is conducted on the properties of fire plume through the openings. In this study, we quantitatively grasp the influence on the properties of the fire plume when unburned combustible gas blows out from the opening and burns outside, and proposes an evaluation method for preventing the spread of fire in building.

Manabu Kanematsu

"A study on evaluating the durability of fire-retardant-treated wood"

In recent years, fire-retardant-treated wood has been increasingly used as an exterior material for building facades due to its fire-prevention properties. However, concerns have been raised regarding the possibility of the fire-retardant agent leaching out when exposed to rain, which can cause a loss of its required performance over time. This study aims to establish a fire performance evaluation method for fire-retardant-treated wood for exterior use in Japan while taking into account its long-term deterioration characteristics, as well as to clarify the degradation mechanism of fire-retardant-treated wood and develop an accelerated degradation test method by repeated dry-wet cycles.

Hideyuki Kinugasa

"Study on urban functional recovery in the event of natural disasters"

Concerns about the vulnerability of urban functions to natural disasters are growing due to the paralysis and chaos of the capital city "Tokyo" due to recent earthquakes. Based on this background, a method to evaluate the "loss of functionality" and "recovery time" of buildings caused by natural disasters, was developed and resilience analysis of buildings with different collapse mechanisms were carried out. Using this method, establishment of a seismic analysis method from the viewpoint of resilience of a city is expected.

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.

Mamoru Kohno

"Study on the fire resistance performance of building structural members"

Experimental and analytical investigations were conducted on the members that make up buildings, such as columns and floors. Specifically, a finite element method (FEM) analysis technique was developed and analyzed, taking into account creep behavior during fires of columns using high-yield-point steel. In addition, the study focused on a floor frame structure consisting of a steel deck and concrete composite slab and non-fire-protected steel beams. The study involved understanding the behavior through experiments and constructing a finite element analysis procedure benchmarked against the experimental results. Further, the developed methodology was used to analyze the fire resistance performance of these members under different conditions from those of the experiment.

Atsushi Shono

"Study on thermophysical properties of thermal insulation materials"

Evaluation of thermal insulation performance is essential for the development of lightweight insulation materials, and thermal conductivity is one of the most important indices. The purpose of this study is to measure the thermal conductivity of various insulation materials and to clarify the relationship between the structure of insulation materials (fiber orientation, fiber length, fiber diameter, porosity, void shape, continuous porosity, etc.). The anisotropy of thermal conductivity of insulation (fiber orientation) was measured by the steady-state method; the spatial information indexing was modeled from the analysis of the internal structure of insulation using an X-ray CT scanner. The correlation between structure and thermal conductivity was investigated from the obtained results.

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. In this year, overseas regulations and standards regarding the emergency access openings for firefighters to enter indoors were collected, and the contents and the concept of the regulations were organized.

“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. In this year, experimental study was made regarding the manipulation of security lock devices by subjects, but the experiment was postponed due to the spread of COVID-19. The experiment is scheduled to be conducted in the next fiscal year.

Yoshiyuki Matsubara

“Research on mitigating the damage of chemical fires”

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.

“Research to contribute to advanced firefighting activities”

To aid in determining the location of fires at the scene, this research studies the behavior of electrical breakers at the scene of a fire and the U-Net convolutional neural network model that can effectively analyze images of buildings after forest fires using satellite images. The research aims to advance firefighting activities.

Ken Matsuyama

“Smoke exhausting/control systems based on new concepts”

Smoke exhausting/control systems have been mainly concerned with the initial stage of a fire. On the other hand, due to the increasing size of buildings, evacuation times might be longer, and from the viewpoint of supporting firefighters, there is a need for a method to exhaust smoke outside the building for a longer period of time until fire is extinguished. This study focuses on the characteristics of smoke particles, especially their charge, and aims to establish a new smoke exhausting/control methods by improving the efficiency.

Masayuki Mizuno

“Study on planning methods for total building evacuation from high-rise office buildings”

Total building evacuation from high-rise buildings is a potential event that may occur in a disaster, and it is necessary to consider measures to implement it smoothly and safely. Based on the results of investigations conducted on total building evacuation drills in an office building in Tokyo, a method for planning a building evacuation with phased scenario will be considered. A method for evaluating evacuation status in stairways will be proposed, and its applicability will be confirmed.

“Study on the validity evaluation of evacuation behavior characteristic analysis using VR technology”

In recent years, research on evacuation behavior analysis using VR technology has been actively conducted. In this study, we compare experiments conducted in real space and those reproduced in a VR space, focusing on factors such as people passing each other and congestion in front of an exit, in order to reveal differences and identify important features to consider in evacuation behavior analysis using VR technology.

Shinya Yanagita

“Physiological analysis for the prevention of heat stroke in firefighters”

In order to improve the safety of firefighters in fire and rescue operations, physiological measurements of physical and psychological stress during actual firefighting activities are being conducted. Currently, heat acclimatization and body cooling experiments are being conducted in an environment that simulates an actual fire site, with heat stroke prevention as a particular research target.

“Quantifying the physical and mental workload of firefighters”

Not only do firefighters work in a time-consuming environment, such as 24-hour shifts, but they also respond to disasters and accidents, which is considered to be an occupation with an extremely high mental and physical workload. In order to maintain their occupational safety, we are analyzing the physical and mental conditions of firefighters using physiological measures.

Water Frontier Research Center (WaTUS)

Water Frontier Research Center (WaTUS)

1. Overview

Water Frontier Research Center (WaTUS), established on April 2021, is a successor research organization of Water Frontier Science & Technology Research Center (W-FST) 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, aim to pursue leading-edge research and developments relating to "water interface" with multi-disciplinarily collaborative research. Our goal 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 research for industries
(4) Visualization of TUS through our research activities

Formation of research and development hub for "water interface" through our research means creating the place where researchers all over the world can join and establishing research organization which can provide practical solutions to industries.

To accomplish the above missions, highly intensive collaborations of fundamental research and technology developments with researchers inside and outside of the center become a key.

2. Organization and Facilities

WaTUS promotes interdisciplinary collaborative research 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, 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 the center is appreciated in this center.

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

WaTUS has advanced facilities with state-of-the-art analytical systems for pursuing leading-edge research 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 provides 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 consists of three research units, “Materials & Water,” “Life & Water,” and “Environment & Water.” Each unit performs research activities with mutual cooperation. Below we report some of our recent research activities.

3. 1. Nanoscale Droplet on Material Surface

In this research, we investigate atomic- and molecular-scale interaction of water with material surfaces, especially nanoscale wetting. It has been reported that the adsorption structure of water on SiO_2 surface under different humidity conditions is very complex, and that a single layer of structural water is observed when the relative humidity is above 90%, while partial wetting is observed at lower relative humidity of 50-80%, but the details have not been clarified. In this study, nanoscale water droplets on the surface of SiO_2 placed in different humidities were measured using an atomic force microscope (AFM). Experimental results showed the presence of water droplets with a height of a few nm (Fig. 1). The droplet height tends to increase with increasing humidity and gradually disappeared when the humidity was decreased by opening the chamber. The frequency analysis of AFM revealed that these nano-droplets existed on the structural water formed on the SiO_2 surface. Subsequently, the adhesion force between the substrate and the water obtained by the peak force tapping mode clarified that the adhesion force of the nano-water droplet was smaller than that of the adsorbed structural water. This fact suggests that the structures of the water film and the nano-water droplet are different.

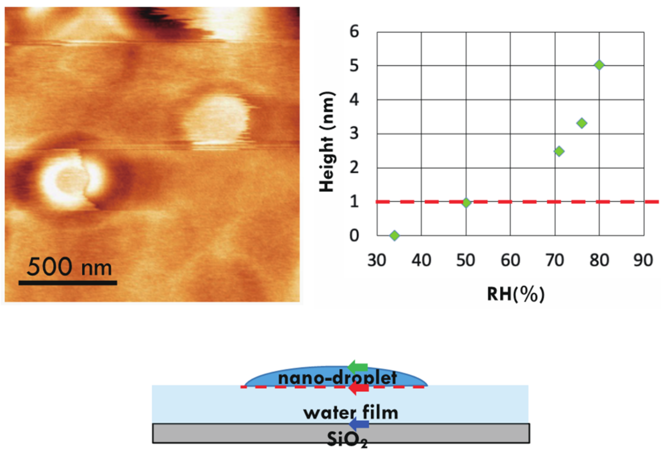

Fig. 1. Nanoscale water droplet.

3. 2. Fluid Mechanics of Spreading Gas-liquid Interface Interacting with Micro-pillar

Dynamic wetting, which involves movement of interface, has a lot of unclear issues in contrast to static wetting. In this research, we investigate dynamic wetting around hydrophobic microstructures on hydrophilic surfaces. When a gas-liquid interface spreading on a hydrophilic surface passes through a hydrophobic micro-particle or structure (10-100 μm in typical size), the interface becomes curved, and then the wetting is abruptly enhanced as the curved interface recovers. Numerical simulation results show that a

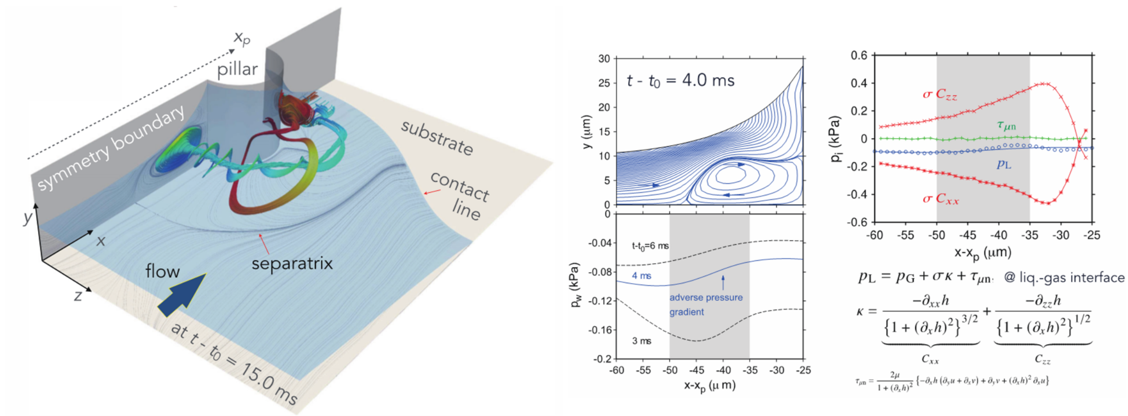

Fig. 2. Complex flow at curved interface around micro-pillar and pressure distribution.

large pressure distribution is generated near the curved interface due to Laplace pressure, resulting in a complex flow structure similar to the horseshoe vortex which is often seen in large scale flows such as those in bridge and building legs (Fig. 2). The formation of surface tension-driven vortices around micro-pillars has not been reported before, and this finding indicates new potential applications of meniscus pumps, not only for liquid transport but also for mixing promotion.

3. 3. Characterization of Carbon Nanoparticles in Water and Effect on Climate

It is known that black carbon particles (BC) originating from human industrial activities cause suppression of thermal convection in atmosphere due to absorption of sunlight, cloud formation and precipitation, and melting of snow surfaces. Moreover, it is said that BC would promote global warming, especially in the Arctic region. Accurate monitoring of BC in the Arctic is important for understanding the causes and considering countermeasures. However, the large uncertainty in the measurement method of BC concentration from collected snow samples has hindered precise estimation of BC. In this study, we developed an improved method to determine the mass concentration and size distribution of BC in water (Fig. 3). BC in water is atomized into the air as droplets, then irradiated by Nd:YAG laser, and incandescent light of multiple wavelengths is acquired. The ratiometric approach was to remove signals from other mineral components. It was then clarified that the particle extraction efficiency in the device was about 50% for particles of 60 nm to 2 μm in diameter, independent of particle size. Consequently, the BC measurement method with high quantitative reliability was established. The same snow samples collected from various regions were compared with the conventional method, and it was found that the conventional method overestimated the BC concentration by a factor of 2 to 25 in samples from Alaska and northern Norway. This large discrepancy in BC concentration will have a great effect on the estimation of the snow surface reflectance of sunlight which influences the climate prediction.

4. Challenges and Prospects

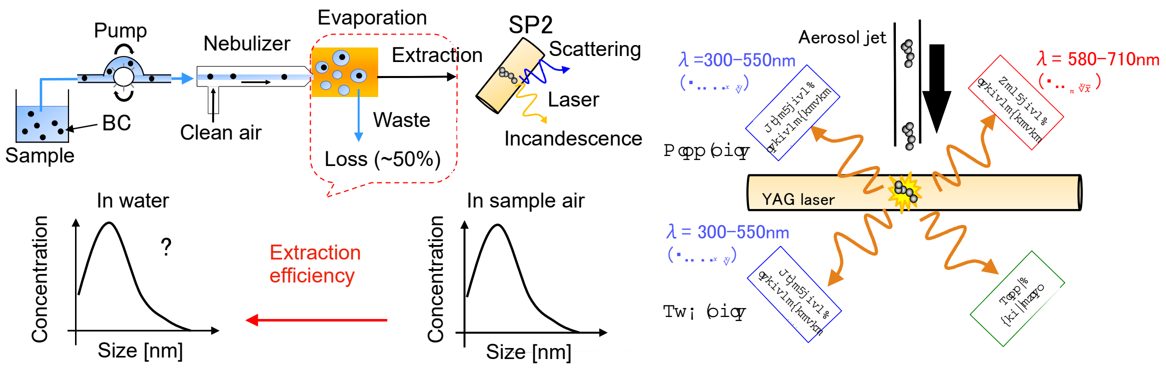

Fig. 3. Schematic diagram of single-carbon-particle detection system.

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. In addition to research, in 2022, 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

New joint research and collaborations have started while on-going projects has actively continued. Therefore, further progress is expected. Also, a multi-level water simulator was partially released. We, Water Frontier Research Center (WaTUS), intend to continue both research and educational activities with high enthusiasm.

Major Research Achievements (FY 2022)

Academic Papers

1. Lubrication effects on droplet manipulation by electrowetting-on-dielectric (EWOD), Ken Yamamoto, Shimpei Takagi, Yoshiyasu Ichikawa, Masahiro Motosuke, Journal of Applied Physics, Vol. 132, No. 20, 204701, 2022 (Peer-reviewed)
2. Enhancing the Foam Stability of Aqueous Solution with High Ethanol Concentration via Co-Addition of Surfactant, Long-Chain Alcohol, and Inorganic Electrolyte, Sakai K, Muto R, Hara M, Hattori R, Harata E, Akamatsu M, Sakai H, Chem. Lett., 51, pp 982-984, 2022 (Peer-reviewed)
3. Correlation between copper particle morphology and number of graphene layers on a palladium substrate, Junro Takahashi, Kengo Nakamura, Yusei Kioka, Hiroki Kato, Takahiro Yamamoto, Yoshikazu Homma, Appl. Phys. Express 16, 015503, 2023 (Peer-reviewed)
4. Catalyst-free synthesis of sub-5 nm silicon nanowire arrays with massive lattice contraction and wide bandgap, Sen Gao, Sanghyun Hong, Soohyung Park, Hyun Young Jung, Wentao Liang, Yonghee Lee, Chi Won Ahn, Ji Young Byun, Juyeon Seo, Myung Gwan Hahm, Hyehee Kim, Kiwoong Kim, Yeonjin Yi, Hailong Wang, Moneesh Upmanyu, Sung-Goo Lee, Yoshikazu Homma, Humberto Terrone, Nat. Commun. 13, 3467, 2022 (Peer-reviewed)
5. Non-destructive estimation of the cation composition of natural carbonates by micro-Raman spectroscopy, Shu-hei Urashima, Mayu Morita, Shintaro Komatani, Hiroharu Yui, Analytica Chimica Acta, vol. 1242, 340798, 2023(Peer-reviewed)
6. Inner and Interfacial Environmental Nanoarchitectonics of Supramolecular Assemblies Formed by Amphiphiles: from Emergence to Application, Akamatsu M, J. Oleo. Sci., Vol. 72, pp 105–116, 2022 (Peer-reviewed)
7. New measurement system based on small-angle neutron scattering for structural analysis of light-responsive materials, Iwase H, Akamatsu M, Inamura Y, Sakaguchi Y, Morikawa T, Kasai S, Oh-uchi K, Kobayashi K, Sakai H, J. Appl. Cryst., Vol. 56, pp 110–115, 2023 (Peer-reviewed)
8. Mechanism of Chiral-Selective Aminoacylation of an RNA Minihelix Explored by QM/MM Free-Energy Simulations, Tadashi Ando, Koji Tamura, Life, Vol. 13, pp. 722, 2023 (Peer-reviewed)
9. Viscoelastic flow behavior and formation of dead zone around triangle-shaped pillar array in microchannel, Yoshiyasu Ichikawa, Masahiro Motosuke, Microfluidics and Nanofluidics, Vol. 26, 44, 2022 (Peer-reviewed)
10. Controlled polymerization of metal complex monomers - fabricating random copolymers comprising different metal species and nano-colloids. Shigehito Osawa, Sosuke Kurokawa, Hidenori Otsuka, Chemical Communications, 58, 5273-5276, 2022 (Peer-reviewed)
11. Photoreduction of copper ions using silica-surfactant hybrid and titanium (IV) oxide under sulfuric acid conditions, S. Machida, R. Kato, K. Hasegawa, T. Gotoh, K. Katsumata, A. Yasumori, Materials, Vol. 15, pp. 5132, 2022 (Peer-reviewed)
12. Simulation model of boiling heat transfer and flow maldistribution in parallel mini-channels heated unequally, Kizuku Kurose, Takuya Kawasuso, Kazushi Miyata, Yoshinori Hamamoto, Int. J. Heat and Mass Transfer, Vol. 195, 123184, 2022 (Peer-reviewed)
13. Binding and Distribution of Water Molecules in DPPC Bilayers Doped with β-Sitosteryl Sulfate, A. Kafle, M. Akamatsu, A. Bhadani, K, Sakai, C. Kaise, T. Kaneko, H. Sakai, Colloids and Surfaces B-Biointerface, 218, 112748, 2022 (with review)
14. High Friction Mechanism of ZDDP Tribofilm Based on in situ AFM Observation of Nano-Friction and Adhesion Properties, Kaisei Sato, Seiya Watanabe, Shinya Sasaki, Tribology Letters, 70, 94,1-15, 2022 (Peer-reviewed)
15. Electrochemical impedance simulation of porous electrodes with variously shaped pores using 3-dimensional finite element method, Noya Loew, Tomohiro Tanaka, Hikari Watanabe, Isao Shitanda, Masayuki Itagaki, Electrochimica Acta, Vol.440, pp. 141723-141730, 2023(Peer-reviewed)

16. Self-emergent vortex flow of microtubule and kinesin in cell-sized droplets under water/water phase separation, Hiroki Sakuta, Naoki Nakatani, Takayuki Torisawa, Yutaka Sumino, Kanta Tsumoto, Kazuhiro Oiwa, Kenichi Yoshikawa, Comm. Chem. 2023, accepted (Peer-reviewed)
17. Proton Conductive Mononuclear Hydrogen-Bonded Cobalt (II) Spin Crossover Complex, [Supplementary Journal Cover] F Kobayashi, T Hiramatsu, K Sueyasu, M Tadokoro, CRYST. GROWTH DES., 23, 1633–1640, 2023 (Peer-reviewed)
18. Multicellular structures in thin free liquid films induced by thermocapillary effect, T. Homma, T. Yamashita, R. Wada, K. Kawazu, K. Kurose, T. Tsukahara, and I. Ueno, Journal of Colloid and Interface Science, Vol. 641, 187-196, 2023 (Peer-reviewed)
19. Spectral analysis on dissimilarity between turbulent momentum and heat transfers in plane Couette turbulence, T. Kawata and T. Tsukahara, Physics of Fluids, Vol. 34, 075135, 2022 (Peer-reviewed)
20. Machine learning to estimate the mass-diffusion distance from a point source under turbulent conditions, T. Ishigami, M. Irikura, and T. Tsukahara, Processes, Vol. 10, 860, 2022 (Peer-reviewed)
21. Extremely large electro-optic effect of TPPS J-aggregates in the PVA or PVP polymer matrix and aqueous solution, Kazuaki Nakata, Takayoshi Kobayashi, Eiji Tokunaga, Phys. Chem. Chem. Phys. 24, 12513-12527, 2022 (Peer-reviewed)
22. Samples returned from the asteroid Ryugu are similar to Ivuna-type carbonaceous meteorites, Tetsuya Yokoyama, Kazuhide Nagashima, Izumi Nakai, Hiroharu Yui, et al., Science, 379, 6634, 2022 (Peer-reviewed)
23. Contribution of Ryugu-like material to Earth’s volatile inventory by Cu and Zn isotopic analysis, Marine Paquet, Frederic Moynier, Tetsuya Yokoyama, Izumi Nakai, Hiroharu Yui, et al., Nature Astronomy, 7, 182-189, 2022 (Peer-reviewed)
24. Ryugu's nucleosynthetic heritage from the outskirts of the Solar System, Timo Hopp, Nicolas Dauphas, Yoshinari Abe, Izumi Nakai, et al., Science Advances, 8, eadd8141, 2022 (Peer-reviewed)
25. Numerical Simulation of the Solidification of a Single Molten Droplet Impinging on Flat Plate Using Multi-Resolution MPS Method, S Kato, K Fukudome, M Yamamoto, Proceedings of Global Power and Propulsion Society (GPPS Chania22) , GPPS-TC-2022-0140, pp.1-6, 2022 (Peer-reviewed)
26. ortho-Substituted Aryldiazonium Design for the Defect Configuration-Controlled Photoluminescent Functionalization of Chiral Single-Walled Carbon Nanotubes, Boda Yu, Sadahito Naka, Haruka Aoki, Koichiro Kato, Daiki Yamashita, Shun Fujii, Yuichiro K Kato, Tsuyohiko Fujigaya, Tomohiro Shiraki, ACS nano, Vol. 16, pp. 21452-21461, 2022 (Peer-reviewed)
27. Numerical study on the rotational and machining accuracy of an end-milling process with spindles supported by aerostatic bearings, Keita Shimada, Daisuke Wakabayashi, Yuma Shimoyakawa, Shouhei Kawada, Masaaki Miyatake, Shigeka Yoshimoto, Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology, Vol. 236, pp. 10541-10553, 2022 (Peer-reviewed)
28. Measurement of number and mass size distribution of light-absorbing iron oxide aerosols in liquid water with a modified single-particle soot photometer, Mori T, Kondo Y, Goto-Azuma K, Moteki N, Yoshida A, Fukuda K, Ogawa-Tsukagawa Y, Ohata S, Koike M, Aerosol Science & Technology, 57, 35–49, 2022 (Peer-reviewed)
29. (Invited) Nanoscale Wetting and Its Connection with Macroscopic Young's Equation, Yasutaka Yamaguchi, Hiroki Kusudo, Carlos Bistafa, Donatas Surblys, Takeshi Omori, Gota Kikugawa, ECS Transactions, 108, pp. 93-102, 2022 (Peer-reviewed).

Invited Lectures

1. Analysis of nanoparticle alignment by localized surface plasmon resonance of metal nanostructures and related thermofluidic phenomena, Masahiro Motosuke, Multiphysics Conference 2022, Tokyo, 2022
2. Improved Stability of Foams in Ethanol/Water Mixtures, Kenichi Sakai, JOCS-AOCS Joint Meeting in the 2nd World Congress on Oleo Science (WCOS2022), Online, 2022

3. Chemical analysis of groundwater, river, and ocean towards SDGs: Nondestructive and Noncontact analysis of cation compositions of sedimentary rocks by Raman microspectroscopy, Shu-hei Urashima, Hiroharu Yui, 7th conference of The Research Society of Water Science for Future Life, Foundation for the Promotion of Engineering Research, Tokyo, 2022.
4. Air and Water Purification by Photocatalyst, Ken-ichi Katsumata, International Congress on Pure & Applied Chemistry (ICPAC) Kota Kinabalu 2022, Kota Kinabalu, Sabah (On-line), 2022
5. Development of a Self-Powered Diaper Glucose Sensor Combining a Low Power Wireless Transmission Device and a Paper Substrate Biofuel Cell, Isao Shitanda, Diabetes Technology Meeting 2023, Online, 2022
6. Molecular Conductor with Proton-Assisted Electron Transfer, Makoto Tadokoro, ICPAC (International Congress on Pure & Applied Chemistry), Kota Kinabalu, Malaysia 11/22~27, 2022
7. Deep learning for viscoelastic fluids and turbulent diffusion, Takahiro Tsukahara, JSME Annual Meeting EFD Workshop: Fluid Engineering and AI, Toyama Sept. 11-14, 2022
8. What does the glass excavated from Okinoshima tell us?, Izumi Nakai, "Sacred Island", World Heritage Open Lecture, Online, February 2, 2022
9. 大気電気学会と私 −イオン・エアロゾルを測って 40 年−, 三浦和彦, 日本大気電気学会第 100 回研究会記念特別講演会, 電気通信大学, 2023 (in Japanese)
10. Numerical Simulation of Enjine Icing ～Current Status and Future Trends～, Makoto Yamamoto, 7th WEATHER-Eye Open Forum, 2022 (without review)
11. In situ observation of nano water droplet on glass, Yuki Araki, Kyoto Workshop on Investigation of Solid-Liquid Interfaces by Atomic Force Microscopy, Kyoto, 2023.
12. Towards a machine learning forcefield using FMO data, Koichiro Kato, 20th Anniversary Symposium of the Society of Computer Chemistry, Japan, Tokyo, 2022
13. Nanoscale Wetting and Its Connection with Macroscopic Young's Equation, Y Yamaguchi, H Kusudo, C Bistafa, D Surblys, T Omori, G Kikugawa, 241st ECS Meeting, Vancouver, Canada, G01-1252, May 2022
14. Investigation on the dynamics of Leidenfrost droplets using interferometry and thermographys, Ken Yamamoto, 50th Symposium of the Visualization Society of Japan, Tokyo, 2022

Public Relations

1. Masahiro Motosuke, Novel Thin and Flexible Sensor Characterizes High-speed Airflows on Curved Surfaces, Press Release of Tokyo University of Science, 2022
2. Intriduction of Water Frontier Research Center, Green Infrastracture Industries Exhibition 2023, 2023.
3. Takahiro Yamamoto, Kids Science Lecture: Volta cell using hot-spring Slime, Scramble Beppu (Uchilabo), November 26, 2022
4. Masahiro Motosuke, Takahiro Yamamoto, Appeared in "Mochiyori Nazo Q-den", TV Asahi, September 24, 2022
5. Takahiro Yamamoto, "Volta cell using pure water [Experiment]" https://youtu.be/hj2hFihmyo8, Educational YouTuber 《Yobinori Yasu》 Channel, August 5, 2022～
6. Makoto Tadokoro, Press Release: Novel Multi-Proton Carrier Complex as Efficient Proton Conductor at High Temperatures Researchers develop a highly symmetric ruthenium (III) complex with six imidazole-imidazolate groups for efficient high-temperature proton conduction in fuel cells, 2022
7. Izumi Nakai, "Beauty of Tsubo" (Yohen Tenmoku), NHK Online, 2023

Awards

1. Ryosuke Yamaguchi, Puneet Jain, Yoshiyasu Ichikawa, Masahiro Motosuke, Best Paper Award, Japan Society of Thermophysical Properties, 2022
2. Kenichi Sakai, 66th Best Paper Award, Foundation, Oil & Fat Industry, 2023
3. Masaaki Akamatsu, JOCS Young Scientist Award, The Japan Oil Chemists' Society (JOCS), 2022
4. H Sakai, Japan Oil Chemists' Society Award, 2022.
5. Shingo Machida, JAICI Award, Japan Association for international chemical information, 2023
6. Shohei Kawada, JSME Young Engineers Award, Japan Society for Mechanical Engineers, 2022

Individual Research Topics

Masahiro Motosuke

“Nanoparticle manipulation using plasmonic bubble”

In this study, the manipulation of nanomaterials suspended in water using plasmonic heating with themophoresis and interfacial flow around a photothermal bubble is investigated. It is found that frequent modulation in the heating provides significant difference in the accumulation pattern of nanomaterials. This would suggest that an itnteraction between heat dissipation and bubble dynamics including the onset of the interfacial flow grealy influence the accumulation phenomena.

Kenichi Sakai

“Preparation and characterization of α-form hydrated crystal (α-gel) with nonionic surfactants”

α-Form hydrated crystal (α-gel) was prepared using nonionic surfactants having oxyethylene units as a hydrophilic group. The addition of salting-in ions resulted in increased lamellar d-spacing. Furthermore, an increased salt concentration resulted in increased cohesion energy between domains consisting of α-form hydrated crystals, leading to increased viscosity. The hydration state of the hydrophilic group significantly affects the structure and property of α-form hydrated crystal (α-gel).

Yoshikazu Homma

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

We investigate the structures and physical properties of 2D nanostructured water on the surface of carbon nanotubes (CNT) and graphene, and 1D nanostructured water in the inner space of CNT based on sophisticated measurements by spectroscopy and atomic force microscopy. Through this, the thermodynamics of the phase change of adsorbed water on the outer surface of CNTs and the water contained therein is constructed.

Takahiro Yamamoto

“Two state coexistence and dynamical heterogeneity of water in a nanotube”

Our group has investigated the phase transition and dynamics of water in carbon nanotube (CNT) using classical molecular dynamics (MD) simulations. It is well-known that no clear first-order phase transition is observed in encapsulated water. We clarify that there are two states distinguished by the strong or weak retention of the (n,0) ice structure, and that the coexistence ratio of the two states varies with temperature. From the fact that these two states have different rotational dynamics, we concluded that the water in CNT is in the dynamical heterogeneity.

Hiroharu Yui

“Interaction between material surfaces and water by cutting-edge vibrational spectroscopy”

The interaction between material surfaces and water drastically affects their properties and functions. The aim of the research is to clarify the interaction from the molecular scale by developing cutting-edge vibrational spectroscopy. The examples are (1) Minerals on the asteroid Ryugu experienced aqueous alteration at the early stage of the solar system, (2) Chemical states of the glass surfaces precisely manufactured, and (3) Molecular self-assembled system including water such as gels and foams.

Masaaki Akamatsu

“Reversible adsorption-desorption of anions at air/water interfaces”

Anion–π interaction is an attractive interaction between an electron-deficient aromatic ring and anions. In recent years, the contribution of the interaction to interfacial phenomena such as bio-adhesion has been clarified. In this work, we have found that the Langmuir membranes formed by naphthalene diimide (NDI) derivatives at the air/water interface can be used to reversibly adsorb and desorb anions by compression manipulation of the membrane materials. The adsorption and desorption processes of anions were also evaluated by measuring the surface potential of the membranes.

Tadashi Ando

“Mechanism of chiral-selective aminoacylation of an RNA minihelix explored by QM/MM free-energy simulations”

A primordial RNA minihelix shows preference for L-amino acid over D-amino acid during its aminoacylation, which is a key reaction determining the chiral selection of amino acids in the evolution of life. In this studt, we used quantum mechanics/molecular mechanics-based simulations to investigate the physiochemical origin of the chiral selective aminoacylation in the primordial RNA. Our calculations showed that the energy barrier for the L-alanine reaction was 9 kcal/mol lower than that of the D-alanine reaction.

Yoshiyasu Ichikawa

“Measurement of complex fluids’ behavior”

This study uses optical flow measurement techniques to reveal the complex behavior of viscoelastic fluids showing instability in a microchannel. We especially focused on the locally changed viscosity affected by the shear rate and tried to establish the viscoelastic fluids’ viscosity distribution measurement technique in the microchannel utilizing fluorescent molecular rotors, which have the sensitivity for the viscosity. Then, the validity of the technique was shown by combining it with the velocity measurement technique.

Ichiro Ueno

“Hrat and mass transfer at three-phase contact line”

This study investigates (i) local acceleration of liquid wetting with tiny obstacles on solidsurface, (ii) phase-change with high heat flux with cooperative oscillation of vapor bubbles, (iii) formation of coherent structure of particles with low Stokes number under surface-tension-driven convection.

Shu-hei Urashima

“Hydrogen-bonding networks of water on material surfaces and interfaces”

Adsorbed water on material surfaces under atmospheric conditions drastically changes their properties such as friction, wettability, and electrification. Oil/water interfaces are ubiquitously found in biological system and utilized in solvent extraction processes, where molecules are dynamically crossing through the interfaces. However, we have still little knowledge about how the water molecules at the surfaces/interfaces change their properties and affect the functions and the transport phenomena. The aim of the study is pushing forward our knowledge from the scale of the microscopic changes in the hydrogen-bonding network structures of water at the surfaces and interfaces.

Shigehito Osawa

“Building locally concentrated state of metal complexes in aqueous milieu based on polymer chemistry toward biomaterial applications”

Metal complexes installed on polymer chains would be under a locally concentrated state because the diffusion of the metal complexes is limited on inside of polymer conformation even though the metal complexes total concentration is quite low. During chemical reaction, the locally concentrated state would promote formation of the reaction intermediates composed of the multiple metal complexes, eventually changing catalytic activity of the metal complexes. We develop the polymers having metal complexes toward biomaterial applications through investigations and evaluations on the catalytic activity and molecular recognition properties of the locally concentrated state of metal complexes under physiological circumstances.

Hidenori Otsuka
"Structural design of novel self-healing interpenetrating polymer network (IPN) gels with hydrazone bond-derived cross-links"

An IPN gel consisting of three components, hyaluronic acid-polyethylene glycol-peptide, was designed. Structurally, it employs chemical cross-linking formed by hydrazone-dynamic bonds and physical cross-linking formed by peptides, and it is characterized by its self-healing properties. At the moment of strong strain, it showed a sol state with a storage modulus G' < loss modulus G'' and recovered a gel state at weak strain. Repeated measurements confirmed that the mesh density in the gel state does not change, i.e. that it has self-healing properties.

Ken-ichi Katsumata
"Development of photocatalytic materials for decomposition of nitrate ion in water"

Photocatalysts with Pd and Cu loaded on the surface of titanium dioxide (TiO_2) and graphene (GnP) composite were prepared, and changes in the concentration of nitrate ion in water were measured. Therefore, it was considered that the loading of Cu, Pd, and GnP on TiO_2 contributed to the decomposition of NO_3^-. The concentrations of NO_2^-, NH_3, and NH_4^+ that may have been formed in the aqueous solution after decomposition were measured, and only a slight increase in NH_4^+ concentration was observed, suggesting that 90% of the NO_3^- decomposition destination were gas products.

Kizuku Kurose
"Heat transport characteristics of pulsating heat pipe"

We conduct heat transfer experiments and develop a simulation model to improve the heat transport performance and clarify the complex gas-liquid two-phase flow with boiling and condensation in Pulsating Heat Pipes (PHPs). In the experiments, we confirmed that the heat transfer was enhanced by sintered metal porous structure. In the simulation, the predicted transition boundary condition between oscillating and pulsating-circulating flows well reproduced the experiments, and the transition mechanism was proposed based on the simulation results.

Hideki Sakai
"Effect of phytosterol derivatives on membrane properties and hydration state of phospholipid bilayers"

In the previous year, we reported that the addition of phytosterol sulfate (PSO_4) to liposomes formed from saturated phospholipids (DPPC) enhanced hydration of hydrophilic groups and improved dispersion stability in aqueous solutions. In this year, we investigated the effect of PSO_4 on the membrane properties of DPPC/unsaturated phospholipid (DOPC)-mixed liposomes mimicking cell membranes, and found that the addition of a small amount of DOPC to DPPC resulted in formation of flexible bilayers and improved dispersion stability of the liposomes.

Kenji Sasaoka
"Study on phase state of water encapsulated in carbon nanotube by molecular dynamics simulation"

The phase state of water encapsulated in a carbon nanotube (CNT) using the molecular dynamics (MD) method is studied. By analyzing the time-series data obtained by the MD method from the viewpoint of the rotational motion of water molecules and the hydrogen bond network, it is clarified that randomly rotating water molecules and frozen water molecules coexisted in the water included in CNT. It is also found that water molecules whose rotational motion is frozen form a domain structure of about 1 nm.

Shinya Sasaki

"Study on friction mechanism by interface nanostructure control"

We are conducting research to control the macro-friction characteristics by adding nanostructures to the friction surface. Water molecules in the atmosphere and lubricating oil form an adsorption layer on the friction surface, but in the case of polymer materials, in addition to the water molecule adsorption structure, the layer in which the surface polymer captures water molecules is a constant layer. It is believed that having the above-mentioned load bearing capacity will produce an excellent friction reduction effect. In this study, in order to elucidate the mechanism of low friction of contact lenses, we measured the interface nanostructure before and after friction using FM-AFM, and confirmed the friction reduction effect of the hydration layer.

Isao Shitanda

"Study on the behavior of water/enzyme/carbon interfaces in local space to improve the performance of biofuel cells"

The activity and stability of enzymes in biofuel cells depend on the design of the water/enzyme/porous carbon interface, which requires a detailed evaluation of the interface behavior. We are studying the dynamics of enzymes at the water/enzyme/porous carbon interface by using small-angle X-ray and electrochemical measurements. In this year, we established a method to evaluate the kinetic changes of enzymes in electrolyte solutions during redox in electrochemical measurements.

Yutaka Sumino

"Self-organization of hierarchical structure with biological molecular motors under water/water phase separation"

A water/water phase separation is a type of phase separation between two aqueous phases composed of polymer and salt solution. In this research, we created a droplet system with biological molecular motors under water/water phase separation. Here, we found spontaneous formation of organized hierarchical structure which leads to the formation of continuous vortical flows. A mathematical model revealed that the vortex flow is realized via super critical pitch fork bifurcation.

Makoto Tadokoro

"Ion-conducting behavior of water molecular cluster confined to hydrophilic molecular nano-porous crystals"

Our research has revealed that water molecular cluster (WMCs) confined to nano-porous crystals with quasi-one-dimensional pores adopt a hierarchical cluster structure. When electrolyte ions such as NMe_4Cl were disolved into the WMC, the ionic conduction of the electrolyte ions and the proton conduction drived from H_2O were competed. In this research, we would like to construct an equipment for a measuement of DC ionic conductivity, and clarify ionic conductivity through WMCs with a nano-meter scale.

Takahiro Tsukahara

"Diffusion source estimation and viscoelastic fluid surrogate-model building using machine learning"

Using convolutional neural networks (CNN), a kind of machine learning, we have extracted information on instantaneous local concentration or stress fields, and estimated the distance from the observed field to the scalar concentration diffusion source, or from the velocity field to the constitutive stress field. The former is a necessary technique for gas leakage prevention in various plants. The latter is developed to construct a data-driven simulator instead of solving numerically the constitutive equations of viscoelastic fluids, which are numerically unstable in nature. The feasibility of both have been demonstrated successfully.

Eiji Tokunaga

“Study of mechanism and application 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 and to apply the interfacial water Pockels effect. This year, we found that the Pockels coefficient of water at the interface of titanium electrodes is comparable to that of water at the interface of transparent oxide electrodes due to the effect of the surface oxide film, and that the effects of the application of a steady magnetic field and pressure on the Pockels effect of water at the electrode interface are characteristic dependences, although their mechanisms are unknown.

Izumi Nakai

“XRF analysis of light elements in asteroid”

The chemical composition of Ryugu is similar to that of Ivuna-type carbonaceous meteorites (CI chondrite). The sample is characterized with a high water content, which could be directly quantified by determining its total O content. Energy dispersive XRF enabled the analysis of C by introducing a new silicon drift detector (SDD) that uses graphene as a detector window material. The proposed method allows nondestructive analysis of light elements and expands the applications of XRF analysis to a wide range of geological samples.

Shingo Machida

“Improvement of anion adsorption capability of layered double hyddroxide-supported glass-beads filter”

Layered double hydroxide (LDH) features anion exchange capability and can be supported on glass-beads fileter, a sintered body of spherical glass beads. This fileter adsorbs anions under running water, although the adsorption capability is not relatively high. This study thus improves such the low anion capablity by changing the sizes of both LDH particles and GBF pore.

Kazuhiko Miura

“Study on climate effects of atmospheric aerosols”

In order to investigate the effects of anthropogenic 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 have continued year-round observations at Tarobo (1290m) at the foot of Mt. Fuji in order to see post-coronavirus changes, but there was no tendency for a decrease in the total particle concentration in the summer from 2017 to 2022 at Tarobo. we would like to analyze it in detail in future.

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.

Yuki Araki

“Research on microscopic wetting of glass surfaces”

We investigated the physical property of nano water droplets formed on glass by measuring the adhesion force on the glass by peak force tapping atomic force microscopy. Existence of thin water film under the condition which nano droplets form was confirmed as well as by previous frequency atomic force microscopy (FM-AFM) measurement. We will clarify the microscopic structure of the interface of nano droplet and thin film by observation of liquid structure by FM-AFM.

Koichiro Kato

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

Molecular simulation and data science will be used to study the structure of water at the micro- and meso-scale. Microstructural analysis of water on graphene surfaces using persistent homology has successfully revealed the transition from surface water to free water, and these methods will be extended to other material surfaces. In addition, mesoscale phase-separated structural analysis of polymeric materials and water by coarse-grained simulation and persistent homology will be initiated.

Shouhei Kawada

“Relationship between of lubricationg properties of ionic liquids and relative humidity”

Ionic liquids form stable electric double layer and exhibit low friction. From this property, it is considered that more stable layer can be formed by using surface potential and lead ultra-low friction. On the other hand, water molecules also move on surface and show disadvantage about lubricating properties and corrosion properties. In particular , as the relative humidity became high, the tribological properties of ionic liquids became poor trend.

Tatsuhiro Mori

“Development of the technique for measuring a charge distribution of black carbon particles”

The purpose of my study is to develop the technique for measuring the size-resolved number concentration of charged black carbon (BC) particles to estimate the charge distribution of BC, which is a system consisting of a parallel electrode plate device and a single-particle soot photometer (SP2). In this year, I developed a flow system that automatically switches the flow paths using four electric ball valves and a relay. In addition, the optical axis was adjusted by aligning the laser of SP2 so that BC particles could be detected correctly.

Yasutaka Yamaguchi

“Microscopic and Macroscopic physics of liquid-solid interface regarding wetting and friction”

We examine the physics of liquid-solid interface regarding wetting and friction using molecular dynamics analysis. Specifically, we focus on the water wetting on silica and graphene surface and on the method to extract liquid-solid friction from the equilibrium fluctuation of the shear force between liquid and solid.

Ken Yamamoto

“Investigation on the efficient droplet manipulation”

We achieved efficient manipulation of droplets using the Leidenfrost effect and electrowetting effect. In droplet manipulation using the Leidenfrost effect, we hydrophobically processed the ratchet substrate and controlled the substrate temperature relatively low. This increased the driving force of the droplets by an order of magnitude by causing solid–liquid contact at the microscale. In droplet manipulation using the electrowetting effect, we realized low-voltage and high-speed droplet manipulation using microstructured surfaces and a lubricating liquid.

Naoki Watanabe

“Improvement of unified water simulator”

We have improved unified water simulator which was developed to carry numerical simulations of atomic structure, dynamics, and calculations of physical properties of water molecules on material surface. By these improvements, it has become possible to simulate dynamics of water molecules at given temperature, pressure and volume by statistical ensembles. Also, it has become possible to calculate viscosity and surface tension of water from the dynamics of water molecules. In addition, at the WaTUS seminar held on Dec 2022, we have demonstrated those simulations and calculations by using the unified water simulator.

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.

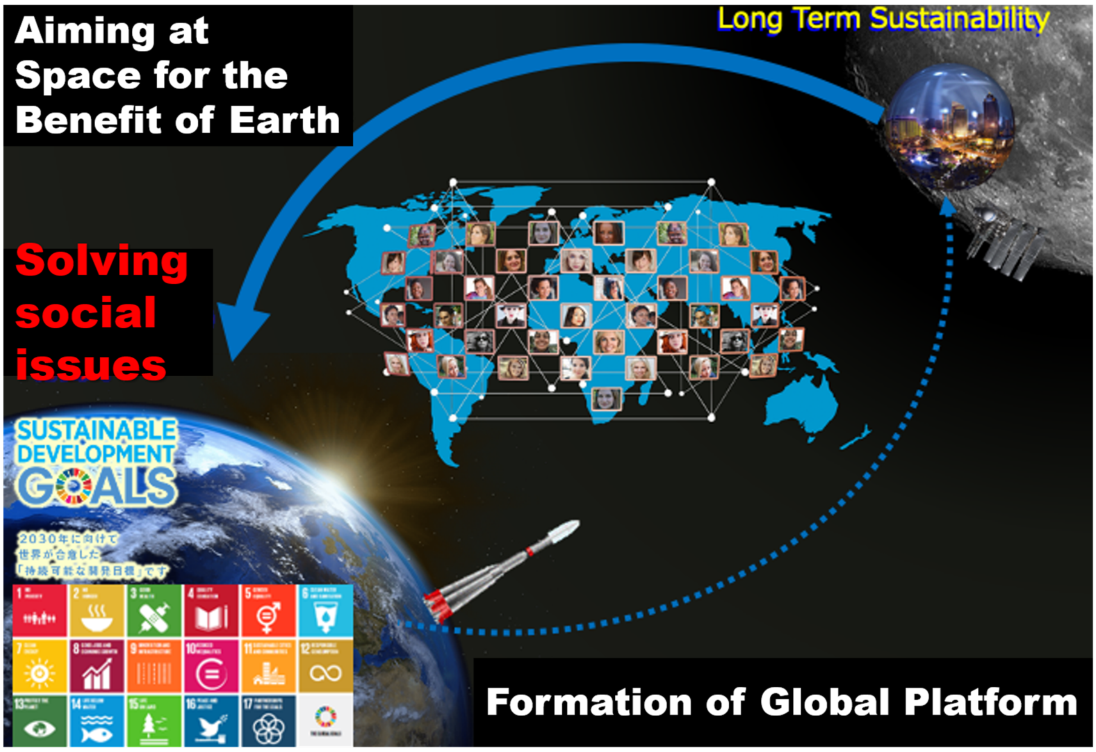

Fig. 1. Dual development on earth and in space.

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."

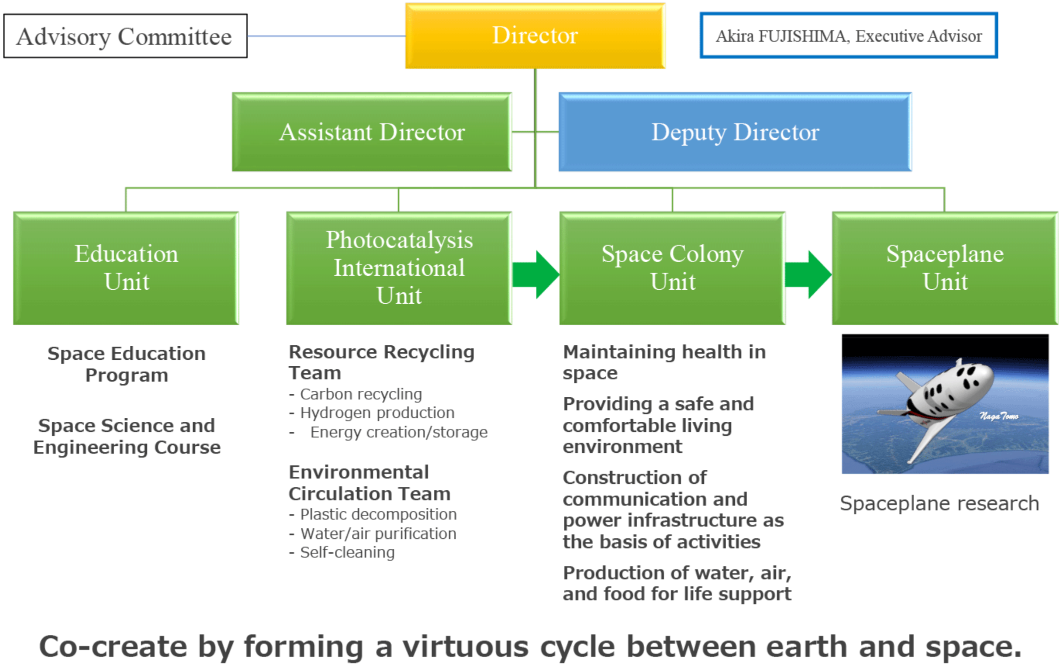

Fig. 2. Research Center for Space System Innovation's structure.

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

The Education Unit participates in propagating active-learning educational programs in cooperation with the Space Education Program. The program was started as the Interdisciplinary Study of Space Humanities program (a Commissioned Expense for Promoting Space Aeronautics and Technology by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)) as educational material. As a result, multiple educational events have been implemented such as STEM education events at the Science Museum, Tokyo, and space events performed by the Adachi City—spun off from the "Space Education Program" and rolled out by the Academic Venture Business called "Ucyunomanabiya Seed." It has also implemented "Space Education Program Lectures" and "Space Education Program Presentations" that have been newly constructed as courses of the Graduate School of Science and Engineering.

3. 2. Photocatalysis International Unit

The symposium on photocatalysis was held on 16th December 2022, with the concerted efforts of this unit. Total number of participants was 174. Based on a rigorous review process, ten student poster awards (Photo 1) were selected, in order to encourage the young researchers.

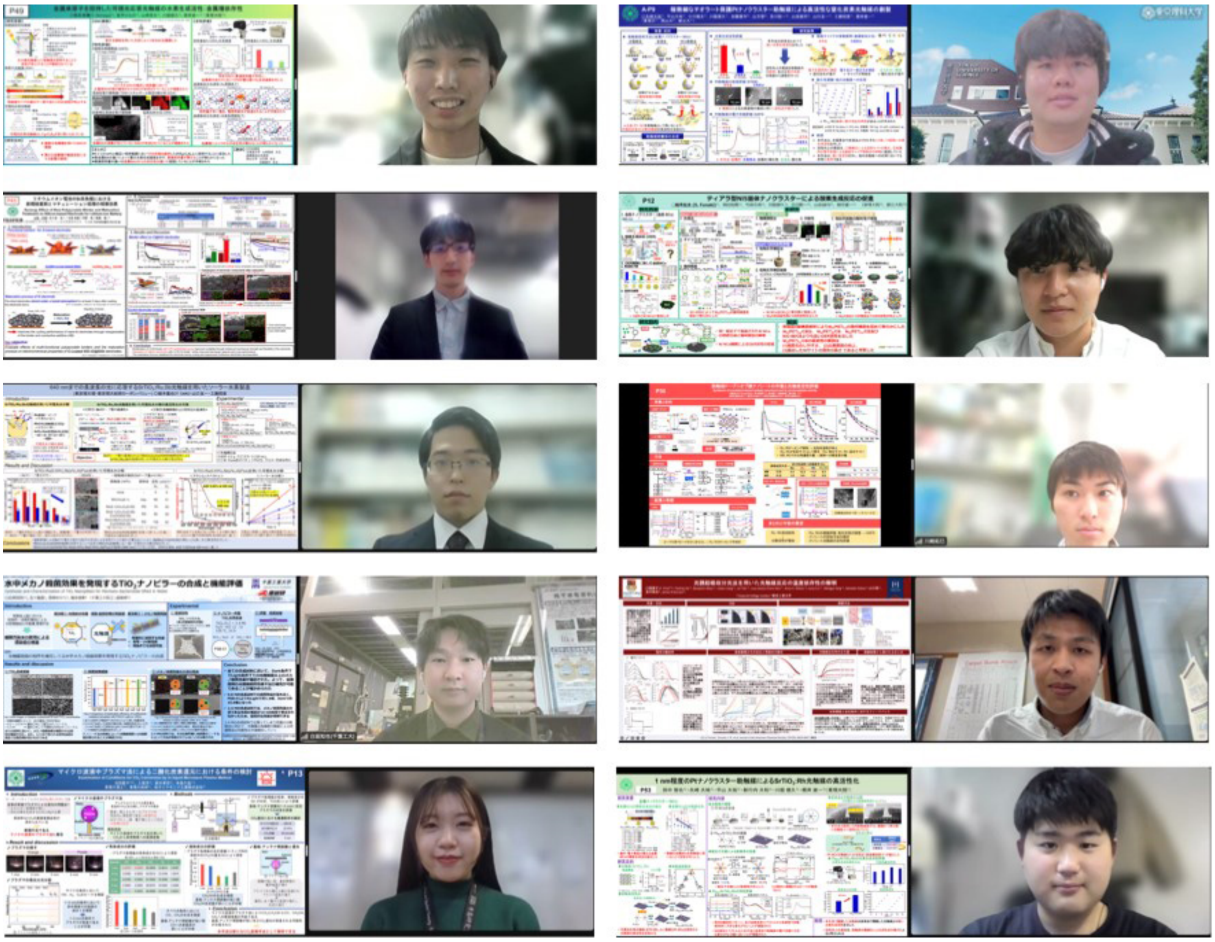

Photo 1. Student poster awards.

3. 3. Space Colony Unit

The Space Colony Unit is engaged in technological development for future long-term space habitation and is built on five pillars: (1) Health maintenance, (2) Radiation measurement and protection, (3) Environmental Control and Life Support Systems (ECLSS), (4) Food production, and (5) Communication and energy infrastructure.

In research results from 2022, a flight model for an experimental odor-elimination device using photocatalyst technology was developed by the Japan Manned Space System Corporation and the Tokyo University of Agriculture and Technology, jointly. In the study an experiment was performed on the International Space Station in cooperation with AXIOM SPACE, a private space travel company, that warrants special mention.

In addition, during space habitation R&D in the development of inflatable habitation modules—which was performed jointly between Shimizu and Taiyo Kogyo and intended for the construction of space colonies—has been phased up from a Feasibility Study (FS) to a Research Study (RS) of the StarDust Program of the Japan Cabinet Office. It has shifted to full-on research and development.

The associated study “Realization of Advanced Homeostatic Inflatable Autonomous Structure (HIDAS)” has been selected as a moon-shot program and the study “Earth-Space Dual Development Research Base for Near-future Urban Function” has been selected as a COI-Next program, and their activities have begun.

In the Building 7 “Space Colony Demo Module” room is prepared for outreach of its unit’s research activities. The unit has accepted many visitors, such as the Mutual-understanding, Intellectual Relations and Academic Exchange Initiative (MIRAI) organized by the Ministry of Foreign Affairs, together with several introductions in the media, including “Saturday Watch 9” on NHK, “Let’s Talk About Space” on BS11, and in “Science Focus: Living on the Moon” in the Yomiuri Shimbun.

In addition, the unit has been recognized as an official partner of GUNDAM Open Innovation and is performing research and development on future space habitation in an officially recognized project called "Team Space Life" with companies such as Takasago Thermal Engineering, NTT DATA SBC, and the International University of Health and Welfare.

3. 4. Spaceplane Unit

The basic design phase (part 3) started in October 2021 with partner companies Kawasaki Heavy Industries, IHI, I-NET, Toray Carbon Magic, and with the Japan Aerospace Exploration Agency (JAXA), strategically working together on the development of suborbital spaceplanes for science missions and small satellite launch missions.

As a joint research project between the Tokyo University of Science and JAXA, we have started manufacturing the experimental winged rocket, WIRES #015, which is a technology demonstrator under a partnership agreement with the German Aerospace Center (DLR). Flight safety reviews have been conducted by the Swedish Space Corporation (SSC), which is a candidate site for the flight experiment.

Furthermore, with DLR Augsburg, in January 2022, we started joint research and prototyping of the world's first composite tank compatible with liquid oxygen, using a liquid-oxygen-compatible material for which the Tokyo University of Science has applied for domestic and international patents. ArianeGroup Germany, which manufactures Europe's flagship Ariane rocket, has decided to provide support to promote this joint research. Airbus, which is a commercial airliner manufacturer, has also expressed its anticipation of the outcome of the above research and prototyping.

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 COI-NEXT Program for Creating Innovation through Interaction among Core Technologies" and the "JST Moonshot Research and Development Program," are promoting research and development on space habitation. The success of these projects 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. In addition to 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; and the GUNDAM Open Innovation "SPACE UTILITY PROJECT" for realizing the "Space Century'" (directed by Bandai Namco,) we have accelerated our future space habitation programs, starting with the "JST COI-NEXT Program for Creating Innovation through Interaction among Core Technologies" and the "JST Moonshot Research and Development Program."

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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12. Effect of Microbial Components on the Photocatalytic Bactericidal Effect, Haruka Motomura, Shigehumi Ogura, Akane Saikachi, Kotone Sugasawara, Ayano Takao, Chiaki Terashima, Akira Fujishima, Tomonori Suzuki, Seikei-Kakou, 35, 48-52, 2023 (non-peer-reviewed paper)
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Invited Lectures

1. Research on antioxidant anticancer drugs using metal porphyrin complexes, Makoto Yuasa, The Color Materials Association of Japan, 2023 Pigment Property Study Group, 1st Research Report Meeting and General Meeting, Gakushi Kaikan (Kandanishikicho, Chiyoda-ku), March 7th 2023

2. Numerical Simulation of Enjine Icing ～Current Status and Future Trends～", Makoto Yamamoto, 7th WEATHER-Eye Open Forum, Dec. 6th 2022
3. Synthesis of mesoporous TiO_2/BDD hybrid and its application toward an efficient water purification" Norihiro Suzuki, One Day International Symposium on Advances in Photocatalysis, Online, April 13th 2022.
4. Development of a Self-Powered Diaper Glucose Sensor Combining a Low Power Wireless Transmission Device and a Paper Substrate Biofuel Cell, Isao Shitanda, Diabetes Technology Meeting 2023,On-line, 2022
5. Application of Controlled Metal Nanoclusters as Active Sites in Energy and Environmental Catalysts, Yuichi Negishi, Nanoscience Days 2022, 2022
6. Total Scattering Studies of Lithium-Rich Transition-Metal Oxides for High-Energy Rechargeable Batteries, Naoto Kitamura, AsCA2022, Jeju, Republic of Korea, 2022
7. Development Trends of Magnesium Secondary Batteries - Focusing on Cathode Materials, Yasushi Idemoto, Seminar D (The Electrochemical Society of Japan), Chiba, 2023
8. Photocatalytic water splitting and CO_2 fixation as artificial photosynthesis, A. Kudo, The 9th Tokyo Conference on Advanced Catalytic Science and Technology (TOCAT9) (Keynote), July 24-29, 2022. (Fukuoka International Congress Center, Japan)
9. Boron-doped Diamond Powder for Electrolytic Electrode Material, Takeshi Kondo, International Conference on Materials Science and Engineering 2022 (Materials Oceania 2022), Gold Coast, Australia, 2022
10. The Challenge of Automated High-Throughput Experiments on a Variety of Powder Libraries, Kenjiro Fujimoto, 241st ECS Meeting, Vancouver convention center, BC, Canada (Hybrid), 2022.6.1
11. Novel "Photoswitchable" Molecular Assemblies, H. Sakai, M. Akamatsu, K. Sakai, The 5th International Conference on Nanospace Materials (ICNM2022), Pattaya, Thailand, Dec. 11th 2022
12. Air and Water Purification by Photocatalyst, Ken-ichi Katsumata, International Congress on Pure & Applied Chemistry (ICPAC) Kota Kinabalu 2022, Kota Kinabalu, Sabah (On-line), 2022
13. HRTEM-EELS Analyses of Carbon Nanostructures for Catalytic Applications, K. Miyazawa and Y. Tanaka, 6th Global Webinar on Materials Science & Engineering (GWMSE-2023), WEB, 2023
14. Bringing Space Technology Down to Earth – Next Generation Composite Vessels, A. Manabe and K. Yonemoto, JEC World 2022, Paris in France, May 3-5, 2022

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1. Takeshi Kondo, Tatsuo Aikawa, Makoto Yuasa, Kentake Miyashita, Masahiro Nishikawa, Takahiro Takahiro, Electrode material for capacitors,Patent No. 7174956, Nov.10-2022

Public Relations

1. Y. Idemoto, N. Kitamura, Tokyo University of Science develops Mg secondary battery cathode material with maxmum discharge capacity of 256 mAh/g, Nikkan Kogyo Shimbun, March 2023
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4. Ferdinand Peper, Kenji Leibnitz, Tetsuya Shimokawa, Mikio Hasegawa, Kaori Kuroda, "Communication method and network system," US11405072B2, Aug. 2022

Awards

1. Shingo Machida, JAICI Award, Japan Association for international chemical information, 2023
2. Yuichi Negishi, IAAM Inovation Award, 2022

3. Mayu Hamazaki, Kento Torii, Miao Shan, Mitsuo Kameyama, Jericho Victor L Mercado and Kiyoshi Dowaki, Best Paper Award, International Conference of Biomass and Bioenergy 2022, 2022
4. A. Ikeda, N. Suzuki, A. Fujishima, C. Terashima, "CO_2 conversion by in−liquid microwave plasma CVD with multiple parameters ", Organizing Commitee of the joint Symposium 12th International Symposium on Non-Thermal Plasma & International Symposium on Electrohydro Dynamics 2022, ISNTP-12 & ISEHD International conference Best Poster Presentation, Sep. 2nd 2022
5. Yohei Sato, Ryohei Hayami, Kazuki Yamamoto, Takahiro Gunji, Selected Polymer Journal's Featured Article, Syntheses and properties of Cu(II), Al(III), and Ti(IV) coordination polymers using an acetylacetonato-terminated polyhedral oligomeric silsesquioxane, Polymer Journal, 54, pp. 985-993, Aug. 2022
6. Tokuhisa Kawawaki, 19th Honda-Fujishima Prize (The Electrochemical Society of Japan) , 2022
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8. Akihiko Kudo, Contribution to Promotion of Technology Award from Tokyo metropolitan, Oct. 3rd 2022

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

“Numerical simulation of multi-physical phenomena in propulsion system”

The intermixing of solid microparticles, fluid droplets, and chunks of ice into theflow within aerospace propulsion systems results in multi-physical phenomena. The objective of my research is to develop methods to numerically predict multi-physical flow phenomena in propulsion systems to enhance safety.

Koichi Yonemoto

“Winged reusable space transport system (spaceplane)”

We are researching a winged, reusable space transport system, commonly known as “spaceplane,” to replace conventional expendable rockets. The ultimate goal is to create a future in which space travel is as accessible and effortless as air travel for everyone. In cooperation with universities, research institutes, and enterprises inside and outside Japan, we are engaged in basic research on system optimization technology, advanced guidance and control technology, and cryogenic propellant tanks made of composite materials. Additionally, we are developing small experimental aircraft and performing flight demonstrations and tests on our emerging technologies.

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.

Kozo Fujii

“Research on moving means in dilute gas”

I am engaged in research on propulsion means for outer space and flight technologies enabling transport in thin atmospheres such as Mars, which is the next destination after the moon. This year, I have engaged in foundational experiments and numerical simulations on wing-equipped missile shapes and similar features, which may enhance lift.

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

"Interfacial thermo-hydrodynamics in the space environment"

We have performed research on thermal and material transport using space environments such as surface tension-driven convection and phase change heat transfer. Since 1999, we have been joint researchers in interfacial thermo-hydrodynamics experiments on the Japanese Experiment Module of the International Space Station. We are currently preparing for the Japan-Europe Research Experiment on Marangoni Instability (JEREMI) on the International Space Station.

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.

Hiroshi Gotoda

“Spatiotemporal dynamics and short-term prediction of a buoyancy-driven turbulent fire”

The interface between the high-temperature combustion products and the ambient atmosphere becomes hydrodynamically unstable due to buoyancy, forming turbulent fire. A major topic in the field of fire is the elucidation of the complex relationship of Kelvin-Helmholtz and Rayleigh-Taylor instabilities with hydrodynamic structures. In this research, we have posited various space environments and elucidated the behavior of turbulent fire from low-gravity to high-gravity fields.

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.

Norihiro Suzuki

“Enhancement of photocatalytic activity by utilizing mesopore-induced lattice distortion”

As an environmental purification technology, photocatalysts (such as TiO_2) have been attracted great attention in various fields. Recently, several studies have reported that lattice distortion forms potential slopes and/or a dipole moment and induced internal electric field promote photocarrier separation, resulting improved photocatalytic activity. In this study, I aim at enhancing photocatalytic activity with mesopores, which can induce lattice distortion facilely and inexpensively.

Idemoto Yasushi

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

We focused on $MgMn_2O_4$ as a cathode material for magnesium secondary batteries and succeeded in improving cycle properties by surface modification. In addition, as for high-capacity cathode materials used in lithium-ion batteries, structural analysis of the electrodes after charge/discharge was performed to clarify the effect of current density on the crystal and electronic structures.

Akihiko Kudo

"Water splitting and CO_2 reduction over powder-based photocatalysts using water as an electron donor"

Development of a highly efficient photocatalyst as artificial photosynthesis is an important research topic to realize carbon neutral society. We successfully developed a highly efficient $Bi_4Ti_3O_{12}$ photocatalyst for water splitting by the flux method using two kinds of flux reagents. In addition, highly efficient CO_2 reduction over a metal oxide photocatalyst loaded with cocatalysts based on novel and transition metals was achieved. We will keep on developing highly efficient photocatalysts by utilizing the strategies such as 'elemental strategy', 'band engineering' and etc.

Shinichi Komaba

"Study on next generation Na-ion batteries with Earth-abundant elements"

We study on new materials for Na-ion batteries which are free from rare metals and toxic elements. Commercialization plans of Na-ion battery have been released from industry and large-format Na-ion battery is expected to be used for ESS application. In 2022, we studied the layered manganese-based oxide and hard-carbon materials for positive and negative electrodes and their compatibility to all-solid-state NA-ion batteries are demonstrated and K-ion batteries are successfully solidified with dry polymer electrolyte.

Yuichi Negishi

"Creation and evaluation of highly active water splitting photocatalysts with fine metal clusters"

Water splitting photocatalysts, which can produce hydrogen from water and sunlight, have attracted attention as a truly clean hydrogen production method. In order to increase the activity of this photocatalyst, it is effective to load fine metal particles, called cocatalysts. However, it is difficult to precisely control the "size" and "electronic state" with conventional loading methods. In this study, we aim to further increase the activity of water-splitting photocatalysts by establishing a novel method to load ultrafine metal clusters synthesized in the liquid phase on the surface of photocatalysts.

Naoto Kitamura

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

We focused on $MgMn_2O_4$ as a cathode material for magnesium secondary batteries and succeeded in improving cycle properties by surface modification. In addition, as for high-capacity cathode materials used in lithium-ion batteries, structural analysis of the electrodes after charge/discharge was performed to clarify the effect of current density on the crystal and electronic structures.

Yumi Tanaka

"Study on ceramic electret for electrostatic vibration generator"

With a motivation for developing high-performance electrets, which are the dielectric materials that holds stable static electricity, for electrostatic vibration generators based on ceramics, the relationship between the composition, dielectric/conduction properties, and electret performance of various ceramics is investigated.

Yuichi Yamaguchi

"Development of novel visible-light-driven metal oxide photocatalysts based on a Ag metal ion for oxygen evolution"

Development of a novel visible-light-driven photocatalyst is of a great importance for realizing green hydrogen production using a photocatalyst. We developed novel visible-light-driven photocatalysts by focusing on an Ag ion. As a result, $AgMVO_4$ (M = Zn, Ca, Mg) and $Ag_2Zn(VO_3)_4$ showing the activity for sacrificial oxygen evolution under visible light irradiation were successfully developed. We will keep on developing novel visible-light-driven photocatalysts by utilizing the strategies found by our lab.

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.

Ryoichi Tatara

“Study on next generation Na-ion batteries with earth-abundant elements”

We study on new materials for Na-ion batteries which are free from rare metals and toxic elements. Commercialization plans of Na-ion battery have been released from industry and large-format Na-ion battery is expected to be used for ESS application. In 2022, we studied the layered manganese-based oxide and hard-carbon materials for positive and negative electrodes and their compatibility to all-solid-state Na-ion batteries are demonstrated and K-ion batteries are successfully solidified with dry polymer electrolyte.

Tomoki Hosaka

“Study on electrolytes and insertion materials for potassium-ion batteries”

Potassium-ion batteries can be constructed with abundant elements and are expected to achieve high-voltage operation and fast charging. I have discovered electrolytes and positive electrode materials for realizing the high-voltage operation of potassium-ion batteries and have achieved stable operation for five hundred cycles and more.

Chiaki Ishibashi

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

We focused on $MgMn_2O_4$ as a cathode material for magnesium secondary batteries and succeeded in improving cycle properties by surface modification. In addition, as for high-capacity cathode materials used in lithium-ion batteries, structural analysis of the electrodes after charge/discharge was performed to clarify the effect of current density on the crystal and electronic structures.

Makoto Yuasa

“Research on reactive oxygen sensors by biomimetic approach, as well as antioxidants and anticancer drugs”

We examined a sensor of superoxide anion radicals ($O_2^{\cdot-}$), that is, active oxygen species, which are highly useful in space colonies in outer space or on the ground, and can confirm the physical condition of the pre-disease state. In the future, we will consider the construction of $O_2^{\cdot-}$ sensors with higher functionality, improved quantitation, and compatibility with living organisms.

Hideki Sakai

“Effect of hydrogen peroxide addition on the formation of rare sugars and formic acid using photocatalytic reactions”

We have reported in the previous year that rare sugars such as arabinose and erythrose were efficiently generated from biomass-derived starting materials (glucose and gluconic acid) by using rutile-type titanium dioxide as a photocatalyst. This year, we found that the addition of a low concentration of hydrogen peroxide to the system during the photocatalytic reaction increased the production efficiency of erythrose, and that formic acid was also produced with high efficiency.

Isao Shitanda

"Development of wearable biosensors for stress monitoring needed in outer space health management"

In this study, I will develop a wearable biosensing system capable of the noninvasive and real-time monitoring of components in sweat when worn in outer space. This year, I performed implementation evaluation tests, particularly of lactate sensors, sodium sensors, and chloride sensors worn on the skin.

Ken-Ichi Katsumata

"Development of photocatalytic materials for decomposition of nitrate ion in water"

Photocatalysts with Pd and Cu loaded on the surface of titanium dioxide (TiO_2) and graphene (GnP) composite were prepared, and changes in the concentration of nitrate ion in water were measured. Therefore, it was considered that the loading of Cu, Pd, and GnP on TiO_2 contributed to the decomposition of NO_3^-. The concentrations of NO_2^-, NH_3, and NH_4^+ that may have been formed in the aqueous solution after decomposition were measured, and only a slight increase in NH_4^+ concentration was observed, suggesting that 90% of the NO_3^- decomposition destination was gas products.

Kiyoshi Dowaki

"A comprehensive study on the FC-bike with metal alloy cartridge fueled by bio-H_2 from sewage sludge"

The comprehensive R&D of bio-H_2 synthesized through the indirect pyrolysis process using sewage sludge has been conducted. In addition, this year, the basic tests of a fuel cell with a hydrogen metal alloy cartridge for FC-assisted bikes were discussed regarding waste recovery heat use.

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 analyses of sterilization mechanism of photocatalyst and its application"

Diaminopimelic acid-type peptidoglycan and its constituent amino sugar and diaminopimelic acid enhanced the photocatalytic bactericidal effect. However, this effect was not confirmed for lysine-type peptidoglycan. Bacterial flora and fungal flora were analyzed as a preliminary survey for using photocatalysts to preserve the cultural properties of Nikko shrines and temples. The effectiveness of the wastewater treatment system with photocatalyst diamond electrode was demonstrated, but the presence of resistant bacteria was confirmed.

Kenjiro Fujimoto, Akihisa Aimi

“Photocatalysts are anticipated”

A quarter century has passed since we discovered that oxides with a Hollandite crystal structure—which were researched as one-dimensional superionic conductors—function as nitric oxide selective reduction catalysts and photocatalysts. We are attempting to improve the material synthesis process for a higher specific surface area and we are pursuing the differences in catalytic activity performance according to differences in particle morphology, and the novel possibility of carbon monoxide adsorption.

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. The BDDP-packed layer was found to act as a porous electrode, and it was able to efficiently decompose an organic substance in an electrolyte via electrolysis. In addition, a repeated electrolysis test revealed excellent long-term durability of the BDDP-packed flow cell.

Shingo Machida

“Development of techniques for stabilizing powders with photocatalytic activity or adsorption capability to bulk materials”

Although photocatalysts and adsorbents have high expectations from materials besides environmental publication, such as water purification, because powder samples can hardly be handled, I develop techniques for stabilizing powders to bulk materials without both detachments of them and decreasing their photocatalytic activities and adsorption capabilities.

Toshifumi Tojo

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

I have been studying the superoxide anion radical ($O_2^{\cdot-}$), 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 $O_2^{\cdot-}$ sensors with greater functionality, superior quantitative performance, and biocompatibility.

Mutsumi Sugiyama

“Research on semiconductor IoT devices for space application”

We investigated the high efficiency and radiation resistance of SnO-based gas sensors that can be manufactured at low cost and can be used in space where radiation is strong. The sensitivity of the gas sensor can be significantly improved by optimizing the crystal growth conditions and controlling SnO and SnO_2. It was also revealed that the sensor has very high resistance to electron and proton beams and will not deteriorate for several hundred years in terms of radiation exposure on the ISS, showing promise for practical use.

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, Tsutomu Iida

"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.

Noboru Katayama

"Fuel cell, energy devices diagnosis, energy management"

We propose using deep reinforcement learning to manage energy systems as the diversification of decentralized energy sources, such as solar power, wind power, and fuel cells, has made energy management more complex. We have conducted experimental verification using actual equipment, introduced a 6kW solar power generation system and a 5.4kWh storage battery, and completed the system construction. Using the model learned in simulations, we confirmed that it is possible to control the storage battery of the actual system and that the entire system behaves according to the simulation.

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 microgravity 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.

"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. Qualitative effects on movement, stopping, and posture control resulting from differences in walking methods are expected to be considered.

Yoshihiro Kanai

"Development of mushroom production technology and technology to recycle medium from mushroom production in closed space environments"

I aim to develop technology to recycle medium from mushroom production. Waste medium from mushroom production may be reused as medium or used as fuel energy. This will be useful for food production and the effective use of resources in the closed space environments.

Yoshihiro Maeda

"A study on real-time vital sensing by using image infomation"

We study non-contact sensing technology utilizing image information to acquire the vitals of space visitors. In order to acquire vitals in real-time, we also investigate acceleration methods for the image filtering process, which is a fundamental process in image sensing. We tackle constructing a vital sensing system that operates in real time.

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 Ogiwara

“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.

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.

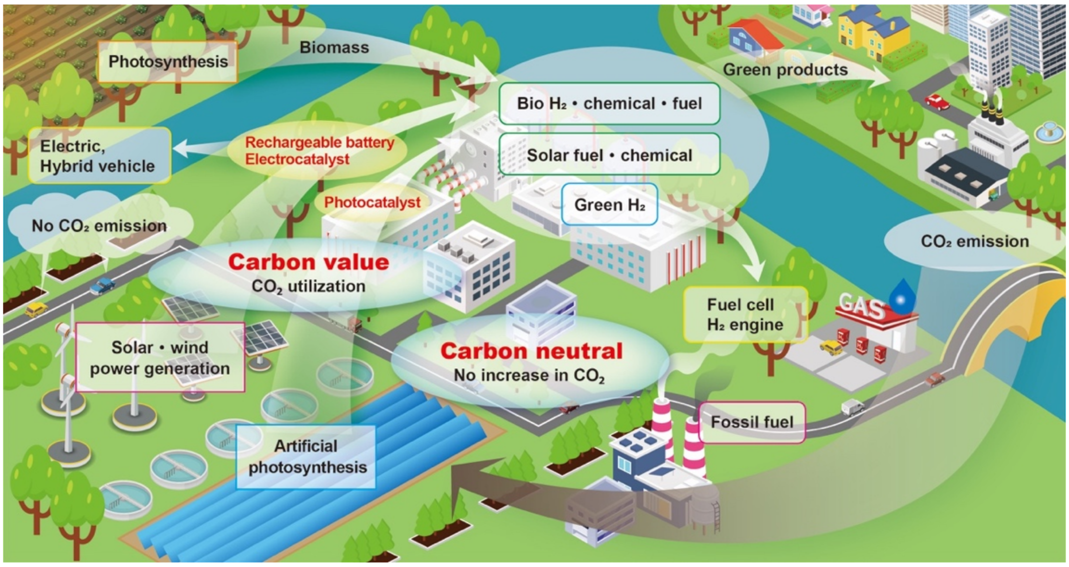

Fig. 1. Future vision that the CV center aims at.

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.

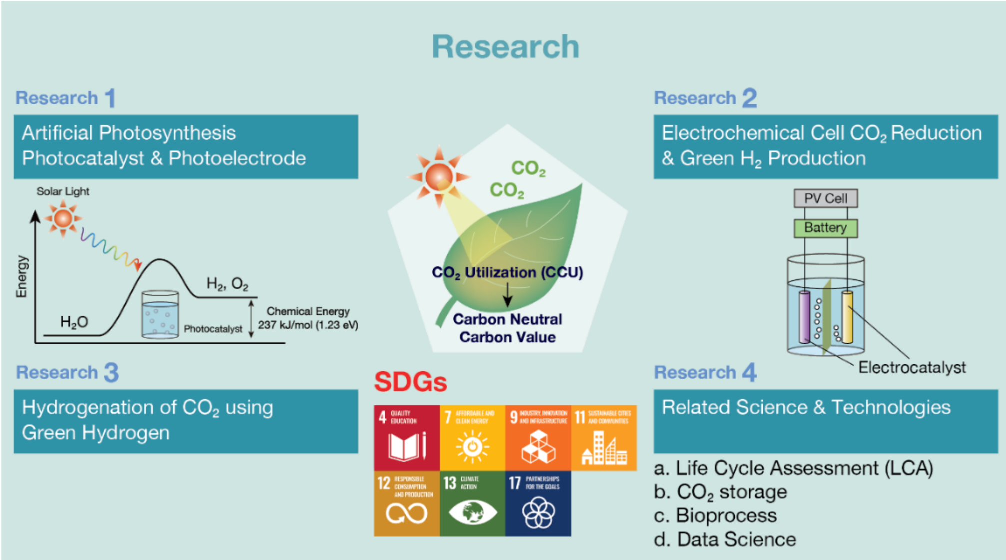

Fig. 2. Research topics of the CV center.

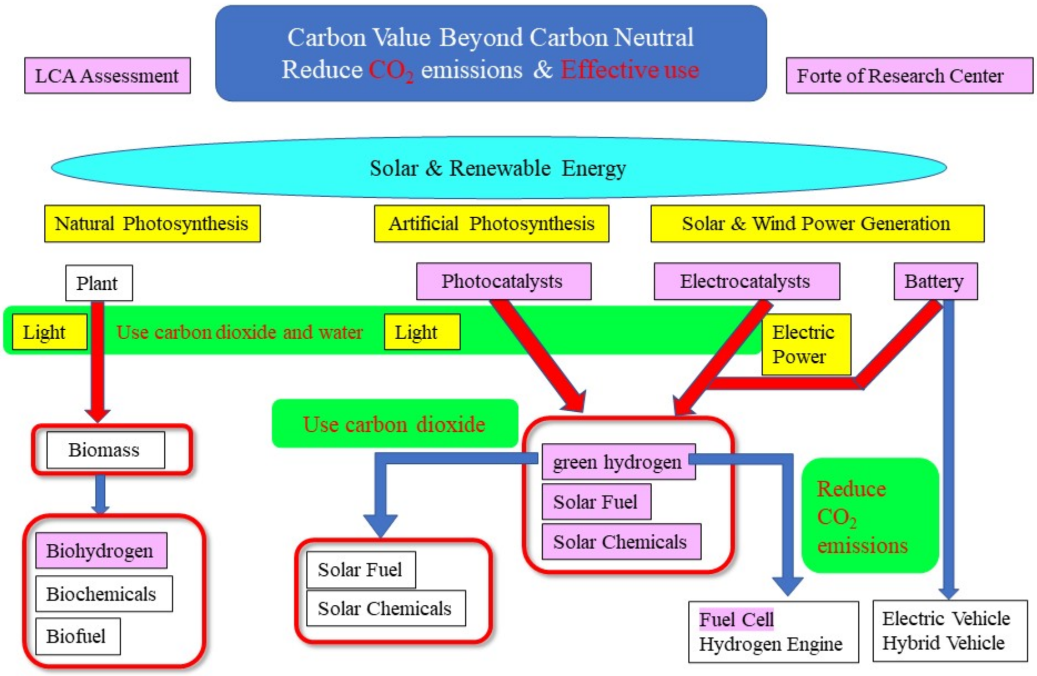

Fig. 3. Strengths of the CV center.

2.2.1. Green HydrogenProduction 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 are still remaining. 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), Matrix Assisted Laser Desorption/Ionization-Time of Flight Mass Spectrometer (MALDI-TOFMS), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), etc.

3. Activity Reports

In 2022, the CV center organized “The 1st International Workshop on Carbon Value Science & Technology” (on-line). Leading scientists working on carbon neutral from oversea and Japan, and the member of the CV center gave presentations on Artificial Photosynthesis, Photo/Electrocatalyst, Energy material & CO_2 reduction, and Fuel Cell and Rechargeable Ion Battery. We also co-organized “the 27th Recent development of photocatalytic reactions” with Photofunctional Material Society and Research Center for Space System Innovation (RIST, TUS).

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.

3.1. Photocatalyst Group

This group developed various photocatalysts for waters splitting to produce green hydrogen and CO_2 reduction using water as an electron donor. For example, novel visible-light-driven photocatalysts based on an Ag ion were successfully developed. This group also developed a semiconductor photocatalyst-molecular catalyst hybrid system for highly selective CO_2 reduction with a collaboration of Dr. Morikawa’s group at Toyota Central Laboratory. This group collaborated the usage of technology for electret and loading technology of Pt fine particle with Prof. Tanaka’s group.

3.2. CO_2 Conversion Group

Synthesis of solar-thermal CO_2 conversion materials and the development of reaction processes were studied. This group also examined extracting dense and pure formic acid from the diluted aqueous solution with an electrolyte by utilizing “molecular sieve effect” and “selective adsorption” of commercially available zeolite membranes.

3.3. Cluster Catalyst Group

This group proposed a method to synthesize ultrafine metal clusters in the liquid phase and support them on the surface of the photocatalyst, thereby creating a water-splitting photocatalyst with precisely controlled particle size and electronic state.

3.4. Secondary battery group

This group developed new functional binders for high capacity lithium-ion batteries and analyzed the mechansm of the binders functionality to improve their performance. This group also developed new sodium manganese oxides doped with copper for sodium-ion batteries and reported the investigation of the relation between the crystal structure and electrode properies.

3.5. Biomass Group

The R&D of hydrogen production through an indirect pyrolysis process using sewage sludge has been conducted under an industry-academia collaboration scheme.

3.6. Physical Property-Control Group

Garnet-type yttrium aluminate ($Y_3Al_5O_{12}$; YAG), in which Y^{3+} is partially replaced by Mg^{2+}, was attempted to be converted to electret by polarization formation using oxygen vacancies and/or electron defects as carriers.

4. Challenges and Prospects

Individual studies were mainly conducted by the member, while collaborations among the members were not enough. The CV center is planning some seminars by the member and researchers outside to exchange information and opinion to accelerate the collaboration. The 2nd international workshop will be arranged.

5. Conclusion

The CV center was established in 2022. We have been studying to make excellent achievements with our originality and strength and will contribute to the establishment of carbon neutral society.

Major Research Achievements (FY 2022)

Academic Papers

1. Examination of photocatalytic Z-scheme system for overall water splitting with its electronic structure, T. Tani, Y. Yamaguchi, T. Nishimi, T. Uchida, A. Kudo, *Phys. Chem. Chem. Phys.*, **2023**, *25*, 11418.
2. Well-Defined Single and Bundled Rutile Nanorods in Mesoporous Silica for Efficient Hydrogen Evolution Photocatalysis, K. Vibulyaseak, N. Paengjun, A. Kudo, M. Ogawa, *ACS Appl. Nano Mater.*, **2022**, *5*, 18004.
3. Photocatalytic CO_2 reduction by a Z-scheme mechanism in an aqueous suspension of particulate $(CuGa)_{0.3}Zn_{1.4}S_2$, $BiVO_4$ and a Co complex operating dual-functionally as an electron mediator and as a cocatalyst, T. M. Suzuki, S. Yoshino, K. Sekizawa, Y. Yamaguchi, A. Kudo, T. Morikawa, *Appl. Catal. B Environ.,* **2022**, *316*, 121600.
4. Powder-Based Cu_3VS_4 Photocathode Prepared by Particle-Transfer Method for Water Splitting Using the Whole Range of Visible Light, H. Fukai, K. Nagatsuka, Y. Yamaguchi, A. Iwase, A. Kudo, *ECS J. Solid State Sci. Technol.,* **2022**, *11*, 063002.
5. Development and Functionalization of Visible-light-driven Water-splitting Photocatalysts, T. Kawawaki, M. Kawachi, D. Yazaki, Y. Akinaga, D. Hirayama, Y. Negishi, *Nanomaterials,* **2022**, *12*, 344.
6. Promoting Photocatalytic Carbon-Dioxide Reduction by Tuning the Properties of Cocatalysts, T. Kawawaki, Y. Akinaga, D. Yazaki, H. Kameko, D. Hirayama, Y. Negishi, *Chem. Euro. J.*, **2023**, *29*, e202203387.
7. Improved Activity for the Oxygen Evolution Reaction using a Tiara–like Thiolate-protected Nickel Nanocluster, S. Funaki, T. Kawawaki, T. Okada, K. Takemae, S. Hossain, Y. Niihori, T. Naitoh, M. Takagi, T. Shimazaki, S. Kikkawa, S. Yamazoe, Tachikawa, Y. Negishi, *Nanoscale*, **2023**, *15,* 5201.
8. Reduction and Diffusion of Cr-Oxide Layers into P_{25}, $BaLa_4Ti_4O_{15}$, and Al:$SrTiO_3$ Particles upon High-Temperature Annealing, A. S. Alotabi, Y. Yin, D. J. Osborn, T. D. Small, S. Ozaki, Y. Kataoka, Y. Negishi, K. Domen, G. F. Metha, G. G. Andersson, *ACS Appl. Mater. Interfaces*, **2023**, *15*, 14990.
9. Photocatalytic Inactivation of Co-Culture of E. coli and S. epidermidis Using APTES-Modified TiO_2, P. Rokicka-Konieczna, A. Wanag, A. Sienkiewicz, D. S. Izuma, E. Ekiert, E. Kusiak-Nejman, C. Terashima, Atsuo Yasumori, A. Fujishima, A. W. Morawski, *Molecules,* **2023**, *28,* 1655/1.
10. Enhanced Photocatalytic Degradation Activity Using the V_2O_5/RGO Composite, A. A.Yadav, Y. M. Hunge, S. W. Kang, A. Fujishima, C. Terashima, *Nanomaterials*, **2023**, *13*, 338/1.
11. A Floatable and Highly Water-Durable TiO_2-Coated Net for Photocatalytic Antibacterial Water Treatment in Developing Countries, D. S. Izuma, N. Suzuki, T. Suzuki, H. Motomura, S. Ando, A. Fujishima, K. Teshima, C. Terashima, *Water,* **2023**,*15*, 320/1.
12. Synergistically regulated surface structure and water transportation of sponge hydrogel evaporator for efficient water desalination, W. Lei, Y. Liu, S. Khan, N. Suzuki, C. Terashima, A. Fujishima, M. Liu, *Desalination,* **2022**, *533,* 115780/1.
13. Active material and interphase structures governing performance in sodium and potassium ion batteries, E. J. Kim, P. R. Kumar, Z. Gossage, K. Kubota, T. Hosaka, R. Tatara, S. Komaba, *Chem. Sci.*, **2022**, *13*, 6121.
14. Effect of Cu substitution in P'2- and P2-type sodium manganese-based oxides, E. J. Kim, T. Hosaka, K. Kubota, R. Tatara, S. Kumakura, S. Komaba, *ACS Appl. Energy Mater.,* **2022**, *5*, 12999.
15. Sulfated Alginate as an Effective Polymer Binder for High-Voltage $LiNi_{0.5}Mn_{1.5}O_4$ Electrodes in Lithium-Ion Batteries, A. Oishi, R. Tatara, E. Togo, H. Inoue, S. Yasuno, S. Komaba, *ACS Appl. Mater. Interfaces,* **2022**, *14*, 51808.
16. Fluorosulfonamide-type Electrolyte Additives for Long-Life K-Ion Batteries, Z. T. Gossage, T. Hosaka, T. Matsuyama, R. Tatara, S. Komaba, *J. Mater. Chem. A,* **2023**, *11*, 914.
17. High-Performance SiO Electrode for Lithium-ion Batteries: Merged Effect of New Polyacrylate Binder and Electrode-Maturation Process, S. Yamazaki, R. Tatara, H. Mizuta, K. Kawano, S. Yasuno, S. Komaba, *Mater. Adv.*, **2023**, *4*, 1637.

18. LCA analysis and quantification of adsorption performance of Kanuma clay by simultaneous adsorption of H_2S and NH_3, K. Torii, K. Dowaki, *IOP Conf. Series: Earth and Environmental Science,* **2022**, *1034,* 012068.
19. Environmental Impact Assessment of PEM Fuel Cell Combined Heat and Power Generation System for Residential Application Considering Cathode Catalyst Layer Degradation, S. Tochigi, K. Dowaki, *Energies,* **2023**, *16*, 1985.
20. A System Analysis of a Bio-Hydrogen Production System Using Granulated Mine Residue as a H_2S Adsorbent, K. Torii, M. Hamazaki, S. Kumon, K. Sato, S. Kato, K. Dowaki, *Energies,* **2023**, *16,* 2625.
21. Surface atomic structures of nickel plating films reacted with methane at high temperature, K. Miyazawa, M. Asahara, T. Miyasaka, T. Nagai, K. Kimoto, Y. Tanaka, *Surface and Interface Analysis*, **2023**, *55*, 321.
22. Dual function of rhodium photodeposition on ZnO/ZnS: Enhanced H_2 Production and photocorrosion suppression in water, S. Khan, V. Poliukhova, N. Tamir, J. Park, N. Suzuki, C. Terashima, K. Katsumata, S. H. Cho, *Int. J. Hydro. Energy*, **2023**, *48*, 9713.

Book

1. Photocatalytic Water Pollutant Treatment: Fundamental, Analysis and Benchmarking, K. R. Davies, B. Jones, C. Terashima, A. Fujishima, S. Pitchaimuthu, *Nanostructured Materials for Environmental Applications*, **2023**, Springer, ISBN: 978-3-030-72075-9.

Invited Lectures

1. Photocatalytic water splitting and CO_2 fixation as artificial photosynthesis, A. Kudo (Keynote), The 9th Tokyo Conference on Advanced Catalytic Science and Technology (TOCAT9), July 24-29, 2022. (Fukuoka International Congress Center, Japan).
2. Atomically Precise Metal Nanoclusters as Energy and Environmental Catalysts, Y. Negishi, Atomically Precise Nanochemistry Gordon Research Conference, USA, 2022.
3. 太陽光を利用した炭酸ガス還元触媒の開発, 寺島千晶, 丸田晃大, 石田直哉, 第 12 回 CSJ 化学フェスタ 2022, 口頭発表（招待・特別）, 国内会議, タワーホール船堀, 2022 年 10 月 18 日（in Japanese）.
4. HRTEM-EELS Analyses of Carbon Nanostructures for Catalytic Applications, K. Miyazawa, Y. Tanaka, 6th Global Webinar on Materials Science & Engineering (GWMSE-2023), WEB, 2023.
5. Synthesis of mesoporous TiO_2/BDD hybrid and its application toward an efficient water purification, N. Suzuki, One Day International Symposium on Advances in Photocatalysis, Online, April 13th, 2022.

Awards

1. 工藤昭彦, 令和 4 年度 東京都功労者表彰（技術振興功労）2022/10/3 (in Japanese).
2. Y. Negishi, IAAM Innovation Award, IAAM, 2022.
3. 根岸雄一, 第 34 回向井賞, 2023 (in Japanese).
4. S. Komaba, Highly Cited Researchers 2022.
5. 川脇徳久, 第 19 回 Honda-Fujishima Prize, 電気化学会, 2022 (in Japanese).

Individual Research Topics

Akihiko Kudo
“Development of photocatalysts aiming at production of green hydorgen 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 novel metal oxide photocatalysts showing the activity for sacrificial hydrogen evolution under visible light irradiation by doping tiny amount of Ir. In addition, the novel visible-light-driven photocatalysts composed of Ag showing the activity for sacrificial oxygen evolution under visible light irradiation were successfully developed by using a ball-milling device. Also, highly efficient CO_2 reduction over metal oxide photocatalysts was achieved by loading with various dual-cocatalysts.

Yuichi Negishi
“Creation and evaluation of highly active water-splitting photocatalysts with metal nano clusters”

Water-splitting photocatalysts, which can produce hydrogen from water and sunlight, are attracting attention as a clean hydrogen-evolution method. To increase the activity of the photocatalyst, it is effective to support metal nanoparticles called cocatalysts. In this study, we proposed a method to synthesize ultrafine metal clusters in the liquid phase and support them on the surface of the photocatalyst, thereby creating a water-splitting photocatalyst with precisely controlled particle size and electronic state. Furthermore, we evaluate the activity of this catalyst and assess the impact of the precision cocatalyst on the high activity of the catalyst.

Chiaki Terashima
“Photothermal catalysts for carbon recycling”

CO_2 reduction technology that views CO_2 as a resource and converts it into a useful resource, is attracting attention. In artificial photosynthesis, TiO_2 photocatalysts can only utilize about 6% of sunlight. The R&D into visible light response 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 were examined.

Shinichi Komaba
“Materials of next generation battery for efficient ulitization of electricity”

We study on materials of sodium-ion and potassium-ion batteries free from minor and toxic metal elemetns along with that of lithium-ion battery. In FY2022, we developed new functional binders for high capacity lithium-ion batteries and analyzed the mechansm of the binders functionality to improve their performances. Furthermore, we developed new sodium manganese oxides doped with copper for sodium-ion batteries and reported the investigation of the relation between the crystal structure and electrode properties.

Kiyoshi Dowaki
“A study on characteristics of pyrolysis bio-H_2 process from sewage sludge using heat carriers of alumina balls”

The R&D of hydrogen production through an indirect pyrolysis process using sewage sludge has been conducted under an industry-academia collaboration scheme. This year, we analyzed the heat transfer characteristics of the alumina balls (heat carriers, HCs) using CFD (Computational Fluid Dynamics) model. In this model, based on the operation data in the demo plant, the behavior characteristics of gas and tar generation are discussed, verifying the calculation and the test data. In the next fiscal year, we plan to improve the heat flux of HCs and evaluate it based on basic tests of heat transfer characteristics.

Yumi Tanaka

“Research on inorganic energy conversion materials and related devices”

Garnet-type yttrium aluminate ($Y_3Al_5O_{12}$; YAG), in which Y^{3+} is partially replaced by Mg^{2+}, was attempted to be converted to electret by polarization formation using oxygen vacancies and/or electron defects as carriers. As a result, the YAG electret with a surface potential of about 4.5 kV was successfully fabricated, and it was clarified that multiple polarization states (relaxation barrier: about 0.6 eV to 3.3 eV) existed within this sample.

Norihiro Suzuki

“Separation and purification of formic acid formed by electroreduction of CO_2 with zeolite membrane”

To realize the practical use of formic acid produced by an electroreduction of CO_2, a facile and inexpensive technology that separates formic acid diluted with a liquid electrolyte should be developed. In this study, I aim at extracting dense and pure formic acid by utilizing “molecular sieve effect” and “selective adsorption” of commercially available zeolite membranes.

Yuichi Yamaguchi

“Development of novel visible-ligh-driven metal oxide photocatalysts based on a Ag metal ion for oxygen evolution”

Development of a novel visible-light-driven photocatalyst is of a great importance for realizing green hydrogen production using a photocatalyst. We developed novel visible-light-driven photocatalysts by focusing on a Ag ion. As a result, $AgMVO_4$ (M=Zn, Ca, Mg) and $Ag_2Zn(VO_3)_4$ showing the activity for sacrificial oxygen evolution under visible light irradiation were successfully developed. We will keep on developing novel visible-light-driven photocatalysts by utilizing the strategies found by our lab.

Division of Nanocarbon Research

Division of Nanocarbon Research

1. Overview

Carbon nanotubes and graphene are low dimensional materials (with linear and flat shapes, respectively) composed of networks of 6-members rings (honeycomb structure). Owing to strong covalent bonds of carbon atoms, they have excellent mechanical strength and chemical stability enough to sustain the monolayered structure in a free space. Furthermore, they exhibit properties peculiar to the geometrical configuration and low dimensionality, which cannot be expected for three-dimensional crystals. As you can see from the fact that the Nobel Prize in Physics 2010 relates to graphene, nanocarbons such as carbon nanotubes and graphene are extensively studied in basic science. In the future, nanocarbons are expected to play a main role in an industrial revolution as iron and silicon did in the Industrial Revolution and the information technology revolution, respectively. The Division of Nanocarbon Research covers topics of nanocarbons from fundamental to applied research by collaboration of experts in theoretical and experimental condensed matter physics, electrical engineering, thermal engineering, and biophysics. We expect synergy effects by enhancing mutual discussion and exchange of ideas in the division.

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).

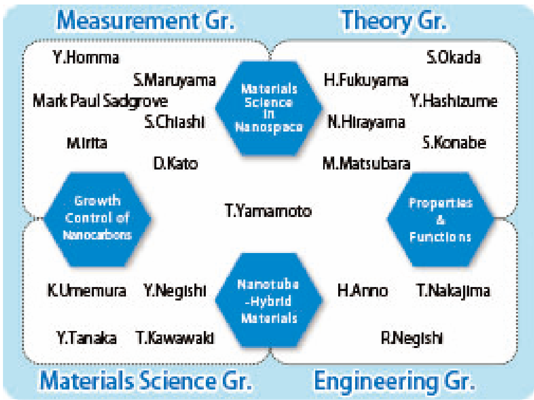

Fig. 1. Configuration of the Division.

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.

2. 2. Nanotube-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

Thermal properties of SWCNT

We analyzed the one-dimensional (steady-state) heat conduction equation based on experimental temperature distributions of single-walled carbon nanotubes (SWCNTs). We found an improvement in the handing of differential equations proposed in the previous study and are now proceeding with the implementation of a new calculation method incorporating it. (M. Irita,Y. Homma)

Research and development of optical isolator using SWCNT and nanofiber

Chirality-separated (10,3) and (9,7) SWCNTs have different absorption wavelengths depending on their chirality. We attached these SWCNTs to an optical nanofiber and measured the propagating light in the nanofiber. In each absorption wavelength band, we found that transmission varied depending on the direction of light propagation. Based on the results of this research, we have obtained a Grant-in-Aid for Scientific Research (C) and are proceeding with the patent application for the SWCNT optical isolator. (M. Irita, Y. Homma)

Hot spring - bathtub temperature automatic control

As part of research on SWCNT thin films, we have researched and developed a device for automatic temperature control of bathtubs in Kannada Onsen, Oita prefecture, and have achieved a bath temperature of 42°C at all times. In addition to proceeding with preparations for applying for patents on these research activities, we performed publicity activities by appearing on “NHK WORLD-JAPAN”. (M. Irita)

Thermoelectric measurements of carbon nanotubes

We developed a technique to measure the electromotive force by measuring the temperature difference between electrodes using nitrogen-vacancy (NV) centers in nanodiamonds. The problem of reduced accuracy was solved by canceling the magnetic field caused by the local heater. The accuracy of thermoelectric force was reduced when the resistivity was high. (Shimizu)

We have revealed the temperature dependence of the thermoelectric performance of impurity-doped carbon nanotubes (CNTs) and found that the maximum power factor increases exponentially with decreasing the CNT diameter. In addition, we present the optimal impurity concentration that maximum the power factor of CNTs with various diameters. (Matsubara)

3. 2. Materials Sciense Group

We focused on publishing reviewed papers because it was the final year of the JST SICORP eASIA research Program. In particular, we reported developments of micrometer size biosensing devices that were hybrids of nanoporous biosilica and single-walled carbon nanotubes. (Umemura)

We succeeded in synthesizing nanoclusters by using the polyol reduction method and the ligand exchange method in air. It was found that the use of such platinum nanoclusters as a hydrogen-producing co-catalyst for a water-splitting photocatalyst exhibits higher hydrogen-producing activity than the conventional platinum nanoparticle co-catalyst. (Kawawaki)

3. 3. Engineering Group

Using finite element simulation, we found the element size and structure that maximizes the output power of the kirigami type thermoelectric device, and demonstrated that the device can generate more than 100 μW. This device is expected to have new application developments as it allows for power generation on curved surfaces and movable parts. In addition, we have developed a new method to induce carrier modulation in a composite structure of polymers and SWCNTs by the electric field effect while sustaining the carrier modulation for a long period of time in a zero electric field. (T. Nakajima)

Inorganic materials were investigated for the creation of hybrids between inorganic nanoparticles and nanocarbons. The density functional theory calculations using the nonequilibrium Green's function method revealed the layer number dependence of electronic structure and thermoelectric transport properties of layered sulfides. (Anno)

We examined the synthesis of multilayer graphene by vapor-solid phase growth with a solid template using our developed infrared furnace system in a reactive carbon gas environment. We found that graphene growth proceeds via layer-by-layer mode as van der Waals hetero-epitaxial growth on the hexagonal Boron Nitride (h-BN) flakes. Since h-BN is an insulating material, this crystal growth method has a great potential for electronic device applications. (R. Negishi, Toyo University)

3. 4. Theory Group

We designed the novel 2D materials by polymerizing spiro [4,4]nonatetraene where two pentagonal rings are connected via sp^3 C atom. The electronic structures of these polymeric spiro [4,4]nonatetraene (spiro-graphene) are sensitive to the arrangement of spiro [4,4]nonatetraene, ranging from metal to semiconductors. We also reported that the electronic properties of polymeric triangular graphene flakes embedded in hBN are strongly depends on the shape of the graphitic networks. Our calculations demonstrated that these in-plane heterostructures of CBN have 0-dimensional electron system at and near the Fermi level, even though sp^2 C atoms has two dimensional covalent networks in hBN. Finally, we investigated the electronic structure of diamond nanowire under the external electric field and found that the metallic diamond nanowire can perfectly screen the external electric field, although their diameter is 1 nm. (Okada)

We worked on extending the theory of emissivity for carbon nanotubes, which we had constructed by FY2021, to two-dimensional atomic layer materials such as transition metal dichalcogenides. As a result, we express the emissivity of atomic layer materials using the dyadic Green's function for electromagnetic fields and the scattering matrix that represents the interaction between electromagnetic fields and materials. (S. Konabe)

In order to perform highly accurate theoretical analyses of electronic states and carrier transport properties at low computational cost, we have introduced the AkaiKKR (Machikaneyama) code based on the Green's function method. Using this code, we obtained electronic states of thermoelectric semiconductors and calculated the transport coefficients using the Kubo-Greenwood formula. Our results for *n*- and *p*-type carrier-doped Mg_2Si were in good agreement with experimental data. (Hirayama)

The fabrication of devices using new materials such as carbon nanotubes is currently conducted by the members of this project. We have been analyzing the signal data obtained by such devices. In this year, we promoted the linkage of these technologies with the preArch system so that they can be linked to actual sensors and alerts. ((Hashizume)

4. Challenges and Prospects

We tried to publish all our works; however, two manuscripts for reviewed papers were not accepted within March 2023. Publishing high impact papers was not achieved. We will try to obtain acceptance of the two papers as soon as possible. (Umemura)

Since the co-catalyst loading method in this research is based on chemical adsorption using the interaction between the photocatalyst support and platinum clusters, there is a problem that the co-catalyst is randomly loaded on the crystal plane of the photocatalyst. Therefore, it is considered necessary to establish a new loading method for selectively loading a specific crystal plane of the photocatalyst. In the future, we will work on the development of such a new loading method. (Kawawaki)

To obtain emissivity for specific atomic layer materials, we should calculate the dyadic Green's function and scattering matrix by considering the properties of each material, but this is not easy. The next challenge is to obtain a simple and easy-to-use emissivity formula for atomic layer materials using dielectric functions, as in the case of carbon nanotubes. (S. Konabe)

We have introduced a calculation method for carrier transport properties of impurity-doped semiconductors using the Green's function method and the linear response theory. The results demonstrate that these methods show superior accuracy and computational efficiency. We will consider more complex structures, such as systems with multiple dopants and those containing lattice defects in the future work. Furthermore, in order to perform more accurate analysis considering finite temperature effects, it is necessary to incorporate phonon free energies. (Hirayama)

In the hybridization of inorganic nanoparticles and nanocarbons, the interaction between layered sulfide nanosheets and nanocarbons and its effect on thermoelectric properties will be investigated by density functional theory calculations using the nonequilibrium Green's function method. On the other hand, we will also explore nanoparticles of inorganic thermoelectric materials other than layered sulfide to investigate the processes of nanosizing, dispersion, and hybridization of inorganic thermoelectric materials, and experimentally investigate the thermoelectric properties of their hybrids. We will also continue to investigate the control of fixed injected charge in electric double-layer transistor structures with CNTs as the channel layer. (Anno)

We have found that activation of the edge sites at grown graphene layer is important in the graphene layer growth on h-BN template. We plan to introduce a hydrogen gas supply system as an etching gas to selectively remove amorphous structures that cause the deactivation of the edge sites, will achieve to improves the crystallinity of grown graphene layers. We also plan to reveal quantum conduction originating from linear dispersion by the observation of the transfer characteristics in the field effect devices using grown graphene channel. (R. Negishi, Toyo University)

In the present stage, it has not been clarified what sensor structure would be appropriate to link with the actual sensor. Therefore, at present, the equations for analysis must be modified for each sensor. This is not suitable for general usage, and then, we have to consider more general methods. (Hashizume)

5. Conclusion

Researchers belonging different fields of physics, materials, mechanics, data science, and architecture collaborated to develop carbon nanotube thermoelectric sensors and achieved not only basic research but also social implementation. We restarted real face-to-face research presentations and it is expected to further collaboration.

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Major Research Achievements (FY 2022)

Academic Papers

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2. Continues Fermi level tuning of Nb-doped WSe2 by the external electric field, K. Hisama, Y. Gao, M. Maruyama, R. Kitaura, S. Okada, Jpn. J. Appl. Phys., 61, 015002 (2022). (peer-reviewed)
3. Investigation of bactericidal effect of a mid-infrared free electron laser on Escherichia coli, T. Toyama, J. Fujioka, K. Watanabe, A. Yoshida, T. Sakuma, K. Inaba, T. Imai, T. Nakajima, K. Tsukiyama, N. Hamada, and F. Yoshino, Sci. Rep., 12 pp 18111, 2022. (peer-reviewed)
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6. スクッテルダイト $CoSb_3$ の電子構造と輸送特性, 阿武宏明, 橋國克明, 山陽小野田市立山口東京理科大学紀要, 第 6 号, 23–30（2023 年 3 月 13 日） (peer-reviewed) (in Japanese)
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8. Thermoelectrical random stick network method and its application to carbon nanotube films, Junei Kobayashi, Takahiro Yamamoto, Japanese Journal of Applied Physics, 61 09500130,August 2022. (peer-reviewed)
9. Correlation between copper particle morphology and number of graphene layers on a palladium substrate, Junro Takahashi, Kengo Nakamura, Yusei Kioka, Hiroki Kato, Takahiro Yamamoto, and Yoshikazu Homma, Appl. Phys. Express 16, 015503 (2023). (peer-reviewed)
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12. Carbon dioxide triggers carbon nanotube nucleation: isotope labeling study on the growth process of individual nanotubes, R. Ishimaru, K. Otsuka†, T. Inoue, S. Chiashi, S. Maruyama†, ECS J. Solid State Sc. 11, 071002 (2022).
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Books

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2. Quantum Hybrid Electronics and Materials, Ryota Negishi and Yoshihiro Kobayashi, Springer, pp149-180,2022
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4. Suspended Carbon Nanotubes for Quantum Hybrid Electronics in Quantum Hybrid Electronics and Materials in Quantum Hybrid Electronics and Materials, Yoshikazu Homma, Takumi Inaba, and Shohei Chiashi, Ed. by Yoshiro Hirayama, Kazuhiko Hirakawa, Hiroshi Yamaguchi, Springer, pp 99-122, 2022

Invited Lectures

1. A Micron Size Optical Sensor Using Single-Walled Carbon Nanotubes and Diatom Frustule, Kazuo Umemura, 2022 International Conference on Nanoscience and Nanotechnology, December 8-9, 2022, Hotel Oazis, Butuan City, Philippines
2. Microbiodevices developed via the eASIA research project, Kazuo Umemura, Leo Cristobal C. Ambolode II, Mai Anh Tuan, Eko Siswoyo, 2022 International Conference on Advanced Functional Materials and Nanotechnology (ICAFMN) & 24th Samahang Pisika ng Visayas at Mindanao National Physics Conference, October 27-28, 2022, Metrocentre Hotel and Panda Tea Garden Suites, Tagbilaran City, Bohol, Philippines
3. Smart mechatronics based on piezoelectric polymer energy harvesting, Takashi Nakajima, The 17th International Conference on Nano/Micro Engineered and Molecular Systems (IEEE-NEMS 2022), Online. 2022
4. 柔軟性材料を用いた IoT センサデバイス, 中嶋宇史, 第 16 回グリーンシステム技術分科会, オンライン, 2022 (in Japanese)
5. 高分子圧電材料の物性と応用例, 中嶋宇史, 第 24 回圧電 MEMS 研究会, 東京, 2022 (in Japanese)
6. 水素社会の実現に向けた金属ナノクラスターを用いた触媒創製の取り組み, 川脇徳久, 旭化成株式会社定期講演会, オンライン, 2022 年 7 月 22 日 (in Japanese)
7. 金属クラスター触媒の水素生成への応用, 川脇徳久, 新学術領域ハイドロジェノミクス第９回若手育成スクール 自然科学研究機構 岡崎コンファレンスセンター, 2022 年 9 月 26 日 (in Japanese)
8. 液相合成した金属ナノクラスターの触媒応用,川脇徳久, DV-Xα 研究協会量子材料化学講演会, 岡山理科大学, 2022 年 12 月 3 日 (in Japanese)
9. 金属ナノクラスターのエネルギー・環境分野への触媒応用, 川脇徳久, 日本金属学会鉄鋼協会・関西分析研究会, 龍谷大学大宮学舎, 2023 年 1 月 23 日 (in Japanese)
10. Anomalous carrier transport properties in multilayer graphene materials with a weak interlayer coupling synthesized by a solid template method, Ryota Negishi, The 19th International Symposium on Bioscience and Nanotechnology, Japan (Nov.2, 2022)
11. Thermoelectricity and SDGs, Hidetoshi Fukuyama, ICOT2022, Japan (1124, 2022)
12. ナノカーボン特別講演 マルチハザード時代の都市防災科学技術 ～東京理科大学の取り組み～, 山本貴博, 第 23 回国際ナノテクノロジー総合展・技術会議,東京ビックサイト, 2023,2,1 (in Japanese)
13. HRTEM-EELS Analyses of Carbon Nanostructures for Catalytic Applications, K. Miyazawa and Y. Tanaka, 6th Global Webinar on Materials Science & Engineering (GWMSE-2023), WEB, 2023
14. セラミックエレクトレットの創成と静電ハーベスターへの展開, 田中優実, 加納一彦, MEMS センシング&ネットワークシステム展 2023 特別シンポジウム「MEMS・半導体次世代テクノロジーフォーラム」, 東京, 2023 (in Japanese)
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16. Mechanical and structural changes in the surface of SUS304 and SUS316L austenitic stainless steels that were subjected to repeated cryogenic heat treatments, K. Miyazawa, Y. Tanaka, R. Suzuki, M. Tachibana, "5th IUMRS-ICYRAMB 2022, WEB, 2022
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18. Phase transition behavior of encapsulated water molecules in single-walled carbon nanotubes, S. Chiashi, K. Sasaoka, Y. Maekawa, T. Yamamoto, Y. Homma, 8th Annual Workshop on Nanotube Optics and Nanotube Spectroscopy (Wonton 2022) (University of Wisconsin-Madison, Memorial Union, Madison, U.S.A.).

Patents

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2. 長谷川幹雄, 中嶋宇史, 酒造 孝, 特願 2022-155623（2022.9.28）「情報処理方法、情報処理装置、情報処理プログラム及び記録媒体」 (in Japanese)
3. 中嶋宇史, 長谷川幹雄, 酒造 孝, 特願 2022-151941（2022.9.22）「位置検出システム、位置検出サーバ, 制御装置, 位置検出方法, 及びプログラム」 (in Japanese)
4. 中嶋宇史, 横山諒伍, 特願 2022-087189（2022.5.27）「圧力分布計測システム, 圧力分布計測方法, 圧力分布計測プログラム, 及び差動増幅計測の測定回路」 (in Japanese)
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Public Relations

1. Masaru Irita, Appeared on "NHK WORLD-JAPAN", 2023/1/13 (in Japanese)
2. 山本貴博, 「武田双雲展　感謝～祈り～@伊勢丹新宿店」ビスマスアートワークスへの協力, 2022/4/13-25 (in Japanese)
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6. 工藤昭彦, 田中優実,「CO_2 と水素」（インタビュー記事）, TUS Journal 第 225 号 ※東京理科大学広報誌 (in Japanese)
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8. 田中研究室, （株）デンソー, 第 39 回センサ・マイクロマシンと応用システムシンポジウム（アスティ徳島）におけるブース出展＆静電式振動発電機のデモデバイス展示, 2022 (in Japanese)

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Awards

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3. 山本貴博, アジア熱科学会議 貢献賞 (Distinguished contribution to thermal science), Second Asian Conference on Thermal Science (2nd ACTS), 2022, 4, 16
4. 山本貴博, 日本表面真空学会フェロー, 公益社団法人日本表面真空学会, 2022
5. 小林遵栄（山本研究室, D1）, 2021 年日本表面真空学会学術講演会講演奨励賞 スチューデント部門, 公益社団法人日本表面真空学会, 2022, 5, 21

※21 others

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 spectroscopic measurements of single carbon nanotubes (SWCNTs), we elucidate the interactions between excitons and phonons in SWCNTs. In addition, using scanning electron microscopy (SEM) and spectroscopy, we investigate the morphology and structure of novel nanocarbon materials.

Kazuo Umemura
“Fabrication of thermostable enzyme devices by hybridization of South East Asian specific biomolecules and nanocarbon. ”

Fabrication of thermostable enzyme devices by hybridization of South East Asian specific biomolecules and nanocarbon. We will fabricate thermostable enzyme devices using hybrids of South East Asian specific biomolecules and nanocarbon.

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
“Development of Functional Nanocarbon Materials Based on Hierarchical Structural Control”

We have improved the characteristics and promoted the application of flexible thermoelectric devices with Kirigami structures. Additionally, we have tried to form a CNT composite structure with a polymer material that also features flexibility, and investigate the carrier modulation effect of the CNT layer.

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

“Creation of highly active water splitting photocatalysts with～1 nm platinum nanoclusters and elucidation of their mechanism”

Water-splitting photocatalysts, which can produce hydrogen from water and sunlight, are attracting attention as a truly clean hydrogen production method. Loading fine metal particles called a co-catalyst is effective for increasing the activity of the photocatalyst. However, it was difficult to precisely control the "particle size" and "electronic state" of conventional loading methods. Therefore, in this research, we aim to create a highly active water-splitting photocatalyst by synthesizing platinum nanoclusters of about 1 nm in size and applying them as co-catalysts.

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.

Shin Okada

“Electronic properties of graphene nanostructures and CNT under an external electric field”

Using the density functional theory combined with the effective screening medium method, we investigated the electronic properties of atomic layer materials and CNT thin films.

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

"Theoretical study on thermal radiation properties of nanocarbon materials and atomic layer materials"

We derive emissivity formulas for nanocarbon materials and atomic layer materials to theoretically clarify their thermal radiation properties and thermal photovoltaic effects.

Shohei Chiashi

"Fabrication of novel structures of nanocarbon materials and evaluation of their physical properties"

I aim to develop novel nanomaterial construction techniques for single-walled carbon nanotubes (SWCNTs), graphene, and other nanocarbon materials, and to combine them with other nanomaterials such as boron hexagonal nitride (e.g., stacked or lateral structures), and to explore and clarify their physical properties. In the case of SWCNTs, I will develop a chirality-controlled synthesis method, and in the case of graphene and other nanomaterials, I will promote the development of large-area and high-quality nanomaterials. At the same time, I will develop optical analysis methods for these nanomaterials and nanostructures.

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 (JEOL Ltd.)

"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 and device using the composite. Energy dispersive spectrometer (EDS) attached to FIB-SEM gives a hyperspectral data, that consists of voxels including X-ray spectrum exited with electron beam of SEM. In this study, we will investigate issues in application of multivariate analysis for the hyperspectral data of 3D-EDS, and work to solve the issues.

Naomi Hirayama

"Calculation of thermoelectric transport properties of semiconductors with high accuracy and low computational cost"

We establish a theoretical method for predicting thermoelectric properties with high accuracy and low computational cost for systems containing impurity atoms and lattice defects. For this purpose, we have introduced the AkaiKKR (Machikaneyama) first-principles calculation code based on the Green's function method. Using this code, we first calculate the electronic states considering impurity dopants and defects. Then, we obtain the thermoelectric transport coefficients using the Kubo-Greenwood formula. We also evaluate the influence of phonons on the transport properties and crystal stability. This approach will enable more realistic predictions of thermoelectric performance than conventional first-principles calculations.

Maki Shimizu

"Thermoelectric measurement of carbon nanotubes"

We will perform thermoelectric measurement of a single carbon nanotube. We will search for a more accurate method to measure high resistivity range. We will construct a system to measure the temperature dependence and measure the physical properties of carbon nanotubes.

Division of Colloid and Interface Science

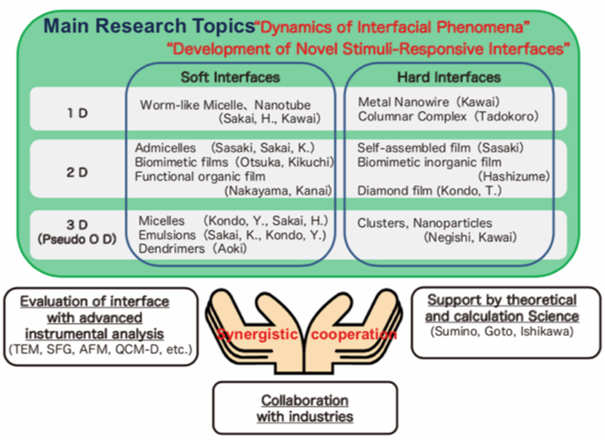
Division of Colloid and Interface Science

1. Overview

Tokyo University of Science has laboratories specializing in interface science in each faculty. The Division of Colloid and Interface Science has an approximately 40-year history since its establishment in 1981 by interface science researchers from each faculty. Universities with research facilities specializing in interface science are rare both in Japan and abroad. Until now, the division has led the field of interface science through the activities of the division members such as organizing many domestic and international conferences and serving as editors of major international journals. Since 2013, the division has categorized its research focus into soft and hard interfaces for a profound understanding of dynamic interfacial phenomena.

Although most division members were chemists until 2018, physicists, mechanical engineers in fluid mechanics and tribology, and theoretical scientists have joined the division. The participation of these researchers supports our priority topics on manufacturing with interface science and developing functional materials that respond to external stimuli such as light, temperature, and electricity by advanced measurements and theoretical calculations. We progress our research to achieve a precious understanding of interface dynamics and the reaction mechanism at the interfaces through collaboration among the researchers. We have obtained new findings on static/dynamic behaviors and interfacial structures related to interfaces and interfacial reactions. We will feed these findings into creating novel functional materials originating from the Research Institute for Science & Technology (RIST).

2. Organization and Facilities



Soft interfaces are dynamic interfaces where the elements (atoms) forming the interface are constantly exchanged within a normal observation timeframe. This corresponds to the formation of molecular aggregates such as micelles by surfactants. On the other hand, hard interfaces are rigid interfaces with no exchange of surface constituent atoms, represented by metal and semiconductor nanoparticles. Soft and hard interfaces can also be referred to as dynamic and static interfaces, respectively. We are researching one-, two-, and three-dimensional interfaces for a profound understanding of the dynamic interfacial phenomena and their application in developing functional materials.

In this research division, experts 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. Each division member has their research targets relating to various dimensionalities and dynamics of interfaces and conducts collaborative research with domestic, international, and industrial researchers as shown in the figure.

The division members can always use each other's 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). In addition, cryo-TEM and FF-TEM in the Research Equipment Center enable the direct observation of colloidal particles dispersed in solutions and various molecular aggregates. 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.

3. Activity Reports

3. 1. 2022 Research Results Presentation Meeting (Hybrid Event)

Date: Thursday, March 9, and Friday, March 10, 2023
Venue: 6th floor hall, Building No. 7, Noda Campus and Online
Summary: A 1.5-day meeting was held to summarize the five-year research period. Research reports by all division members and the following six keynote and invited lectures were given, and the participants actively discussed in the Q&A sessions.

1) Prof. Shin Aoki (TUS)
   Design and Synthesis of Functional Supramolecules Based on Combinatorial Molecular Aggregation–Interaction of Supramolecular Metal Complexes with Interfaces and Biomembranes
2) Dr. Shigeru Deguchi (Japan Agency for Marine-Earth Science and Technology)
   Deep-sea Inspired Chemistry: An Approach to Sustainable Ocean Use from Materials Chemistry
3) Professor Srinivasa R. Raghavan (University of Maryland)
   Colloidal Engineering at the Nano, Micro, and Macro Scales: Materials that Can Move, Morph, Protect, and Heal
4) Dr. Rie Kakehashi (Osaka Research Institute of Industrial Science and Technology)
   Amidoamine Oxide Surfactants — Function as Hydrogelators and Application to Oil Gelation Agents
5) Dr. Toshiyuki Suzuki (Nikko Chemicals Co., Ltd.)
   Emulsification Using Molecular Aggregates and its Application to Cosmetics
6) Professor Makoto Ogawa (Vidyasirimedhi Institute of Science and Technology)
   Interface-Dependent Hybrid Materials and Function Design

Many results from the joint research conducted by division members were also reported and published as conference presentations and papers. Furthermore, three corporate researchers gave lectures at the meeting instead of the Industry-Academia Collaboration Seminar of the Division of Colloids and Interface Science this year. The 198 people (144 internal and 54 external) attended the meeting and actively discussed.

3. 2. 2022 Division of Colloids and Interface Science Summer Symposium

Date: August 3, 2022
Venue: Building No. 13 (Morito Memorial Hall) in Kagurazaka Campus and Online
Summary: Although the summer symposium had been held online until last year due to the COVID-19 pandemic, we held it in person this year. Professor Gary Richards of the Shibaura Institute of Technology; Professor Chien-Hsiang Chang of the National Cheng Kung University, Taiwan; and Dr. Taisuke Banno of Keio University gave invited lectures, followed by active discussions. In addition, 14 students from laboratories belonging to the Division of Colloids and Interface Science gave oral presentations in English, followed by Q&A sessions. It was impressive that the students gave their presentations and answered the questions seriously. The 123 internal and 17 external participants attended the symposium.

4. Challenges, Prospects, and Conclusion

Division members have conducted collaborative research on functional materials for applications in pharmaceuticals, cosmetics, foods, inks, and electronic components over a long period, and the results of the research are now prospering. From next year, we aim to develop these technologies into technologies “only at TUS.” We will also conduct advanced measurements and theoretical analyses of these materials to understand phenomena profoundly and gain new knowledge, particularly on the dynamics of interfaces.

During the five-year research terms, the division has also disseminated the results of its activities by sponsoring and co-sponsoring various events such as cosmetics lectures at the University's Open College and industry–academia collaborative seminars. We will continue to strengthen the dissemination of information from the division.

Furthermore, we will systematically turn the division into an international hub from the next academic year onward.

In the future, we intend to promote the publication of research results in international journals and conduct international joint research, as well as further improve the activities of subcommittees to establish a division–industry consortium to promote division–industry joint research, human resource development, and obtain large budgets by division members.

Major Research Achievements (FY 2022)

Academic Papers

1. Properties and Applications of Highly Stable Vesicles Formed by Nanoarchitectonics of Amphiphilic Molecules, H. Sakai, J. Oleo Sci., 72, 1-9, 2023. (Peer-reviewed)
2. Effect of Polyol Type on The Structure and Properties of Lecithin Liposomes Prepared Using The Polyol Dilution Method, K. Ohishi, K. Tsuchiya, T. Ogura, A. Ebisawa, A. Sekine, Y. Masubuchi, M. Akamatsu, K. Sakai, M. Abe, H. Sakai, Colloids Surf. A, 656 (B), 130509, 2023. (Peer-reviewed)
3. Enhancing the Foam Stability of Aqueous Solution with High Ethanol Concentration via Co-Addition of Surfactant, Long-Chain Alcohol, and Inorganic Electrolyte, K. Sakai, R. Muto, M. Hara, R. Hattori, E. Harata, M. Akamatsu, H. Sakai, Chem. Lett., 51, 982-984, 2022. (Peer-reviewed)
4. Controlled Polymerization of Metal Complex Monomers – Fabricating Random Copolymers Comprising Different Metal Species and Nano-Colloids. S. Osawa, S. Kurokawa, H. Otsuka, Chem. Commun., 58, 5273–5276, 2022. (Peer-reviewed)
5. Proton Conduction at High Temperature in High-Symmetry Hydrogen-Bonded Molecular Crystals of RuIII Complexes with Six Imidazole–Imidazolate Ligands, M. Tadokoro, M. Itoh, R. Nishimura, K. Sekiguchi, N. Hoshino, H. Kamebuchi, J. Miyazaki, F. Kobayashi, M. Mizuno, T. Akutagawa, Chem. Eur. J., 28, e202201397, 2022. (Peer-reviewed)[Front Cover] [Hot Paper] [Press Release]
6. Silver Cluster-Assembled Materials for Label-Free DNA Detection, S. Das, T. Sekine, H. Mabuchi, S. Hossain, S. Das, S. Aoki, S. Takahashi, Y. Negishi, Chem. Commun., 59, 4000-4003, 2023. (Peer-reviewed)
7. Pairing-Induced Motion of Source and Inert Particles Driven by Surface Tension, H. Ishikawa, Y. Koyano, H. Kitahata, Y. Sumino, Phys. Rev. E. 106, 024604-1-11, 2022. (Peer-reviewed)
8. Chiral Π-Conjugated Liquid Crystals: Impacts of Ethynyl Linker and Bilateral Symmetry on the Molecular Packing and Functions, A. Seki, K. Shimizu, K. Aoki, Crystals, 12, 1278, 2022. (Peer-reviewed)
9. Chiral Transcription from Chiral Au Nanowires to Self-Assembled Monolayers of Achiral Azobenzene Derivatives. Y. Kawasaki, M. Nakagawa, T. Ito, Y. Imura, K.-H. Wang, T. Kawai, Bull. Chem. Soc. Jpn., 95, 1006-1010, 2022. (Peer-reviewed) [Selected Paper]
10. Synthesis and Optical/Electronic Properties of Imitation-copper Crystals Based on Low-molecular Azobenzene Derivatives, K. Onodera, N. Saito, Y. Kondo, Chem. Lett., 51, 485-488, 2022. (Peer-reviewed)
11. Preparation of Mechanically Anisotropic Polysaccharide Composite Films Using Roll-Press Techniques, T. Sagawa, Y. Nikaido, K. Iijima, M. Sakaguchi, Y. Yataka, M. Hashizume, ACS Omega, 8, 5607-5616, 2023. (Peer-reviewed)
12. Effects of Gusty Flow on Aerodynamic Performance of Multirotor Drone Propellers in Hovering Flight, M. Murakami, H. Abe, H. Aono and H. Ishikawa, J. Fluid Sci. Tech., 17, 2022. (Peer-reviewed)
13. Processes of Molecular Adsorption and Ordering Enhanced by Mechanical Stimuli under High Contact Pressure, S. Watanabe, C. Tadokoro, K. Miyake, S. Sasaki, K. Nakano, Sci. Rep., 12, 3870, 1-9, 2022. (Peer-reviewed)
14. Effects of Local Anesthetics on Liposomal Membranes Determined by Their Inhibitory Activity of Lipid Peroxidation, Y. Horizumi, S. Goto, M. Takatsuka, H. Yokoyama, Mol. Pharmaceutics, 20, 2911-2918, 2023. (Peer-reviewed)
15. Degradation and Drug Release Profile of Degradable Core-Corona Type Particles under Acidic Condition for Cancer Treatment, S. Komatsu, S. Ishida, T. Asoh, A. Kikuchi, React. Funct. Polym., 177, 105321, 2022. (Peer-reviewed)
16. Influence of Ion Exchange on Photoresponsive Properties of Potassium Poly(Heptazine Imide), M. Hattori, M. Nakamichi, A. Yamaguchi, C. Miyazaki, G. Seo, R. Ohnuki, S. Yoshioka, K. Kanai, Chem. Mater., 35, 1283-1294, 2023. (Peer-reviewed)

17. Boron-Doped Diamond Powder-Packed Electrolysis Flow Cell, T. Kondo, S. Nakamura, T. Tojo, M. Yuasa, Chem. Lett., 51, 873-876, 2022. (Peer-reviewed)
18. High-Throughput Transient Photoluminescence Spectrometer for Deep Learning of Thermally Activated Delayed Fluorescence Materials, M. Furukori, Y. Nagamune, Y. Nakayama, T. Hosokai, J. Mater. Chem. C, 11, 4357-4364, 2022. (Peer-reviewed)

Books

1. 錯体化学会フロンティア選書「フロンティア　ナノ金属錯体」 3.3 ナノ金属錯体集積体に安定化される巨大ナノチューブ型水分子クラスター, 田所誠, 三共出版, 108-128, 2022. (in Japanese)
2. 製品利用に向けたバイオマテリアル開発の基本事項と注意点 —材料の特徴・材料劣化・表面解析・安全性試験・ニーズ収集—, 佐川拓矢, 橋詰峰雄, 情報機構, 33-44, 2022. (in Japanese)
3. イオン液体の実用化に向けた最新動向, 川田将平, 佐々木信也, シーエムシー出版, 216-222, 2022. (in Japanese)

Invited Lectures

1. Research on Properties and Functionalities of Vesicles Formed by Surfactants and Lipids, H. Sakai, 2nd World Congress on Oleo Science (WCOS 2022), 2022.
2. Novel Liposomes and Niosomes with High Effectiveness and Sustainability for Cosmetic Applications in the Post-Pandemic Era, H. Sakai, The Cosmetic and Beauty International Conference 2022 (CBIC 2022), Chiang Rai, Thailand, 2022.
3. Novel “Photoswitchable” Molecular Assemblies, H. Sakai, M. Akamatsu, K. Sakai, The 5th International Conference on Nanospace Materials (ICNM2022), Pattaya, Thailand, 2022.
4. Molecular Conductor with Proton-Assisted Electron Transfer, M. Tadokoro, ICPAC (International Congress on Pure & Applied Chemistry), Kota Kinabalu, Malaysia, 2022.
5. Ligand-Protected Metal Nanoclusters: Recent Development in Synthesis and Application in Energy and Environmental Field, Y. Negishi, Special Seminar in Department of Chemical Engineering of National University of Singapore, National University of Singapore, 2022.
6. Dynamics and Control of the Injection Front Induced by Precipitation Formation, Y. Sumino, Active Matter Workshop 2023 Tokyo, 2023.
7. Tribology That Contributes to the Realization of a Carbon-Neutral Society, S. Sasaki, India International Tribology Conference 2022, New Delhi, India, 2022.
8. Stimuli-responsive particles as biomaterials, A. Kikuchi, International Symposium on Advanced Biomaterials, Nomi, Ishikawa, Japan Advanced Institute of Science and Technology, and Online, 2022.
9. Improved Stability of Foams in Ethanol/Water Mixtures, K. Sakai, JOCS-AOCS Joint Meeting in the 2nd World Congress on Oleo Science (WCOS2022), Online, 2022.
10. Epitaxial Organic Molecular Interfaces as Well-ordered Model Systems for Molecular Semiconductor p-n Junctions for Optoelectronic Applications, Y. Nakayama, 241st ECS Meeting, Canada, 2022.

Patent

1. 根岸雄一, Saikat Das, 関根大修, 馬淵春菜, Ag ナノクラスター集積体およびその製造方法, 特願 2022-101501, 2022. (in Japanese)

Public Relations

1. Novel Multi-Proton Carrier Complex as Efficient Proton Conductor at High Temperatures Researchers develop a highly symmetric ruthenium (III) complex with six imidazole-imidazolate groups for efficient high-temperature proton conduction in fuel cells, Tokyo 8 July 2022.
https://www.tus.ac.jp/today/archive/20220719_8127.html

2. 根岸雄一, 軽元素の優れた多孔質材料を合成, 幅広い応用期待 東京理科大, JST Science Portal, 2022. (in Japanese)
3. 中山泰生, 日刊工業新聞 2023 年 3 月 23 日朝刊 33 面「蛍光材料 3 秒で測定」(in Japanese)
4. 酒井健一, 泡タイプのエタノール消毒剤, 抗菌剤の実現に光　～高濃度エタノール水溶液によって形成される泡の安定化に成功～, 2022. (in Japanese)

Awards

1. 酒井秀樹, 日本油化学会賞, 2022. (in Japanese)
2. 根岸雄一, IAAM Innovation Award, 2022. (in Japanese)
3. 佐々木信也, 日本機械学会賞（技術）, 2022. (in Japanese)
4. 酒井健一, 油脂技術優秀論文賞, 2023. (in Japanese)

Individual Research Topics

Hideki Sakai

"Dynamics of photo-responsive molecular assemblies studied by simultaneous measurements of small angle neutron scattering (SANS) and UV/Visible absorption spectroscopy"

An advanced analysis system combining a small angle neutron scattering (SANS) instrument with a spectrophotometer has been co-developed. This system evaluated the dynamics of structural changes under light irradiation of molecular assemblies formed by novel photo-responsive amphiphilic molecules (amphiphilic lophine dimers) and the release and uptake of fluorescent probes contained in the assemblies. It was found that the fluorescent molecules were rapidly released to the bulk solution in the initial stage of the morphological change of the molecular assemblies induced by the photoisomerization reaction.

Makoto Tadokoro

"Self-organization to nano-porous crystals containing PEG-M^+ ionic conductors and their physical properties"

One-pot synthesis using self-organization is used to construct nano-porous crystals enclosing solid electrolytes of polyethyleneglycol (PEG) and alkali metal ions (M^+). This PEG-M^+ is confined in an anionic one-dimensional nanochannel interface and is a stimulus-responsive molecular crystal that can transport ions in response to an electric field.

Hidenori Otsuka

"Activation of redox reaction by polymerization of complexes and evaluation of anticancer activity"

To solve the remaining problems in the conventional standard treatment for cancer, we (1) developed a macromolecular drug as a cytotoxic anticancer drug with a high antitumor effect, and (2) improved side effects by using a target-directed DDS that can be delivered only to cancer cells and at lower doses. Thus, an improvement in treatment satisfaction has been achieved. In this study, it was found that the multivalency effect of the polymeric metal complexes, which are grafted in a macromolecular backbone, causes a more efficient DNA cleavage reaction, resulting in high anti-cancer activity.

Yuichi Negishi

"Synthesis and structural design of novel metal nanocluster linkages"

Metal nanoclusters with a particle size of ca. 1 nm exhibit electronic/geometric structures different from those of bulk metals and have been actively studied as new nanomaterials. Furthermore, metal-nanocluster self-assembled materials are expected to produce new physicochemical properties based on the interaction among the metal nanoclusters. Therefore, we aim to create metal nanoclusters and metal-nanocluster self-assembled materials to develop new physical properties using them.

Yutaka Sumino

"Experimental study of active interface-patterns and dynamics"

A surfactant changes the surface tension of an interface and the rheology of the bulk solution. These characteristic features of surfactant can create an active interface with deformation and flow when a system is under far-from-equilibrium conditions with the flux of chemicals. In this research project, we created a system with floating camphor particles that modify surface tension and sublimate from an interface. We also created a system with inner and outer fluids that creates a worm-like micellar solution when they are mixed. With these systems, we analyzed spatiotemporal patterns and motion of interface and created simplified mathematical models that reproduce essential features of the experimental results.

Kenichi Aoki

"Large-scale synthesis of dendritic polyacrylates and polyols and their application to photofunctional materials"

We have developed a large-scale synthesis method of polyol and polyacrylate dendrimers in one-pot manners by alternately repeating two types of click reaction, Michael addition and urethane formation. Partial modifications of the dendritic terminals with carboxylic acid derivatives gave water-soluble dendrimers to apply to benign UV-curable resins of VOC-free types.

Takeshi Kawai

"Fabrication of emulsions developing color in two temperature ranges"

We have reported the development of a consistent structural color within a narrow temperature range for all-liquid-type emulsions comprising a long-chain amidoamine derivative and tetraoctylammonium bromide. We examined the phenomenon of rapid color change under external mechanical stimuli (e.g., stirring) in detail. The color change was caused by changing the emulsion from a lamellar phase to a cubic phase with stirring. We also demonstrated that the return time from the cubic phase to the lamellar phase was shortened with an increase in temperature.

Yukishige Kondo

"Novel preparation of flexible freestanding thin films from low-molecular-weight compounds"

We have found that azobenzene derivatives form golden luster crystal films. In this study, we synthesized new low-molecular-weight compounds having azobenzene structures at both ends of tetraethylene glycol to add flexibility to this golden luster crystal film. As a result, it is found that the freestanding thin film composed of the novel compound is flexible and can be bent many times.

Mineo Hashizume

"pH-Responsiveness of molecules loaded in polysaccharide polyion complexes"

We have been conducting functionalization of freestanding films made of polyion complexes consisting of oppositely charged polysaccharides. In this fiscal year, we focused on the stimuli-responsiveness of the molecules loaded in the films. The films loading pH-responsive fluorescein (FL) molecules were prepared to evaluate the pH responsiveness of the FL in the films. The results showed that the ionic structure of FL in the films was different from that in solution under neutral pH regions, which indicated that the interactions with polysaccharides can control the pH responsiveness of loaded molecules.

Hitoshi Ishikawa

"Study of flow control by viscosity change"

The viscosity of CTAB/C4AzoNa solution is increased by irradiation of UV light and decreased by visible light. The solution in a small gap of rotating coaxial cylinders was irradiated locally by UV light to measure its torque caused by shear force. The local irradiation of UV light enables local viscosity change of the solution and increases the torque larger than the overall irradiation.

Shinya Sasaki

"Study on growth process of chemical reaction film formed on friction surface"

A chemical reaction film derived from lubrication oil additives with a thickness of about 100 nm is formed on the friction interface under lubrication. By in situ observation of the growth process of reaction film using AFM, we researched the effect mechanism of additives on friction and wear behavior of the Tribo-system.

Satoru Goto

“Hyperspace analysis of experimental data treated by singular value decomposition”

Singular value decomposition (SVD) separates and extracts the tendency depending on the experimental condition parameters from the observed data. Our subjects involve the fluorescent probe responses to neutral surfactants on cyclodextrin as a protein model, interaction of polypharmacy drugs with cyclodextrin as a drug carrier, adsorption of drugs and dyes to polyfluorocarbon membranes, and the inhibitory activity of drugs to the protective action of tocopherol derivatives on liposomal lipid peroxidation.

Akihiko Kikuchi

“Preparation of stimuli-responsive nanoparticles for diagnostic use”

For a simple diagnosis of blood glucose levels using dispersibility changes of nanoparticles, we prepared thermoresponsive core-corona type nanoparticles having phenylboronic acid (PBA) at the outermost surfaces with a particle diameter of 280 nm. The nanoparticles showed dispersion and aggregation changes in the glucose concentration range of 100~200 mg/dL at a given temperature. These results indicate the possibility of diagnosis of blood glucose levels using the hydrophilic/ hydrophobic surface property alteration of the particle surfaces.

Kaname Kanai

“Mechanism of poly(heptazine imide) photo-catalyst”

Poly(heptazine imide) (PHI) is a photo-catalyst 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 irradiated conditions, stable hydrogen collection can be realized by combining its 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.

Takeshi Kondo

“Application of surface-modified conductive diamond powder to electrochemical detection”

Boron-doped diamond powder (BDDP)-cast electrodes are fabricated by casting an ink containing BDDP and polyester resin binder onto a screen-printed graphite electrode. Based on the low background current at the BDDP-cast electrode, electrochemical detection of levofloxacin via square-wave voltammetry showed a lower detection limit of 0.29 mM at the oxygen-terminated BDDP-cast electrode than at the bare graphite-printed electrode (1.07 μM).

Kenichi Sakai

“Enhancing the foam stability of aqueous solution with high ethanol concentration”

The foam stability in an aqueous solution with a high ethanol concentration (60 vol.%) was assessed under the co-addition of an anionic surfactant, a long-chain alcohol, and an inorganic electrolyte. The addition of the electrolyte resulted in a decreased surface tension and an increased surface viscosity, leading to enhanced foam stability. This study proposes a new strategy for formulating foam-type disinfectants with high ethanol concentrations.

Yasuo Nakayama

“Design and characterization of well-defined epitaxial molecular semiconductor interfaces”

The functionalities of organic electronic devices such as OLEDs originate from the interfaces where different kinds of organic semiconductor molecules make direct contact with each other. Hence, the structural designs and electronic properties at such interfaces are the key points of the development. In FY2022, our group published a review paper summarizing well-defined epitaxial interfaces of organic semiconductor molecules. We have also developed a method to evaluate the light-emitting properties of luminescent molecules for OLEDs quickly and efficiently as cooperative research with our joint graduate school (AIST).

Chemical Biology Division Supported by Practical Organic Synthesis

Chemical Biology Division Supported by Practical Organic Synthesis

1. Overview

Most human medicines comprise carbon-based organic compounds synthesized through multiple reaction steps, consuming considerable time and effort and discarding much waste. As a result, the production of pharmaceuticals has a huge environmental burden.

Our synthetic team has investigated reaction methods to improve the synthetic yield of pharmaceutical products to the maximum. In 2002, the Shiina group developed a new dehydration condensation agent, 2-methyl-6-nitrobenzoic anhydride (MNBA), which can drastically enhance the production efficiency of antibiotics and anticancer drugs.

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 since the establishment of this new synthetic method.

One of the achievements of this year is the total synthesis of violaceoids. Violaceoids are compounds whose structures were determined after the isolation from cultures of fungi parasitic on moss inhabiting Arashiyama, Kyoto. Violaceoids are expected to be novel lead compounds for anticancer drugs because of their toxicity to cancer cell lines. In addition, we newly synthesized 1,4-dideoxyviolaceoid A and 1,4-dideoxyviolaceoid B as artificial analogues of natural products violaceoid A and violaceoid B, respectively.

In 2022, we investigated the ability of the 1,4-dideoxyviolaceoids to inhibit cell proliferation in multiple cell lines such as lung adenocarcinoma strains NCI-H1650 [EGFR(Δ746-750)], PC-9 [EGFR(Δ746-750)] and breast adenocarcinoma strain (MDA-MB-231). Natural violaceoid B exhibited effective growth inhibition against NCI-H1650 with $GI_{50} = 30\ \mu M$. The artificially synthesized 1,4-dideoxyviolaceoid B also exhibited specific activity ($GI_{50} = 50\ \mu M$) against NCI-H1650. Therefore, various violaceoids can selectively suppress the proliferation of cancer cells.

This research division has independently developed anticancer drugs using protein intracellular transport inhibitors as molecular-targeted drugs and antiviral drugs originating from our university, and applications based on basic research. We are promoting practical research strongly oriented to developing new drugs through industry-academia collaboration. A new research organization will be established in 2023 after the closing of the current division in 2022 due to the expiration of the research period. We will continue research and development aimed at social implementation.

2. Organization and Facilities

This research division supported the close collaboration between the synthetic organic chemistry group and the chemical biology group inside and outside the university from 2018 to 2022. The division consists of 2 groups: the development and application of practical organic synthesis technology group and the chemical biology and drug development group. 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 located at Kagurazaka School Building No. 11 Annex. The facility takes over nuclear magnetic resonance

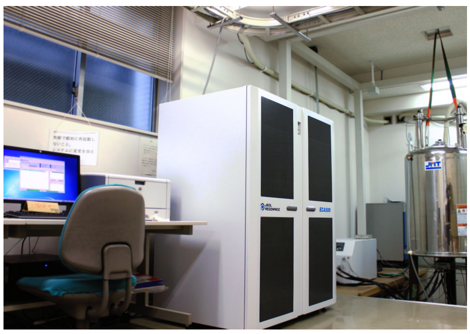


Fig. 1. NMR Equipment (500 MHz).

spectrometers (500 MHz (Fig. 1) and 300 MHz NMR), a gas chromatograph mass spectrometer, and time-of-flight mass spectrometers from The Chirality Research Center (2012-2016, Center Director: Isamu Shiina), the predecessor of this research division. In addition, the facility has other analytical instruments such as a single-crystal X-ray structure analyzer and a circular dichroism spectrometer (CD). We have used these high-performance analyzers effectively to promote research.

3. Activity Reports

3. 1. The Development and Application Group for Practical Organic Synthesis Technology

We have developed total synthesis of natural products, asymmetric synthesis using organic catalysts and metal complexes, dehydration condensation reactions, and asymmetric self-amplification reactions to provide practical organic synthesis methods.

3. 2. The Chemical Biology and Drug Development Group

Ridaifen which is the university's original compound is our main research object. Ridaifen was synthesized using the technology of our research division to investigate its biological activity in the Shiina, Shimonaka, Sakai/Sakai, Higami, and Mano laboratories. In addition, the Shiina, Shimonaka, and Kawasaki laboratories collaboratively evaluated the biological activity of compounds obtained by asymmetric synthetic technology. To expand the applicability of asymmetric synthetic technology in the research on bioactive compounds, we will develop drugs based on the synthesis of natural products with complicated structures. We have conducted research and development to launch antifungal agents with FE399 as the core, and antitumor agents with tanzawaic acid B and violaceoids as the cores.

4. Challenges and Prospects

All the issues 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 translational research [Seeds preB] in 2020-21, and AMED [Innovative Cancer Treatment Practical Research Project] in 2022-25 (Reference 1). We have established a method to synthesize tanzawaic acid analogs on a gram scale and have confirmed their anticancer effects on mutated cancers, resistant cancers, and endoplasmic reticulum stress-sensitive cancer cells at a non-clinical level. We are acquiring data sets to prepare PMDA interviews to complete the non-clinical studies required for the start of clinical trials.

The division will be reorganized to establish a new organization in 2023 because of the expiration of the research period in 2022. We will continue research and development aimed at social implementation.

5. Conclusion

The Chemical Biology Research Division based on practical organic synthesis is an organization that actively supported the close collaboration between the synthetic organic chemistry groups and the chemical biology groups inside and outside the university from 2018 to 2022. We promoted the project as planned. During this period, we effectively used the organic synthesis methods and compounds developed at our university. We will expand our division to apply them to fundamental and biological research.

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Major Research Achievements（FY2022）

Academic Papers

1. The First Total Synthesis of Tanzawaic Acid B, Takatsugu Murata, Hisazumi Tsutsui, Takumi Yoshida, Hirokazu Kubota, Shintaro Hiraishi, Hiyo Natsukawa, Yuki Suzuki, Daiki Hiraga, Takahiro Mori, Yutaro Maekawa, Satoru Tateyama, Kiyotaka Toyoyama, Keiichi Ito, Kyohei Suzuki, Keita Yonekura, Natsumi Shibata, Teruyuki Sato, Yasutaka Tasaki, Takehiko Inohana, Atsuhiro Takano, Naoki Egashira, Masaki Honda, Yuma Umezaki, Isamu Shiina, ChemRxiv, DOI: 10.26434/chemrxiv-2022-p8hxs-v3.
2. First Total Synthesis of (–)-Merrillianin, Isamu Shiina, Takashi Iizumi, Saori Taniguchi, Masuhiro Sugimoto, Takahisa Shimazaki, Yu-suke Yamai, Go Ogawa, Tetsuro Yamada, Shojiro Shinohara, Yosuke Kageyama, Teppei Kuboki, Yuki Suwa, Keita Yonekura, Keiichi Ito, Kiyotaka Toyoyama, Satoru Tateyama, Takahiro Mori, Takatsugu Murata, ChemRxiv, DOI: 10.26434/chemrxiv-2022-0k1bz.
3. Golgi Retention and Oncogenic KIT Signaling via PLCγ2-PKD2-PI4KIIIβ Activation in GIST Cells, Yuuki Obata, Kazuo Kurokawa, Takuro Tojima, Miyuki Natsume, Isamu Shiina, Tsuyoshi Takahashi, Ryo Abe, Akihiko Nakano, Toshirou Nishida, bioRxiv, DOI: https://doi.org/10.1101/2022.12.19.520889.
4. Chirally and Chemically Reversible Strecker Reaction,Yutaro Machida, Yudai Tanaka, Yuya Masuda, Aya Kimura, Tsuneomi Kawasaki, *Chemical Science*, **2023**, *14*, 4480-4484. (Peer-reviewed)
5. Asymmetric Strecker Reaction at the Solid/Solid Interface, Yuki Yoshimura, Yudai Tanaka, Ryota Kobayashi, Kohei Niikura, Tsuneomi Kawasaki, *Organic & Biomolecular Chemistry*, **2023**, *21*, 520-524. (Peer-reviewed)

Books/Reviews/Commentaries

1. 椎名　勇, 椎名研究室で合成された「リダイフェン」ならびに「タンザワ酸 B」の名称の由来に関する解説, 教育情報紙「朝日新聞　EduA（エデュア）」, 2022 年 10 月 14 日（in Japanese）
2. Asymmetric Autocatalysis as an Efficient Link Between the Origin of Homochirality and Highly Enantioenriched Compounds, Kenso Soai, Tsuneomi Kawasaki, Arimasa Matsumoto, *Origins of Life and Evolution of Biospheres*, **2022**, *52*, 57-74. (Peer-reviewed)
3. キラリティの基礎および生命のホモキラリティの意義と起源, 硤合憲三, 川﨑常臣, *化学と教育*, **2022**, *70*, 254-257.（in Japanese）

Invited Lectures

1. 椎名　勇, 臨床試験を目指した全合成研究ならびに生命現象解析ツールとしての有機合成化学, 早稲田大学理工学術院総合研究所　先端化学知の社会実装研究所　第 15 回先端化学知の社会実装コロキウム, 2022 年 10 月 12 日, 早稲田大学・西早稲田キャンパス. (in Japanese)
2. Tsuneomi Kawasaki, Chiral hydrogen isotopomer induced highly enantioselective amino acid synthesis with amplification of enantiomeric excess of alpha-aminonitrile, CD 2022; 18th ICCS, July 25th, 2022, New York University, New York.
3. 川﨑常臣, ストレッカー合成を利用したアミノ酸ホモキラリティの研究, 計算アストロバイオロジー2022, 2022 年 11 月 11 日, 筑波大学・筑波. (in Japanese)

Public Relations

1. 椎名　勇, 下仲基之, 真野泰成, 《令和 4 年度　「革新的がん医療実用化研究事業」（一次公募）の採択課題について》, 日本医療研究開発機構（AMED）採択課題発表, 2022 年 4 月 1 日公開（https://www.amed.go.jp/koubo/15/01/1501C_00038.html）.（in Japanese）
2. 椎名　勇, 《アクセリード株式会社が非臨床試験の実施を支援する東京理科大学・椎名教授の新規抗がん剤開発に関する研究課題が、AMED「革新的がん医療実用化研究事業」に採択》, Axcelead Drug Discovery Partners 社」HP ニュース, 2022 年 4 月 1 日報道 (https://www.axcelead.com/info/7091/). (in Japanese)

Awards

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2. Tsuneomi Kawasaki, *Organic & Biomolecular Chemistry* (Volume 21, Issue 3), Selected as Front Cover, January 21st, 2023, Royal Society of Chemistry.
3. Chihiro Kase (Master course student, Kawasaki Laboratory), Molecular Chirality Asia 2022 Online Poster Award, October 29-31st, 2022, Molecular Chirality Research Organization.

Individual Research Topics

Development and Application Group for Practical Organic Synthesis Technology

Isamu Shiina and **Takatsugu Murata**

“Development of anticancer agents from naturally occurring products”

Violaceoids are compounds whose structures were determined after the isolation from cultures of fungi parasitic on moss inhabiting Arashiyama, Kyoto. Violaceoids are expected to be novel lead compounds for anticancer drugs because of their toxicity to cancer cell lines. In 2022, we designed and synthesized new analogue compounds such as 1,4-dideoxyviolaceoid A and 1,4-dideoxyviolaceoid B based on the molecular structures of natural violaceoids, and we investigated their growth inhibitory effects on cancer cells.

Tsuneomi Kawasaki

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

Amino acids are typical chiral compounds that make up living organisms. Although amino acids have the L- and D-enantiomers (homochirality), only the L-enantiomers compose living organisms. In a study on the reaction pathway leading to homochirality in biologically relevant compounds, we elucidated the asymmetric generation and amplification mechanism for aminonitrile as an intermediate in the Strecker amino acid synthesis. We conducted a cell proliferation inhibitory activity test using amino acid derivatives prepared by the Strecker synthesis and found a novel compound that does not affect the proliferation of both cancer and normal cells. In FY2022, we expanded the compound library in preparation for concluding a contracted compound evaluation system with Inospin.

Chemical Biology and Drug Development Group

Motoyuki Shimonaka

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

Various boron-containing compounds including boronophenylalanine analogues were synthesized using asymmetric synthesis in the Shiina and Kawasaki laboratories. We examined the toxicity of synthesized compounds to cancer cells, normal skin cells, and other cancer cells to classify them into two groups according to the presence or absence of cytotoxicity. As a result of the examination, we successfully obtained novel compounds that are selectively toxic to specific cancer cells and others that do not affect the proliferation of cancer cells and normal cells. In 2022, we compared the cell growth inhibitory ability of natural violaceoids and artificial violaceoids using multiple cell lines such as lung adenocarcinoma cell lines. The in vitro growth suppression studies showed high activities of Violaceoid B and 1,4-Dideoxyviolaceoid B against NCI-H1650 with GI_{50} = 30 μM and GI_{50} = 50 μM, respectively.

Yoshikazu Higami

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

Lipoprofen is a novel cholesterol accumulation-inducing compound found in the Shiina Laboratory. We intraperitoneally administered lipoprofen to diet-induced obesity model mice for 3 weeks to demonstrate its cholesterol-lowering effect on the animal level. As a result, lipoprofen administration reduced the total cholesterol level in the blood by about 30%. Furthermore, we confirmed an increase in the gene expression of the LDL receptor important in cholesterol uptake and an insignificant change in the cholesterol level in the liver of the treated group. This result suggests that lipoprofen lowers blood cholesterol by promoting cholesterol uptake into the liver and its metabolism in the liver. A preliminary *in vivo* test was performed by oral administration to support the above biological activity, and a similar decrease in blood total cholesterol was observed.

Yasunari Mano

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

We analyzed pharmacokinetics by the time sampling of blood and urine from male Wistar rats after the single intravenous dose of lipoprofen. The elimination half-life of lipoprofen in the rats was approximately 3.6 hours with a biphasic transition with a gradual decrease following a rapid elimination until 1 hour after the administration. It was revealed that lipoprofen has moderate clearance and is a liver-metabolized drug with a large volume of distribution. 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. Subsequent preliminary *in vivo* studies were conducted with the "PassPort® System", and we observed a reduction in blood total cholesterol similar to the results obtained with intraperitoneal administration.

Kenichi Sakai

"Analysis and evaluation of the behavior (transport) of ridaifen from the aspect of biocolloid surface chemistry and formulation"

The skin permeability of redaifen was verified from a physicochemical point of view. In the percutaneous absorption test, the ridaifen derivative was applied to hairless rat skin using a vertical diffusion cell (Franz cell). Thereafter, the receptor solution was sampled over time, and the amount of percutaneous absorption of ridaifen was measured by high-performance liquid chromatography. As a result, we were able to quantitatively demonstrate that the application of the "PassPort® System" promotes the penetration of the ridaifen derivative into the stratum corneum of the skin.

Advanced Composite Materials and Structural CAE Research Division

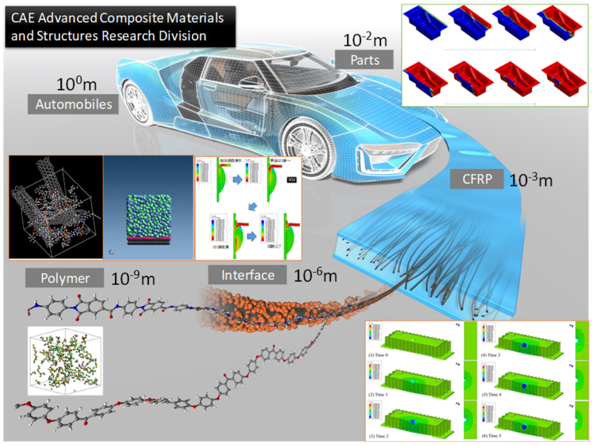
Advanced Composite Materials and Structural CAE Research Division

1. Overview

The Advanced Composite Materials and Structural CAE Research Division focuses on composite materials, which can be said to be the materials of the 21st century. With the motto of “hands-on”, we aim to train and produce CAE engineers whose demand has been increasing in the industry in recent years.

2. Organization and Facilities

Prof. Koyanagi (division chair), Prof. Kogo, Prof. Okada, Prof. Ogihara, Prof. Arimitsu, Prof. Takahashi, Prof. Matsuzaki, Junior Associate Professor Inoue, Assistant Professor Arai, and Assistant Professor M. Fikry are affiliated with this division. The above faculty members from the materials system to the computational science department are conducting interdisciplinary research on composite materials by making full use of CAE technology. Our division did not introduce additional facilities or equipment until the end of FY2022. On the other hand, we already possess high CAE technologies. We have contributed to the industry in the long term by teaching these technologies to students and producing talented graduates.



3. Activity Reports

Our steady research and education activities until the last year successfully acquired large-scale funding from 2022. As a co-investigator of the Full-scale R&D Project in JST-Mirai Program, Tokyo University of Science (TUS) will receive 138 million yen in direct expenses from 2022 to 2026. The project title is “Elucidation of Fatigue Deterioration Mechanism and Establishment of Evaluation Method to Estimate the Remaining Life of CFRP Laminates” and the principal investigator is Professor Arai of Nagoya University. A large-scale share of the research expenses was allocated to the TUS group led by Professor Koyanagi, the head of the department, as the first collaborative group. In FY2022, 30 million yen was allocated as direct expenses. More than 20 million yen will be distributed every year from 2023.

On the other hand, regarding the Ministry of Land, Infrastructure, Transport and Tourism Moon Residence Program, which is a part of the Stardust Program, the theme of CFRP 3D printing was adopted as a contributor. In 2022, TUS was funded with a research budget of 2 million yen, and this fund will continue until 2025. In 2022, the theme of CFRP 3D printing was adopted in JAXA joint research, and 5 million yen in research funding was obtained.

4. Challenges and Prospects

This division aims to acquire large-scale funding for three main projects: research on the strength and durability of CFRP, research on ultrasonic welding of thermoplastic CFRP, and research on CFRP 3D printers. However, funding for research on ultrasonic welding has not been achieved. In FY2022, we would like to promote the practical application of the technology and aim to acquire large-scale funds for the theme.

5. Conclusion

Five years have passed since the inauguration of the department, and we have achieved great results in terms of obtaining research funds and publishing papers. We believe that the acquired research budget scale is enough to promote the department to a center. However, our application to promote our department to a center in FY 2022 was unfortunately rejected. From FY2023, we will continue our activities as a department again. Aiming to attract more and more attention as a base for research on composite materials in Japan, we will build stronger industry-academia collaboration.

Major Research Achievements (FY 2022)

Academic Papers

1. N. Yamada, Y. Oya, N. Kato, K. Mori, J. Koyanagi, A molecular dynamics simulation for thermal activation process in covalent bond dissociation of a crosslinked thermosetting polymer, Molecules, Vol. 28 (2023), pp. 2736.
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4. Shun Iwamoto, Yutaka Oya, Jun Koyanagi, Evaluation of microscopic damage of PEEK polymers under cyclic loadings using molecular dynamics simulations, Polymers, Vol. 14 (2022), pp. 4955.
5. J. Kajimoto, A. Fujii, Y. Maruyama, H. Kajita, J. Koyanagi, R. Matsuzaki, Automatic strengthening in thickness direction using lap joint of carbon fiber for fused filament fabrication 3D printing, Composite Structures, Vol. 303 (2023), pp. 116290.
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7. M. Morita, Y. Oya, N. Kato, K. Mori, J. Koyanagi, Effect of electrostatic interactions on the interfacial energy between thermoplastic polymers and graphene oxide: a molecular dynamics study, Polymers, Vol. 14 (2022), pp. 2579.
8. Y. Sato, S. Masumizu, K. Sakaue, J. Koyanagi, A. Ohtani, T. Sakai, Evaluation of viscoelastic non-isochoric plastic behavior of PBT and PA6, Mechanics of Time-Dependent Materials, Vol. 27 (2023) pp. 829-841.
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11. T. Sakai, N Takase, Y. Oya, J. Koyanagi, A possibility for quantitative detection of mechanically-induced invisible damage by thermal property measurement via entropy generation for a polymer material, Materials, Vol. 15 (2022), pp. 737.
12. J. Koyanagi, M. Takamura, K. Wakayama, K. Uehara, S. Takeda, Numerical simulation of ultrasonic welding for CFRP using energy director, Advanced Composite Materials, Vol. 31 (2022), pp. 428-441.
13. Yutaro Arai, Yuka Daigo, Esuke Kojo, Ryo Inoue, Yasuo Kogo, Geometric factors affecting Young's modulus of porous carbon with a three-dimensional network structure, International Journal of Applied Ceramic Technology, Vol. 19, pp. 523-532.
14. Daisuke Kuba, Ryosuke Matsuzaki, Shono Ochi and Shinji Ogihara, 3D printing of composite materials using ultralow-melt-viscosity polymer and continuous carbon fiber, Composites Part C, Vol. 8, pp. 100250.
15. M. J. Mohammad Fikry, Vladimir Vinogradov and Shinji Ogihara, Experimental observation and modeling of resin pocket cracking in unidirectional laminates with ply discontinuity, Composites Science and Technology, Vol. 218, pp. 109175.
16. M. Parker, A. Inthavong, E. Law, S. Waddell, N. Ezeokeke, R. Matsuzaki, D. Arola, 3D printing of continuous carbon fiber reinforced polyphenylene sulfide: exploring printability and importance of fiber volume fraction, Additive Manufacturing, Vol. 54, pp. 102763.

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20. Hiroshi OKADA, Daichi NAKAHARA, Ayaka NAGASHIMA, Rino WATANABE, Yusuke SUNAOKA, Yasunori YUSA, Yuto OTOGURO, Singular patch method for linear elastic fracture mechanics analysis using isogeometric analysis, Mechanical Engineering Journal, Vol.9, pp. 22-00291.
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22. M. S. Shaari, S. D. Urai, A. Takahashi, M. R. M. Akramin, Predicting Fatigue Crack Growth Behavior of Coalesced Cracks Using the Global-Local Superimposed Technique, Fracture and Structural Integrity, vol. 62 (2022) pp. 437-446.
23. Masahiro Furutani; Kentaro Nakayama; Kazuki Okuma; Koji Arimitsu, Role of dipyridyl disulfide cross-linking moieties in an acrylate photo-adhesive material, Journal of Polymer Research, vol. 29 (2022) 245.

Book

1. Jun Koyanagi, Numerical simulation for tensile failure of fiber-reinforced polymer composites based on viscoelastic-entropy-damage criterion, Advanced Structured Materials, Vol. 188 (2023), pp. 65-83.

Individual Research Topics

Jun Koyanagi

"Mechanical study of composite materials using CAE technology"

Our research target is advanced composite materials, which are the materials of the 21st century, represented by carbon fiber reinforced plastics (CFRP). We have conducted engineering research by utilizing CAE technologies such as the molecular-level material development using the molecular orbital method (MO) and molecular dynamics (MD), the destruction simulation using the finite element method (FEM), particle method (SPH), and computational fluid dynamics (CFD), the design of actual structures, molding simulation, and fluid analysis. We have carried out practical research activities as joint research with manufacturers and contributed directly to the industry. Furthermore, we have trained and produced able CAE engineers for the industry.

Shinji Ogihara

"Research on Microscopic Damage Behavior of Fiber Reinforced Composites"

We experimentally studied the microscopic damage generation and propagation process within the material due to various forms of load, mainly in laminated fiber-reinforced composite materials. Furthermore, we experimentally evaluated the effect of damage on the mechanical properties of the material. Based on the obtained results, we compared them with the predictions by the finite element method and the damage mechanics model and examined their validity. We laid the foundation for application to material systems with more complicated internal structures. This is expected to contribute to the structural integrity evaluation of materials in operation.

Ryosuke Matsuzaki

"Research on 3D printing of composite materials"

We develop 3D printing to create high-strength and high-rigidity products that can be applied to structural materials for automobiles and aerospace using resin-based composite materials reinforced with continuous carbon fibers. This fiscal year, we conducted optimization and demonstration tests of fiber orientation including curved fibers, and researched the superiority and issues of composite 3D printing.

Ryo Inoue

"Study on visualization of deformation/damage of inhomogeneous materials"

Understanding the local deformation distribution in composite materials is essential to clarify their damage and failure and derive new material design criteria. In the case of composite materials with a ceramic matrix, their local deformation distribution must be measured at high temperatures. However, the influence of thermal radiation makes accurate evaluation difficult. In this fiscal year, we succeeded in visualizing three-dimensional deformation on the material surface in an environment exceeding 1000°C and the mismatch of the elastic modulus and thermal expansion coefficient of the constituent materials. In addition, we succeeded in quantitatively understanding the deformation distribution inside the material from the volume images acquired by laboratory and synchrotron CTs. We plan to develop the strength and life prediction using machine learning based on the obtained data.

Hiroshi Okada

"Study on linear/nonlinear fracture mechanics analysis for inhomogeneous materials"

The weld metal and heat-affected zone of weld joints are inhomogeneous because the thermal history and solidification process during welding affects the mechanical properties of the materials. A functionally graded material regarded as a kind of composite material creates a spatial distribution of the intended mechanical and thermal properties of the material. In general, the mechanical and thermal properties change continuously within the material. I have researched stress intensity factor calculation methods using the J-integral and cross-integral methods for rigorously evaluating the fracture mechanics of materials with non-uniform mechanical properties. In this fiscal year, various mutual integral method formulations were formulated and their accuracy was evaluated to advance linear fracture mechanics analysis of welded joints and functionally graded materials. In addition, we have advanced the analysis method of the cycle jump method to shorten the analysis time of fracture phenomena progressing under cyclic loading.

Akitoshi Takahashi

“A study on quantitative fatigue crack propagation analysis considering the effect of crack opening and closing behavior”

In the fatigue crack growth problem, it is known that the plastic deformation of a small region at the crack tip changes the opening and closing behavior of the crack tip, which slows down the fatigue crack growth rate. Numerical analysis of opening and closing behavior using elastoplastic finite element analysis was implemented in the fatigue crack growth analysis system using the polymerization mesh method that we have developed. The system enabled us to directly calculate the effect of plastic deformation at the crack tip on the fatigue crack growth rate. Furthermore, we created a model of the opening and closing behavior by two-dimensional elastoplastic analysis as a different approach. A Three-dimensional fatigue crack growth analysis based on the model realized a simple fatigue crack propagation simulation considering the opening and closing behavior.

Yasuo Kogo

“Research on the mechanical properties of CFRP ropes for electric wires”

We are studying the mechanical properties of CFRP ropes. They are special composite ropes made by twisting seven strands of CFRP and used as the core materials in power transmission cables. However, their mechanical behaviors remain unclear. In this study, we evaluate the mechanical behavior of the twisted CFRP single wire and the CFRP rope made from strands of single wires. In this fiscal year, we performed a characteristic test using the compression bending test method to evaluate their mechanical properties without the effect of the contact area. We confirmed the extremely high usefulness of this test for the evaluation of flexural deformation and fracture behavior.

Koji Arimitsu

“Research on anionic UV curing of epoxy/bismaleimide mixed resin”

When anionic UV curing of a mixed resin film consisting of a photobase generator, bismaleimide resin (BMI), and epoxy resin (jER828) is performed, a higher hardness than each resin can be achieved at the mixing ratio of BMI:jER828 = 1:1. However, long-time heating at high temperatures was required after light irradiation. In this research, we achieved a short-time anionic UV curing at low temperatures by adding polyfunctional thiol to the mixed resin film. The hardness of the prepared resin was comparable to that of simple thermosetting systems.

Division of Nucleic Acid Drug Development

Division of Nucleic Acid Drug Development

1. Overview

Developing nucleic acid drugs requires knowledge from a wide range of research fields. Many prominent researchers work on nucleic acid or related research at TUS. Hence, innovative and unique results are highly anticipated through their collaborations. In this division, one of our missions is the development of novel nucleic acid derivatives that overwhelm conventional ones in the viewpoint of efficacy, stability, and safety. Also, we aim to develop novel carrier molecules that bind to nucleic acids to improve their stability and pharmacokinetics in the body and to establish formulation technology. We chose the immune system, metabolic system-related diseases, and cancer as targets. As just described, the development of original nucleic acid drugs targeting unique diseases is highly expected by a gathering of in-house competent researchers in this division.

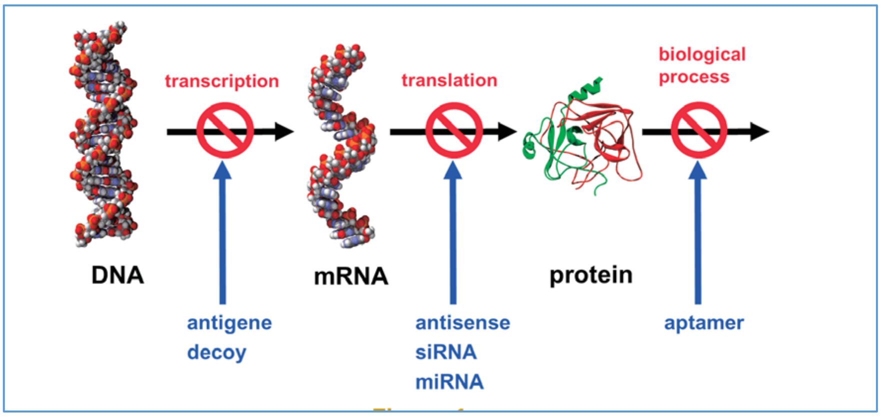

Fig. 1. Oligonucleotides as therapeutic agents.

2. Organization and Facilities

Organization

Faculty of Pharmaceutical Sciences

Takeshi Wada (Organic chemistry)

Makiya Nishikawa (Drug delivery system)

Takehisa Hanawa (Medicinal formulation)

Yoshikazu Higami (Molecular pathology and metabolic diseases)

Kazunori Akimoto (Molecular pathology)

Chikamasa Yamashita (Physical pharmacy)

Yosuke Harada (Immunology)

Faculty of Science

Satoru Miyazaki (Bioinformatics)

Hidetaka Torigoe (Biophysical chemistry)

Hidenori Otsuka (Polymer chemistry)

Faculty of Advanced Engineering

Chiharu Nishiyama (Immunology, allergy and molecular biology)

Suguru Yoshida (Organic synthesis)

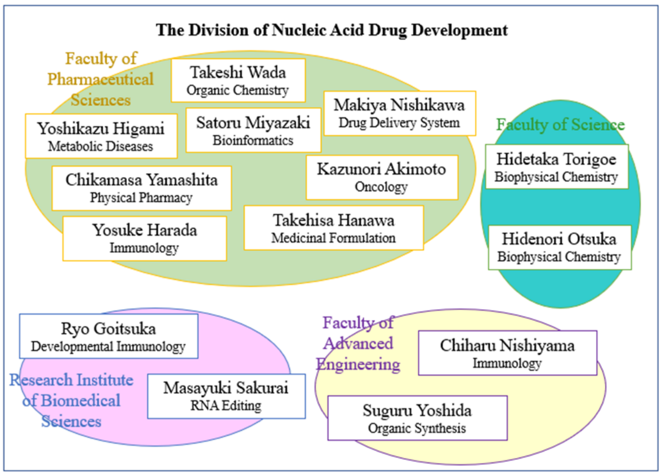

Fig. 2. Researchers belonging to this division.

Research Institute of Biomedical Sciences
Ryo Goitsuka (Developmental immunology)
Masayuki Sakurai (RNA editing)

Principal research equipment in the Division of Nucleic Acid Drug Development

Nuclear magnetic resonance (NMR) spectrometer
1. Model JNM-ECZ400S （JEOL Ltd.）
2. Installation site Building No.15, Noda Campus
3. Feature
This equipment is a nuclear magnetic resonance spectrometer that can collect 1H, 13C, 11B, 19F, 31P, and other nuclei NMR spectra at a frequency of 400 MHz. Furthermore, 2D NMR experiments such as COSY, HMQC, HMBC, and NOESY are available to characterize synthesized samples and natural compounds.

Mass spectrometer
1. Model SCIEX X500R QTOF（SCIEX）
2. Installation site Building No.15, Noda Campus
3. Feature
The equipment measures m/z values of chemical compounds ionized by the electrospray ionization (ESI) method. High-resolution mass analysis and MS/MS analysis are also available.

3. Activity Reports

Joint Symposium of Medical Data Science and Division of Nucleic Acid Drug Development
-Synergy of data science and oligonucleotide therapeutics-
Date: 9/24/2022
Venue: Katsushika Campus, Tokyo University of Science
Summary: Division of Nucleic Acid Drug Development and the newly established Medical Data Science (department head: Prof. Kazunori Akimoto) held a joint symposium. The purpose of the symposium was to deepen mutual understanding among members of the two divisions through the presentation and discussion of their research. Since it was the first in-person symposium held in the post-COVID-19 era, active discussions were conducted.
Invited lecturers: Dr. Takao Fujisawa (National Cancer Center Japan, East Hospital)
Dr. Kazuya Tsuchihara (National Cancer Center Japan, Exploratory Oncology Research & Clinical Trial Center)

7th Symposium of Division of Nucleic Acid Drug Development
Date: 2/25/2022
Venue: Fujimi Building, Kagurazaka Campus, Tokyo University of Science
Summary: The division members made presentations on their research to strengthen mutual understanding and enhance the opportunity for collaborative research.
Invited lecturers: Prof. Kohji Seio (Tokyo Institute of Technology, Department of Life Science and Technology)
Dr. Masamitsu Konno (National Institute of Advanced Industrial Science and Technology, Cellular and Molecular Biotechnology Research Institute)

4. Challenges and Prospects

While advancing ongoing collaborative research on specific targets such as cutaneous wounds, breast cancer, and COVID-19 using oligonucleotide therapeutics, the new application for controlling immunity and lipid metabolism systems will be investigated in detail.

In addition, the development of a method for the stereoselective synthesis of boranophosphate oligonucleotides, which are promising alternatives for phosphorothioate as antisense oligonucleotides, is in progress, and the examination of their safety and efficacy will be explored.

Moreover, platform technology for highly functionalized oligonucleotides and novel DDS will be established using DNA nanotechnology.

Besides, although the 3-year installation period of this division expired in March 2022, a 2-year extension of the installation period was permitted, and the division aims to promote the center.

5. Conclusions

The division combines the knowledge of in-house researchers engaging in oligonucleotide therapeutics and related research. The collaborative research will be actively advanced for the development of oligonucleotide therapeutics made at Tokyo University of Science.

Major Research Achievements (FY2022)

Academic Papers

1. Solid-phase synthesis of N-trichloroacetyl mannosamine 1-phosphate repeating units mimicking capsular polysaccharide derived from Neisseria meningitidis serotype A, Kazuki Sato, Akie Chiba, Tomomi Shiraishi, Yuki Ogawa, Rintaro Iwata Hara, Takeshi Wada, Carbohydr. Res., 518, pp 108585, 2022. (Peer-reviewed)
2. Synthesis and properties of oligodiaminogalactoses that bind to A-type oligonucleotide duplexes, Tomomi Shiraishi, Kazuki Sato, Rintaro Iwata Hara, Takeshi Wada, Org. Biomol. Chem., 20, pp 8243-8258, 2022. (Peer-reviewed)
3. Development of a new synthetic method for oligodeoxynucleotides using 3′-H-phosphonamidate derivatives, Taiki Tsurusaki, Kazuki Sato, Takeshi Wada, Org. Biomol. Chem., 21, pp 2486-2492, 2023. (Peer-reviewed)
4. Individual evaluation of aging- and caloric restriction-related changes to distinct multimeric complexes of circulating adiponectin by immunoblotting. Masaki Kobayashi, Yuichiro Nezu, Mayu Itoh, Rio Uchida, Tomoya Arikawa, Minami Otsubo, Yuka Nozaki, Ryoma Tagawa, Yuya Fujishima, Norikazu Maeda, Iichiro Shimomura, Yoshikazu Higami, Experimental Gerontology, 164, pp 111821, 2022. (Peer-reviewed)
5. Long-term dietary taurine lowers plasma levels of cholesterol and bile acids. Ryoma Tagawa, Masaki Kobayashi, Misako Sakurai, Maho Yoshida, Hiroki Kaneko, Yuhei Mizunoe, Yuka Nozaki, Naoyuki Okita, Yuka Sudo, Yoshikazu Higami, International Journal of Molecular Sciences, 23, pp 1793, 2022. (Peer-reviewed)
6. High expression of SLC20A1 is less effective for endocrine therapy and predicts late recurrence in ER-positive breast cancer, Chotaro Onaga, Shoma Tamori, Izumi Matsuoka, Ayaka Ozaki, Hitomi Motomura, Yuka Nagashima, Tsugumichi Sato, Keiko Sato, Yuyun Xiong, Kazunori Sasaki, Shigeo Ohno, Kazunori Akimoto, PLoS One, 17, e0268799, 2022. (Peer-reviewed)
7. Intradermal delivery of Cryj1 loaded in CpG DNA hydrogel for inhibiting allergic reactions in mice, Takumi Tanifuji, Moeka Nishimura, Kosuke Kusamori, Makiya Nishikawa, Journal of Controlled Release, 354, pp 429-438, 2023. (Peer-reviewed)
8. Physicochemical Properties of Egg-Box-Mediated Hydrogels with Transiently Decreased pH Employing Carbonated Water, Ryota Teshima, Shigehito Osawa, Yayoi Kawano, Takehisa Hanawa, Akihiko Kikuchi, and Hidenori Otsuka, ACS Omega,8, pp 7800-7807, 2022. (Peer-reviewed)
9. Involvement of trigeminal axons in nose-to-brain delivery of glucagon-like peptide-2 derivative, Tomomi Akita, Yusuke Oda, Ryosuke Kimura, Mio Nagai, Ayano Tezuka, Mizuki Shimamura, Kaho Washizu, Jun-Ichiro Oka, Chikamasa Yamashita, Journal of Controlled Release, 351, pp 573-580, 2022. (Peer-reviewed)

Books

1. New Molecular Technologies for Oligonucleotide Therapeutics-1: Properties and Synthesis of Boranophosphate DNAs, Kazuki Sato, Takeshi Wada, In: Sugimoto, N. (eds) Handbook of Chemical Biology of Nucleic Acids, Springer, Singapore, 2023.
2. New Molecular Technologies for Oligonucleotide Therapeutics-2: A-Type Nucleic Acid Duplex-Specific Binding Oligocationic Molecules for Oligonucleotide Therapeutics, Rintaro Iwata Hara, Takeshi Wada, In: Sugimoto, N. (eds) Handbook of Chemical Biology of Nucleic Acids. Springer, Singapore, 2023.
3. Nanobiomaterials, 2nd edition, Hidenori Otsuka, Ami Yamamura, Elsevier, pp1–20, 2023.
4. Interdisciplinary Cancer Research, Hidenori Otsuka, Springer Nature, pp1–23, 2023.
5. Hydrogels for Wound Healing Applications, Hidenori Otsuka, Elsevier, pp1–25, 2023.

Invited Lectures

1. A brief history of stereopure oligonucleotide therapeutics: chemical synthesis and applications, 和田 猛, 日本核酸医薬学会第 7 回年会, 東京, 2022.
2. NEW APPROACH FOR BREAST CANCER STRATIFICATION BASED ON CANCER GENOMICS DB, Kazunori Akimoto, The 9th International Postgraduate Conference on Pharmaceutical Sciences 2022, Malaysia, 2022.
3. High expression of p62 and ALDH1A3 is associated with poor prognosis in luminal B breast cancer, Ayaka Ozaki, Shoma Tamori, Kazunori Akimoto, The 9th International Postgraduate Conference on Pharmaceutical Sciences 2022, Malaysia, 2022.
4. Development of bioactive nanosystems with optimized pharmacokinetic properties, Makiya Nishikawa, 9th International Postgraduate Conference on Pharmaceutical Sciences 2022, online, 2022.
5. Cell-Based Tumor-Targeted Therapy by Cell Surface Engineering, Kosuke Kusamori, Yukiya Takayama, Makiya Nishikawa, ICPAC Kota Kinabalu 2022, Malaysia, 2022.
6. Aryne chemistry for the synthesis of diverse heterocyclic compounds, 吉田 優, Thime WebCheminars 2022 Aryne Chemistry in Synthesis, online, 2022.

Patents

1. Takeshi Wada, Kazuki Sato, Yuhei Takahashi, 国際出願, CHIMERIC NUCLEIC ACID OLIGOMER INCLUDING PHOSPHOROTHIOATE AND BORANOPHOSPHATE, AND METHOD FOR PRODUCING SAME, PCT/JP2022/022556, 2022
2. 樋上賀一, 小林正樹, 野崎優香, 出口祐介, 平田琢朗, 八谷一貴, 国内優先出願, 新規細胞老化マーカーおよび senolytic drug 開発のための標的タンパク質の発見, T2022-067, 2022 (in Japanese)
3. 山下親正, 糖鎖修飾神経ペプチド誘導体, 医薬組成物, 経鼻・点鼻製剤及び医薬組成物の使用, WO2022/239839, 2022 (in Japanese)
4. 山下親正, 国内優先出願, 特願 2022-180380, 2022 (in Japanese)
5. 山下親正, 国内優先出願, 特願 2022-180381, 2022 (in Japanese)
6. 大塚英典, 大澤重仁, 山村明未, ハイドロゲル及びハイドロゲルを形成するための組成物, 特願 2023-70135, 2023 (in Japanese)

Public Relations

1. 和田 猛, 新規 DDS 膵がん組織に送達 日触, siRNA で実用へ, 化学工業日報, 2022 (https://www.nikkei-science.com/page/magazine/202212.html) (in Japanese)
2. 花輪剛久, 東邦大・東京理科大・東大, 皮膚組織修復における瘢痕抑制性 microRNA146b-5p を同定, 日本経済新聞, 2022 (in Japanese)
3. 山下親正, 秋田智后, 東京理科大学「プレスリリース配信」(Journal of Controlled Release November 2022 に論文掲載「神経科学の既成概念をくつがえす新たな中枢デリバリー技術の作用機序を解明～経鼻投与された神経ペプチド誘導体が神経細胞を乗り継ぎ脳へ移行する～」, 2022(in Japanese)
4. Chikamasa Yamashita, Tomomi Akita, EurekAlert!「The Nose-Brain Pathway: Exploring the Role of Trigeminal Nerves in Delivering Intranasally Administered Antidepressant」, 2022(in Japanese)
5. 大澤重仁, 大塚英典, 複数の金属元素を有するナノ材料の新規合成法の開発に成功, プレスリリース, 2022 (https://www.tus.ac.jp/today/archive/20220620_3392.html) (in Japanese)

Awards

1. 野崎優香, 第 45 回日本基礎老化学会大会, 若手奨励賞, 日本基礎老化学会, 2022 (in Japanese)
2. 草森浩輔, 第 14 回日本 DDS 学会奨励賞(実用化・臨床研究), 日本 DDS 学会, 2022 (in Japanese)
3. 草森浩輔, 2022 年度日本薬剤学会奨励賞, 日本薬剤学会, 2022 (in Japanese)

4. 秋田智后, 2023 年度長井記念若手薬学研究者賞, 日本薬学会, 2023 (in Japanese)
5. Ryota Teshima, Shigehito Osawa, Yayoi Kawano, Takehisa Hanawa, Akihiko Kikuchi, and Hidenori Otsuka, ACS Omega, Supplementary Cover, American Chemical Society, 2023
6. 手島涼太, 大澤重仁, 花輪剛久, 菊池明彦, 大塚英典, テクノアイデアコンテスト"テクノ愛 2022"グランプリ, 京都技術科学センター, 2022 (in Japanese)

Individual Research Topics

Takeshi Wada
"Development of a new synthetic method for oligodeoxynucleotides using 3'-H-phosphonamidate derivatives"

A new approach for the solution-phase synthesis of oligodeoxynucleotides (ODNs) was developed using nucleoside 3'-*H*-phosphonamidate derivatives with a heterocyclic amino group as monomers. The condensation reaction of the *H*-phosphoamidate monomer and a hydroxy group proceeded without using additives. This strategy enables us to reduce the number of reagents and simplify the purification process.

Kazuki Sato
"Solid-phase synthesis of stereocontrolled boranophosphate/phosphate and phosphoro-thioate/phosphate chimeric oligouridylates"

The stereoselective synthesis of boranosphate/phosphate (PB/PO) and phosphorothioate/phosphate (PS/PO) chimeric oligouridylates was achieved using the solid-phase method. Oxazaphospholidine monomer was used to construct the stereodefined PB and PS linkages. The method enables the introduction of modifications to oligouridylate derivatives in the intended positions with the intended stereochemistry of phosphorous atoms.

Yoshikazu Higami
"Functional elucidation of PARIS/ZNF746 for development of novel cellular senescence markers and senolytic drugs"

We found that PARIS/ZNF746 is highly localized in the vascular mesenchymal fraction of adipose tissue and is increased in adipose tissue during aging and obesity. While PARIS expression is decreased in adipose tissue from calorie-restricted mice, which has metabolic-improving, anti-aging, and life-extending effects. We also found that PARIS overexpression suppressed adipocyte differentiation, reduced mitochondrial function, and increased $p16^{INK4a}$ protein expression, a known marker of cellular senescence. Therefore, we believe that PARIS/ZNF746 is a novel marker of cellular senescence and a drug target for the development of a novel senolytic drug. We are currently analyzing PARIS function using PARIS-overexpressing adipose progenitor cell 3T3-L1 and developing antisense oligonucleotide to down-regulate PARIS expression.

Yuka Nozaki
"Age-related transition of adipose-specific mitochondrial stress"

Mitochondrial intermediate peptidase (MIPEP) plays an important role in mitochondrial matrix proteostasis by processing certain mitochondrial matrix proteins. Therefore, MIPEP dysfunction may cause mitochondrial matrix proteostasis disorder. However, a difference between short-term and long-term mitochondrial stress responses has not been investigated. To evaluate the difference, we generate and analyze adipose-specific Mipep knockout (aMKO) mice.

Kazunori Akimoto, Shoma Tamori
"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 2022, we also proceeded with the function analysis in cancer stem cells of prognostic marker candidates isolated by 2021 and therapeutic target molecule candidates of oligonucleotide therapeutics. In 2023, we will continue to isolate new candidates and advance the functional analysis of molecules that have already been isolated.

Makiya Nishikawa

"Development of high functional nucleic acids based on DNA nanotechnology"

DNA nanostructures with potent immunostimulatory activity were developed. The location of the CpG motif in the nanostructured DNAs consisting of CpG oligodeoxynucleotide (ODN) was found to be important for their immunostimulatory activities. In addition, a guanine quadruplex structure consisting of CpG ODN with consecutive guanine nucleotides efficiently induced proinflammatory cytokine release from immune cells.

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.

Satoru Miyazaki

"Informative analysis for the development of anti-nucleic acids sequence based on comparison between whole human genes and COVID-19 genome sequence"

We have been identifying the length of 20-23 base sequences in the COVID-19 genome sequence as the candidates of anti-sense nucleic base sequences, that do not exist in coding genes and ncRNA genes of humans. For the candidate sequences, we developed a new protocol to check them from the viewpoint of RNA secondary structure predictions and substitution rate with point mutations of COVID-19 strains.

Takehisa Hanawa

"Application of PVA hydrogels as nucleic acid delivery carriers"

We have focused on gels as carriers that can stably support and deliver nucleic acids by freezing and thawing. This year, we prepared PVA hydrogels and investigated their potential application as drug carriers, focusing on the evaluation of their physical properties. The release behavior of PVA hydrogels using a yellow dye as a model drug was investigated, and it was found that the release can be controlled by the difference in gel fraction. Hence, we believe that PVA hydrogels can be applied as a carrier for nucleic acids.

Chikamasa Yamashita, Tomomi Akita

"Research on the usefulness of functional lipid nanoparticles encapsulating active vitamin D3 for the curative treatment of COPD by alveolar regeneration"

Our previous study found that active vitamin D3 (VD3) showed alveolar repair effects in a mouse model of COPD while inducing serious side effects. Therefore, we encapsulated active VD3 in functional lipid (SS-OP) nanoparticles for efficient delivery to the site of action and reducing the side effects. As a result, we found that active VD3 encapsulated SS-OP nanoparticles including DOPE showed an alveolar repair effect at a low dosage and reduced side effects.

Chiharu Nishiyama, Masakazu Hachisu

"Screening of immunomodulatory natural compounds"

We identified salicylaldehyde (***Int. J. Mol. Sci.*** 2022) and β-damascone (***Front. Nutr.*** 2023) as an anti-allergic compound and an anti-inflammatory compound, respectively, by screenings of an aroma compound library. Salicylaldehyde suppressed pathology of anaphylaxis in mouse models, and contact hypersensitivity was ameliorated in β-damascone orally administered mice.

Chiharu Nishiyama

"Anti-allergic effects of short chain fatty acid (SCFA)"

To clarify the involvement of GPR109A in SCFA-mediated inhibitory effects on mast cells, we utilized an anaphylaxis mouse model. We found that the pathology of anaphylaxis was attenuated by the administration of nicotinic acid with GPR109A ligand activity while a nicotine amide which is a vitamin B3 without GPR109A ligand activity did not show any efficacy. We generated GPR109A full knockout mice in collaboration with Hiroshima University.

Ryo Goitsuka

"Establishment of the time-stamping system of embryonic lymphoid cells for the application to perinatal diagnosis and therapy of diseases stemmed before birth"

We have generated a novel mouse model system to temporally pulse label lymphoid lineage cells that activate RAG2 gene locus for V-(D)-J gene recombination of antigen receptor gene loci at three distinct developmental time points, including embryonic, neonatal, and adult periods. This system allows the analyses of diseases that are stemmed before birth.

Masayuki Sakurai

"Unexplored regions of adenosine deamination editing: identification of genomic DNA inosinylation sites"

The genetic code is comprised of four bases, A, G, C, and T(U). However, cells contain an adenosine deaminase ADAR that leads the editing mechanism of adenosine to inosine, which is synonymous with the sequence change from A to G. We recently discovered that ADAR not only acts on RNA but also on DNA. In this study, we have developed a unique inosine identification method to label and isolate trace amounts of inosine. In addition, the comprehensive identification of inosine sites on DNA is in progress.

Masayuki Sakurai

"Regulation of nucleic acid-protein interactions controlled by A-to-I editing"

Focusing on the dynamics of dsRNA and DNA:RNA hybrid strands in cells, the project aims to establish the concept of the Nova Epinucleome, a gene network connected by nucleic acid base modifications, as a system to optimize gene expression by altering nucleic acid structure, sequence function, and binding factors through A-to-I editing by ADAR. In particular, we are focusing on DNA damage repair mechanisms and RNA-dependent transcriptional regulation mechanisms that lead to cell carcinoma.

Masayuki Sakurai

"Techniques for introducing artificial A-to-I DNA editing at arbitrary target genomic sites"

This research aims to unravel the molecular mechanisms of A-to-I RNA and DNA editing and to develop a new technology for editing genomic DNA sequences by harnessing these mechanisms. Moreover, we aim to develop A-to-I editing guide nucleic acids that will be effective for genetic engineering, cancer mutation, single gene mutation disease, and antiviral technology.

Hidenori Otsuka

"Structural design of novel self-healing interpenetrating polymer network (IPN) gels with hydrazone bond-derived cross-links"

We designed an IPN gel with self-healing properties by employing chemical cross-linking formed by hydrazone-dynamic bonding and physical cross-linking formed by peptides. The gel showed a sol state with storage modulus G' < loss modulus G'' at the moment of strong strain (strain=60%) while it recovered the gel state at weak strain (strain=5%). In repeated measurements, G' in the gel state repeated complete recovery, confirming that the mesh density in the gel state does not change, i.e., it has self-healing properties.

Hidetaka Torigoe

"Artificial degradation of target proteins by the use of chaperone-mediated autophagy: Application to artificial degradation of N protein in SARS-CoV-2"

Chaperone-mediated autophagy is a biological system to degrades unnecessary proteins *in vivo*. Hsc70 binds to the Hsc70-binding motif (Hsc70bm) of target proteins and delivers them to the lysosome. Then, the target proteins are degraded by Lamp-2A and Hsp90. The nucleocapsid (N) protein is involved in virus replication of the SARS-CoV-2 that widely spread over the world recently. We have developed the single-chain antibody with an Hsc70bm sequence to specifically recognize and form a complex with the N protein and Hsc70. The complex was delivered to the lysosome, and the N protein was successfully degraded.

Yohsuke Harada

"Investigation of the pathogenesis of atopic dermatitis"

Atopic dermatitis (AD) is a common chronic skin disease caused by immune dysfunction. We found that the conditional deletion of both *Foxp3* and *Bcl6* genes induced the spontaneous development of AD-like skin inflammation. Furthermore, the development of AD-like skin inflammation was heavily dependent on IL-4/13 signaling. This novel mouse model will be a useful tool for investigating mechanisms of the pathogenesis of severe AD.

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 and utilized them in the sequential three-step click reactions. Further studies for applications including the dual modifications of biomolecules such as nucleic acids are ongoing in our laboratory.

Yoshio Nakano

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

We explore effective nucleic acid therapeutics against SARS-CoV-2. Although the sequence specificity of RNA has been often focused on, few studies have been conducted with off-target effects from the design stage. Therefore, we will investigate sequences present in SARS-CoV-2 while less abundant in human pre-mRNAs, ncRNAs, and mRNAs using bioinformatics to develop targets for nucleic acid therapeutics.

Research Division for Advanced Disaster Prevention on Cities

Research Division for Advanced Disaster Prevention on Cities

1. Overview

Research Division for Advanced Disaster Prevention on Cities was reorganized and renamed from Research Division of Architectures in Advanced Cities in 2021.

“Resolving to the increasingly complex city environment and city life in the 21st century by combining the wisdom of various fields in architectonics”, "Seeking the ideal Tokyo as a metropolis in the 21st century from the Sotohori and Kagurazaka areas, where the TUS is based on”. In addition to these themes of the former division, we incorporated a new perspective: “How can the city prepare for and overcome the harsh disasters and the catastrophic disasters in the future?” in the reorganization.

We have built modern city systems to make our lives more comfortable. However, the city systems have been occasionally destroyed by natural disasters.

For example, the Kanto Earthquake in 1923 destroyed the most advanced city functions of the time which were built with technologies introduced from Western countries since the opening of Japan. The earthquake and the following disasters exposed the problems of modern cities.

In addition, the 2011 Tohoku earthquake and tsunami destroyed city functions and environments that relied on the Internet and the interrelationships of other cities.

The damage to power plants and other infrastructure facilities by the earthquake and tsunami caused rolling blackouts and disruptions to the transportation network connecting the Tohoku and Kanto regions and indirectly long-term damage to city functions in the Tokyo metropolitan area as well.

Each time we have suffered such catastrophes, we have learned and struggled to protect the city systems.

However, we must prepare against catastrophic disasters surpassing the lessons in the past.

For instance, the inland earthquake in Tokyo has been estimated to have a 100% chance of occurrence within 30 years.

In addition, the Tonankai earthquake was estimated as “Causing catastrophic damages to almost the entire land of Japan and lasts severe paralysis on the functions of the nation”.

With these menaces, the division has given greater weight to the theme of “disaster prevention in cities with advanced systems.” to build city systems that sustain the culture and functions of entire cities and facilitate their restoration (resilience) in the event of a disaster.

Therefore, the division was reorganized as Research Division for Advanced Disaster Prevention on Cities.

2. Organization and Facilities

1. Responding to the city environment and life that has become increasingly complex and inconsistent with the advanced development of the 21st century, by bringing together the best of various fields of architectural science.
2. Exploring the ideal of "Tokyo as a metropolis of the 21st century" from the Sotobori (Outer Moat) and Kagurazaka areas, the base of Tokyo University of Science
3. Prospecting for modern cities against incoming catastrophic disasters.

As mentioned above, the propositions changed with its reorganization, and the structure of the division itself remains the same as its predecessor.

The division members consist of specialists in each field belonging to the following faculties:

1. Faculty of Engineering,
2. Former Second Faculty of Engineering
3. Faculty of Science and Technology
4. Department of Global Fire Science and Technology

There are three research groups under the division. The interrelationships among them create a reciprocal relationship.

The names and interrelationships of the groups are shown in Figure 1.

1. **Research Group of City Cultures**: Conducting basic architectural research on traditions and city culture to maintain and create unique regional values.
2. **Research Group of City Performances**: Conducting applied research to improve the planning and engineering performance of city functions, especially in disaster prevention.
3. **Research Group of City Designing**: Conducting applied research on architectural and regional renewal model design studies in collaboration with the other two groups above.

Our headquarters are located in the "Research and Promotion Office for Sotobori and Kagurazaka Areas" on the first floor of Building No. 12 of the TUS Kagurazaka Campus. The headquarters exhibit various contents, such as scaled models of Kagurazaka or panels of our proposals. These are updated as needed.

In addition, we held annual presentations and seminars regarding our research studies by inviting residents in Kagurazaka. In the term of 2021, we launched our official website to enable publicity activities on the Internet as well.

The division continues expanding its equipment for activities every year. In the term 2021, we installed a 3-D printer in the headquarters to build detailed content for the exhibition. In the next term, we will install two new laptops to refresh our computer facilities.

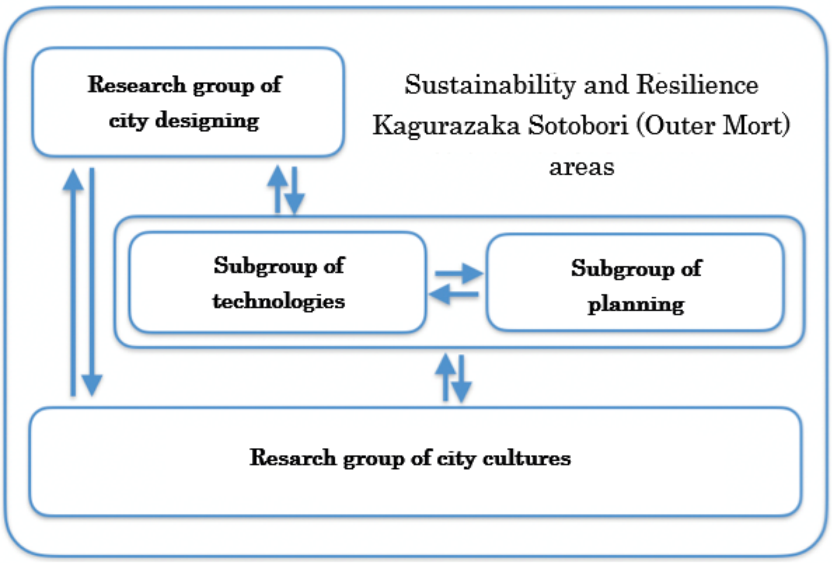

Fig. 1. Research groups in the Division and their interrelationships

3. Activity Reports

3. 1. Research Group of City Cultures

Hirohisa Ito (Chief of the group) and Madoka Kayanoki:

City planning in the 21st century must consider the importance of research for cultures, heritages, transformations, compositions, and formation of modern and contemporary cities, and traditional construction methods for wooden structures.

By organizing, integrating, and systematizing the accumulation obtained through these studies, we will conduct basic research to build a platform that will contribute to the evaluation of city performance and city design research.

While studying waterfront areas in city centers, we will accumulate knowledge on the formation of future city environments by focusing on layered natural landforms and their changes from time to time. In addition, we are also conducting research on disaster prevention based on these studies.

3. 2. Research Group of City Performances

- **Subgroup of Planning (City Planning · Analyzation)**

Momoyo Gota (Chief of the group) and Kaori Ito:

The Kagurazaka area is characterized by its highly dense low-rise wooden buildings and alleyways that slope toward the Sotobori (Outer Moat) area. This uniqueness creates individuality and attracts customers.

In addition, unique characteristics in those areas can be found in terms of the flow of people and behavior patterns.

These factors of the Sotobori-Kagurazaka area contribute to forming one of the most diverse and unique city spaces in the World.

By analyzing the planning conditions of buildings and cities that contribute to the study of planning, city design, and architectural design in this area, we will compile research and create a proposal of an evaluation of resilience from disasters to the government.

- **Subgroup of Technologies (Prevention of Disaster and fire)**

Osamu Takahashi (Chief of the group), Keiichi Imamoto, Mamoru Kono,
Ryohei Kumagai and Yuji Miyazu:

We research countermeasure plans for earthquake, fire, and flood damage for high-rise buildings by assuming a case of a university campus and its surrounding areas in Tokyo's central metropolitan district.

Likewise, we are developing, researching, and proposing city planning systems and methods that contribute to improving the disaster-prevention performance of local districts by evaluating the fire-resistance performance of building materials, the disaster-prevention performance of building construction methods, and reinforcement methods for seismic retrofitting of buildings from multiple perspectives.

3. 3. Research Group of City Designing

Motomu Uno (Chief of the group) and Kaon Ko

We are now researching to propose a definitive consensus regarding city design and development in the metropolitan districts of Tokyo, with sustainability and resilience.

For this purpose, we are examining the vulnerabilities of recent city planning on uneven geological and topographical terrain by referring to the results of revitalization projects in the central areas of Tokyo.

In addition, we are creating draft plans by analyzing, evaluating, or integrating characteristics as follows: forms of cities, materials for buildings, modeling, and planning for disaster prevention.

4. Conclusion

Through the change of division heads and the renewal of divisions and research themes, we have gradually been able to align those areas that were not aligned.

Although there are still some effects, such as delays and restrictions on research surveys due to COVID-19 since 2020, we will continue to promote further research.

In the next fiscal year, we intend to make regional recommendations based on the local disaster prevention performance of the Kagurazaka and Sotobori (Outer Moat) areas, with the following three items pointed out by the Advisory Committee.

1. Compilation and presentation of evaluation and planning methods for appropriate and rational space utilization
2. Evaluation methods for disaster prevention performance and engineering proposals for performance improvement to prepare for disasters
3. Design methods for architectural and city environments that integrate the above and present concrete results in practical application.

Major Research Achievements (FY2022)

(Lab. of Momoyo GOTA) Planning

1. Investing in the social places of heritage towns, Tomoko Kano, Takae Tanaka, Momoyo Gota, “Investing in Disaster Risk Reduction for Resilience Design, Methods and Knowledge in the Face of Climate Change” Elsevier, 2022, 55-76. (Peer-reviewed)

(Lab. of Kaori ITO) Planning

1. 第 30 回国際地図学会議（イタリア・フィレンツェ及びオンライン）参加報告, 伊藤香織, 太田 弘, 若林芳樹, 有川正俊, 矢野桂司, 常泉佑太 60 巻, 1 号, 94-108 頁, 2022.4, 地図 (in Japanese)

(Lab. of Keiichi IMAMOTO) Materials

1. Biomineralization Analysis and Hydration Acceleration Effect in Self-healing Concrete using *Bacillus subtilis natto*, Nguyen Ngoc Tri Huynh, Kei-ichi Imamoto, Chizuru Kiyohara, Journal of Advanced Concrete Technology, 2022, 20, 609-623. (Peer-reviewed)

(Lab. of Mamoru KONO) Materials

1. 無耐火被覆小梁を有する鋼構造床架構の火災高温時崩壊挙動評価, 高木次郎, 王 松, 栗原 純, 河野 守, 松山 賢, 日本建築学会構造系論文集(電子媒体), 87 巻.799 号.944-953 頁, 2022 年 9 月, レフェリー付学術論文 (in Japanese)

(Lab. of Yuji MIYAZU) Structure and materials

1. 中層木質ラーメン建築物用の方杖型摩擦ダンパの開発, 下山雅人, 宮津裕次, 宮田雄二郎, 脇田健裕, 石山央樹, 日本建築学会技術報告集, 28 巻, 70 号, 1189-1194 頁, 2022 年 10 月, レフェリー付学術論文 (in Japanese)

Invited Lectures

1. 第 28 回「震災対策技術展」横浜,「新材料・新構造で未来の社会を創造する〜国土交通省に認められ実践した新技術〜」, パシフィコ横浜, 2023. 2, 髙橋 治 (in Japanese)

Publishments

1. 関東大震災と東京, 栢木まどか, 113 巻, 6 号, 4-18 頁, 2022. 6, 講演録 (in Japanese)

Individual Research Topics

Motomu UNO, Kaon KO

"Research on the city architectural design of Kagurazaka, Sotobori (Outer Moat) and its surrounding area"

We are conducting a structural analysis of the topography, historical transition, architectural form, and arrangement of the area surrounding the "Outer Moat" that separates the old city district from the old Edo castle. In addition, design works to examine and adjust the inconsistencies of the area as a modern city.

We are in charge of method research and practice to realize a superior design proposal by integrating elemental technologies and specialized knowledge.

Hirohisa ITO, Madoka KAYANOKI

"Historical research of city and architecture on Kagurazaka, Sotobori (Outer Moat) and the surrounding area"

We are now researching the history of cities in Tokyo from the modern transition period of the Meiji and Taisho periods to the Showa period before World War II.

At the same time, we are attempting to discover cultural assets by focusing on festival events found in the neighborhoods of the old city center.

To maintain the presence of the region, we are trying to preserve cultural assets by investigating historical traditions and regional specificities.

Momoyo GOTA, Kaori ITO、

"Analysis and evaluation technique research of city and architectural planning concerning Kagurazaka, outer moat, and surrounding areas"

This project will study the renewal planning of city zoning and architectural planning techniques to preserve public space appropriately.

In the Kagurazaka area, we conducted a quantitative analysis of the streetscape focusing on the materials and colors of building facades, and route analysis for a two-directional evacuation in particular districts with dead ends.

Mamoru KAWANO

"Researches on the capabilities for fire protection and disaster prevention of Kagurazaka, Sotobori and their surrounding areas"

I am researching the performance against fire in cities where wooden houses were constructed densely, such as the Kagurazaka area.

Osamu TAKAHASHI、Hideyuki KINUGASA

"Research on structural performance of buildings in Kagurazaka, Sotobori (outer moat) and surrounding areas"

Under the theme of vibration control structures and seismic isolation structures, we are going to survey and evaluate buildings in the area that use vibration control structures.

In addition, practical research is now being conducted on new high-strength materials that apply to wooden buildings, block walls, and other concrete structures.

Keiichi IMAMOTO, Yuji MIYAZU

"Research on the performance of materials used in buildings in Kagurazaka-Sotobori areas and their surroundings"

From the viewpoint of building materials, we are conducting research on the integrity of wooden buildings and concrete structures in the Kagurazaka area, including exploration of wooden buildings that have deteriorated due to ant damage, and basic studies on reinforcement methods using resin filling.

Ryohei KUMAGAI

“Research on architectural structures in Kagurazaka-Sotobori area, and their surroundings”

I have researched the exterior and structural characteristics of wooden buildings constructed densely in the Kagurazaka area after World War II.

I am going to study and elucidate the characteristics of the stores and their changes in the densely built wooden building area and the town block.

Division of Synthetic Biology

Division of Synthetic Biology

1. Overview

The Division of Synthetic Biology, which consists of researchers in the biological field of the Faculty of Science, the Faculty of Advanced Engineering, the Faculty of Science and Engineering, and the Research Institute for Biomedical Sciences at the Tokyo University of Science, is a cross-disciplinary unit. We promote the research to achieve the clear goal of creating “Hybrid cells” among organism species. This division will make the most of the strengths of our university, where outstanding researchers in the fields of biology and medical science are enrolled. By sharing state-of-the-art biological technology, synergistic effects can be expected to create breakthrough research.

Synthetic biology elucidates the working principle of life through artificial cell production and DNA synthesis. Pet animals such as dogs and cats, horticultural crops such as orchids sold at flower shops, livestock such as mules and chickens, and agricultural crops such as wheat and fruits are hybrids created by crossing among related species. Since ancient times, human beings have created and utilized hybrid organisms without being conscious of genome crossbreeding and genome transplantation. Current technological innovations have enabled genome crossing and genome transplantation of species other than closely related species. In order to create frontier areas from this new biotechnology, we will promote research by making use of the strengths of our university, where excellent life scientists gather.

2. Organization and Facilities

Analysis of hybrid cells by synthetic biology requires not only experimental biological approaches but also informatics approaches using computers and artificial intelligence. By analyzing the three-dimensional distribution of heterologous genomes in hybrid cells, network analysis of gene expression, changes in epigenetic states, etc., we will analyze the coexistence, competition, and collaboration of heterogeneous genomes. By integrating and analyzing the huge amount of bioinformatics data obtained by deep sequencing, we will clarify the molecular and cellular events in newly synthesized cells.

The research division is mainly composed of three groups: the plant genome transplantation group, the genome transplantation group among related species, and the cell creation group that leads to drug discovery and medical treatment.

3. Activity Reports

Synthetic biology always needs to be aware of the ethical, legal and social issues (ELSI). We conduct research with ELSI while always being conscious of “what do we want to know and for what purpose?” We are working on the following three research themes for establishing genome transplantation technology with sufficient safety measures, which will lead to the production of useful substances and medical application in the future. The achievements of each group in this fiscal year are described below.

3. 1. Plant Genome Transplantation Group

Tatsuya Tomo (Liberal Arts), Hisataka Ohta (Liberal Arts), Takuya Sakamoto (BS), Sachihiro Matsunaga (Univ. Tokyo), Shigeo Sugano(AIST), Yusuke Kazama (Fukui Pref. Univ.), Keizo Nishida (Kobe Univ.)

The Tomo Laboratory conducts research on chlorophyll (Chl), which plays an important role in photosynthetic energy conversion, and molecular hydrogen produced during photosynthesis. In this fiscal year, they investigated the performance of hydrogen-producing cyanobacteria and Chl, whose absorption is shifted to longer wavelengths. In addition, using the concept of synthetic biology, they tried a new method for isolating and purifying photosystem complexes using proteins expressed by genetic recombination.

In order to reproduce the secondary symbiosis phenomenon using synthetic biology, Sakamoto and Matsunaga laboratories conducted a cell fusion study of algae and cultured animal cells to transfer the genome and were able to construct cultured animal cells that retain the transferred algal genome. From the constructed cell lines, these laboratories selected cell lines that retained more than 95% of the algal genome and performed long-read analysis, which revealed that the algal genome was transplanted by chromosome.

Dr. Kazama and his team induce irradiated the dioecious plant *Silene latifolia* with heavy-ion beams, which can induce chromosome rearrangements with high frequency, to produce a large number of mutants with a partial deletion of the Y chromosome. By using the mutants that have commonly hermaphroditic flowers, Y chromosome deletion mapping was performed to identify a sex-determining gene, *GSFY*, which suppresses pistil development. This discovery marks a significant milestone in the field, as it took 99 years to identify the sex-determining gene since the first discovery of plant sex chromosomes in *S. latifolia* in 1923.

The Nishida Laboratory has developed a DNA editing technology that utilizes DNA base conversion reactions, making it possible to directly introduce point mutations. This has enabled genome editing technology that avoids the uncertainties and toxicities associated with DNA breaks. In 2022, they expanded the scope of application of DNA editing and established highly efficient introduction of point mutations in lactic acid bacteria.

3. 2. Genome transplantation group among related species

Takashi Kamakura (BS), Takayuki Arazoe (BS), Kiminori Shimizu (TS), Jiro Toshima (TS)

Drs. Kamakura and Arazoe discovered novel genome maintenance and hybridization mechanisms by analyzing fungal hybrid cells generated though cell fusion. Subsequently, they utilized these mechanisms toward new genome transfer, genome rearrangement, and genome editing. Based on the findings of their study, they have filed a patent application. Additionally, they successfully developed the smallest artificial chromosome and self-replicating plasmid of filamentous fungi and applied them to the genome editing tool, while analyzing the underlying cell fusion mechanism.

In the Shimizu Laboratory, they have analyzed the competition of the productivity among different secondary metabolites. They also sequenced the genome of an entomopathogenic fungus and detected secondary metabolism gene clusters. They are currently expressing those gene clusters in a model filamentous fungus.

Human chemokine receptors are G protein-coupled receptors (GPCRs) that are closely related to cancer cell migration, invasion, and metastasis. The Toshima Laboratory generated human-yeast hybrid cells in which the receptors for human chemokines, CCL2 and SDF1, were expressed in budding yeast, and succeeded in developing a screening system for inhibitors of the activation signals of the receptors by agonist stimulation. They also succeeded in purifying these chemokines using *E. coli* expression system.

3. 3. Cell creation group that leads to drug discovery and medical application

Tomokatsu Ikawa (RIBS), Mahito Sadaie (BS), Toshiki Furuya (BS), Shin Aoki (PS), Yoshikazu Nakamura (BS), So Maezawa (BS), Hiroshi Haeno (RIBS), Kengo Morohashi (Chitose Inst. Sci. Technol.)

The Ikawa Laboratory has developed a method to induce the differentiation of T/NK progenitor cells from hematopoietic stem and progenitor cells in human umbilical cord blood. T/NK progenitor cells expanded more than 1000-fold in vitro. They also developed a method to induce NK cells from T/NK progenitor cells, which enabled them to produce large amounts of NK cells. Furthermore, they introduced a chimeric antigen receptor (CAR) targeting cancer antigens into the NK cells, and succeeded in generating CAR-NK cells.

Sadaie's laboratory searched for cell growth inhibitors targeting the loss of ATRX expression, characteristic of telomerase-independent cancer cells, and identified one of the nucleic acid synthesis inhibitors as a hit compound. They also identified genes showing differential expression other than ATRX by comparing the telomerase-dependent and telomerase-independent cell groups derived from osteosarcoma.

The Furuya Laboratory has worked on the efficient production of hydroxydaidzein, a rare polyphenol, and vanillin, a fragrance compound, by synthetic biological methods using microorganisms.

In Aoki's laboratory, they constructed amphiphilic supramolecules by self-assembly of chemically modified molecular blocks and confirmed that they catalyze the dephosphorylation of phosphate monoesters in two-phase solvents. High-speed camera imaging and analysis of biphasic reactions suggested that amphiphilic supramolecules may form micelles in both organic and aqueous phases. They also designed and synthesized boron-containing macrocyclic polyamines for boron neutron capture therapy (BNCT), one of cancer radiotherapy. In joint research with the Institute for Integrated Radiation and Nuclear Science, Kyoto University, they discovered a molecule with high selective accumulation in cancer/normal cells and a BNCT effect.

The Nakamura Laboratory has been conducting research aimed at elucidating the role of biological membrane phospholipids in the determination and maintenance of epithelial cell identity. It has been revealed that the phosphoinositide, which are abundant in epithelial cells, has the function of maintaining epithelial cell-specific properties by promoting the transport of cell-cell adhesion molecules to the cell membrane. Additionally, the phosphoinositide is suggested to be involved in cellular senescence.

The Maezawa Laboratory has developed an experimental framework to express DNMT-fused dCas12a in cultured cells for the epigenome editing system "CRISPRoff," which ensures stable suppression of gene expression. In addition, using the single-cell ATAC-seq method, they have identified regulatory regions governing gene expression during marmoset spermatogenesis. By comparing these regions with those identified in mouse spermatogenesis, they are investigating the conserved regulatory mechanism and potential transcription factors involved in mammalian spermatogenesis.

The model consists of a population of normal cells with no mutation; several populations of premalignant cells with varying number of mutations and a population of malignant cells. The model computes a stage of cancer detection and surgery to eliminate malignant cells but spares premalignant cells and then estimates the time for malignant cells to re-emerge. The Haeno Laboratory reported the cellular conditions that give rise to different patterns of cancer initiation and the conditions favoring a shorter cancer recurrence by analyzing premalignant cell types at the time of surgery.

To elucidate the network within living organisms, the Morohashi Laboratory has been working on unraveling the transcriptional regulatory mechanisms through transcription factor complexes. Specifically, they have compared the combinations of transcription factors and target genes between the primitive land plant, *Marchantia polymorpha*, and the higher plant, *Arabidopsis thaliana*, with respect to the relationship between land plant evolution and transcription factor complex networks. They have also investigated the dynamics of small molecules that interact with transcription factors.

4. Challenges and Prospects

Research is being vigorously pursued in each research group and individual research topic, but there are many cases where the analysis of newly generated xenogenic genome-transplanted cells and genetically modified cells for cancer treatment is still in progress. In the future, we would like to further clarify the molecular mechanism for industrial and medical applications.

5. Conclusion

The research division aims to create xenogeneic transplanted cells by cell engineering and contribute to the production of useful substances and medical treatment. In this fiscal year, we carried out research on fusing algae and animal cultured cells to transplant the genome, and succeeded in constructing and maintaining the animal cells that retain the transplanted algal genome. In addition, we generated genetically modified immune cells that are effective in cancer treatment and confirmed their functions. In the future, we would like to carry out integrated informatics analysis of big data in the life sciences and promote xenogeneic transplantation research using cell engineering technologies such as long-chain DNA synthesis, cell fusion, microinjection, and microlaser technology. While carrying out this research, we will emphasize the ethical, legal, and social impacts, which will allow us to develop genome transplantation technology with sufficient safety measures. We would like to continue to demonstrate the frontier spirit and promote the project to "create cells". In addition, we would like this research division to become a platform for joint research, information sharing, and technology exchange with domestic and foreign synthetic biology researchers.

Major Research Achievements (FY 2022)

Academic Papers

1. Ayshat M. Bozieva, Makhmadyusuf Kh. Khasimov,Roman A. Voloshin, Maria A. Sinetova, Elena V. Kupriyanova, Sergey K. Zharmukhamedov, Dmitry O. Dunikov, Anatoly A. Tsygankov, Tatsuya Tomo, Suleyman I. Allakhverdiev, Raman Spectroscopy and Its Modifications Applied to Biological and Medical Research, ***International Journal of Hydrogen Energy,*** 48, 7569–7581, 2023 (Peer-reviewed)
2. 篠田稔行, 加藤公児, 長尾 遼, 秋本誠志, 鈴木健裕, 堂前 直, 沈 建仁, 秋田総理, 宮崎直幸, 鞆 達也, クロロフィル f を結合した光化学系 I の構造機能相関, ***光合成研究*** 32, 87–93, 2022 ((Peer-reviewed) in Japanese)
3. Temman, H., Sakamoto, T., Ueda, M., Sugimoto, K., Migihashi, M., Yamamoto, K., Tsujimoto-Inui, Y., Sato, H., Shibuta, M. K., Nishino, N., Nakamura, T., Shimada, H., Taniguchi, Y. Y., Takeda, S., Aida, M., Suzuki, T., Seki, M., and Matsunaga, S.* (2023) Histone deacetylation regulates de novo shoot regeneration. ***PNAS Nexus***, 2, pdad002 (12 pages). (Peer-reviewed)
4. Kato, S., Misumi, O., Maruyama, S., Nozaki, H., Tsujimoto-Inui, Y., Takusagawa, M., Suzuki, S., Kuwata, K., Noda, S., Ito, N., Okabe, Y., Sakamoto, T., Yagisawa, F., Matsunaga, T. M., Matsubayashi, Y., Yamaguchi, H., Kawachi, M., Kuroiwa, H., Kuroiwa, T.* and Matsunaga, S.* (2023) Genomic analysis of an ultrasmall freshwater green alga, Medakamo hakoo. ***Commun. Biol.***, 6, 89 (13 pages). (Peer-reviewed)
5. Sakamoto, T.*, Sakamoto, Y., Grob, S., Slane, D., Yamashita, T., Ito, N., Oko, Y., Sugiyama, T., Higaki, T., Hasezawa, S., Tanaka, M., Matsui, A., Seki, M., Suzuki, T., Grossniklaus, U. and Matsunaga, S.* (2022) Two-step regulation of centromere distribution by condensin II and the nuclear envelope proteins. ***Nature Plants***, 8, 940-953 (14 pages). (Peer-reviewed)
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7. Nishijima, R., Sanjaya, A., Shinoyama, H., Kazama, Y. Touch-induced transcriptional changes in flower buds of a non-model horticultural plant *Dianthus hybrida*. ***Horticulturae***, 8, 918, 2022 (Peer-reviewed)
8. Kazama, Y.* , Kitoh, M., Kobayashi, T., Ishii, K., Krasovec, M., Yasui, Y., Abe, T., Kawano, S., and Filatov, D. A.* (2022). A *CLAVATA3*-like gene acts as a gynoecium suppression function in White campion. ***Mol. Biol. Evol.***, 39, msac195, 2022 (Peer-reviewed)
9. Hirano, T.*, Kazama, Y., Kunitake, H., Abe, T. Mutagenic effects of heavy-ion beam irradiation to plant genome. ***Cytologia***, 87, 3–6, 2022 (Peer-reviewed)
10. 風間裕介*, 畑下昌範, 木元 久, 櫻井明彦,イオンビームを用いた微生物の品種改良, ***アグリバイオ*** 6, 29-33, 2022. (in Japanese)
11. Ang Li, Hitoshi Mitsunobu, Shin Yoshioka, Takahisa Suzuki, Akihiko Kondo and Keiji Nishida, "Cytosine base editing systems with minimized off-target effect and molecular size", ***Nature Commun***, volume 13, Article number: 4531 (2022) (Peer-reviewed)
12. Sachiko Kashojiya, Yu Lu, Mariko Takayama, Hiroki Komatsu, Luyen Hieu Thi Minh, Keiji Nishida, Kenta Shirasawa, Kenji Miura, Satoko Nonaka, Jun-Ichiro Masuda, Akihiko Kondo, Hiroshi Ezura, Tohru Ariizumi "Modification of tomato breeding traits and plant hormone signaling by target-AID, the genome-editing system inducing efficient nucleotide substitution", ***Horistic Research***, volume 9, Article number: uhab004 (2022) (Peer-reviewed)
13. Johan Hunziker, Keiji Nishida, Akihiko Kondo, Tohru Ariizumi and Hiroshi Ezura "Phenotypic Characterization of High Carotenoid Tomato Mutants Generated by the Target-AID Base-Editing Technology", ***Frontier in Plant Science***, volume 13, Article number: 848560 (2022) (Peer-reviewed)

14. Sota Shinkado, Hiroki Saito, Masaya Yamazaki, Shunsuke Kotera, Takayuki Arazoe*, Tsutomu Arie*, Takashi Kamakura*. Genome editing using a versatile vector-based CRISPR/Cas9 system in *Fusarium* species. ***Sci Rep*** **12**, 16243, 2022 (Peer-reviewed)
15. Ngoc-Hung Nguyen, Tomokazu Tamura, Kiminori Shimizu. Draft genome sequence of *Purpureocillium takamizusanense*, a potential bioinsecticide. ***Microbiology Resource Announcement*** 11: e00268-22, 2022. (Peer-reviewed)
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19. Takano J, Ito S, Dong Y, Sharif J, Nakajima-Takagi Y, Umeyama T, Han YW, Isono K, Kondo T, Iizuka Y, Miyai T, Koseki Y, Ikegaya M, Sakihara M, Nakayama M, Ohara O, Hasegawa Y, Hashimoto K, Arner E, Klose RJ, Iwama A, Koseki H, and Ikawa T. PCGF1-PRC1 links chromatin repression with DNA replication during hematopoietic cell lineage commitment. ***Nat Commun.*** DOI: 10.1038/s41467-022-34856-8, 2022. (Peer-reviewed)
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27. Ryutaro Kasikuma, Makoto Nagano, Hiroyuki Shimamura, Kouya Nukaga, Ikumi Katsumata, Junko Y. Toshima, Jiro Toshima: Role of phosphatidylserine in the localization of cell surface membrane protein. ***Cell Struct. Funct.***, 48 (1): 19-30, (2023). doi: 10.1247/csf.22068 (Peer-reviewed)
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1. 荒添貴之 「ゲノム編集技術～実験上のポイント/産業利用に向けた研究開発動向と安全性周知，第 5 節，第 1 項 バクテリアへのゲノム編集技術導入と課題解決アプローチ」情報機構 ISBN: 978-4-86502-242-1 (総ページ数 315) (分担執筆), 2023 年 1 月 (in Japanese)
2. Makoto Nagano, Junko Y. Toshima, and Jiro Toshima: **Plasma membrane shaping (**Editor: Shiro Suetsugu)／Elsevier, Capter 14. Membrane shaping for clathrin-coated pits and endocytosis., 2022 ISBN：9780323899116
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4. バイオスティミュラントハンドブック, 第 1 編 7 章 4 節 植物の免疫システムを活性化する微生物の簡便な評価手法の開発, 古屋俊樹, 朽津和幸, エヌ・ティー・エス, 209-215, 2022(in Japanese)
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Invited Lectures

1. 荒添貴之「細胞壁多糖を介した植物と植物病原菌の攻防～イネいもち病菌の感染戦略～」令和 4 年度 日本応用糖質科学会東日本支部ミニシンポジウム『千葉県における食と農の研究開発～多糖・微生物研究から食品開発まで～』, 2022 年 12 月 3 日 (in Japanese)
2. 風間裕介「重イオンビーム誘発欠失変異を用いた植物性染色体の研究」若狭湾エネルギー研究センター第 24 回研究報告会, 2022 年 12 月–2023 年 11 月, オンデマンド (in Japanese)
3. Yusuke Kazama and Tomoko Abe, Effect of linear energy transfer in the heavy-ion mutagenesis and breeding. The 32nd annual meeting of MRS-J, 2022 年 12 月 6 日, 横浜 (in Japanese)
4. 風間裕介, 鬼頭 萌, 小林壮生, 石井公太郎, Marc Krasovec, 安井康夫, 阿部知子, 河野重行, Dmitry A. Filatov「ついに発見！ヒロハノマンテマの性決定遺伝子」理研シンポジウム, 2023 年 1 月 19 日, 和光 (in Japanese)
5. Keiji Nishida, Base editing technology for industrial applications, Genome Editing Technology: From Research to Industrial Application. Osaka, Japan. 2022 年 9 月 10 日
6. Keiji Nishida, Development and application of base editing technology, The International Human Microbiome Consortium Congress. Kobe, Japan. 2022 年 11 月 9 日
7. 西田敬二, ゲノムと遺伝子を作って変える時代, 垂水文化講座 神戸市 2022 年 12 月 19 日 (in Japanese)
8. 伊川友活「ポリコーム群タンパクによるリンパ球分化制御機構」
9. 東京理科大学先進工学部生命システム工学科セミナー 2022 年 6 月 17 日 東京都 (in Japanese)
10. 伊川友活「iLS 細胞を用いた白血病治療モデル」(in Japanese)
11. 令和 4 年度 HM-SCREEN 班会議 2022 年 10 月 22 日 オンライン (in Japanese)
12. Shin Aoki, “Development of Interdisciplinary Methods for Cancer Theranostics”, Symposium on World Cancer Research 2022 (SWCR2022) (online seminar), 5/6-5/8, 2022, Singapore.

13. 青木　伸, Post-complexation Functionalization of Iridium(III) Complexes and Applications to Pharmaceutical Sciences（イリジウム(III)錯体の Post-complexation functionalization と薬学分野への展開）, 第 31 回金属の関与する生体関連反応シンポジウム (SRM2022), 6/18-6/19, 2022, 大阪市 (同志社大学京田辺キャンパス) (特別講演) (in Japanese)
14. Shin Aoki, "Design and Synthesis of Metallosupramolecular Complexes and Their Applications to Bioorganic Chemistry and Biomedical Sciences in Association with 10 Years of iPoPS" 9th International Postgraduate Conference on Pharmaceutical Sciences 2022 (iPoPS2022), 6/21~6/22, 2022, International Medical University (IMU), Malaysia (online) (Plenary lecture)
15. Shin Aoki, Induction of Paraptotic Cell Death in Cancer Cells Induced by the Hybrid Compounds of Cyclometalated Iridium(III) Complexes and Triptylenes with Cationic Peptides, 3rd European Public Health Webinar (online seminar), 7/15, 2022, UK+Online.
16. Shin Aoki, Kenta Yokoi, Chandrasekar Balachandran, Design, Synthesis, and Biological Evaluation of Cyclometalated Iridium(III) Complex-Peptide Hybrids that Induce Paraptotic Programmed Cell Death in Cancer Cells. The Asian Conference on Coordination Chemistry (ACCC8), 8/7-11, 2022, Taipei + Online.
17. Shin Aoki, Development of New Cyclometalated Iridium(III) Complexes for Induction of Programmed Cell Death, Detection of Dead Cells, and Mechanistic Study, Baltic Conference and Fellow Summit, IAAM (International Association of Advanced Materials), 8/28-31, 2022, Baltic Sea + Online (Keynote lecture).
18. Shin Aoki, Kenta Yokoi, Kohei Yamaguchi, Azusa Kanbe, Mayuka Nii, Chandrasekar Balachandran, Masaki Kakihana, Design and Synthesis of Hybrid Compounds of Cyclometalated Iridium(III) Complexes and Triptycenes with Basic Peptides that Induce Paraptosis in Cancer Cells, The 3rd International Conference on Pharmacology and Toxicology, 8/29-8/30, 2022, Bangkok, Thailand+Online (Hybrid) (Keynote lecture).
19. Shin Aoki, Post-Complexation Functionalizations of Cyclometalated Iridium(III) Complexes and Applications to Biological and Material Sciences, Nankai Mini-Symposium on Advanced Functionalized Materials, 9/21, 2022, Online
20. Shin Aoki, Design and Synthesis of Peptide-Hybrid Compounds of Cyclometalated Iridium (III) Complexes and Triptycenes that Induce Cell Death in Cancer Cells, 4th European Public Health Webinar, 11/4-11/5, 2022, UK+Online] (Keynote lecture)
21. Shin Aoki, Hiroki Ueda, Tomohiro Tanaka, Minoru Suzuki, and Yoshinori Sakurai, Design and Synthesis of Boron-Containing Macrocyclic Polyamines as Boron Neutron capture Therapy (BNCT) Agents, International Congress on Pure & Applied Chemistry, Kota Kinabalu (ICPAC KK), 11/24-11/27, 2022, Kota Kinabalu, Sabah, Malaysia.
22. Shin Aoki, Kenta Yokoi, Chancrasekar Balachandran, Azusa Kanbe, Design and Synthesis of Metal Complex-Peptide Hybrids that Possess Dual Functions as Paraptosis Inducers in Cancer Cells and Detectors of Dead Cells, The 10th Asian Symposium on Bioinorganic Chemistry (AsBIC10), 11/28-12/3, 2022, Kobe, Japan.
23. Shin Aoki, Hirokazu Okamoto, Akib Bin Rahman, Yoshito Tsuruda, Hiroshi Takemura, Design and Synthesis of Metallosupramolecular Catalysts Functionalized with Lewis Acidic Sites in the Two-Phase Solvent Systems and Analysis of the Interface betwen Organic and Aqueous Phases, 7th International Conference on Catalysis and Chemical Engineering (CCE-2023), 2/20-22, 2023, Las Vegas USA, and online .
24. Shin Aoki, Kenta Yokoi, Kanbe Azusa, Kohei Yamaguchi, Mayuka Nii, Masaki Kakihana, Nozomi Narushima, Chandrasekar Balachandran, Induction of Paraptosis, a Class of Programmed Cell Death, in Cancer Cells by the Hybrid Compounds of Cyclometalated Iridium(III) Complexes and Triptycenes with Peptides, The 5th International Conference on Pharma Research and Development (Pharma R & D 2023), 2/20-22, 2023, Las Vegas, USA, and online (Invited lecture).

25. Shin Aoki, Design, Synthesis and Biological Activity of Macrocyclic Polyamine-based Boron Agents for Boron Neutron Capture Therapy (BNCT), 5th European Public Health Webinar (online seminar), 3/2-3/3, 2023, UK (online) (Keynote lecture)
26. 前澤 創, 生命の連続性を担う, 生殖細胞のエピゲノム形成機構, 日本医科大学・東京理科大学　第 9 回合同シンポジウム, 2022 年 12 月 10 日, 東京（in Japanese)
27. 前澤 創, マウス精子形成期におけるエピゲノムおよびクロマチン制御機構, 第 3 回有性生殖研究会, 2023 年 3 月 10-11 日, 神戸（in Japanese)
28. 波江野洋, 総合研究院データサイエンス医療研究部門・核酸創薬研究部門　合同シンポジウム「大腸癌における免疫逃避機構の数理モデル解析」, 2022 年 9 月 24 日、東京理科大学葛飾キャンパス図書館大ホール（in Japanese)
29. 波江野　洋, 第 6 回東京理科大学−慈恵医科大学合同シンポジウム「大腸癌における免疫逃避進化の数理モデル解析」2022 年 10 月 22 日、東京理科大学葛飾キャンパス図書館大ホール）(in Japanese)
30. 波江野洋, 第 2 回 ASHBi 数理ヒト生物学研究会（MathHuB 2022) 「Mathematical Analysis of Tumor Immune Escape in Colorectal Canceer」2022 年 11 月 18 日英語（in Japanese)
31. 波江野洋, ゲーム理論ワークショップ「がん進化の理論研究」2022 年 3 月 4-6 日、一橋大学 (in Japanese)

Patent

1. 鎌倉高志，荒添貴之，國場 遼，国内優先出願，ゲノム編集された細胞の作製方法及び交雑促進方法，特願 2022-196304，令和 4 (2022) 年 12 月 8 日 (in Japanese)

Public Relations

1. 風間裕介, 各国研究 100 年 県立大など快挙, 雌雄異株植物性決定遺伝子を特定 福井新聞, 2022（in Japanese)
2. 風間裕介, 雌雄異株植物ヒロハノマンテマ性決定遺伝子を同定 科学新聞, 2022（in Japanese)
3. 風間裕介, 約 1 世紀続いた遺伝子研究、県立大世界的快挙 日刊県民福井, 2022（in Japanese)
4. 風間裕介, ヒロハノマンテマ雄株決める遺伝子 中日新聞, 2022（in Japanese)
5. 風間裕介, 接触刺激に反応！花の遺伝子特定 福井新聞, 2022（in Japanese)

Award

1. 阿部知子, 風間裕介, 平野智也, 「重イオンビームによる育種技術の開発」日本育種学会賞, 2023 年 3 月 17 日 (in Japanese)

Individual Research Topics

Tatsuya Tomo

“Fundamental research for plant genome transplantation”

Photosynthetic light-energy conversion has supported the global environment and life energy. For understanding this reaction, site-specific amino acid substitutions are one of the most important research methods. In this study, perturbations of photosynthetic pigment substitutions are used to elucidate the reaction mechanism.

Hisataka Ohta

“Analysis of transporters in cyanobacteria”

More than 50 ATP-binding cassette (ABC) transporter-related genes have been detected in the cyanobacterium Synechocystis sp. Deletion mutants of the substrate-unknown ABC transporter gene will be screened and analyzed for acid stress sensitivity in low pH media.

Sachihiro Matsunaga

“Synthetic biological studies of transfer of the plant genome to animal sells”

To reproduce the phenomenon of secondary symbiosis using synthetic biology, I will promote research on cell fusion of algae and cultured animal cells to transfer the genome, and develop methods to maintain chloroplasts and algae in animal cells.

Takuya Sakamoto

“Ohm analysis of animal and plant hybrid cells”

Gene expression analysis and genome analysis of animal and plant hybrid cells in which algal genomes are transplanted into animal culture cells will be performed. In addition, DNA interaction analysis of the transplanted genome and host genome will be conducted.

Yusuke Kazama

“Genetic analysis of chromosome rearrangements"

Chromosomal rearrangements including translocations, deletions, duplications, and inversions are important mutations that have been involved in speciation and evolution of organisms. We promote the study on the induction of chromosomal rearrangements to alter gene order, copy number, and the higher-dimensional arrangement of DNA in the cell nucleus.

Keiji Nishida

“Development of non-cleaving genome editing technology”

Base editing technology using DNA base exchange reactions has been developed, enabling the direct introduction of point mutations. In FY2022, the application of base editing was expanded to establish highly efficient point mutation introduction in lactic acid bacteria.

Shigeo Sugano

“Development of highly efficient knock-in method using non-homologous end-joining repair”

We will develop efficient knock-in technology using non-homologous end-joining repair pathway instead of homologous recombination pathway. Using this method, we will investigate whether plant transcription factors can work in animals. We will also apply knock-in technology to plants.

Takashi Kamakura and Takayuki Arazoe

"Generation of hybrid filamentous fungi across species"

Interspecific hybridization is constrained by the "species barrier", even among closely related species. Using genome engineering via cell fusion, here we aimed to generate hybrid filamentous fungi with novel traits that can produce useful products.

Kiminori Shimizu

"Molecular biological study towards functional regulation of microorganisms"

In order to regulate the microbiological function, they employ genetics and molecular biology to drive researches on synthetic biology.

Jiro Toshima

"Development of detection system of human GPCR signals using budding yeast"

More than 900 G protein-coupled receptors (GPCRs) exist in the human genome and they are important target proteins for drug discovery. Among them, the human chemokine receptor, CCR2 is involved in the proliferation and migration of cancer cells. In this study, using human-yeast hybrid cells expressing the human CCR2 receptor and its downstream signaling proteins in Saccharomyces cerevisiae, we are going to develop an efficient detection method for activation signals of CCR2 receptor stimulated by the ligand.

Tomokatsu Ikawa

"Development of a novel immune cell therapy using iLS cells"

Chimeric antigen receptor (CAR)-T cells are attracting attention as one of cancer immunotherapy. However, since patient-derived peripheral blood lymphocytes are used, it is difficult to expand them to a sufficient number, and the cells are exhausted and aged. Therefore, in this study, we use induce Leukocyte Stem (iLS) cells, which are multipotent hematopoietic progenitor cells developed in our laboratory, to generate CAR-NK cells and CAR-T cells that target cancer and infectious diseases and analyzed their functions.

Mahito Sadaie

"Exploring cancer vulnerability and developing strategy to prevent cancers"

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.

Toshiki Furuya

"Characterization of novel microorganisms and enzymes"

Using synthetic biology techniques, we design and construct new metabolic pathways in microorganisms such as Escherichia coli and establish methods for producing useful substances. Specifically, we aim to efficiently produce rare polyphenols and fragrance compounds.

Shin Aoki

"Development of cancer therapy by modeling and controlling intracellular reactions and irradiation"

Phosphorylation/dephosphorylation is important metabolic and signaling pathways within the cell. In order to catalyze intracellular dephosphorylation reactions, we aim to develop supramolecular phosphatases generated by self-assembly of artificial compounds. We are also designing and synthesizing novel boron-containing drugs for boron neutron capture therapy (BNCT), a neutron-based cancer therapy. We will also examine genetic modification of plant by neutron irradiation.

Yoshikazu Nakamura

“Elucidating the role of biological membrane phospholipids in the regulation of cellular identity”

In the determination of cellular identity, while much knowledge has been accumulated regarding the role of proteins, including transcription factors, the role of lipids remains largely unclear. Thus, the aim of this study is to elucidate the role of biological membrane phospholipids in cellular identity determination. Additionally, we aim to attempt the development of a method for controlling cellular identity through manipulation of biological membrane phospholipids.

So Maezawa

“Epigenome editing-based in vitro spermatogenesis”

Recent advances in developmental biology hold great promise for organ regeneration, stem cell-based therapy, and tissue engineering. In vitro gametogenesis from pluripotent stem cells is currently being developed to overcome infertility, particularly germ cell aplasia. However, the induction efficiency to create functional sperm and egg cells is still low by the existing method. Here we aim to develop the epigenome editing-based in vitro gametogenesis by rewriting germ cell-like epigenome into pluripotent stem cells.

Hiroshi Haeno

“Computational modeling of locoregional recurrence with spatial structure”

Local and regional recurrence after surgical intervention is a significant problem in cancer management. This study constructs a computational model for cancer initiation and recurrence by combining the Moran and branching processes in which cells requires 3 or more mutations to become malignant.

Kengo Morohashi

“Elucidation of life science events by network analysis”

Focusing on the connections and/or networks that exist within living organisms, we conducted to develop bioinformatics analysis techniques and promoted studies that can be useful in synthetic biology.

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 13 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 four research objectives, and to activate and promote research and development of renewable energy utilization technology at Tokyo University of Science. In FY2022, although research activities were restricted due to the corona disaster, the following external and student activities were carried out in addition to various joint research projects.

+ The 3rd symposium of the division "Recent Trends in Renewable Energy Technologies

The symposium on renewable energy technologies was held on January 31, 2023 at the Morito Memorial Hall on the Kagurazaka Campus, mainly in person, with a hybrid session using Zoom online. The lectures were given by leading researchers who are active in these fields. More than 100 people from inside and outside the university attended the symposium, which was more than the previous 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 2023

The 17th Renewable Energy World Exhibition & Forum RENEWABLE ENERGY 2023, one of the largest renewable energy-related exhibitions in Japan, was held on February 1-3, 2023, 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.)

+ *Summer day camps for face-to-face interaction*

A half-day day camp was held in Building No. 7 on the Noda Campus, with sufficient infection prevention measures taken, mainly to promote interaction among students from each laboratory. Random groups were formed, and after group work, presentations were made on the future of renewable energy and the creation of new global warming prevention projects from the students' viewpoints. Awards were given to groups that came up with outstanding ideas. For the students, it was a good opportunity to learn about the cutting edge of renewable energy technology outside their own laboratory and to get to know other students.

+ *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.

Through these activities in FY2022, 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	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	Assistant Professor	Tomoyuki Haraguchi	Coordination chemistry / Dye sensitized solar cell
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 Science and Technology Department of Electrical Engineering	Assistant Professor	Kim Joonam	Semiconductor material engineering / Nano energy harvest
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 FY2021. Activities have been carried out by each laboratory to reduce the risk of novel corona infection among faculty and students.

Sugiyama et al. have been working on the development of low-cost solar cells using SnS-based compound semiconductors. They found that irradiation of H_2 gas during sputter deposition of the light-absorbing layer of SnS-based sulfide solar cells can control the composition ratio of the semiconductor and contribute to improving the power generation efficiency of the solar cells. He also attempted to develop an electrode that does not change its electrical properties even if it is bent, in order to realize solar cells for use in IoT devices such as clothing and flexible materials. Zhao developed organic/inorganic semiconductor thin-film solar cells, paying particular attention to the properties of the hetero-interface and improving the current-voltage characteristics. In addition, in the prototyping of transparent solar cells, he used bulk-type quantum dot-type organic semiconductor thin films and was able to generate electricity. The dispersion of the quantum dots improved the characteristics. Akitsu et al. (Haraguchi and Nakane) synthesized a new metal complex mediator consisting of a salen-type manganese complex and a hexacyano-iron complex bridged by cyano groups to increase the electron transfer efficiency to laccase (a copper enzyme that reduces oxygen to water) from Trametes versicolor, and evaluated its properties including electrochemical characteristics. Crystal structure analysis revealed that it is a trinuclear anion and mononuclear cation complex, and that the aggregates diverge in solution. In addition, a two-dimensional inorganic compound, MXene, was tested as an electrode material to compare with carbon nanotubes. Nagata developed a new CdS composite photocatalyst made from MOF for photoreforming reactions in which a photocatalyst excited by light absorption decomposes waste into organic acids and other substances while producing hydrogen, a clean fuel, from organic waste such as cellulosic biomass, animal biomass, and plastics under quasi-sunlight conditions. Ikuno engaged in research on improving the output of triboelectric power generation devices, which are expected to have low power generation costs. In this device, which generates electricity by contact and separation between a polymer film and a metal foil, the power output was dramatically improved (190 W/m^2) by adding different nanomaterials to the polymer film. He also promoted the development of a new thin-film deposition method in collaboration with Sugiyama, and developed a loss recovery technique for triboelectric devices during power generation in collaboration with Kim, and demonstrated its operation. 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 $Fe(pyrazine)[Pt(CN)_4]$. Nakane confirmed the spectroscopic and electrochemical properties of Fe(III) complex catalysts synthesized last year as an anodic electrode catalysts for direct methanol fuel cells, and the reproducibility of their methanol oxidation ability to formaldehyde by dioxygen. He also found that superoxide ions were formed upon the methanol oxidation, indicating that the methanol oxidation proceeds by dioxygen. Furthermore, he succeeded in modifying these Fe(III) complexes on a platinum substrate under specific conditions. Kim is working on the application of multilayer 2D materials to the energy field. Using MoS_2 grown longitudinally to the substrate, he investigated the growth mechanism and orientation control of multilayer MoS_2 nanosheets and confirmed for the first time in the world that the orientation of MoS_2 nanosheets and the number of sheets can be controlled by controlling precise deposition conditions, even on metal substrates. Watanabe fabricated an organic thin-film solar cell (OPV) with an active layer that absorbs near-infrared light to improve the efficiency of OPVs, and in collaboration with the Sugiyama Laboratory, fabricated a translucent organic thin-film solar cell (ST-OPV) using ITiO, a transparent electrode that transmits near-infrared light, as the middle electrode in a tandem device. Furthermore, he designed molecules for the active layer of OPVs that transmit light necessary for photosynthesis, fabricated OPVs using molecules with green light absorption selectivity, measured photosynthesis of crops by light transmitted through OPVs, and demonstrated the possibility of combining solar power generation and photosynthesis based on quantitative data. Shirakata grew bulk single crystals of Cu_2SnS_3 (CTS), a candidate for new thin-film solar cells. The crystal structure was tetragonal, the growth was performed by slow cooling from the melting point. CTS thin films used in solar cells are monoclinic, so the properties of bulk crystals and single crystals cannot be compared. In the future, he plans to grow bulk crystals of monoclinic crystal using the two-temperature method. Kanai performed low-temperature PL measurements to investigate the defect properties of $Cu_2Sn_{1-x}Ge_xS_3$ (CTGS) thin films, a next-generation optical absorption layer material. PL was observed for CTGS thin films with different Ge concentrations (= x) and the activation energy was estimated, which did not fluctuate from a shallow value of ~20 meV for x > 20%. Therefore, it is suggested that the shallow acceptor level can be maintained by controlling x and increasing or decreasing the forbidden bandwidth.

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 FY2021, We have conducted researches, while avoiding the risk of new type corona infection among faculty members and students. Each laboratory has been working on its own activities for this purpose.

Ueda is participating in a NEDO project that started in FY2021 to develop technology to create raising adjustment power by systematically suppressing and controlling power generation at solar power plants. He is developing a planning method for imbalance control based on the creation of tertiary adjustment power (2) by forecasting the next day's power generation and spot market prices, and securing two sources of boosting capacity: one to accommodate forecast errors and the other for suppression for boosting adjustment power. Kondoh found that PV power generation can hardly be expected as supply power during the winter peak power demand period in the Tohoku and Tokyo Electric Power Company areas, which experienced a power generation power shortage on March 22, 2022, and that wind power generation can instead be highly expected, based on the temperature dependence of their average generation output and the evaluation results of kW value during the winter season. Katayama proceeded with a demonstration test of an energy management method based on deep reinforcement learning using actual equipment: a 6 kW PV system and a 5.4 kWh storage battery were installed, and the system construction was completed. It was found that the storage batteries in the actual system can be controlled using the model learned in the simulation. It was also confirmed that the entire system behaved in accordance with the simulation. Cui developed an algorithm to secure the headroom to absorb the forecast error for the generation of photovoltaic adjustment power for a photovoltaic power plant that does not take into account the installation of storage batteries. A statistical model based on historical data, a machine learning Support Vector Regulation (SVR) model, and a combined model of these two models were created, and an imbalance evaluation of each model was conducted. She also examined the VI-SVR model by changing the initial values, analyzed the importance of each predictor, and updated the model. Hirata aimed to construct a renewable energy restoration system that utilizes smart power outlets in case of power outages due to disasters. He completed an EMS simulation with the operating characteristics of the PV system, batteries, and load equipment when weather and temperature were used as inputs. Although there was a discrepancy between the simulation and actual measurements, it was confirmed that the discrepancy was due to power consumption by the BMS system and that the discrepancy could be eliminated if this was taken into account. Ohnishi conducted environmental, economic, and social assessments for biomass utilization in Mishima-cho, Fukushima Prefecture, as well as surveyed and analyzed the current state of industrial clusters in Hamadori, Fukushima Prefecture, and designed a heat and electricity supply system using renewable energy. A model was constructed to estimate the utility facilities and energy consumption patterns of new factories, and a design method for a biomass utilization system that balances supply and demand was developed. Kodaira integrated the control algorithm for storage batteries based on deep reinforcement learning implemented last year with i) a forecasting algorithm for PV power generation and ii) a battery control algorithm for predicting electricity prices. In particular, the forecasting algorithm was integrated with a joint research project with Kondoh Lab, which was published in a paper.

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 (FY 2022)

Academic Papers

1. Mutsumi Sugiyama, “Introduction of visible-light-transparent novel devices using widegap nickel oxide (NiO) thin film”, JSAP Review, 2023 (2023) 230410. (Peer-reviewed)
2. Shunsuke Nakamura and Mutsumi Sugiyama, “Effect of Ar and H_2 mixture gas on SnS thin films deposited by radio frequency (RF) magnetron sputtering”, Thin Solid Films, 755 (2022) 139329. (Peer-reviewed)
3. Takahiro Yashiro and Mutsumi Sugiyama, “Effect of the valence band maximum control of $Cu(In,Ga)Se_2$ photoelectrode surface on water splitting”, Japanese Journal of Applied Physics, 61 (2022) 054002. (Peer-reviewed)
4. Takashiro Akitsu, Daizuke Nakane: “Recent Topics of Laccase Focused on Chemical Reactions and Applications”, Universal Journal of Green Chemistry, 1(2022)2-17. (reviewed).
5. Takashiro Akitsu: “[Editorial] Hybrid or Component?—Schiff Base Complexes and Laccase”, Compounds, 2(2022)307-310. (Peer-reviewed)
6. Yukino Uesugi, Haruki Nagakawa, and Morio Nagata, Highly Efficient Photocatalytic Degradation of Hydrogen Sulfide in the Gas Phase Using Anatase/TiO_2(B) Nanotubes, ACS Omega, 7, 14, 11946-11955 (2022) Front Cover (Peer-reviewed)
7. Junji Kondoh, "Winter Capacity Values of Wind Power in Eastern Japan Power Systems", Grand Renewable Energy 2022 International Conference, pp. 1-4, Web Conference.
8. Hiroki Yamamoto, Taiki Kure, Junji Kondoh, Daisuke Kodaira, "Multi-point forecasting of photovoltaic power generation by light gradient boosting machine", Grand Renewable Energy 2022 International Conference, pp. 1-4, Web Conference.
9. Junji Kondoh: "Analysis of the Behavior of Induction Machine Loads in a Test for Preventing the Independent Operation of Multiple Interconnection Type Power Conditioners," 2022 IEEJ Industrial Applications Division Conference, 3-4, pp. III-76-79.
10. Hikaru Arai, Koki Asami, Hajime Ito, Noboru Katayama “Effect of the settings of electrospray deposition method on the structure and performance of the fuel cell catalyst layer” , Current Applied Physics, Volume 39, July 2022, 296-303 (Peer-reviewed)
11. Junnosuke Shimogawa, Daisuke Hara, Shan Miao, Noboru Katayama, Kiyoshi Dowaki “Design and Temperature Analysis of a Metal Hydride Cartridge Using Exhaust Heat of a Fuel Cell for Electric-assisted Bicycles” , Journal of the Japan Institute of Energy, Volume 101, August 2022, 152-161 (Peer-reviewed)
12. Q. Zhou, R. Takita, and T. Ikuno: “Improving the Performance of a Triboelectric Nanogenerator by Using an Asymmetric TiO_2/PDMS Composite Layer”, Nanomaterials, 13 (2023) 832. (Peer-reviewed)
13. H. Komatsu, T. Matsunami, Y. Sugita, and T. Ikuno: “Direct formation of carbon nanotube wiring with controlled electrical resistance on plastic films”, Scientific Reports, 13 (2023) 2254. (Peer-reviewed)
14. T. Ikuno, K. Takahashi, and A. Kadogawa: “Light-Driven Flying Balloons Based on Hybrids of Carbon Nanotubes and Cellulose Nanofibers”, Materials 15 (2022) 7739. (Peer-reviewed)
15. Y. Onami, T. Kawasaki, T. Haraguchi, K. Tsukiyama, D. Moon, Y. Kitahama, T. Hosokai, H. Matsuzaki, H. Sakiyama, T. Akitsu: “Effect of dipeptide derivative Schiff-base Zn(II) complexes on lysozyme molecules damaged by means of IR-FEL irradiation”, Trends in Photochemistry & Photobiology, 21(2022), 15. (Peer-reviewed).
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19. Togawa, T., Ohnishi, S., Fukushima, H., Goto, R. and Gomi, Y. (2022) Pattern Language in Co-creative Processes in Advanced Cities for Environmental and Urban Development: A Case Study of Shiwa Town, Onagawa Town and Nichinan City, Journal of JSCE D3 (Civil Engineering Planning), 78(6): II_491-II_508 (Peer-reviewed)
20. Seiya Maki, Satoshi Ohnishi, Minoru Fujii, Naohiro Goto, Lu Sun (2022) Using waste to supply steam for industry transition Selection of target industries through economic evaluation and statistical analysis, Journal of Industrial Ecology, 10 (Peer-reviewed)
21. Fujii, M., S. Ohnishi, S. Maki, T. Okadera, and N. Goto (2022) Study on Information Sharing and Stable Supply and Demand to Promote Utilization of Waste Incineration Heat in Industry, Journal of Environmental Science, 35(5): 282-291 (Peer-reviewed)
22. Wafaa Magdy, Ayaka Kanai, Esam. T. El Shenawy, Sherif. A. Khairy, Hussam. H. Hassan, and Mutsumi Sugiyama, and Fawzy. A. Mahmoud, "Correlation between some physical properties of pure and Sb doped Cu_2SnS_3 thin films under the effect of sulfur amount for solar cell application", Mater. Chem. Phys. **295**, 1 (2022) (Peer-reviewed)
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24. Kazuya Okamura, Ren Saito, Ayaka Kanai, Kunihiko Tanaka, "Fabrication of Cu_2SnS_3 thin films by dual-source fine channel mist CVD", Appl. Phys. A **128**, 980 (2022). (Peer-reviewed)
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26. H. Yamamoto, J. Kondoh, and D. Kodaira, "Assessing the Impact of Features on Probabilistic Modeling of Photovoltaic Power Generation," Energies, vol. 15, no. 15, p. 5337, Jul. 2022. (Peer-reviewed)
27. T. Kure, H. Danil Tsuchiya, Y. Kameda, H. Yamamoto, D. Kodaira, and J. Kondoh, "Parameter Evaluation in Motion Estimation for Forecasting Multiple Photovoltaic Power Generation," Energies, vol. 15, p. 2855, 2022. (Peer-reviewed)

Books

1. Takashiro Akitsu (Ed. By H. Song, T. A. Nguyen, G. Yasin, N. B. Singh, R. K. Gupta); "Using XRD technique for model composite and related materials", Nanotechnology in the Automotive Industry, chapter 2, 2022, Pages 15-35, Elsevier.
2. Haruki Nagakawa and Morio Nagata, Energy conversion using photocatalysts learned from photosynthesis, Journal of the Color Material Society of Japan, Vol. 95, 2022(9), 269-274

Invited Lectures

1. Asaki Ishizuka, Daizuke Nakane and Takashiro Akitsu: "Hybrid systems of metal complexes and oxygen reducing laccase", 7th International Conference on New Energy and Future Energy System (NEFES 2022), Online
2. Takashiro Akitsu: "Cyanide-bridged metal complexes and laccase for oxygen reducing biofuel cells", 4th Global Webinar on Martials Science and Engineering (GWMSE-2022), Online
3. Takashi Ikuno: "High yield conversión of plastics into carbon nanotubes", International Conference on Science and Technology of Emerging Materials (STEMa2022), Pattaya, Thailand, August 4th, 2022 (Online).
4. Y. Watanabe: "Design guideline of light-transmitting organic thin-film solar cells for photosynthesis and evaluation of cultivation of agricultural crops," Society of Polymer Science, Japan, Organic Electronics Society, December 8, 2022, Hiroshima.

5. Y. Watanabe: “Development of Oil-Producing Algae Cultivation Technology Using Light-Transmitting Organic Thin-Film Solar Cells for Photosynthesis,” IEEJ National Convention 2023, Symposium S9, Frontiers of Innovative Material, Process and Device Development toward Society5.0, March 17, 2023. March 17, 2023, Nagoya University. 6.
6. S. Ohnishi (2022) Research to support the creation of an environmental city using local resources: Past trends and future developments, 33rd Research and Presentation Meeting of the Japan Society of Material Cycles and Waste Management, Young Scientists' Meeting Planning Session.
7. S. Ohnishi (2023) Study on the creation of a regional recycling symbiosis zone centering on a carbon neutral industrial complex by utilizing biomass - with the reconstruction of Hamadori, Fukushima Prefecture Renewable Energy Related Industry Promotion Study Group, 3rd biomass subcommittee meeting in FY2022
8. Ayaka Kanai, Mutsumi Sugiyama, Hideaki Araki, Kunihiko Tanaka; “Current Status of Environmentally Conscious Compound Thin Film Solar Cells”, Japan Photovoltaic Society Women in Photovoltaics Sectional Meeting, at Tokyou Institute of Technology Ookayama Campus, 2022/09/02.
9. Ayaka Kanai, Mutsumi Sugiyama, Hideaki Araki, Kunihiko Tanaka; "Characteristics and High Efficiency Technology of Cu2SnS3-based Solar Cells", The 70th SPSJ Autumn Meeting 2023 at Sophia University, 15a-E502-2, 2023-03-15.

Awards

1. 1. Innovative PV Encouragement Award: 19th Symposium on “Photovoltaic Power Generation System for Next Generation”, Akito Sakai and Yuzuru Ueda, “Evaluation of Solar Radiation Potential of Photographic Points by Sky Area Identification of Sky Images” (June, 2022)
2. YOC Best Presentation Award: 2022 Electric Power and Energy Division Annual Conference, Seiki Sato and Yuzuru Ueda, “Power Generation Estimation of Photovoltaic Power Plants Using Physical Models and Short-Time Learning with Gradient-Boosting Decision Trees” (September 2022)
3. YOC Incentive Award: 2022 Electric Power and Energy Division Conference of the Institute of Electrical Engineers of Japan, Kimitaka Asami, Noboru Katayama, “Structural changes in the catalyst layer of polymer electrolyte fuel cells depending on the ionomer to carbon ratio” (October 2022).
4. YOC Incentive Award: 2022 IEEJ Power and Energy Division Annual Meeting, Kouhei Agata, Yasutaka Koyano, Noboru Katayama, Hiromi Kamei, Risa Nakamura, Yoshitaka Baba, “Structural changes in the catalyst layer of polymer electrolyte fuel cells as a function of ionomer/carbon ratio” (October 2022).
5. YOC Incentive Award: 2022 Electric Power and Energy Division Conference of the Institution of Electrical Engineers of Japan, Yasutaka Kohya, Kohei Agata, Noboru Katayama, Hiromi Kamei, Risa Nakamura, Yoshitaka Baba, “Impedance characteristics of solar cells under changing irradiance” (October 2022)
6. Takashi Ikuno, Academia Award for Excellence: “Development of Up-Cycling Technology from Waste Plastic to High Value-Added Functional Nanocarbon Materials”, SEMICON JAPAN (December 14, 2022)
7. Best Poster Award: The 8th Asian Conference on Coordination Chemistry (ACCC8), Qiyuan Zhang, Tomoyuki Haraguchi, Takashiro Akitsu: “Fabrication of 3D Hofmann-type thin film by casting method”, Taipai, Taiwan (online). (August 2022). 8.
8. 2022 Research Presentation Encouragement Award: The 14th Joint Sectional Meeting of the Korean Association of Scientists and Engineers in Japan, Kim Joonam and Takashi Ikuno, “Proposal of a New Method to Improve Energy Recovery Rate of Frictionally Charged Power Generation” (March 2023).

Individual Research Topics

Mutsumi Sugiyama
"Research on next-generation solar cells using earth-abundant materials"

In order to improve the power generation efficiency of SnS solar cells, which are one of the earth-abundant solar cells composed of common materials, we achieved the control on semiconductor properties such as Sn-S composition ratio and bandgap energy by supplying hydrogen and nitrogen gas during sputter deposition. The correlation between the composition and surface morphology was also investigated, and the foundation was laid for the realization of high-efficiency solar cells.

Zhao Xinwei
"Research on transparent solar cells"

In this year, we fabricated prototypes of organic semiconductor/oxide semiconductor and all-organic semiconductor transparent solar cells, and continued to confirm their operation and improve their characteristics. In addition, a prototype of a bulk quantum dot type solar cell was fabricated and found to be capable of generating electricity by improving the dispersion of the dots. In the next fiscal year, we will further improve the conversion efficiency and fabricate and evaluate a transparent solar cell prototype.

Takashiro Akitsu
"Exploration of cyano-bridged iron-manganese complexes for biofuel cell cathode mediators"

Laccase, a copper enzyme that reduces oxygen to water, is a catalyst for oxygen reduction at the cathode of biofuel cells. Following the search for a mediator using 1- to 3-dimensional cyano-bridged ethylenediamine-based copper-metal complexes in the previous year, this year we newly synthesized metal complexes in which a salen-type manganese complex and a hexacyano-iron complex are bridged by cyano groups, and evaluated using crystal structure analysis, various spectroscopic methods, electrochemical measurements, DFT calculations, docking calculations, etc. They were compared with previously studied non-crosslinked hexacyano-iron complexes and salen-type manganese complexes with different shapes and bonding modes. In addition, a two-dimensional inorganic compound MXene (Maxine) was also tested as an electrode material to compare with carbon nanotubes.

Yuzuru Ueda
"Research on photovoltaic power generation systems"

In FY2022, we are developing technology to predict and evaluate the amount of electricity generated by photovoltaic power plants, and developing a system for energy management using photovoltaic power generation systems as distributed power sources on the customer side. In FY2022, we are participating in a NEDO project to develop technology to predict and evaluate the amount of electricity generated by photovoltaic power plants, and to research operational methods to create a regulating power in addition to the amount of electricity generated.

Morio Nagata
"Research on organic solar cells and artificial photosynthesis"

In order to improve the efficiency of bio solar cells using photosynthetic proteins, we introduced scattering layers and up-conversion materials into TiO_2 layers. In artificial photosynthesis, CdS composite photocatalysts prepared from MOFs were applied to photoreforming reactions of plant biomass under sunlight, and it was found that hydrogen could be produced with high efficiency. In addition, his paper on hydrogen sulfide decomposition using anatase and bronze titanium dioxide composite photocatalysts was selected for the Front Cover of the Journal of the American Chemical Society.

Junji Kondoh

"Research on winter kW value of wind power generation in East Japan Grid"

On March 22, 2022, the Tohoku and Tokyo Electric Power Company areas experienced a shortage of electricity generation due to a combination of unseasonably low temperatures and other adverse conditions. Some have argued that renewable energy is useless, as solar power, which has been installed in large quantities, generated almost no electricity on that day. In contrast, an analysis using wind speed data measured at lighthouses along the eastern coast of Japan and surface observation data from the Japan Meteorological Agency revealed that offshore wind power in the Tohoku region has great potential as a supply source of electricity during the peak demand period in winter, based on the temperature dependence of their average power output and an evaluation of their kW value during winter.

Noboru Katayama

"Research on energy system management using deep reinforcement learning"

Energy management has become more complex due to the diversification of distributed energy sources such as photovoltaic, wind power, and fuel cells, and we propose to manage energy systems using deep reinforcement learning. We have conducted a demonstration test using actual equipment and completed the system construction by installing a 6 kW photovoltaic power generation system and 5.4 kWh storage batteries. We confirmed that the model learned on the simulation can be used to control the storage batteries in the actual system and that the entire system behaves in accordance with the simulation.

Takashi Ikuno

"Research on low-cost vibration power generation devices"

We are conducting research and development of triboelectric power generation devices that generate electricity by contact, separation, or friction of different materials. The output voltage was dramatically increased (190 W/m^2) by adding high dielectric particles and surface modification to the polymer film used in the triboelectric device, and by forming a negative permanent fixed charge by corona discharge. In the future, we will try to improve the output voltage by modifying polymer materials.

Tomoyuki Haraguchi

"Construction of oriented crystalline films with printable porous metal complexes"

We have investigated the application of metal-organic complexes (MOFs) to dye-sensitized solar cells, etc. We found that various MOFs such as Fe(pyrazine)[$Pt(CN)_4$] 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.

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 power of dioxygen, as in the methanol fuel cell. Furthermore, we succeeded in modifying these Fe(III) complexes on a platinum substrate.

Cui Jindan

"Headroom control for generating regulating power from photovoltaic power generation"

The promotion of photovoltaic power generation, which is greatly affected by weather conditions, requires the securing of regulating power. In addition, the expansion of photovoltaic power generation is expected to lower the market price of electricity during the daytime, and selling electricity only to the spot market is not profitable. Based on these two points, we studied headroom control to create ΔkW value in addition to the energy (kWh) value of photovoltaic power generation. We developed an algorithm that solves the problem in two stages: the problem of absorbing the error in the generation forecast and the problem of ratio of the forecasted values to the two markets. For the forecast error absorption problem, a simple statistical model and a machine learning model were studied, and for the plan value ratio problem, a model using linear programming was studied to maximize the profit.

Kim Joonam

"Multilayered layered materials for energy devices"

Multilayered layered materials are attracting attention as next-generation semiconductor materials for the energy field because of their high optical absorption coefficient, mobility, and scientific stability. However, there are still only a few reports on the details of the growth mechanism and the practical application of devices. As a way to achieve this, we investigated the control of nanosheet orientation and nanostructure during deposition on metal substrates. We will clarify the growth mechanism of layered materials on metal substrates for precise deposition control, and secure the basic technology necessary for large-area production.

Yoichi Hirata

"Renewable energy restoration system utilizing smart outlets in case of power outage due to disaster"

In the previous fiscal year, we completed an EMS simulation with the operating characteristics of the photovoltaic system, battery, and load equipment when weather and temperature were inputted. This fiscal year, we aim to connect a regional local line and connect several micro-grid systems to it, thereby loosely linking the system to the electric power transmission line. As a result, we would like to prove that the loose local interconnection line is more economical.

Yasuyuki Watanabe

"Development of advanced photovoltaic technology for combining photosynthesis and photovoltaic cells"

To improve the power generation efficiency of semi-transparent organic thin-film solar cells (ST-OPV), we conducted joint research with Sugiyama Laboratory and succeeded in fabricating a tandem structure of OPVs by forming transparent electrodes on organic semiconductors, which are the power generation layer. In addition, crop cultivation tests utilizing the wavelength selectivity of OPVs were conducted indoors under white LEDs, and the power generation characteristics of OPVs and the photosynthesis rate of plants under OPVs were measured, proving that both power generation and agriculture are feasible. Furthermore, to achieve compatibility between power generation and oil fuel production, we conducted demonstration tests under artificial sunlight and showed that both power generation and oil-producing algae are feasible.

Sho Shirakata

"Research on narrow-gap chalcopyrite semiconductors"

We grow bulk single crystals of polycrystalline semiconductors, which are candidates for new thin-film solar cells, and measure their basic physical properties: crystal structure, band gap, absorption coefficient law, and Raman scattering. From these measurements, we will compare the properties of bulk and polycrystalline semiconductors. The above measurements will be performed on bulk single crystals of $CuIn(Se_{1-x}Te_x)_2$ grown in the previous year and Cu_2SnS_3 (CTS) crystals fabricated in the previous year. The CTS crystals were grown by slow cooling from the melting point. In the future, we plan to grow bulk monoclinic crystals using the two-temperature method.

Satoru Ohnishi

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

The appropriate introduction of renewable energy into the industrial sector, mainly through biomass heat utilization, is an important issue for realizing regionally driven decarbonization. We will support actual community development by developing a system of public-private-academic collaboration to create a vision and business model for the introduction of renewable energy with a view to regional planning and social implementation in industrial cities, mountainous areas, and earthquake recovery areas, and by setting up and evaluating the system according to regional characteristics.

Ayaka Kanai

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

Aiming to realize a novel electron transport structure for next-generation CTS solar cells with low cost, non-toxicity, and high efficiency, we focused on optimization of the deposition method and characterization of $Cu_2Sn_{1-x}Ge_xS_3$ (CTGS) thin films whose conduction band position can be controlled by the Ge/(Ge+Sn);x composition ratio. Hall measurements confirmed that the carrier concentration and mobility of CTGS films decrease with increasing x ratio. Therefore, it was found that controlling the x ratio between 0.1 and 0.2 is optimal for the application to solar cell devices from the viewpoints of crystal growth and electrical properties.

Daisuke Kodaira

"Storage battery recharge/discharge control using deep reinforcement learning and integration into P2P transactions"

The storage battery control algorithm developed in this research project determines the amount of control for the next day in advance based on the forecast of the next day's PV generation and electricity prices. However, the larger the forecast error, the lower the profit on electricity sales. Therefore, this year we quantitatively evaluated the relationship between the forecast error and the decrease in profit on electricity sales. In addition, there is a high possibility that the electricity sold by the storage battery control algorithm can maximize profit through local power trading in P2P transactions. Therefore, we stayed at University of Hamburg in Germany for two weeks to discuss the reduction of computational complexity and the design of incentives for users in P2P trading of electricity. The exchange is expected to continue in the next fiscal year with the aim of obtaining an international joint grant.

Division of Ambient Devices Research

Division of Ambient Devices Research

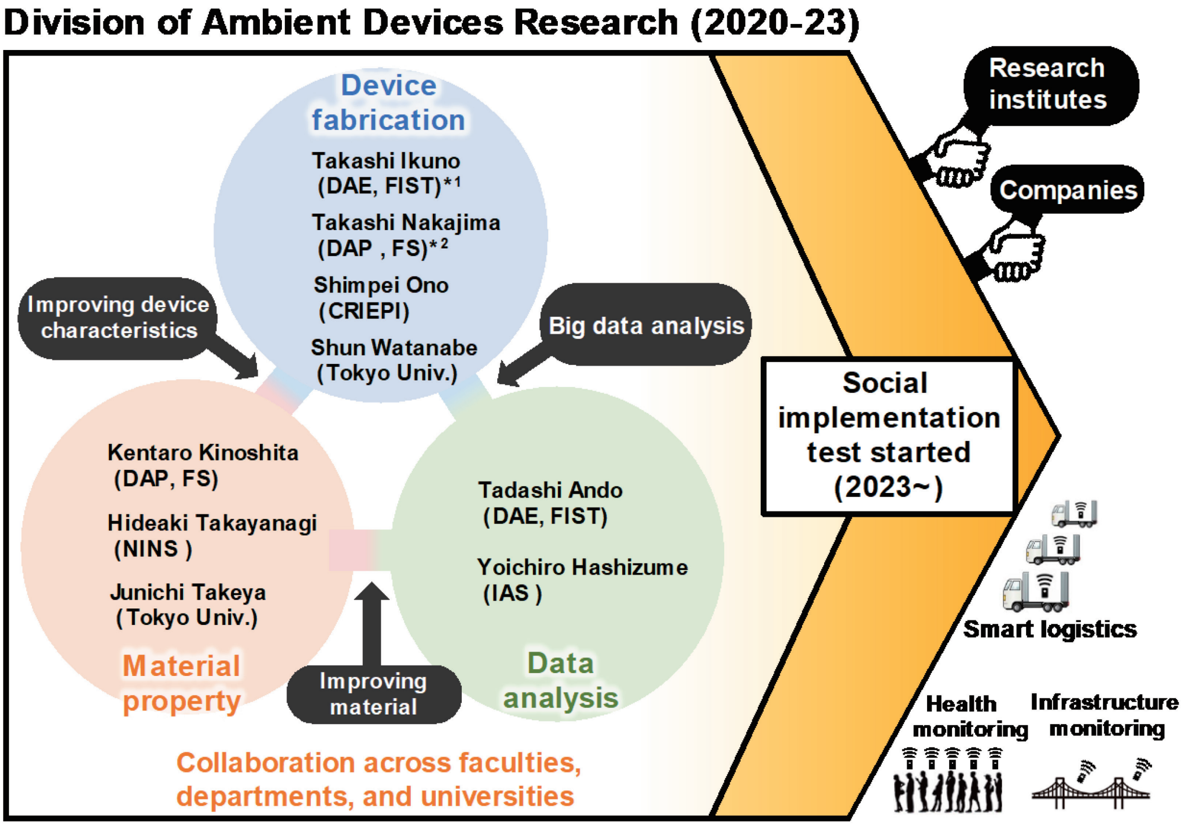
1. Overview

The Division of Ambient Devices Research conducts research on material property control, device creation, and acquired data analysis related to ambient devices during the establishment period of the division, in anticipation of the era of mass spread of ambient devices. Ambient devices blend into the environment and extract environmental information. We also aim to implement the ambient devices, including recycling and upcycling, eco-friendly regeneration processes that take into consideration the process of returning devices to the soil, and use and analysis methods (AI, stochastic resonance, etc.) of the extracted data will also be the subject of our research.

2. Organization and Facilities

▪ **Members**

Title	Name	Affiliation
Group leader・Professor	Kentaro Kinoshita	Department of Applied Physics, Faculty of Science (DAP, FS)
Associate Professor	Takashi Ikuno	Department of Applied Electronics, Faculty of Industrial Science and Technology (DAE, FIST)
Visiting Professor	Hideaki Takayanagi	National Institute of Nature Science (NINS)
Associate Professor	Takashi Nakajima	Department of Applied Physics, Faculty of Science
Associate Professor	Tadashi Ando	Department of Applied Electronics, Faculty of Industrial Science and Technology (DAE, FIST)
Associate Professor	Yoichiro Hashizume	Institute of Arts and Sciences (IAS)
Visiting Professor	Shimpei Ono	Central Research Institute of Electric Power Industry (CRIEPI)
Visiting Professor	Jyunichi Takeya	The University of Tokyo, Graduate School of Frontier Sciences
Visiting Associate Professor	Shunichiro Watanabe	The University of Tokyo, Graduate School of Frontier Sciences



3. Activity Reports

3. 1. "Thermal property of ionic liquids due to confinement in metal-organic frameworks (MOFs)"

In 2021, it was clarified that both the low moisture resistance and the fragility of mechanical strength of $Cu_3(btc)_2$ were improved by filling the pores of metal-organic framework $Cu_3(btc)_2$ with ionic liquid (IL). In 2022, we evaluated the thermophysical properties of IL before and after filling the pores of $Cu_3(btc)_2$, and clarified that the phase change that was confirmed before the introduction of IL into pores was suppressed. This result indicates that the introduction of IL into $Cu_3(btc)_2$ not only modulates the physical and chemical properties of $Cu_3(btc)_2$, but also affects the properties of IL. This means that it can be a method for the systematical modulation of the physical property of IL. (Kinoshita)

3. 2. "Development of edge AI devices based on ionic liquids"

So far, we have proposed the use of ionic liquids (ILs), which have high molecular designability, as reservoirs in order to create devices for Reservoir Computing (RC), a learning algorithm that is highly applicable to edge AI. In 2022, we clarified the effects of changing IL anion and cation species on the learning performance of the IL reservoir device. It was found that the dependence of learning performance on cationic species is relatively weak, while the dependence on anionic species is extremely strong. This result cannot be explained only by the time-scale change of dielectric relaxation due to the viscosity change of IL. It is expected that this will enable learning of time-series signals over a wider time scale in the future. To further improve learning performance, elucidation of the mechanism is urgently needed. (Kinoshita)

3. 3. "Development of optical learning devices"

We have developed an optical learning reservoir device that utilizes the generation and decay of photo-induced current observed when a transparent electrode ITO/Nb:$SrTiO_3$ junction is irradiated with light. By changing the DC voltage applied to the junction within the range of ±0.5 V, it was found that the time scale of the transient response after UV irradiation was stopped could be modulated over 7 orders of magnitude.

Due to this property, it is expected that optical signals with various time scales can be learned by a single device. (Kinoshita)

3. 4. "High output of friction vibration power generation devices by asymmetric polymer film containing high dielectric constant particles"

As a power source for RFID tags, we constructed a frictional vibration power generation device using a polymer film. By encapsulating high-dielectric fine particles in a polymer film and modifying the surface, the power generation output was greatly improved (280 mW/m^2). We aim to further improve the output in near future. (Ikuno)

3. 5. "Converting used flexible devices into carbon nanotubes"

We have established a technology to convert flexible devices composed of plastic substrates and organic semiconductors into industrially useful CNTs instead of simply discarding them after use. Various plastics were converted into high-purity CNTs in large quantities at high speed by effectively controlling the polymer decomposition process and the fluid. In the future, we will convert waste organic semiconductor devices into CNTs. (Ikuno)

3. 6. "Development of edge devices based on energy harvesting"

We have developed a battery-less diagnostic system based on electricity supplied by vibration power generation and thermoelectric power generation. To improve the power generation efficiency, we improved the characteristics of piezoelectric polymer materials and realized a thermoelectric power generation by applying a Kirigami structure. In order to develop a low-power consumption edge device for fault diagnosis, we devised an analog circuit that intermittently releases charging energy to the load, and by combining this with machine learning-based analysis, the discrimination accuracy of the system was totally improved. (Nakajima)

3. 7. "Big data analysis"

For big data analysis, we studied a method for analyzing the time and location information that would be obtained in a distributed manner, as well as the accompanying temperature, humidity, and other information. This dataset contained noise and missing data. Although it is possible to reproduce more detailed data by removing or supplementing these data, in practical use, it is often more important to know "what part of the data is hot and on what scale to make decisions such as shutting off the power" rather than detailed raw data. We showed that automatic scale decomposition using singular value decomposition can be applied to this problem. If actual data can be obtained, it is ready to be implemented immediately. (Hashizume)

4. Challenges and Prospects

All of the above research themes, which are being pursued individually by department members, have made remarkable progress and are top runners in their respective fields. On the other hand, the fusion of each theme toward the creation of ambient devices, which is our critical goal, has not progressed well, but the preparations have been steadily completed.

5. Conclusion

Unfortunately, this year is the final year of activities for this division, but we would like to continue to cooperate with the division members and advance the research. We would like to express my gratitude to Director Prof. Nishihara, Deputy Director Prof. Aoki, everyone in the Noda Research Support Section, advisory committee members, department members, and everyone involved who have supported us.

Major Research Achievements (FY 2022)

Academic Papers

1. MASAKAZU KOBAYASHI, YASUMITSU ORII, HISASHI SHIMA, YASUHISA NAITOH, HIROYUKI AKINAGA, DAN SATO, TAKUMA MATSUO, KENTARO KINOSHITA, TOSHIKI NOKAMI, AND TOSHIYUKI ITOH: "Temperature Driven Current–Voltage Characteristics of Ionic Liquid Type Intelligent Connection Device", IEEE Journal of the Electron Devices Society 10, 893 (2022). (Peer-reviewed)
2. Takuma Matsuo, Dan Sato, Sang-Gyu Koh, Hisashi Shima, Yasuhisa Naitoh, Hiroyuki Akinaga, Toshiyuki Itoh, Toshiki Nokami, Masakazu Kobayashi, and Kentaro Kinoshita: "Dynamic Nonlinear Behavior of Ionic Liquid-Based Reservoir Computing Devices", ACS Appl. Mater. Interfaces 14, 36890 (2022). (Peer-reviewed)
3. Sang-Gyu Koh, Hisashi Shima, Yasuhisa Naitoh, HiroyukiAkinaga, Kentaro Kinoshita: "Reservoir computing with dielectric relaxation at an electrode–ionic liquid interface", Scientific Reports 12, 6958-1-9 (2022). (Peer-reviewed)
4. Sang-Gyu Koh, Taiki Koide, Asahi Arai, Ichiro Ohira, and Kentaro Kinoshita: "Structural Strengthening of Metal−Organic Frameworks Owing to the Confinement Effect of Ionic Liquids in the Nanopores", Journal of Physical Chemistry C 126, 6736 (2022). (Peer-reviewed)
5. T. Ikuno, K. Takahashi, and A. Kadogawa: "Light-Driven Flying Balloons Based on Hybrids of Carbon Nanotubes and Cellulose Nanofibers", Molecules, 15 (2022) 7739. (Peer-reviewed)
6. 福山智子, 金 侖美, 生野 孝: "セメント系材料の載荷に伴う発電現象に対する遷移帯の影響", 76 (2023) 229. (in Japanese) (Peer-reviewed)
7. 福山智子, 金 侖美, 生野 孝: "導電性の異なるセメントペースト複合体における繰返し載荷に対する発電応答", 76 (2023) 220. (in Japanese) (Peer-reviewed)
8. Q. Zhou, R. Takita, and T. Ikuno: "Improving the Performance of a Triboelectric Nanogenerator by Using an Asymmetric TiO2/PDMS Composite Layer", 13 (2023) 832. (Peer-reviewed)
9. H. Komatsu, T. Matsunami, Y. Sugita, and T. Ikuno: "Direct formation of carbon nanotube wiring with controlled electrical resistance on plastic films", Scientific Reports, 13 (2023) 2254. (Peer-reviewed)
10. T. Ikuno, K. Takahashi, and A. Kadogawa: "Light-Driven Flying Balloons Based on Hybrids of Carbon Nanotubes and Cellulose Nanofibers", Molecules, 15 (2022) 7739. (Peer-reviewed)
11. T. Toyama, J. Fujioka, K. Watanabe, A. Yoshida, T. Sakuma, K. Inaba, T. Imai, T. Nakajima, K. Tsukiyama, N. Hamada, and F. Yoshino: "Investigation of bactericidal effect of a mid-infrared free electron laser on Escherichia coli", Sci. Rep. 12, 18111 (2022). (Peer-reviewed)
12. S. H. Mat Zin, T. S. Velayutham, T. Furukawa, H.Kodama, W.C.Gan, Sirinart Chio-Srichan, M. Kriechbaum, and T. Nakajima: "Quantitative study on the face shear piezoelectricity and its relaxation in uniaxially-drawn and annealed poly-l-lactic acid", Polymer 254, 125095 (2022). (Peer-reviewed)
13. T. Sato, M. Funato, K. Imai, and T. Nakajima: "Self-powered Fault Diagnosis Using Vibration Energy Harvesting and Machine Learning", Sens. Mater. 34, 1909 (2022). (Peer-reviewed)

Invited Lectures

1. イオン液体の分子ダイナミクスと電気化学反応を利用した物理リザバー, 木下健太郎, 第 70 回応用物理学会春季学術講演会 領域 6 シンポジウム T11 「誘電体研究における機械学習」, 上智大学, 2022. (in Japanese)
2. イオン液体が創る電子材料・デバイスの未来, 木下健太郎, 鳥取大学工学部付属 GSC センター創立 10 周年記念シンポジウム, 2022. (in Japanese)
3. T. Ikuno: "High-yield Conversion of Plastics into Carbon Nanotubes", The third international conference on science and technology of emerging materials, Pattaya, Thailand (Online), 2022.

4. Smart mechatronics based on piezoelectric polymer energy harvesting, Takashi Nakajima, The 17th International Conference on Nano/Micro Engineered and Molecular Systems (IEEE-NEMS 2022), Online. 2022.
5. 柔軟性材料を用いた IoT センサデバイス, 中嶋宇史, 第 16 回グリーンシステム技術分科会, オンライン, 2022. (in Japanese)
6. 高分子圧電材料の物性と応用例, 中嶋宇史, 第 24 回圧電 MEMS 研究会, 東京, 2022. (in Japanese)

Patents

1. 松川雄二, 生野 孝 : 特願 2022-116366 (2022.7.25) 「カーボンナノチューブ製造装置及び製造方法」. (in Japanese)
2. 田中聖二, 市川充史, 小野新平, 寺瀬勇人, 中嶋宇史, 洲崎 崇, 特願 2022-165745 (2022.10.14) 「コンテンツ再生制御システム」. (in Japanese)
3. 長谷川幹雄, 中嶋宇史, 酒造 孝, 特願 2022-155623（2022.9.28）「情報処理方法、情報処理装置, 情報処理プログラム及び記録媒体」. (in Japanese)
4. 中嶋宇史, 長谷川幹雄, 酒造 孝, 特願 2022-151941（2022.9.22）「位置検出システム, 位置検出サーバ, 制御装置, 位置検出方法, 及びプログラム」. (in Japanese)
5. 中嶋宇史, 横山諒伍, 特願 2022-087189（2022.5.27）「圧力分布計測システム, 圧力分布計測方法, 圧力分布計測プログラム, 及び差動増幅計測の測定回路」. (in Japanese)

Public Relations

1. 生野 孝 : 株式会社日立ハイテク・ウェブサイト（みんなの試作広場）, 2022/4/12．(in Japanese)
2. 生野 孝 : Yahoo ニュース，2023/3/10．(in Japanese)
3. 生野 孝 : マイナビニュース，2023/3/11．(in Japanese)

Awards

1. 生野 孝: 第一回アカデミア Award 優秀賞, “廃プラスチックから高付加価値機能性ナノカーボン材料へのアップサイクル技術開発”, SEMICON JAPAN, 2022/12/14. (in Japanese)
2. J. Kim and T. Ikuno: Research Presentation Encouragement Award, “Proposal of a New Method to Improve Energy Recovery Rate of Frictionally Charged Power Generation”, The 14th Joint Sectional Meeting of the Korean Association of Scientists and Engineers in Japan, 2023/3.

Individual Research Topics

Kentaro Kinoshita

“Research on resistive change memory application for embedding in organic devices and for developing edge AI device”

Resistance change memory is roughly divided into three types: anion diffusion type, cation diffusion type, and interface type. Taking advantage of the achievements in research and development of these memories, we design and manufacture resistance change memory suitable for purposes. We are also working on AI application research that makes use of the analog resistance change and resistance attenuation characteristics of resistance change memory.

“Device applications of metal-organic frameworks (MOFs) and ionic liquids”

We will synthesize large single crystals of $Cu_3(btc)_2$, a representative MOF, and clarify the essential physical properties of $Cu_3(btc)_2$. By filling the high-density pores of the MOF with an ionic liquid, we will realize a highly ion-conducting material that can be used like a solid, regardless of whether it is in the air or in a vacuum.

Takashi Ikuno

“Characterization of organic semiconductor devices and upcycling of used devices”

With the goal of improving the homogeneity of device characteristics, we analyze the characteristics of organic semiconductor devices and feed them back to the experimental process. We also establish a process to convert used flexible devices into useful functional materials.

Takashi Nakajima

“Development of IoT devices using flexible energy harvesting”

This group aims to realize attachable energy harvesting using piezoelectric and thermoelectric materials with great flexibility and formability. Additionally, low-consumption diagnostic edge devices will be developed to operate independently by micro-power generation.

Yoichiro Hashizume

“Examination on analysis methods for data from multiple signal sources”

In 2022, we proposed a method using singular value decomposition as a method for analyzing data obtained from multiple signal sources. Singular value decomposition mainly corresponds to coordinate transformation in the direction of the largest correlation scale for a two-variable data set. That is, a linear transformation with the highest correlation in the dataset can be generated. The new coordinate axis obtained in this way (especially its first principal component) shows the most typical correlation scale. It can be calculated back to the original two variables. For example, in the case of coordinates and temperature, it was shown that it is possible to uniformly determine the radius in which a subject has been exposed to high temperatures. This approach is ready for implementation.

Tadashi Ando

“Molecular dynamics simulation study on cellulose nanofiber/calcium carbonate mixture in water”

The viscosity of cellulose nanofiber suspensions is significantly changed by adding calcium carbonate. We performed molecular dynamics (MD) simulations to investigate this mechanism. Calcium carbonate, which is an ionic crystal, has very strong charges, which makes MD calculations in water very difficult. We are trying to develop force field parameters and simulation method for efficient and stable MD simulations of calcium carbonate.

Division of Biological Environment Innovation

Division of Biological Environment Innovation

1. Overview

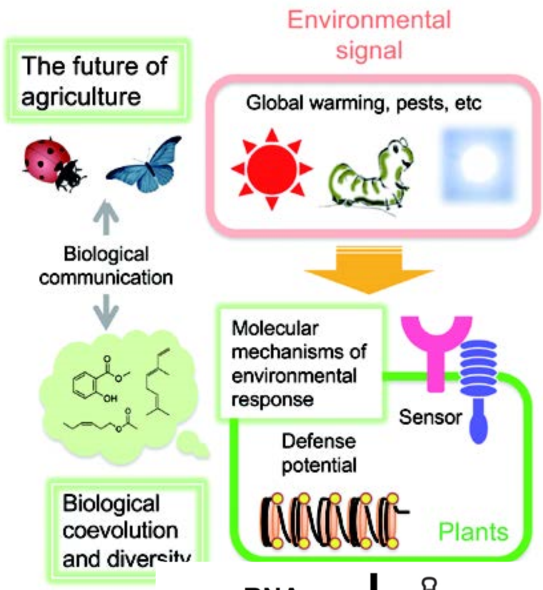
Academic experts in the fields of environmental adaptation, biological interactions, molecular evolution, co-evolution, and ecology of living organisms have formed three subgroups “the section of environmental adaptation”, “the section of molecular evolution”, and the “section of nature symbiosis”. In 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.

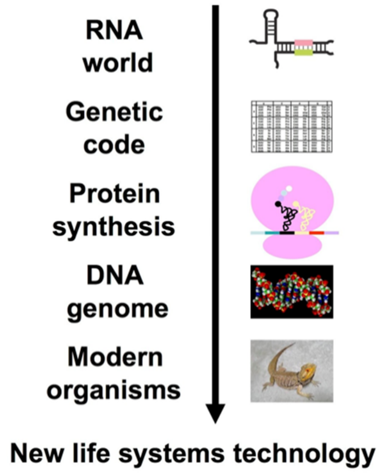
- Elucidation of the mechanisms underlying the evolution and diversity of lives
- Development of significant plant lines adapted for environmental stress tolerance and biological interaction, leading to the creation of next-generation organic cultivation systems using immunostimulants and companion plants that contribute to reduced pesticide use.



Members: Gen-ichiro Arimura, Kazuyuki Kuchitsu, Ryuichi Nishihama, Hisataka Ohta, Fuminori Takahashi, Yoshitake Desaki, Kenji Hashimoto, Takuya Sakamoto, Sachihiro Matsunaga (The Univ. of Tokyo)

<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

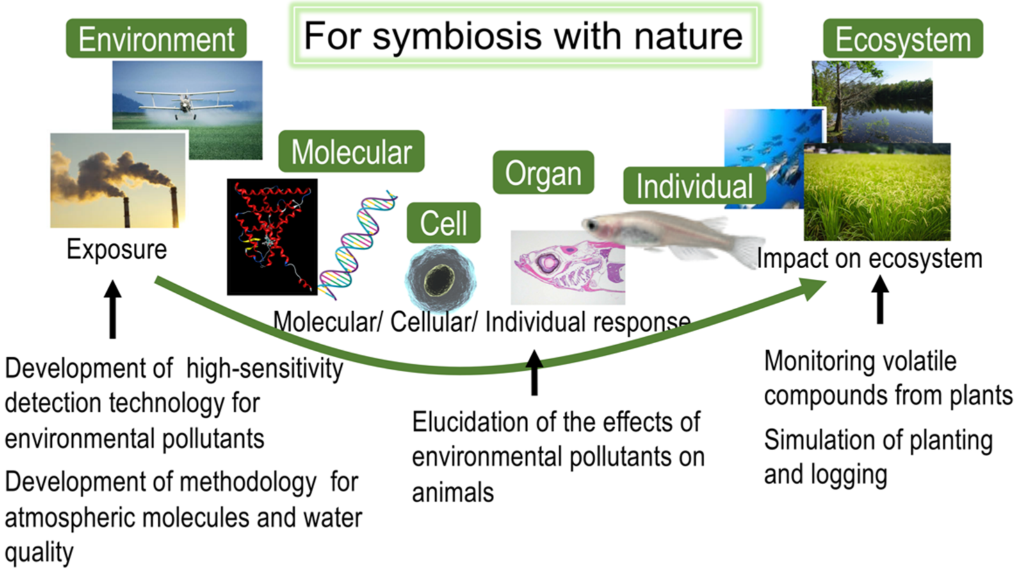
Members: Koji Tamura, Toshiki Furuya, Mitsunori Shiroishi, Masayuki Sakurai, Kazunori Okada (The Univ. of Tokyo), Akiko Soma (Chiba Univ.)

<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, Takuya Saito (NIES)



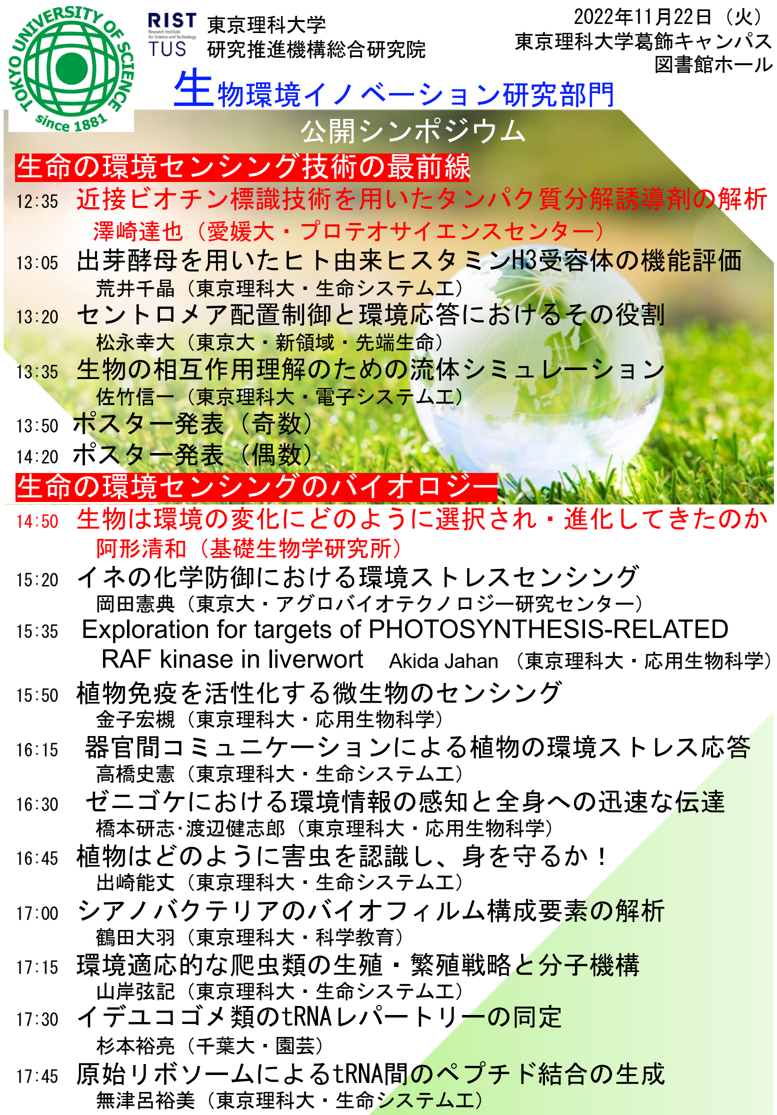
3. Activity Reports

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 22, 2022

Outcome: To promote bioenvironmental innovation research, we held a symposium with division members and leading researchers on the theme of "Environmental Sensing Technology and Biology of Life". 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.



Seminar

2022. 7. 12

Dr. Masahiro Nishihara (Iwate Biotechnology Research Center)

Title: 植物における花色発色機構と遺伝子工学による改変 (in JA)

2022.10.5

Dr. Yoichi Kainoh (Tsukuba University)

Title: 寄生蜂の HIPVs に対する反応とその行動解析 (in JA)

2022. 11. 18

Dr. Norimichi Nomura (Kyoto University)

Title: 膜タンパク質構造研究の動向と今後の展望 (in JA)

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 (FY 2022)

Original Papers

1. Metabolic engineering of betacyanin in vegetables for anti-inflammatory therapy, Saito S., Nishihara M., Kohakura M., Kimura K., Yashiro T., Takasawa S., Arimura G., *Biotechnol. Bioengineer.*, in press
2. Sustained defense response via volatile signaling and its epigenetic transcriptional regulation, Onosato H., Sakamoto T., Matsunaga S., Arimura G. et al., Plant Physiol., 189, pp 922-933, 2022
3. Genomic analysis of an ultrasmall freshwater green alga, *Medakamo hakoo*, Kato S., Sakamoto T., Matsunaga S. et al., Commun. Biol., 6, pp. 89, 2023
4. Two-step regulation of centromere distribution by condensin II and the nuclear envelope proteins. Sakamoto T., Matsunaga S. et al., Nature Plants, 8, pp. 940-953, 2022
5. Peptide Bond Formation between Aminoacyl-Minihelices by a scaffold derived from the peptidyl transferase center, Kawabata M, Kawashima K, Mutsuro-Aoki H, Ando T, Umehara T, Tamura K., Life, 12, pp 573, 2022
6. Acquisition of Dual Ribozyme-Functions in Nonfunctional Short Hairpin RNAs through Kissing-Loop Interactions, Mutsuro-Aoki H, Tamura K., Life, 12, pp 1561, 2022
7. Relation of leaf terpene contents to terpene emission profiles in Japanese cedar (*Cryptomeria japonica*), Saito T., Kusumoto N., Hiura T., Ecol. Res, 38, pp 74-82, 2023
8. Towards reconstructing the Arctic atmospheric methane history over the 20th century: measurement and modelling results for the North Greenland Ice Core Project firn, Umezawa T., Sugawara S., Kawamura K., Oyabu I., Andrews S.J., Saito T., Aoki S., Nakazawa T., Atmos. Chem. Phy., 22, pp 6899-6917, 2022
9. Evolutionary differentiation of androgen receptor is responsible for sexual characteristic development in a teleost fish, Ogino Y., Miyagawa S., Iguchi T. et al., Nat. Commun., 14, 1428, 2023.
10. Akashi H., Kubota M., Yamamoto H., Miyaoku K., Yamagishi G., Miyagawa S., Chronology of embryonic and gonadal development in the Reeves' turtle, Mauremys Reevesii, Sci. Rep., 12, pp 11619, 2022
11. Myosho T., Ishibashi A., Fujimoto S., Miyagawa S., Iguchi T., Kobayashi T., Pre-self-feeding medaka fry provides a suitable screening system for in vivo assessment of thyroid hormone-disrupting potential, Environ. Sci. Technol., 56, pp 6479-6490, 2022
12. Biocatalytic synthesis and evaluation of antioxidant and antibacterial activities of hydroxyequols, Nozawa D., Matsuyama A., Furuya T., Bioorg. Med. Chem. Lett., 73, pp 128908, 2022
13. Sustainable approach for peroxygenase-catalyzed oxidation reactions using hydrogen peroxide generated from spent coffee grounds and tea leaf residues, Kawana H., Miwa T., Honda Y., Furuya T., ACS Omega, 7, pp 20259-20266, 2022
14. Isolation and characterization of microorganisms capable of cleaving the ether bond of 2-phenoxyacetophenone, Oya S., Tonegawa S., Nakagawa H., Habe H., Furuya T., Sci. Rep., 12, pp 2874, 2022
15. Affinity purification followed by liquid chromatography-tandem mass spectrometry to identify proteins interacting with ABA signaling components, Soma F., Takahashi F. et al., Methods Mol Biol., 2462, pp 181-189, 2022
16. Use of micrografting to study the role played by peptide signals in ABA biosynthesis, Takahashi F., Methods Mol Biol., 2462, pp 101-109, 2022
17. *Arabidopsis* TBP-ASSOCIATED FACTOR 12 ortholog NOBIRO6 controls root elongation with unfolded protein response cofactor activity, Kim JS., Sakamoto Y., Takahashi F. et al., Proc Natl Acad Sci USA., 119, pp e2120219119, 2022
18. Inter-tissue and inter-organ signaling in drought stress response and phenotyping of drought tolerance, Kuromoti T., Fujita M., Takahashi F. et al., Plant J., 109, pp 342-258, 2022
19. ADAR1 downregulation by autophagy drives senescence independently of RNA editing by enhancing p16INK4a levels, Hao, X., Sakurai, M., Zhang, R. et al., Nat. Cell Biol., 24, pp 1202-1210., 2022

20. Regulation of PaRBOH1-mediated ROS production in Norway spruce by Ca^{2+} binding and phosphorylation, Nickolov K, Hashimoto K, Kuchitsu K et al., Front. Plant Sci. 13, pp 978586, 2022
21. Wu D., Akashi S., Okada K., Fan L. et al., Lateral transfers lead to the birth of momilactone biosynthetic gene clusters in grass, Plant J., 111, pp 1354–1367, 2022
22. A methodology for creating mutants of G-protein coupled receptors stabilized in active state by combining statistical thermodynamics and evolutionary molecular engineering, Yamamoto T., , Shiroishi M., Murata T. et al., Protein Sci. 31, e4425, 2022
23. A leaderless mRNA including tRNA-like sequence encodes a small peptide that regulates the expression of GcvB small RNA in *Escherichia coli*, Muto A., Goto S., Kurita D., Ushida C., Soma A., Himeno. J. Biochem., 171, pp 459-465, 2022
24. Tanebe S., Satake S., Iterative blind deconvolution method for dwell-time adjustment, Appl. Opt. 61, pp 1743-1749, 2022
25. Auxin signaling is essential for organogenesis but not for cell survival in the liverwort *Marchantia polymorpha*, Suzuki, H., Kato, H., Iwano, M., Nishihama, R., Kohchi, T. Plant Cell, 35, pp. 1058–1075, 2023
26. Stomatal regulators are co-opted for seta development in the astomatous liverwort *Marchantia polymorpha*, Moriya, K.C., Nishihama, R., Shimada, T. et al., Nat. Plants, 9, pp 302-314, 2023

Books
1. Epigenetic regulation of sex determination and toxicity in non-mammalian vertebrates. In: Genomic and Epigenomic Biomarkers of Toxicology and Disease: Clinical and Therapeutic Actions, Safu S (Ed.), Yamagishi G, Iguchi T, Miyagawa S. Wiley, pp. 415-448, 2022.
2. 日本生物工学会 100 年史, 第 3 章 3-4 酵素探索・改良技術, Kino K., Furuya T., 日本生物工学会, pp 39-41, 2022 (in Japanese)
3. バイオスティミュラントハンドブック, 第 1 編 7 章 4 節 植物の免疫システムを活性化する微生物の簡便な評価手法の開発, Furuya T., Kuchitsu K.,エヌ・ティー・エス, pp 209-215, 2022 (in Japanese)

Invited Lectures
1. Defense system of Arabidopsis plants against the model herbivore *Spodoptera*, Arimura G., Gordon Research Conference Plant Herbivore Interaction, Ventura, CA, USA, 2023
2. ROS and Ca^{2+}-mediated regulation of development and stress responses in *Marchantia polymorpha,* Kuchitsu K, Julius von Sachs Colloquium, Würzburg, Germany, 2022

Public Relations
1. Arimura G., NHK 総合 『あさイチ』 コーナー：ツイ Q 楽ワザ 今日から主役！“青じそ”を味わい尽くす SP」2022.8.2 (in Japanese)
2. Arimura G., NHK ラジオ「マイあさ」けさの“聞きたい”「みどりの日・知られざる植物の“語らい”」22.5.4 (in Japanese)
3. Sakurai M.“Molecular mechanisms of mammalian endogenous RNA-dependent DNA base modification and disease pathogenesis due to dysregulation” Published in JSPS's webpage, 2022 (in Japanese)

Awards
1. Furuya T., 2022 年度長瀬研究振興賞,公益財団法人長瀬科学技術振興財団, 2022 (in Japanese)
2. Kuchitsu K., Hashimoto K., ベストイメージング賞, 日本バイオイメージング学会, 2022 (in Japanese)

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 Yoshitake Desaki

"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, Kenji Hashimoto

"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 autoantibodies”

We elucidated the recognition mechanism of doxepin isomers of human histamine H1 receptor. We performed structural analysis of human H3 receptor by cryo-electron microscopy. We also constructed an insect cell expression system for plant membrane receptor involved in its environmental responses. In addition, in terms of research on autoantibodies, we performed binding analysis and crystallization for structural study for multiple rheumatoid factors mainly on IGHV1-69-derived ones.

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.

Ryuichi Nishihama

“Studies on the mechanisms of environmental control of plant growth using a liverwort”

Roles in bryophytes of two phytohormones, auxin and OPDA (jasmonic acid), important for environmental and defense responses were analyzed using the liverwort *Marchantia polymorpha*. Auxin signaling was found to be dispensable for cell division but essential for three-dimensional patterning of the plant body. In addition, we found that mutations in OPDA biosynthesis genes resulted in reduced resistance to spider mites.

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.

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 conduct 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 the “Data Science Center”, and “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. 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 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）
- Kidney outcomes and all-cause mortality in people with type 2 diabetes exhibiting non-albuminuric kidney insufficiency. (Diabetologia 2022)
- Effectiveness of remdesivir in hospitalized nonsevere patients with COVID-19 in Japan: a large observational study using the COVID-19 Registry Japan. (International Journal of Infectious Diseases 2022)
- Effectiveness of favipiravir on nonsevere, early-stage COVID-19 in Japan: a large observational study using the COVID-19 Registry Japan. (Infectious Diseases and Therapy 2022)
- Effect of antimicrobial prophylaxis duration on health care-associated infections after clean orthopedic surgery a cluster randomized trial. (JAMA Network Open)
- Five-year outcomes after fractional flow reserve-based deferral of revascularization in stable coronary artery disease: final results from the J-CONFIRM Registry. (Circulation: Cardiovascular Interventions 2022)

4. Challenges and Perspectives

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 (FY 2022)

Academic Papers

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4. Memoryless quasi-Newton methods based on the spectral-scaling Broyden family for Riemanian optimization, Narushima, Y., Nakayama, S., Takemura, M., and Yabe, H., Journal of Optimization Theory and Applications, 197(2), 639-664, 2023 (Peer-reviewed).
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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.

Hiroshi Yabe

''Study on numerical methods for nonlinear optimization''

We considered numerical methods for solving nonlinear optimization problems. We proposed memoryless quasi-Newton methods based on the spectral-scaling Broyden family for unconstrained optimization problems on Riemannian manifolds, 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.

Sadao Tomizawa

"Study on measures for representing the degree of departure from symmetry model for square contingency tables"

We proposed the measure to represent the degree of departure from conditional partial symmetry model for square contingency tables with ordered categories, and showed the usefulness of the proposed index for comparing degrees of departure from the model in several square tables.

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 leading the field.

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.

The practical application of the proposed methods will shorten the study duration for each situation.

Kouji Tahata
"Study of modeling on square contingency tables"

A contingency table is one of the essential tools for analyzing categorical data. Especially for the analysis of the square contingency table, which has the same row and column classifications, we are interested in considering the symmetry structure than the independence structure. This research aims to assess the modeling of symmetry and asymmetry. Additionally, we reveal the interpretation of the model concerning information theory and properties of goodness-of-fit test statistics. Moreover, we apply the proposed models to a real data set.

Michiko Tsubaki
"Study on an analysis of factors for improving consumer well-being and UX, DX based on Marketing4.0-5.0"

A purpose of my study is to study analytical methods based on the service information science to be able to create the customer experience value to lead consumer well-being by supporting the development of the feeling of happiness of the consumer, through the value cocreation between a company and a customer, and to develop UX and DX. Specifically, I study the development of the method to extract the customer action with feelings from the large-scale data, and the analyses of factors that satisfy the heart of the customer with the contact at which touch point, in order to understand superior customer experience.

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.

Hiroki Hashiguchi
"Study on the distribution of the singular random matrices"

In this study, we gave some results on the exact distribution theory of the eigenvalues of the singular Wishart matrix, which is a constant multiple of the sample covariance matrix when the dimension of the variate is larger than the sample size. First, we introduced heterogeneous hypergeometric function and showed that the joint density function of the eigenvalues can be expressed using this function. We also showed that the distribution function of the largest eigenvalue can be unify expressed for both of singular and nonsingular Wishart matrices. We obtained the density function of the ratio of the singular Wishart matrix and the independent non-singular Wishart matrix, the joint density function of the eigenvalues, and the larges eigenvalue distribution.

Takuya Matsuzaki
"Study on the mechanism of neural language models"

Neural language models, such as BERT, have become indispensable basic technology for numerous language processing applications. It is however not easy to understand the process of their learning and how they work in the applications. We investigated the properties of these neural language models used as a part of dependency parsers. We also analyzed the mechanism of the position-dependent inference in the self-attention architecture, which is the basis of many neural language models.

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.

Shin Ando

“Study on deep anomaly and out-of-distribution detection”

This study addresses the task of anomaly detection. In relation to the recent topics such as out-of-distribution and novelty detection in deep learning we consider the extraction of features relating to abnormality from examples of normality as the main principle, under which we implement our anomaly detection framework. Based on this principle, we further aim to develop SOTA methods for contrastive representation learning and continual learning.

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.

Hidetoshi Murakami

“Study on the theory of nonparametric test”

In recent years, many new technologies have permitted the accumulation of various data. However, it is not reasonable to assume that the observations follow a specific distribution in many applications. Therefore, applying the parametric approaches, particularly methods based on normality assumptions, is not appropriate. Then, a nonparametric procedure is recommended to analyze data in many scientific fields. We suggested one-, two- and multi-sample nonparametric test statistics with theoretical properties and derived the distributions of proposed test statistics. Simulations were used to investigate the power of proposed tests. We include illustrations of the proposed tests using real data. Finally, we discussed the unbiasedness of various test statistics.

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

“Estimation of eigenvectors for linear combinations of high-dimensional covariance matrices”

Covariance matrices of high-dimensional data are characterized by the fact that their eigenvalues diverge with dimension. Conventional sample eigenvalues are strongly inconsistent, so a new estimator is required. In this study, we consider the eigenvalue estimation of the covariance matrix of mixed classes of high-dimensional data.

Yannan Hu

“Study on two-machine job-shop scheduling problem with one joint job”

We considered a two-machine job-shop scheduling problem with one joint job where a joint job is defined as a job whose operations are to be processed by different machines. We show that the corresponding problem is strongly NP-hard and propose a polynomial-time algorithm based on dynamic programming when the number of jobs is given as a fixed number. We further improve time complexity using various techniques, including the two-pointer method.

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.

Asanao Shimokawa

“Study on prediction of survival time”

I am studying on the analysis of survival time which treating the time from a certain start point to the occurrence of an event. The goal of my research is to establish a method for constructing an optimal tree-structure-based model for predicting survival time.

Tomoyuki Nakagawa

“Study on robust estimation via divergence”

We conducted a study on robust estimation using divergence. Big data contains a large amount of information, but it also contains a lot of unwanted information such as outliers and anomalies. Therefore, in this study, we propose a methodology to reduce the influence of outliers by using robust divergence in the analysis and give theoretical validity to the proposed methodology.

Masato Kitani

“Study on asymptotic properties of goodness-of-fit tests”

In quantitative risk analysis, it is important to assess the quality of fit between the data and the selected distribution. In this study, we propose new one-sample goodness-of-fit test statistics. Simulation results illustrate that proposed tests are more powerful than existing tests. Moreover, we derive the limiting distribution and the asymptotic power of the proposed tests. Furthermore, we discuss approximations to the test statistics, and we investigate the accuracy of the approximation.

Wanwan Zheng

“Study on feature selection”

Many fields have benefited from feature selection, including text mining, bioinformatics, image categorization, voice recognition, etc. With feature selection, the significance of choosing an appropriate classifier is reduced as well as the performance of the classifier is improved. The importance of feature selection has led to extensive study, and numerous methods have been proposed. However, existing methods usually generate “feature rankings” or “valid feature sets”, without providing information about the categories of features. There are four categories of features (i.e., relevant features, interaction features, redundant features, and irrelevant features), and their attributes play a crucial role in practicality. This study proposed a feature selection method that divides features into the four categories outlined above, in order to accommodate both the requirement for minimal-optimal features and the requirement for all-relevant features simultaneously.

Kengo Fujisawa

“Study on model for square contingency tables with ordinal categories”

For a square contingency table with ordinal categories, we proposed an asymmetry plus association model. Also, we provided a separability using the model.

Ayaka Yagi

“Study on AIC for growth curve model with monotone missing data and study on testing equality of two mean vectors with monotone missing data”

We considered the model selection criteria AIC for a growth curve model with monotone missing data. Considering AIC-type risk as a criterion for evaluating the goodness of the model, we proved that the exact correction term is twice the number of independent parameters when the maximum likelihood estimator of unknown mean parameter vector with known covariance matrix is used. We also considered testing the equality of two mean vectors when each dataset has a monotone pattern of missing observations. We proposed transformed test statistics that improve the chi-squared approximation of the simplified T-squared type test statistic under the null hypothesis.

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 manifold includes a circle, a torus, a cylinder, and a space of their joint probability distributions. In the 2022 academic year, we studied statistical inference for skew-symmetric distributions and their identifiability problem. We also studied the statistical analysis of network data and spatial heterogeneity in spatial statistical models.

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.

Tamae Kawasaki

“A test for sub-mean vector with 2-step monotone missing data”

We discussed a test for the sub-mean vector in a one-sample problem with 2-step monotone missing data. We proposed a test statistic and its approximate null distribution by using an asymptotic expansion. The accuracy of the approximation was evaluated by Monte Carlo simulation.

Kazuyuki Koizumi

“Research on data science theory and applications”

Recently, due to the ease of acquiring and accumulating data, it is necessary to obtain new knowledge based on data that could not be handled in the past. In this situation, the data science industry needs to develop both theoretically and practically and this research will carry out theoretical development of data science and applied research in several fields (sports, marketing, and law).

The Technology Management Strategy and Financial Engineering Social Implementation Research Department

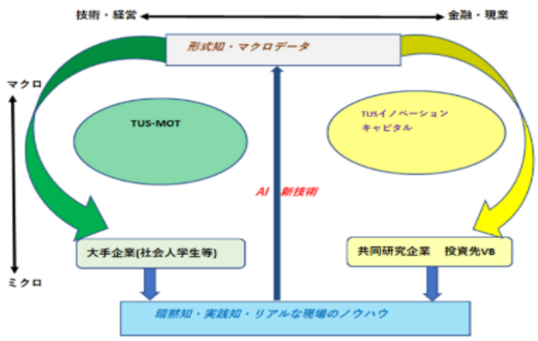
The Technology Management Strategy and Financial Engineering Social Implementation Research Department

1. Overview

The Technology Management Strategy and Financial Engineering Social Implementation Research Department, also known as MOT-FESI or simply FESI, combines theory and practical education in technology management with the leadership of the Innovation Capital of TUS in financial engineering. FESI aims to develop products using advanced technology and knowledge information, conduct empirical research on new services, and promote social implementation through diverse theoretical tools and networks that surround the organization and its members.

2. Organization and Facilities

FESI aims to systematize and create a database of implicit knowledge such as case studies, know-how, and insights related to innovation, management, and venture capital that are accumulated and dormant in MOT and TUS Institute of Innovation Management (IM). The database will support social implementation, research topic selection, and venture investment. By conversion of the knowledge of experts into a database, it is possible to increase the success rate of research topic selection, creating new businesses, and M&A and venture investments.



The following research groups are established, some of which have shared responsibility among guest professors and research associates:

① Cognoscente
② Theoretical study of the DAAE (Design Agility Assemble Economic quality) concept proposed by SHIFT Inc.
③ Survey and database construction of the startup ecosystem and venture database
④ Investigation and research on domestic and international venture investment and support.

3. Research Activities

In the fiscal year 2022, a combination of Zoom and in-person meetings were used due to the COVID-19 pandemic. Collaborations with students and seminar members of the MOT program were made, and presentations were given at the Japan Society for Research Policy and Innovation Management. The research was mainly led by seminar students rather than FESI. Although the number of research meetings decreased due to JUAA's field survey, there were 40 presentations, including those by MOT students and faculty members, at the Japan Society for Research Policy and Innovation Management.

Here is a list of graduation paper themes from the seminar of 2020-2022. All of these papers were presented at the Japan Society for Research Policy and Innovation Management.

- Worldview promotion from online stores - purchasing experiences from both real and web-based stores
- Creating value in semiconductor packaging and chip bonding
- Transformation of Nikon to “video supporters” - new business strategy for the next generation of businesses
- Examination of organizational change and personnel systems in the post-COVID era

• Analysis of star researchers and their organizations through patent co-author networks
• Open innovation through “showcase factories” that promote value creation
• The pros and cons of the regulatory entry barriers for domestic IT infrastructure companies - correlation between entry barriers and innovation through a comparison between Japan and the United States
• Network structure of BUFFALO's secondary sales shops and our strategies
• Business considerations for lithium-ion batteries in EVs - reuse and recycling in both directions
• A new truth about M&A revealed by 15 years of data analysis
• Quality evaluation and redesign of software development for shifting to a solution-oriented organization through metaphors
• Organizational strategy to create synergy between multicultural companies in PMI
• Business survival model resilient to industry structural changes - learning from the middleman and using the optical business as a case study
• Decision-making processes in interrupting research and development themes can determine success or failure - proposal for improving success rates through investment management approaches and researcher career paths
• Proposal for a knowledge friction network that generates innovation based on field experiences - the ideal product development organization that optimally combines various knowledge
• Survival strategy for specialized trading companies caught between EC sites and overseas companies
• Verification of supply chain transformation through the smile curve - from customer value based on quality costs to delivery for Nippon Niche's semiconductor companies amidst significant supply chain fluctuations
• Risk assessment for marine businesses using STAMP/STPA
• Research on the business model of the rapidly expanding sound content market
Social implementation of MaaS in local areas incorporating corporate management perspectives.
• Proposal for a new ecosystem through IoT for the transition to a circular economy in the apparel industry.
・Flexibility over rigidity: the reversal strategy of a challenger company in the inductor industry.
• Development of growth strategy through the new definition of value for friction materials in the CASE era.
• Proposal for new business and M&A strategy for V Technology, through quantitative comparison with Inamori and Nagamori.
• Value creation process in the semiconductor manufacturing equipment business.
• Optimal organization structure for maximizing synergies: a case study of the horizontal cross-functional team.
• Proposal for new technology innovations and business models for EMS survival in the era of major implementation changes, focusing on dissimilar material joining technology.
• Discontinuous convergence of different fields creates new mobility markets: proposal for new businesses that achieve land-sea and heaven-earth collaboration.
• What does Japan Radio lack compared to Huawei?
• Consideration of the conditions for implementing R&D ecosystems using the platform led by semiconductor material manufacturers.
• Optimization of life cycle value through the three categories of value and lifespan in public systems: a case study of disaster prevention radio using the Kano model as a metaphor.

3. 1. Cognoscente Research Group

Presented their research findings at the 37th Annual Academic Conference of the Research and Innovation Society. Their presentation was titled “Redefining ‘Cognoscente’ as a Function System of Value Conversion: Part 2 - The Significance of Differentiation in the Input System” by Hideki Wakabayashi. This research was useful in guiding graduation papers for seminar students and was also helpful for mentoring many working adult students, including Mr. Amano.

3. 2. The DAAE Concept Study Group

Presented some of their research findings at the 37th Annual Academic Conference of the Research and Innovation Society as well. Their paper was titled "Differences in Philosophies between DAAE and QCDS: Using the Kano Model as a Metaphor" by Hideki Wakabayashi and Dai Tange. Mr. Tadao Tateyama, a working adult student at MOT, used this paper as a basis for his graduation paper, which won the Best Paper award.

Additionally, the research was commissioned by Nikkei BP Consulting and was utilized for the semiconductor digital policy of the Ministry of Economy, Trade and Industry. It was highly praised, and the results were published in June 2022, coinciding with the 5th anniversary of the establishment of the new MOT. Two commemorative symposiums were held in coordination with the new MOT's 5th anniversary event, with a total of nearly 200 participants.

3. 3. Survey and construction of a startup database for building a venture ecosystem, as well as research and investigation on domestic and international venture investment and support

Part of the research results were presented at the 37th Annual Academic Conference of the Research and Innovation Society, including a performance analysis of asset allocation in US university funds by Mr.Katayori from TUS-IM, but due to circumstances, Mr. Wakabayashi gave the presentation on the day.

4. Challenges and Prospects

As for the ability to identify promising startups and the implementation of AI in DAAE, several hypotheses were proposed for the overall model in Step 3, but proof and implementation could not be achieved.

Regarding the evaluation of graduation papers in INPUT fields, there is potential for significant reduction in computational power, which suggests possibilities for future research.

Some of the results are being considered for patent applications in companies where working adult students belong.

In the future, we will continue our research on the ability to identify promising startups and DAAE ideas, strengthening collaboration with the graduation papers of MOT. We plan to present our findings at the Research and Innovation Society conference in October.

5. Conclusion

In setting themes at FESI and managing relationships among members, and between social working adult students and research on graduation papers, there were challenges. On the other hand, seminars and research were effective in deepening knowledge.

To address these issues, we have established a research salon and hope to use it to further research and social implementation in a manner more characteristic of MOT. We also plan to hold a symposium.

Major Research Achievements (FY 2022)

Academic Papers

1. Redefining “Cognoscente” as a function system of value conversion: From art to science, Hideki Wakabayashi, Proceedings of the 36th Annual Academic Conference of the Society of Research and Innovation
2. Hybrid lectures during the COVID-19 pandemic: An introduction to the approach taken by the Tokyo University of Science's MOT program, Hideki Wakabayashi, Yukako Nakayama, Tetsu Ishibashi, Graduate School of Management, Tokyo University of Science, Proceedings of the 36th Annual Academic Conference of the Society of Research and Innovation
3. Verification and proposal of R&D policies and strategies for the dual-benefit era of public interest and profit, Hideki Wakabayashi, Proceedings of the 36th Annual Academic Conference of the Society of Research and Innovation
4. Evaluation of semiconductor policies in the new era: In the midst of supply chain reform, Hideki Wakabayashi, Proceedings of the 36th Annual Academic Conference of the Society of Research and Innovation
5. The impact of accounting systems on international competitiveness and innovation: Strategic accounting standards for GAFA development, Hideki Wakabayashi, Proceedings of the 36th Annual Academic Conference of the Society of Research and Innovation
6. The division between GAFAM/BAT and Japanese companies: A comparison of the DAAE concept and the QCD philosophy, Hideki Wakabayashi, Dai Tange, Proceedings of the 36th Annual Academic Conference of the Society of Research and Innovation
7. Key to educational DX: “Sharing introspection” - Lessons from an easy-to-understand project (the National Parliament Accident Investigation Commission), Tetsu Ishibashi, Proceedings of the 36th Annual Academic Conference of the Society of Research and Innovation
8. Establishment status and positioning in the medium- to long-term goals of funds based on the law for promoting the creation of science and technology and innovation, Satoshi Inoue, Proceedings of the 36th Annual Academic Conference of the Society of Research and Innovation

Individual Research Topics

Hideki Wakabayashi
"Research on technology management (R&D, industrial analysis), the electronics industry, and hedge funds"

Satoshi Inoue
"Research on technology management (forecasting, R&D, policy)"

Hiroyuki Nitto
"Research on marketing"

Hidehiko Aoki
"Research on user innovation, retail and distribution industry"

Yukako Nakayama
"Research on IT media industry, DX"

Tetsu Ishibashi
"Research on compliance, industry ethics"

Masanori Sakamoto
"Research on technology management, applied physics"

Shigeaki Shirai
"Research on technology management, industrial policy"

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 Faculties

We have 19 members from our university (8 members from Department of Mathematics, 1 member from Department of Physics, 2 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. Research Activities

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. Group 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 FY2022, further development of the reconstruction formula for the inverse problem of multiple cracks in linear elastic bodies and theoretical results on contact and friction problems in elastic bodies were obtained. These results were published in international academic journals. We also studied the motion of vortex rings. Furthermore, we started a joint research with research teams in Marseille and Toulouse in France, on numerical simulation of the obtained results of inverse problems. Moreover, we have conducted activities such as providing a forum for exchange among young researchers in Japan and abroad in the field of inverse problems.

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.

Major Research Achievements (FY 2022)

Academic Papers

1. Wave front set of solutions to Schrödinger equations with perturbed harmonic oscillators, Shingo Ito and Keiichi Kato, Journal of Mathmatical analysis and applications, 507 125821, 2022
2. Asymptotic expansions of traveling wave solutions for a quasilinear parabolic equation, Koichi Anada, Tetsuya Ishiwata, Takeo Ushijima, Jpn. J. Ind. Appl. Math. 39 (2022), no. 3, pp 889–920
3. Asymptotic series solution for plane poroelastic model with non-penetrating crack driven by hydraulic fracture, Hiromichi Itou, Victor A. Kovtunenko, Nyurgun P. Lazarev, Applications in Engineering Science, 10 100089, 2022
4. Investigation of implicit constitutive relations in which both the stress and strain appear linearly, adjacent to non-penetrating cracks, Hiromichi Itou, Victor A. Kovtunenko, Kumbakonam R. Rajagopal, Mathematical Models and Methods in Applied Sciences, 32 pp. 1475-1492, 2022
5. Unique solvability of a crack problem with Signorini-type and Tresca friction conditions in a linearized elastodynamic body, Takahito Kashiwabara, Hiromichi Itou, Philosophical Transactions of the Royal Society A, 380 20220225, 2022
6. Boundedness and finite-time blow-up in a quasilinear parabolic-elliptic-elliptic attraction-repulsion chemotaxis system, Yutaro Chiyo, Tomomi Yokota, Z. Angew. Math. Phys., 73, Paper No. 61, 27 pp., 2022
7. Weak stabilization in degenerate parabolic equations in divergence form: application to degenerate Keller-Segel systems, Sachiko Ishida, Tomomi Yokota, Calc. Var. Partial Differential Equations, 61, Paper No. 105, 21 pp., 2022
8. Blow-up phenomena for a chemotaxis system with flux limitation, Monica Marras, Stella Vernier-Piro, Tomomi Yokota, J. Math. Anal. Appl. 515, Paper No. 126376, 13 pp., 2022
9. Wave front set of solutions to Schrödinger equations with perturbed harmonic oscillators, Shingo Ito and Keiichi Kato, Journal of Mathmatical analysis and applications, 507 125821, 2022
10. Absence of embedded eigenvalues for non-local Schrödinger operators, Atsuhide Ishida, József Lőrinczi and Itaru Sasaki, Journal of Evolution equations 22 (2022), no.4, Paper No. 82, 30 pp.
11. Nonlocal to local convergence of singular phase field systems of conserved type, S. Kurima, Adv. Math. Sci. Appl.,31 (2022), 481-500.
12. Time discretization of a nonlocal phase-field system with inertial term, S. Kurima, Matematiche (Catania) 77 (2022), 47-66.
13. Existence for a singular nonlocal phase field system with inertial term, S. Kurima, Acta Appl. Math., 178 (2022), Paper No. 10, 20 pp.
14. Characterizations of the gyrator transform via the fractional Fourier transform, Kagawa, Toshinao, and Toshio Suzuki, Integral Transforms and Special Functions, 34 (2023), 399-413.

Books

1. Non-smooth variational problems and applications (Philosophical Transactions of the Royal Society A, Volume 380, Issue 2236), Victor A. Kovtunenko, Hiromichi Itou, Alexander M. Khludnev, Evgeny M. Rudoy (Eds.), The Royal Society Publishing, 2022
2. 工科系のための偏微分方程式入門 (Introduction to Partial Differential Equations for engineering), Yasuyuki Oka，HIroyuki Hirayama，Toshio Suzuki and Kensuke Fujinoki，Gakujutsutosho-shuppan, 2023．(in Japanese).

Invited Lectures

1. 波束変換によるシュレーディンガー方程式の解の構成(Construction of solutions to Schrödinger equations via wave packet transform) ,Keiichi Kato， RIMS Symposia(Open) Regularity and asymptotic analysis for critical cases of partial differential equations, RIMS Kyoto University, June 1st,2022.
2. Application of wave packet transform to Schrödinger equations (Survey Talk I,II), Keiichi Kato, Bibunhouteisiki-no-Sogotekikenkyu, Online， December 24th, 25th, 2022.
3. On cubic-quintic nonlinear Schrödinger equations with delta potential, Mathematical Analysis of Nonlinear Dispersive and Wave Equations, Waseda University, August, 2022.
4. Stability of standing waves for cubic-quintic nonlinear Schrödinger equation with delta potential, Masahito Ohta, Singularity of solutions to Partial Differential Equations and related topics, Tokyo University of Science, January, 2022.
5. On inverse crack problems in linearized elastic bodies by the Enclosure method, Hiromichi Itou, Theoretical and numerical trends in inverse problems and control for PDE's, and Hamilton-Jacobi equation: French-Italian-Japanese conference, Rumigny (France), 2022
6. 囲い込み法を用いた線形弾性体におけるき裂の再構成について(Reconstruction of cracks in linearized elastic bodies by the enclosure method), Masaru Ikehata and Hiromichi Itou, Japan Society for Industrial and Applied Mathematics, Hokkaido University (Hybrid), 2022
7. Analysis of degenerate chemotaxis systems with/without logistic source, Tomomi Yokota, 61st Jitsukansuron · Kansukaisekigaku Godo Symposium Surugadai Campus of Nihon University, August 29th, 2022.
8. Mourre estimate for non-local Schrödinger operators, Atsuhide Ishida, Fractional differential equations (FDE2), Issac Newton Institute for Mathematical Sciences, University of Cambridge, April 25th, 2022.
9. 非局所型シュレディンガー作用素のムールの不等式について(Mourre's inequality for non-local Schrödinger operators), Atsuhide Ishida, 179th Kagurazaka Analysis Seminar,Kagurazaka Campus in Tokyo University of Science, May 28th, 2022.
10. Mourre inequality for non-local Schrödinger operators, Atsuhide Ishida, Tokyo University Friday Analysis Seminar, Tokyo University, June 28th, 2022.
11. 非局所型シュレディンガー作用素のムールの不等式について(On the Mourre's inequality for non-local Schrödinger operators) , Atsuhide Ishida, Operator Theory Seminar, 京 Kyoto University (Online), July 22nd, 2022.
12. 非局所型シュレディンガー作用素のムールの不等式について(Mourre inequality for non-local Schrödinger operators), Atsuhide Ishida,Bibunhouteisiki-no-Sogotekikenkyu, Online, December 24th, 2022.
13. The Hasimoto Transformation for a Finite Length Vortex Filament and its Application， Masashi Aiki， The 40th Kyushu Symposium on Partial Differential Equations，Kyushu University, February 1st, 2023.
14. フェーズフィールドシステムに対する時間離散化法(Time discretization method for Phase field system)(Invited talk), Shunsuke Kurima, Japan Mathematical Society, Chuo University, March 18th, 2023.
15. Dynamics of a prey-predator model describing hunting cooperation, Yoichi Enatsu, The Eighth International Workshop on Biomathematics Modelling and Its Dynamical Analysis, Online, August 26th -28th, 2022.
16. 自由境界をもつ拡散型 SI 感染症モデルの進行波解の存在 (Existence of traveling wave solutions to SI epidemic model of diffusion type with free boundary), Yoichi Enatsu, Seminar on Mathematical Sciences, Kyushu Institute of Technology, February 18th, 2023.

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 of chemotaxis models"

In a joint work with Ph.D student Yutaro Chiyo, a result on the classification of boundedness and blow-up of solutions to quasilinear attraction-repulsion chemotaxis systems by the size of the powers of the attraction and repulstion terms was obtained. Also, in a joint work with Professor Sachiko Ishida (Chiba University), a stabilization result for weak solutions to degenerate Keller-Segel sytems was established. Moreover, in a joint work with Professors Monica Marras and Stella Vernier-Piro, a result on finite-time blow-up and estimates for the blow-up time was obtained.

Tetsuro Nikuni

"Research on Theoretical Analysis of Quantum Many-Body Systems and Applications of Quantum Computers"

We are studying quantum many-body dynamics in ultracold atomic gases in using analytical methods and numerical simulations. We are also conducting theoretical research on the NISQ Noisy Intermediate-Scale Quantum Computer） devices.

Hiromichi Itou

"Study on theoretical analysis of contact and friction problems in elastic bodies and inverse problems related to nondestructive testing"

We considered mathematical analysis of crack problems in elastic bodies describing porous materials such as rock and concrete, as well as dynamic friction problems. 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.

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.

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.

Toshio Suzuki

"Time-frequency analysis"

Time-frequency analysis is a well-known method for simultaneously analyzing the time and frequency information of a signal. The windowed Fourier transform and the wavelet transform are well-known transforms of this method, and various transforms are constructed according to the features of the signal.

In this study, we investigate the characteristics of these transforms and their relationship to other transforms relevant to time-frequency analysis. We also study time-frequency analysis for functions over p-adic fields.

Noriyoshi Fukaya

"Study on solitary wave solutions for nonlinear dispersive equations"

I study the properties of solitary wave solutions for nonlinear dispersive equations. In particular, I deal with equations without scale invariance or Galilean invariance, such as cases with potentials, cases with double power nonlinearities, and systems, to investigate the properties of the profiles of solitary waves and the orbital stability/instability. In addition, I consider asymptotic stability and strong instability in order to reveal the global dynamics.

Yukihide Tadano

"Spectral and scattering theory of discrete Schrödinger operators"

Discrete Schrödinger operators have two different derivations; one is the tight-binding Hamiltonian in the field of solid state physics, and the other is the discretization of Schrödinger operators. I study these operators by focusing on similarity and dissimilarity of spectral and scattering properties.

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, but since the early days of qubit research, physical systems other than superconductivity, such as light, ions, cooling atoms, and other quantum systems have been 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. It also hosted an international conference in this field in 2020. On the other hand, we are also conducting research to cover the theoretical aspects of superconducting quantum circuits.

3. Research Activities

3. 1. Superconducting Quantum Circuits Research Group (Tsai, Yoshihara)

This group is studying quantum circuits based on superconducting qubits using Josephson junctions. Regarding the integration of qubits, we are conducting research on quantum chips that can be packaged planarly using a pseudo-two-dimensional qubit coupling network originally developed by us. In addition, as a research theme of the moonshot program, Bosonic qubits, we are conducting research on quantum information processing using a superconducting Kerr parametric oscillator (KPO). The cat state was generated by KPO, the fidelity was evaluated by quantum tomography, and a one-bit gate operation was successfully demonstrated. In the future, we will proceed with experiments with 2-bit gates and autonomous error correction with KPO. We conducted research on low-frequency noise of KPO oscillation, clarified for the first time that 1/f noise was remarkably present, and succeeded in reducing the noise by injection lock-in technique. In research on the initialization of superconducting qubits, we achieved a high-speed initialization of 200 ns with an accuracy of 99.5% with a novel circuit that involving a SINIS junction. In order to extend the coherence time of superconducting qubits, we studied surface treatment methods and significantly improved T1 and T2 time. Similar surface treatment also reduced the loss of the superconducting resonator by about one order of magnitude. For fast generation of Bell states, we use GRadient Ascent Pulse Engineering (GRAPE) algorithm to design optimized pulse. In the optimization, we allow higher energy levels to be populated during the entangling gates.

3. 2. Quantum Optics Research Group *(Sanaka, Sadgrove, Tkachenko)*

The Optical Quantum Information Group focused on realizing the single-photon emitter required for quantum cryptographic communication, which is the next-generation secure communication system, using a tapered optical fiber system. At present, the most common method of realizing a single-photon emitter is to use high-quality crystalline materials such as semiconductors and diamonds, but some of the technical and economic issues remain (manufacturing and processing costs, restrictions on emission wavelengths, requirement of cooling etc.). On the other hand, by using an optical fiber material doped with optically active atoms in this group, we solved the technical and economic problems in the development of a single photon light source. We succeeded in fundamental works for the commercialization of a single-photon emitter. The single-photon emitter realized by this method currently generates single photons through the process of spontaneous emission from atoms, so the efficiency of single-photon generation is limited by the spontaneous emission coefficient (A factor) of atoms. In the future, we will combine a single-photon emitter in a small mode volume with a cavity structure to develop a highly efficient and highly coherent single-photon emission based on the principles of cavity quantum electrodynamics.

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
  Basic research founded on quantum probability theory, quantum channel theory and quantum entropy theory, including quantum coherence determined based on the mathematics of entanglement.
- (2) Research on the formulation of Quantum Dynamical Mutual Entropy
  The channel coding theorem of commutative systems shows the limit of the average mutual entropy obtained from dynamic entropy from the transmission capacity and provides an important criterion for constructing error-free channels and coding.
- (3) Basic theoretical research and implementation of cryptographic theory.
- (3-1) Construction of authentication algorithm incorporating secure computation and information distribution structure.
- (3-2) Construction and implementation of a mathematical framework for Strongly Asymmetric Public Key Agreement.
- (3-3) Formulation of quantum algorithms using adaptive mechanics.
- (4) Application of “effective” algorithmic methods to quantum system analysis and quantum information theory.
- (4-1) Determination of existence of decoherence-free subspace (DFS).
- (5) Evaluation of quantum annealing including finite temperature dissipation.
- (6) Development of imaginary-time quantum toolbox (JST PRESTO).
- (7) Indicators for large-scale quantum computers.
- (8) Artificial intelligence/machine learning and quantum computers.

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.

In addition, with regard to the expansion of membership of the division as pointed out by the Advisory Committee, that is, the incorporation of new researchers involving in the research of classical control circuits, which are important peripheral circuits of quantum computers, no such researchers are identified within the university.

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.

Although the development of field of quantum information is what the government is paying particular interest, 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.

Major Research Achievements (FY 2022)

Academic Papers

1. "Elucidation of Spin-Correlations, Fermi Surface and Pseudogap in a Copper Oxide Superconductor", Hiroshi Kamimura, Masaaki Araidai, Kunio Ishida, Shunichi Matsuno, Hideaki Sakata, Kenji Sasaoka, Kenji Shiraishi, Osamu Sugino, Jaw-Shen Tsai, and Kazuyoshi Yamada, Condens. Matter 2023, 8, 33, 2023 (Peer-reviewed)
2. "Mitigation of noise in Josephson parametric oscillator by injection locking", Gopika Lakshmi Bhai, Hiroto Mukai, and Jaw-Shen Tsai, Appl. Phys. Lett. 122, 054002, 2023 (Peer-reviewed)
3. "Noise Properties of a Josephson Parametric Oscillator", Gopika Lakshmi Bhai, Hiroto Mukai, Tsuyoshi Yamamoto, and Jaw-Shen Tsai, Physical Review Applied 19, 014065, 2023 (Peer-reviewed)
4. "Autonomous quantum error correction in a four-photon Kerr parametric oscillator", Sangil Kwon, Shohei Watabe, and Jaw-Shen Tsai, npj Quantum Information, 8:40, 2022 (Peer-reviewed)
5. "Deterministic one-way logic gates on a cloud quantum computer", Zhi-Peng Yang, Huan-Yu Ku, Alakesh Baishya, Yu-Ran Zhang, Anton Frisk Kockum, Yuch-Nan Chen, Fu-Li Li, Jaw-Shen Tsai, and Franco Nori, Physical Review A, 105, 042610, 2022 (Peer-reviewed)
6. "On Transmitted Complexity Based on Modified Compound States", Noboru Watanabe, Entropy 2023, 25(3), 455
7. "Note on transmitted complexity for the modified compound states", Noboru Watanabe, International Journal of Modern Physics A, Vol. 37, Nos. 20&21, 2022
8. "Note on Complexity of Communication Processes", Infinite Dimensional Analysis, Noboru Watanabe, Quantum Probability and Applications, Vol.390, Springer, 2022(Peer-reviewed)
9. "A Note on Improved Treatment of Gaussian Communication Process", Taihei Takahashi and Noboru Watanabe, Open Systems and Information Dynamics, Vol. 28, No. 3 (2021) 2150014(Peer-reviewed)
10. "Analysis of The Effect of Noise on Feedback with White Noise Analysis", Taihei Takahashi and Noboru Watanabe, The Proceedings of the 45th Symposium on Information Theory and its Applications SITA2022, Vol.45, pp.320-pp.324, 2022
11. "Improving of Controlled Phase Shift gate based on FTM gate", Yuki ARAI and Noboru Watanabe 信学技報, Vol. 12, No. 128, IT2022-16, pp. 4-9, 2022, ISSN 2432-6380
12. "Formulation of Quantum Teleportation by Using Entangled States Generated by Beam splitters", Ryo Kotaki and Noboru Watanabe, The Proceedings of the 45th Symposium on Information Theory and its Applications SITA2022, Vol.45, pp.20-pp.22, 2022
13. "Quantum Logic Gate with Half Polarizing Beam Splitter and Waveplate", Itaru Nakazawa and Noboru Watanabe, The Proceedings of the 45th Symposium on Information Theory and its Applications SITA2022, Vol.45, pp.14-pp.19, 2022
14. "Plasmon-enhanced single photon source directly coupled to an optical fiber", M Sugawara, Y Xuan, Y Mitsumori, K Edamatsu, M Sadgrove, Physical Review Research 4, 043146 (2022)
15. "Interference-induced directional emission from an unpolarized two-level emitter into a circulating cavity", L Ostrowski, S Parkins, M Shirane, M Sadgrove, Physical Review A 105, 063719 (2022)
16. "Evanescent field trapping and propulsion of Janus particles along optical nanofibers". Tkachenko, G., Truong, V.G., Esporlas, C.L. et al., Nat Commun 14, 1691 (2023)
17. "Roadmap for Optical Tweezers 2023", Giovanni Volpe, Onofrio M Marago, Halina Rubinsztein-Dunlop, Giuseppe Pesce, Alexander Stilgoe, Giorgio Volpe, Georgiy Tkachenko, et al., Journal of Physics: Photonics 5, 022501 (2023)
18. "Enhancing the stimulated emission of polarization-entangled photons using passive optical components", Ryo Nozaki, Yoshiro Sato, Yoshitaka Shimada, Taku Suzuki, Kei Yasuno, Yuta Ikai, Wataru Ueda, Kaito Shimizu, Emi Yukawa, and Kaoru Sanaka, Physical Review A, 107, 023707 (2023)

19. 著書：橋爪洋一郎『物理学レクチャーコース　物理数学』（裳華房）in Japanese
20. "Numerical analysis of quantum circuits for state preparation and unitary operator synthesis", Sahel Ashhab, Naoki Yamamoto, Fumiki Yoshihara, and Kouichi Semba,Phys. Rev. A 106, 022426 (2022)
21. "Hamiltonian of a flux qubit-LC oscillator circuit in the deep-strong- coupling regime", Fumiki Yoshihara, Sahel Ashhab, Tomoko Fuse, Motoaki Bamba, Kouichi Semba, Scientific Reports volume 12, Article number: 6764 (2022)
22. "Speed limits for quantum gates with weakly anharmonic qubits", Sahel Ashhab, Fumiki Yoshihara, Tomoko Fuse, Naoki Yamamoto, Adrian Lupascu, Kouichi Semba,Phys. Rev. A 105, 042614 (2022)

Invited Lectures

1. "Superconducting quantum computer and its future issues", Jaw-Shen Tsai, QPQIS2022, Dec. 1, 2022, Online
2. "Superconducting quantum computer and its future issues", Jaw-Shen Tsai, The First International Conference on Axion Physics and Experiment (Axion 2022), Nov. 22, 2022, Online
3. "Recent progress in superconducting quantum information", Jaw-Shen Tsai, The virtual QBIC Workshop 2022, Oct. 13, 2022, Online
4. "Superconducting Quantum Circuit", Jaw-Shen Tsai, EAIFR Conference, Sep. 12, 2022, Online "超伝導量子ビットの平面集積化", 蔡 兆申, 第７０回応用物理学会春季学術講演会, 上智大学四谷キャンパス, 3/6/2023
5. "超伝導量子コンピュータの展望", 蔡 兆申, 応用物理学会２０２２年度第２回講演会, Online, 1/20/2023
6. **"**On Transmitted Complexity based on Compound States for Quantum Dynamical Systems**"**, Noboru Watanabe, The QBIC Workshop 2022 (Online), Tokyo University of Science, Noda, Japan, 2022-10-12～10-14
7. **"**On Transmitted Complexity for Modified Compound States**"**, Noboru Watanabe,the international conference: "Quantum Information and Probability:from foundations to engineering (QIP22) conference, Linneaus University, Vaxjo, Sweden, 2022-6-14～6-17
8. **"**On Transmitted complexity for Quantum Compound Systems**"**, Noboru Watanabe,The International Symposium on Infinite Dimensional Analysis, Quantum Probability and Related Topics QP43, UTOP Marina Hotel, Yeosu, Korea, 2023-1-9～1-13
9. **"**A Study on the Effects of Input Parameters on Quantum Teleportation Using Squeezed State and Beam Splitter**"**, Masayuki Miyashita, Noboru Watanabe, The QBIC Workshop 2022, Tokyo University of Science, Noda, Japan, 2022-10-12～10-14
10. **"**Analysis of The Effect of Noise on Feedback with White Noise Analysis**"**, Masaki Nakazato and Noboru Watanabe,The QBIC Workshop 2022, Tokyo University of Science, Noda, Japan, 2022-10-12～10-14
11. **"**Improving of Controlled Phase Shift gate based on FTM gate", Yuki Arai Noboru Watanabe, The QBIC Workshop 2022, Tokyo University of Science, Noda, Japan, 2022-10-12～10-14
12. "Formulation of Quantum Teleportation by Using Entangled States Consisted of Beam splitters", Ryo Kotaki and Noboru Watanabe, The QBIC Workshop 2022, Tokyo University of Science, Noda, Japan, 2022-10-12～10-14
13. "Quantum Logic Gate with Polarizing Beam Splitter and Waveplate", Itaru Nakazawa and Noboru Watanabe, The QBIC Workshop 2022, Tokyo University of Science, Noda, Japan, 2022-10-12～10-14
14. "ホワイトノイズ解析によるフィードバックへのノイズの効果の分析", 高橋太平, 渡邉 昇, 第 45 回情報理論とその応用シンポジウム, 北海道登別 登別万世閣, 2022 年 11 月 29 日～12 月 2 日

15. “FTM ゲートを用いた制御位相シフトゲートの改良”, 新井雄己, 渡邉 昇, 電子情報通信学会, 情報理論研究会, 岡山理科大学, 岡山キャンパス, 2022 年 7 月 21 日-7 月 22 日
16. “ビームスプリッターで構成されたエンタングルド状態を用いた量子テレポーテーションの定式化について”, 小滝 遼, 渡邉 昇, 第 45 回情報理論とその応用シンポジウム, 北海道登別 登別万世閣, 2022 年 11 月 29 日～12 月 2 日
17. “偏光ビームスプリッターと半波長板を加えた量子論理ゲート”, 中沢 達, 渡邉 昇, 第 45 回情報理論とその応用シンポジウム, 北海道登別 登別万世閣, 2022 年 11 月 29 日～12 月 2 日
18. “Atoms as a resource for controlling light transport from non-ideal emitters”, Mark Sadgrove, Quantum Transport with Ultracold Atoms Workshop, Max Planck Institute for the Physics of Complex Systems, September 1 (2022)

International Conferences Hosting

1. From October 12 (Wed.) to October 14 (Fri.), Tokyo University of Science and the Division of Nano Quantum Information held the “**Virtual QBIC International Workshop 2022”** via Zoom. The conference was held as a Tokyo University of Science Session and an International Session, and the opening address of the international session was given by Prof. Hideaki Takayanagi. Fourteen researchers from overseas, six researchers from outside the university, seven researchers from the Nano Quantum Information Research Division and one researcher from the Tokyo University of Science gave invited lectures, and poster lectures were given by 10 researchers from this research division, 3 researchers from the Tokyo University of Science, and 2 researchers from outside the university.
   https://www.rs.noda.tus.ac.jp/qbic/VQBICworkshop2022new.html

Individual Research Topics

Jaw-Shen Tsai

We experimentally observe all essential quantum properties of a planar superconducting KPO via Wigner tomography: (i) quantum coherence induced by tunneling between two potential minima in phase space, (ii) coherence-preserving mapping between Fock states and cat states, (iii) tuning the distance between two potential minima by controlling the detuning of the pump, and (iv) effects of single-photon loss on cat states in a KPO. Then, we performed gate operations on this cat state and characterize them using quantum process tomography.

We designed, fabricated, and characterized a 5-qubit superconducting quantum circuit that employs a quasi-two-dimensional coupled architecture using air bridges, which is proposed by our laboratory. The coherence of the qubits was about 10~18us. In the future, further performance improvement and more advanced quantum control will be achieved by realizing all two-qubit gates and by reviewing the fabrication process.

By dipping the as-made resonators or qubit devices (made of niobium) into a buffered hydrofluoric solution, the relaxation and decoherence times are significantly enhanced. Extensive analysis of resonators showed that the loss related to two-level systems in superconducting resonators decreased by about one order of magnitude.

Furthermore, we conducted research on low-frequency noise of KPO oscillation, clarified for the first time that a remarkable 1/f noise was present, and succeeded in reducing the noise by injection lock-in technique. In research on the initialization of superconducting qubits, we achieved a high-speed initialization of 200 ns with an accuracy of 99.5% with a novel circuit that utilizing a SINIS junction. In a quantum optics with novel superconducting artificial atom, in a circuit having ultra-strong coupling, we succeeded in exciting two atoms simultaneously with a single photon.

Fumiki Yoshihara

For fast generation of Bell states, we use GRadient Ascent Pulse Engineering (GRAPE) algorithm to design optimized pulse. In the optimization, we allow higher energy levels to be populated during the entangling gates. We also set the amplitude and frequency restrictions due to the limitations of experimental setup and produce an experimentally implementable entangling pulse. The result indicates that the optimized entangling pulse is well reproduced by the experimental setup. As a future work, we apply the optimized entangling pulse to an actual two-qubits system and evaluate the fidelity of the generated entangled state.

Kaoru Sanaka

We have established a method for efficiently generating “entangled photons”, which are necessary for quantum information communication and quantum repeater technology. Conventional implementations of this light source have limited the efficiency of quantum entanglement generation because they rely on a process called spontaneous parametric down-conversion by nonlinear optical crystals. On the other hand, in this research, by combining a nonlinear optical crystal and a Sagnac interferometer, we succeeded in generating entangled photons in a laser-like stimulated emission process using only passive optical elements.

Mark Sadgrove

In 2022, we published two research papers regarding new types of fiber coupled single photon sources. In particular, in collaboration with Auckland University, we developed a method for creating directional single photons with direction switchable using a control atom. We also developed a Purcell enhanced fiber-coupled single photon source using nanoparticles coupled to quantum dots. These results should provide a base for next generation quantum communication technology.

Georgiy Tkachenko

In 2022, I developed new techniques for nanoparticle manipulation using optical nanofibers along with chiral nano-objects including carbon nanotubes and chiral nanoparticles. These novel materials allow fundamental studies of chiral light matter interaction which we hope to use for the control of photons in the future.

Noboru Watanabe and Satoshi Iriyama

(1) "A Study on Mathematical Formulation of Gaussian Communication Processes Using Entropy-Type Functionals as Complex Quantities"
In this study, based on the research on Gaussian communication processes up to the previous fiscal year, we investigated the entropy-type functional and mutual interaction as a measure to examine information transmission under the conditions of (1) linearity and (2) trace preservation of the channel. A study was carried out to determine the entropy functional.

(2) "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 Complexity. 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

(1) To clarify how the fidelity of quantum annealing at a finite temperature is maintained and what parameters can be effectively controlled.
With fluctuations at finite temperatures, the equilibrated state changes with time. This corresponds to a change of state on a timescale shorter than the equilibration time and longer than the relaxation time. In such cases, it was found that at low temperatures, the equilibration state does not depend much on the coupling to the heat bath; however, at higher temperatures, the coupling to the heat bath has a strong influence.

(2) The fundamental relationship between the behavior of quantum currents and entropy generation in the control of qubits is investigated.
The Lindblad equation was analyzed for a uniform 1D spin chain to verify the current behavior. In the absence of a heat bath (corresponding to the limit of absolute zero), the current is generated through all states regardless of the energy state of the spin chain. However, with a small finite temperature fluctuation, the current reflects the structure of energy levels in the steady state. It was also found that if the effect of the heat bath becomes too large, it is no longer possible to inject current into the system.

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.”

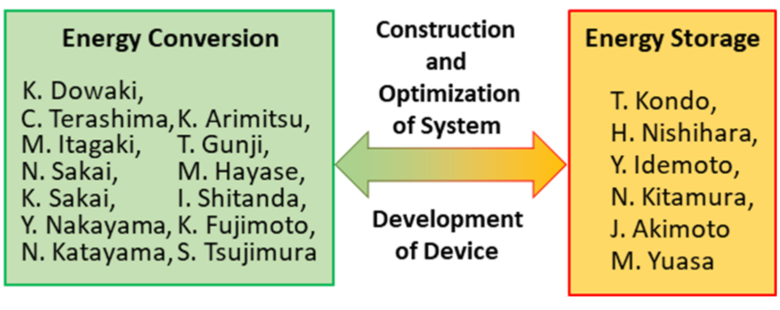
SDG 12: “Ensure sustainable consumption and production patterns.”

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 Faculties

<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 biofuel 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.

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 (FY 2022)

Academic Papers

1. Steam treatment of metal acetylacetonate and ethyl acetoacetate complexes at 90 ºC for preparation of metal oxides, Y. Iida, Y. Sato, R. Hayami, T. Gunji, *Inorganica Chimica Acta*, **535**, 120864, 2022.
2. Superior Multielectron-Transferring Energy Storage by π-d Conjugated Frameworks. D. Xia, K. Sakaushi, A. Lyalin, K. Wada, S. Kumar, M. Amores, H. Maeda, S. Sasaki, T. Taketsugu, H. Nishihara, *Small*, 2202861, 2022.
3. Chemical synthesis of nanoporous $EuTiO_3$ thin film and induced ferromagnetism. N. Suzuki, Y. Fujii, N. Ishida, T. Kondo, M. Yuasa, C. Terashima, A. Fujishima, *Appl. Surf. Sci.*, **615**, 156421, 2023.
4. Detection of Hydrogen Gas Generated upon Magnesium Dissolution Using a Gas Chromatograph–Channel Flow Electrode System, Y. Hoshi, Y. Hirayama, H. Watanabe, I. Shitanda, M. Itagaki, *J. Electrochem. Soc.*, **170**, 021509, 2023.
5. High-Performance Paper-based Biocathode fabricated by Screen-printing an improved Mesoporous Carbon Ink and by Oriented Immobilization of Bilirubin Oxidase, N. Loew, I. Shitanda, H. Goto, H. Watanabe, T. Mikawa, S. Tsujimura, M. Itagaki, *Scientific Reports*, **12**, 14649-14656, 2022.
6. Positive-Electrode Properties and Crystal Structures of Mg-Rich Transition Metal Oxides for Magnesium Rechargeable Batteries, N. Kitamura, Y. Konishi, W. Ma, N. Ishida, T. Mandai, C. Ishibashi, Y. Idemoto, *Scientific Reports*, **12**, 18097, 2022.
7. Electrochemical properties and crystal and electronic structure changes during charge/discharge of spinel type cathode-materials $Mg_{1.33}V_{1.67-x}Mn_xO_4$ for magnesium secondary batteries, Y. Idemoto, M. Takamatsu, C. Ishibashi, N. Ishida, T. Mandai, N. Kitamura, *Journal of Electroanalytical Chemistry*, **928**, 117064, 2023.
8. Synthesis of Dibenzotetrathiafulvalenes of Oxalic Acid with Electron-Rich Aromatic 1,2-Dithiols and Application to Dithioacetalization with 9-Fluorenecarboxylic Acids or Dicarboxylic Acids, N. Sakai, K. Minato, S. Nakata, Y. Ogiwara, *Synthesis*, **54**, 2661, 2022.
9. Performance evaluation of desulfurization and environmental impact of using waste from mines as adsorbent, K. Torii, S. Kumon, K. Sato, S. Kato, K. Dowaki, *Cleaner Engineering and Technology*, **11**, 100573, 2022.
10. Bonding formation and gas absorption using Au/Pt/Ti layers for vacuum packaging, S. Kariya, T. Matsumae, Y. Kurashima, H. Takagi, M. Hayase, E. Higurashi, *Microsystems and Nanoengineering*, **8**, 2, 2022.
11. Exploring the effect of surface chemistry and particle size of boron-doped diamond powder as catalyst and catalyst support for the oxygen reduction reaction, G. Alemany-Molina, B. Martínez-Sánchez, A. Gabe, T. Kondo, D. Cazorla-Amorós, E. Morallón, *Electrochim. Acta*, **446**, 142121, 2023.
12. 酒井健一, 宇野円蔵, 松枝宏尚, 坂田 浩, 赤松允顕, 酒井秀樹, 硫黄系・リン系極圧剤混合系での吸脱着挙動と反応膜組成の解析, トライボロジスト, **67**, 711-717, 2022. (in JA)
13. Abnormal grain growth of 68Cu-16Al-16Zn alloys for elastocaloric cooling via cyclical heat treatments, Y. Kawarada, A. Aimi, A. Santos, G. Nakata, I. Takeuchi, K. Fujimoto, *Journal of Physics: Energy*, **5**, 024012, 2023.
14. Design and Temperature Analysis of a Metal Hydride Cartridge Using Exhaust Heat of a Fuel Cell for Electric-assisted Bicycles, J. Shimogawa, D. Hara, S. Miao, N. Katayama, K. Dowaki, *Journal of the Japan Institute of Energy*, **101**, 152, 2022.
15. High-throughput transient photoluminescence spectrometer for deep learning of thermally activated delayed fluorescence materials, M. Furukori, Y. Nagamune, Y. Nakayama, T. Hosokai, *Journal of Materials Chemistry C*, **11**, 4357, 2023.
16. A disposable enzymatic biofuel cell for glucose sensing via short-circuit current, J. Morshed, M. M. Hossain, A. Zebda, S. Tsujimura, *Biosensor and Bioelectronics*, **230**, 115272, 2023.
17. Role of dipyridyl disulfide cross-linking moieties in an acrylate photo-adhesive material, M. Furutani, K. Nakayama, K. Okuma, K. Arimitsu, *Journal of Polymer Research*, **29**, 245, 2022.

Books

1. 教養の化学: 生命・環境・エネルギー, 西原 寛, 中田宗隆, 東京化学同人, 228 ページ, 2023. (in Japanese)
2. Photocatalytic Water Pollutant Treatment: Fundamental, Analysis and Benchmarking, K. R. Davies, B. Jones, C. Terashima, A. Fujishima, and S. Pitchaimuthu, Nanostructured Materials for Environmental Applications, Springer, 2022.
3. 電気化学インピーダンス法第 3 版, 板垣昌幸, 丸善出版株式会社, 全 210 頁, 2022. (in Japanese)
4. 紫外線硬化樹脂，高分子材料の辞典（高分子学会　編集），有光晃二，朝倉書店，84-85, 2022. (in Japanese)

Invited Lectures

1. Functional Coordination Nanosheets, H. Nishihara, Seventh International Conference on Multifunctional, Hybrid and Nanomaterials, Genoa, Italy, 2022.
2. 太陽光を利用した炭酸ガス還元触媒の開発, 寺島千晶, 丸田晃大, 石田直哉, 第 12 回 CSJ 化学フェスタ 2022, 口頭発表（招待・特別）, 国内会議, タワーホール船堀, 2022. (in JA)
3. バイオ燃料電池で自己発電, 四反田 功, 東京理科大学オープンカレッジ, 東京理科大学オープンカレッジ　セントラルプラザ（神楽坂）, 2022. (in Japanese)
4. Total Scattering Studies of Lithium-Rich Transition-Metal Oxides for High-Energy Rechargeable Batteries, N. Kitamura, AsCA2022, Jeju, Republic of Korea, 2022. (in Japanese)
5. マグネシウム二次電池の開発動向～正極材料を中心として～, 井手本康, 電気化学会セミナーD, 千葉, 2023. (in Japanese)
6. In-Situ Observation of Copper Electroplating with Additves Using Microfluidic Devices, M. Hayase, T. Akita, 242nd Meeting of the Electrochemical Society, Atlanta, 2022.
7. Boron-doped Diamond Powder for Electrolytic Electrode Material, T. Kondo, International Conference on Materials Science and Engineering 2022, Gold Coast, Australia, 2022.
8. The Challenge of Automated High-Throughput Experiments on a Variety of Powder Libraries, K. Fujimoto, 241st ECS Meeting, Vancouver convention center, BC, Canada, 2022.
9. Epitaxial Organic Molecular Interfaces as Well-ordered Model Systems for Molecular Semiconductor p-n Junctions for Optoelectronic Applications, Y. Nakayama, 241st ECS Meeting, Canada, 2022.
10. 有機系メディエータを用いたグルコース脱水素酵素電極の設計, 辻村清也,第 32 回日本 MRS, 横浜, 2022. (in Japanese)
11. カスケード式化学で構築する高感度フォトポリマー, 有光晃二, 日本接着学会　構造接着・精密接着研究会　2022 年度第 2 回研究講演会, オンライン開催, 2022. (in Japanese)

Patents

1. 西原 寛, 宮地麻里子, 佐藤正春, 二次電池用負極及び二次電池, 特許第 7170330 号, 2022. (in Japanese)
2. 板垣昌幸, 国内優先出願, 電子機器および測定方法, No. 2022-006779, 2022. (in Japanese)
3. 四反田功　他３名, バイオ燃料電池、バイオ燃料電池用電極、酵素電極、及びバイオ燃料電池用電極スラリー, 特願 2023-055434, 2023. (in Japanese)
4. 片山 昇, 出願, 状態推定モデル学習装置、方法、及びプログラム, 特願 2022-086983, 2022. (in Japanese)

Public Relations

1. 西原 寛, ユニークな酸化還元特性と整流作用を示すヘテロ積層体のワンポット合成法を開発～液液界面反応を利用して複数の異なる層を段階的に積層～, 東京理科大学プレスリリース, 2022. (in Japanese)
2. 寺島千晶, 「日経メッセ 建築・建材展での講演について」, 日本経済新聞, 2023. (in Japanese)

3. 四反田功, 汗をエネルギー源として活用!? 新開発のウェアラブルバイオ燃料電池をご紹介, 講談社ブルーバックス/リケラボ，2022. (in Japanese)
4. 井手本康, 北村尚斗, 東京理科大, マグネ電池の正極材開発　放電容量は最大 256mAh/g, 日刊工業新聞, 2023. (in Japanese)
5. 中山泰生, 日刊工業新聞「蛍光材料 ３秒で測定」, 2023. (in Japanese)

Awards

1. T. Gunji, Featured Article in Polymer Journal, 2022 (8). "Syntheses and properties of Cu(II), Al(III), and Ti(IV) coordination polymers using an acetylacetonato-terminated polyhedral oligomeric silsesquioxane, Y. Sato, R. Hayami, K. Yamamoto, T. Gunji, *Polymer Journal*, **54**, 985-993, 2022."
2. 西原 寛, 加藤記念賞, 公益財団法人加藤科学振興会, 2022. (in Japanese)
3. A. Ikeda, N. Suzuki, A. Fujishima, C. Terashima, "CO_2 conversion by in−liquid microwave plasma CVD with multiple parameters", Organizing Commitee of the joint Symposium 12th International Symposium on Non-Thermal Plasma & International Symposium on Electrohydro Dynamics 2022, ISNTP-12 & ISEHD 国際会議 Best Poster Presentation, 2022. (in Japanese)
4. M. Itagaki, S. Suzuki, I. Shitanda, and K. Watanabe, Featured in the List of 2022 ANNUALLY MOST DOWNLOADED PAPERS Ranked 1st For Electrochemistry，The Electrochemical Society of Japan, 2023. (in Japanese)
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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. We found that bis (diimino) copper nanosheets are LIB cathode materials with high energy capacity. As for bis (terpyridine) complex nanosheet M-tpy, we have developed a hetero-laminating method of Fe-tpy and Co-tpy and found that it exhibits rectifying properties. The performance of perovskite solar cells was improved by adding Zn-tpy.

Chiaki Terashima

"Development of diamond photocatalyst for highly efficient CO_2 conversion"

Diamond semiconductor 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 of highly proton-conductive polymer materials"

Synthesis of a silicon-containing polymer was investigated as a substitute material for Nafion used in polymer electrolyte batteries. After identifying the structure of the synthesized polymer and examining its heat resistance and thermal decomposition behavior, it was found to be a polymer with high thermal stability.

Masayuki Itagaki

"Studies on the electrochemical methods to evaluate energy transformation devices"

Studies on the electrochemical methods were carried out to evaluate energy transformation 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 aircrafts. And new surface treatments and its evaluation method have been developed for high durability of polymer electrolyte fuel cells.

Isao Shitanda

"Study for wearable biofuel cell"

Paper substrate biofuel cells were fabricated by screen printing on paper substrates. This year, we fabricated a biofuel cell using a novel water-based porous carbon ink. A new carbon ink using polysol as a binder and water as a solvent was prepared. The output power of the new aqueous porous carbon ink was higher than that of the conventional ink with NMP as a solvent and PVdF as a binder.

Yasushi Idemoto and Naoto Kitamura

"Development of new cathode materials for magnesium secondary batteries and investigation of discharge and charge mechanism"

To develop high-capacity cathode materials for magnesium secondary batteries with excellent cycle properties, we investigated the electrochemical properties of spinel-type oxides with various metal compositions, and found that $Mg_{1.33}V_{1.67-x}Mn_xO_4$ exhibited excellent cathode properties. As for some samples, surface modification with Zr compounds was found to be effective in improving cycle properties.

Norio Sakai

"Development of the novel synthetic method of sulfur-containing polycyclic heterocycles toward electroconductive materials"

We focused the development of the effective synthetic method of sulfur-containing polycyclic heterocycles, cyclic sulfide compounds, embedded in the seven-membered ring skeleton, in the hope that the derivatives would be applied to electrochemical devises. It was found that when heating the mixture of a terminal alkyne having a biphenyl group and potassium sulfide with a catalytic system composed of a copper(I) halide and 1,10-phenanthroline as a ligand in *N*-methylpyrrolidone, the corresponding cyclic sulfide was obtained in a relatively high yield.

Kiyoshi Dowaki

"A system analysis of H_2S adsorbent using mine waste in the bio-hydrogen production system"

Energy production systems, through the combined biomass and fuel cells, can produce clean energy with little environmental impact. However, H_2S in the syngas from the plant causes the performance drop of fuel cells. Therefore, in this study, the removal of H_2S from synthesis gas after the gasification process was investigated through experiments on the adsorption performance using granular neutralized sediment, of which soil discharged from abandoned mines. In addition, the environmental impacts are estimated in terms of life cycle engineering to reduce the environmental impact of hydrogen production.

Masanori Hayase

"Studies on the MEMS type miniature fuel cell"

We are developing a miniature fuel cell with silicon electrodes on which the catalyst layer and the fuel channels are fabricated monolithically. Performance was improved by developing an electrolyte membrane that has adapted shape to the recesses of the catalyst layer. Along with this, water flooding has become conspicuous. Therefore, to observe the behavior of the generated water and promote its discharge, a novel transparent PDMS channel cover was proposed.

Takeshi Kondo and Makoto Yuasa

"Research on aqueous electric double-layer capacitors using conductive diamond powder"

An aqueous electric double-layer capacitor (EDLC) was fabricated using boron-doped nanodiamonds (BDND) as the electrode material and concentrated $NaClO_4$ aqueous solution as the electrolyte, and its durability was evaluated. In a charge-discharge cycle test with a cell voltage of 2.3 V, the capacitance reached 84% of the initial capacitance after 10,000 cycles. In addition, the capacitance was found to retain 97% of the initial capacitance after a 10-hour float test at 2.3 V. Therefore, this aqueous EDLC was found to exhibit sufficient durability even when used at a high cell voltage (2.3 V).

Kenichi Sakai

"Adsorption characteristics and reaction film analysis in mixed extreme-pressure agents"

We characterized the adsorption and desorption behavior of mixed extreme-pressure (EP) agents at an iron oxide/dodecane interface. The two EP agents could adsorb on the iron oxide competitively, and the phosphorus-type EP agent inhibited the adsorption of the sulfur-type EP agent. The phosphorus-type EP agent promoted the formation of an oxidized surface film of sulfur components on steel under sliding conditions. This also contributed to decreased kinetic friction coefficient for the mixed EP agent system.

Kenjiro Fujimoto

"Study on chemical oxidation of cathode materials for lithium-ion batteries"

Chemical oxidation with a mild acid was tried on $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ without the strong oxidant NO_2BF_4. In solid-liquid reaction with carbonated water, no change in Li content was observed after 130 hours, and the maximum amount of Li desorption was 67%. XANES spectra of the acid-treated samples showed an increase in Ni and Co valence compared to pristine. The charge balance due to Li^+ desorption was considered to be an increase in transition metal valence and ion exchange to H_3O^+. Thermal analysis of the powder after 25 hours of treatment with carbonated water (Li=0.53) showed a weight loss around 250°C, corresponding to a phase change to a spinel structure. Therefore, the heat treatment conditions were fixed at 200 °C for 30 hours, and the valence and initial discharge capacities were compared before and after heat treatment. Although the initial discharge capacity improved after heat treatment, it did not reach the value indicated by pristine, suggesting residual water in the interlayer.

Noboru Katayama

"Diagnosis of Lithium-ion Batteries Using Machine Learning and Electrochemical Impedance Spectroscopy"

In recent years, there has been growing interest in diagnostic techniques for the internal state of lithium-ion batteries. The electrochemical impedance spectroscopy is a non-destructive approach to estimate the internal state of a device. In this study, a method for estimating the internal state that is independent of measurement conditions was proposed using machine learning. Data on the SoC and SoH of lithium-ion batteries were collected through experiments, and a model using a neural network was trained to perform estimation. The results showed that the internal state can be accurately estimated without being dependent on temperature.

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 are rooted in p-n junctions where different kinds of organic semiconductor molecules come into direct contact with each other, and the structural control and electronic properties in such intermolecular junctions are main points for the development of the devices. In FY2022, we have summarized the researches on well-defined molecular semiconductor heterojunctions as a review paper. We have also developed a new method to evaluate the luminescent properties of OLED material molecules promptly and efficiently as a collaborative research with the Joint Graduate School (AIST).

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.

Junji Akimoto

"Synthesis, crystal structure and conduction properties of novel lithium ion conducting oxides"

We focused on Li_4SiO_4-Li_3PO_4 solid electrolytes as lithium ion conducting oxides and optimized the synthesis conditions. The crystal structures of the synthesized samples were investigated in detail, and the correlation between the crystal structure and lithium ion conductivity was examined.

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 regenerative medicine. We aim to develop “Superior Cells” by enhancing the functionality of cells that are administered to the body for therapeutic purposes. We also plan to develop drug delivery systems (DDS) that precisely control the pharmacokinetics of cells and other functional molecules in the body. The therapeutic targets of the developed superior cells and DDS will include the respiratory system, brain, immunological system, cancer, and other disease areas, with the goal of developing therapeutic methods for these diseases.

This research division consists of four collaborative groups that promote research on the development of superior cells and DDS to accelerate regenerative medicine. The “Superior cell/DDS Development Group” will design and develop superior cells and DDS for controlling the pharmacokinetics of cells and various bioactive substances within the body. Superior cells are developed by adding new functions to cells, constructing cell spheroids and organoids, and utilizing extracellular microparticles. In addition, DDS technology will be utilized for superior cells, and its effectiveness will be verified in animal disease models. The “Cell Function Regulation System Development Group” will create new molecules that control cell function and develop functional materials to support regenerative medicine and cell therapy. The “Physical Properties Control and Evaluation Group” will evaluate the physical properties of the various functional molecules and materials developed by the above groups to support the optimization of the functions of the superior cells and DDS. The “Cell/tissue Regeneration Group” will elucidate the mechanisms of organ regeneration and treatment of the lungs, bones, and other organs, as well as the interactions of DDS and the immune system.

2. Organization and Faculties

As shown in Figure, 15 researchers from inside 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 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 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.

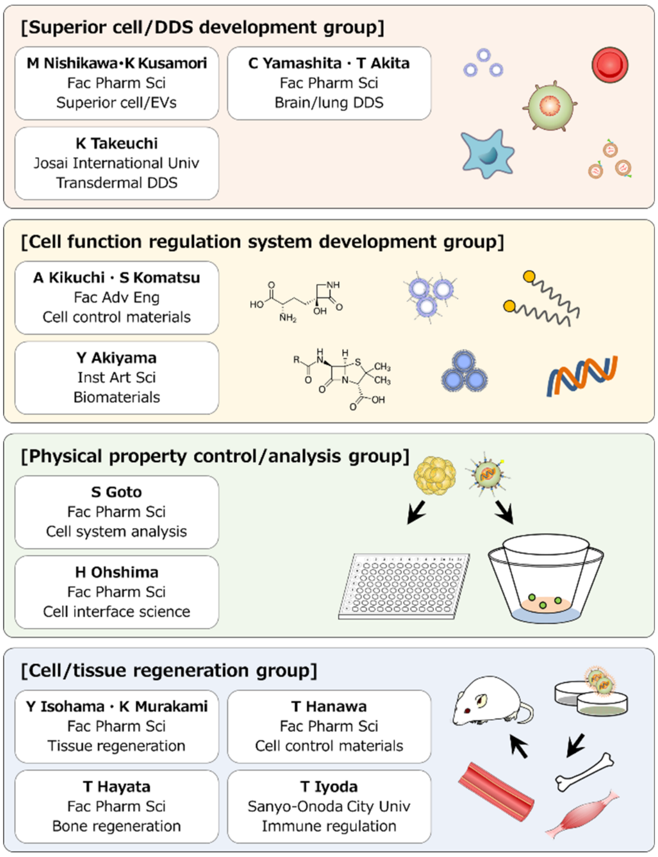

Figure. Members in each group for Development of Superior Cell and DDS for Regenerative Medicine.

3. Activity Reports

On December 8, 2022, the division hosted the “TUS DDS Symposium 2022”. In addition to the progress reports from each research group, two invited lectures were given. Dr. Nobuhiro Nishiyama (Tokyo Institute of Technology) gave a talk entitled “Core-Shell Design of Polymeric Micelles for Biopharmaceutical Delivery Systems. Also, Dr. Mitsuhiro Ebara (National Institute for Materials Science) gave a lecture entitled “Development of Medical Devices Utilizing Shape Memory Polymers: Application to Cell Function Manipulation.” The symposium was held as a closed-door event and was attended by 59 participants, mainly from the departments within the university.

3. 1. Superior cell/DDS Development Group

This group conducted research on the preparation of mesenchymal stem cell spheroids with anti-inflammatory properties. The cell spheroids resulted in a significant improvement in cell viability in the lungs as well as a suppression of the inflammation in a pulmonary inflammation mouse model. The use of an on-chip electrochemical device has successfully measured oxygen consumption of cell spheroids without destruction. In addition, active vitamin D3-encapsulated functional lipid nanoparticles have been found to exhibit alveolar repair effects at low doses with reduced side effects. Furthermore, the results of an *in vivo* treatment study using lysozyme-sensitized mice revealed that lysozyme-containing biodegradable nanoparticles in combination with iontophoresis for transdermal immunotherapy could provide a therapeutic effect equivalent to that of an injection containing conventional biodegradable nanoparticles.

3 .2. Cell Function Regulation System Development Group

This group established new methodologies to introduce mannose, which is specifically recognized by macrophages and dendritic cells, onto the outermost surface of core-corona type thermoresponsive microparticles that can change their surface properties in response to temperature changes. In addition, the group has successfully prepared a DNA-covered nanostructure with self-immolative ability in an intracellular reducing environment.

3. 3. Physical Properties Control and Evaluation Group

This group performed singular value decomposition on the interaction between drug carriers and functional molecules, including several drugs. The group also developed theoretical studies on the diffusiophoresis of spherical and cylindrical hard particles and particles covered with a layer of polyelectrolyte.

3. 4. Cell/tissue Regeneration Group

This group independently found that Goreisan, a Kampo medicine, suppresses inflammatory responses through the inhibition of AQP4 water channel function. Also, hydrogels based on sodium alginate or pectin were successfully prepared for pharmaceutical additives that improve the efficacy and stability of the main drug in pharmaceutical manufacturing. In addition, the group succeeded in generating a disease model mouse that is expected to contribute to the elucidation of various human pathological conditions and new therapeutic strategies. Furthermore, the group successfully elucidated the mechanism of the relationship between the environmental abnormalities in cell adhesion signaling and the progression of age-related diseases.

4. Challenges and Prospects

This division promoted collaboration within the division, which was identified as an issue raised in the 1st year establishment. As a result, we were able to obtain patents and publish original papers through collaboration within the research group in this division. On the other hand, the importance of collaboration between groups was shared by the members of this division, but unfortunately it has not been extensively performed. Importantly, this division is composed of researchers with various specialties in interdisciplinary areas. In order to take advantage of this situation, we will work on discussing a strategy to realize collaboration among the group. This is expected to produce results that will accelerate regenerative medicine, which is the objective of this division.

5. Conclusion

This division has entered its second year since its establishment. The division had the opportunity to hold several steering committee meetings and division-organized symposiums, which have supported to promote mutual understanding of the research topics that each member is working on with their own unique concepts. As a result, progress has been made in collaboration within the division. This division will continue to follow 1st year-direction and work as a division to develop “superior cells” and new treatment methods through the promotion of collaborative research. These efforts will create new concepts based on the keywords “superior cells”, “regenerative medicine”, and “DDS”. The division plans to promote research in collaboration with outside research institutions and in partnership with hospitals to conduct clinical trials and obtain patents.

Major Research Achievements (FY 2022)

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Ohshima laboratory; Hiroyuki Ohshima

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Isohama laboratory; Kazuhito Murakami

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Individual Research Topics

Makiya Nishikawa, Kosuke Kusamori

“Study on the development of cell-based therapeutic system”

In the fiscal year 2022, we mainly performed experiments on cell spheroids. We developed spheroids of mesenchymal stem cells, and succeeded in improving the survival of the cells in the lung after intravenous injection in mice and in increasing their anti-inflammatory activity in lipopolysaccharide-induced inflammation model mice. We also succeeded in evaluating the quality of cell spheroids without destruction using an on-chip electrochemical devise.

Chikamasa Yamashita, Tomomi Akita

“Study on the usefulness of functional lipid nanoparticles encapsulating active vitamin D3 for the curative treatment of COPD by alveolar regeneration”

In our previous study, we found that active vitamin D3 (VD3) showed alveolar repair effects in a mouse model of COPD, but caused serious side effects. Therefore, we encapsulated active VD3 in functional lipid (SS-OP) nanoparticles to efficiently deliver VD3 to the site of action and reduce the side effects. As a result, we found that SS-OP nanoparticles encapsulated with active VD3 including DOPE showed alveolar repair effect with a small dosage and reduced side effects.

Issei Takeuchi

“Study on chitosan-coated PLGA nanoparticles for transcutaneous immunization”

We prepared the hen egg-white lysozyme (HEL)-loaded poly(DL-lactide-*co*-glycolide) (PLGA) nanoparticles. The results of *in vivo* therapeutic studies using lysozyme-sensitized mice indicate that the combined use of PLGA nanoparticles and iontophoresis may provide the same therapeutic effect as an injection. The results of this study will accelerate the application of existing technologies related to polymeric nanoparticles to transcutaneous immunotherapy.

Akihiko Kikuchi, Syuuhei Komatsu

“Preparation and characterization of surface functionalized thermoresponsive microparticles”

We have previously prepared core-corona type thermoresponsive microparticles those surface properties change in response to temperature alteration and analyzed their interaction with cells. Since macrophages and dendritic cells, those are responsible for early immune reaction in our body, recognize mannose, we intended to introduce mannose to the outermost surface of the microparticles in this study. Using living radical polymerization and conversion of terminal functional groups, we established a preparation route of the mannose-possessing microparticles. By using these microparticles, we aim to develop immune cell-specific interaction of microparticles by controlling the surface property alteration and the specific interaction of mannose with mannose receptor on the cell surfaces.

Yoshitsugu Akiyama

“Construction of reduction-responsive DNA-based nanostructures from DNA-poly(carbamate) conjugates with self-immolative fragmentation ability”

We developed spherical nucleic acids having a core structure of self-immolative pol(carbamate) (PC) derivatives that can expect to undergo disassembly through a self-immolative fragmentation in a reductive intracellular environment. In present study, DNA-poly(carbamate) conjugates with self-immolative fragmentation ability was newly designed and synthesized. Dialysis against water resulted in a self-assembly of BuSS-PC-oligoDNA conjugate with a narrow unimodal size distribution in DLS measurements, indicating formation of nanostructure covered with a dense DNA shell in aqueous soliton. The nanostructure thus obtained would undergo domino-like disassembly of PC to release nucleic acid drugs at the reductive intracellular environment.

Satoru Goto

"Hyperspace analysis of experimental data treated by singular value decomposition"

Singular value decomposition (SVD) of the observed data separates and extracts the tendency latent in the observed data depending on the experimental condition parameters. Our subjects involve the fluorescent probe responses to neutral surfactants on cyclodextrin as a protein model, interaction of polypharmacy drugs with cyclodextrin as a drug carrier, adsorption of drugs and dyes to polyfluorocarbon membranes, and the inhibitory activity of drugs to the protective action of tocopherol derivatives on liposomal lipid peroxidation.

Hiroyuki Ohshima

"Theoretical study on the motion of colloidal particles in a salt-concentration gradient"

The motion of colloidal particles including spherical and cylindrical hard particles and polyelectrolyte-coated particles (soft particles) in an applied salt-concentration gradient has been theoretically investigated and analytic expressions for their diffusiophoretic mobility have been derived. Diffusiophoresis measurement has advantages over electrical methods such as electrophoresis, since electrical methods are associated with electrodes and power supplies, while diffusiophoresis is free from all of these devices. Even more applications of diffusiophoresis to DDS can thus be expected.

Yoichiro Isohama, Kazuhito Murakami

"Study on new therapeutic strategies for brain inflammation targeting aquaporin-4"

Brain inflammation is mainly caused by cytokine production in activated microglia. On the other hand, astrocyte swelling is associated with this, and it has been suggested that the water channel aquaporin 4 (AQP4) is important for this activation. In this year, we found that Goreisan, a Kampo medicine, suppresses inflammatory response through inhibition of AQP4 water channel function. There is no known drug that inhibits astrocyte activation through AQP4 inhibition, and it may lead to the proposal of a new concept in considering the treatment of brain inflammation and neuropathy.

Takehisa Hanawa

"Investigation of the Application of Water-Soluble Polymers to Hydrogel Substrates"

Various pharmaceutical additives are used to manufacture pharmaceuticals to improve the efficacy and stability of the main drug. We have discovered new functions of water-soluble polymers, which have been conventionally used in the manufacture of pharmaceuticals, and have studied their potential application as drug carriers in DDS formulations. As a result, we investigated the preparation and characterization of hydrogels based on sodium alginate and pectin and found that they can be used as drug carriers.

Tadayoshi Hayata

"Research on elucidation of pathological conditions in mouse models of locomotor diseases"

In FY2022, we generated mice lacking the Ctdnep1 gene throughout the body as adults and found that these mice developed osteoporosis and motor neuropathy. We also found that mice lacking Ctdnep1 in tendons and periosteum developed ectopic ossification and osteochondroma. Our originally generated mouse models of disease are expected to contribute to the elucidation of the pathogenesis of osteoporosis, neurodegenerative disorders, and ectopic ossification/osteochondroma in humans and to new therapeutic strategies.

Takuya Iyoda

"Deregulated cell adhesion and age-related diseases"

Accompanied by aging, reconstitution of extracellular-matrix (ECM) would progress gradually. Since abnormal cell adhesion with reconstituted aged ECM might activate abnormal intracellular signaling, there is a possibility that the cells adhered to aged ECM contribute to the progression of age-related diseases. In this year, we found that the potentiated and sustained activation of beta1-integrin expressed on renal epithelial cells leads activation of Notch signaling cascade, followed by changes in their growth morphology. On the other, suppressed proliferation induced by beta-1-integrin inactivation was observed in a certain type of tumor cells.

Parallel Brain Interaction Sensing Division

Parallel Brain Interaction Sensing Division

1. Overview

Neuroscience (brain science) is a field of life science that is dramatically 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 the human mind is connected to the Internet (IoM: Internet of Minds). This is indeed the arrival 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 become 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

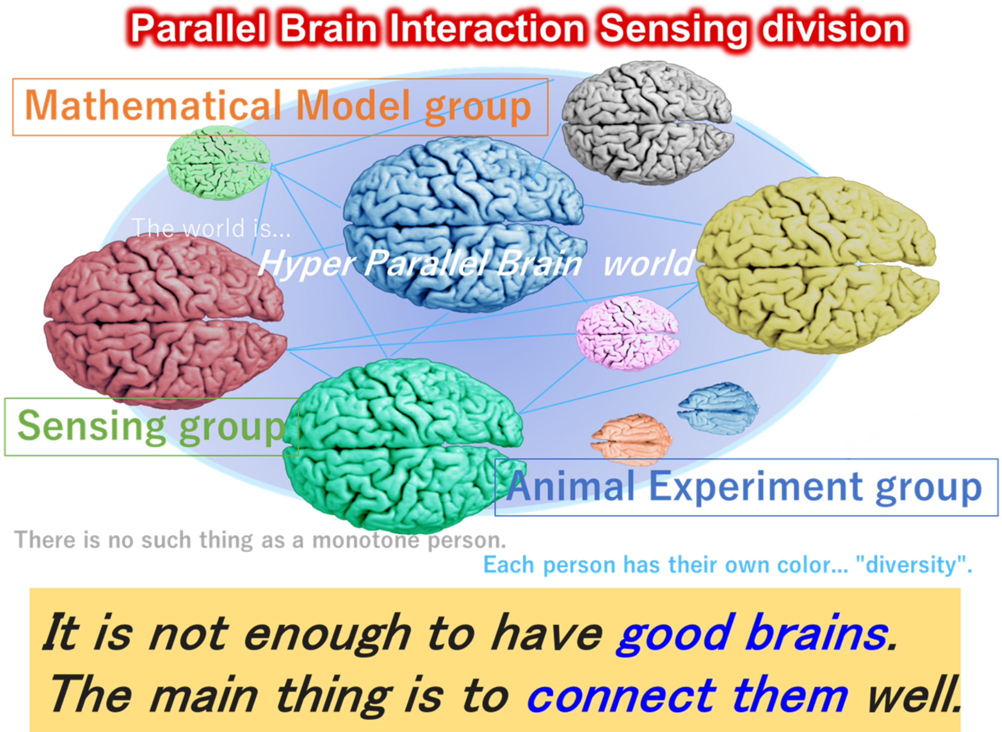
The Sensing Group conducts multidimensional research on the analysis and evaluation of brain dysfunction concerning personality traits focusing on gaze behavior and physiological indicators in developmental disorders, etc., and aims to create related measurement technologies and assistive devices.

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 aims to elucidate of brain information processing systems and to develop the models and the theories.

The division consists of 17 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 two visiting researchers: Ryohei Hasegawa (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 use of the unique talents and strengths of each member. The following is a list of ongoing collaborative research projects that transcend the boundaries of each specialized field, which are possible only 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 FY2022 is the following.

3. 1. Research Collaborations Beyond Groups

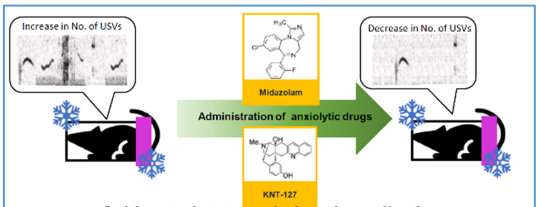
3. 1. 1. Elucidation of brain functions regulating social behavior "Evaluation of social behavior and brain developmental changes in a human chromosome deletion disease model of autism" (Segi-Nishida [TUS] /Oguro-Ando [Univ. of Exeter])

We focus on a human chromosome deletion disease, a three-gene deletion in the p26.3 region of chromosome 3. This disease is a *de novo* mutation that occurs after fertilization and its symptoms include developmental delay, including intelligence and autism (Fernandez et al. 2008). Three genes involved in neural adhesion factors, CHL1, CNTN4 and CNTN6, are located in this region and have been reported as risk factors for autism. Oguro has generated triple knockout (3PKO) mice of these three genes. Although these mice were known to survive, it was completely unknown how they affected emotional behaviors such as social cognition, anxiety and depression, as well as cognition such as memory, etc. In FY2022, we evaluated social behavior, motor coordination and anxiety behavior in 3PKO mice. 3PKO mice showed a decrease in anxiety-like behavior, while a decrease in social behavior was observed. In addition, histological analysis of the brain suggested a morphological defect in the hippocampus. To assess the specificity of the emotional and social changes, we will measure stress adaptation, cognition, memory, and basic need motivation in these mice and examine changes in hippocampal neurodifferentiation and synaptic development. These studies are expected to advance our understanding of hippocampal function and the contribution to social and emotional behavior of three neighboring genes, CHL1, CNTN4, and CNTN6, which mimic human chromosomal deletion diseases that have not been previously elucidated.

3. 1. 2. Examination of cross-species vocal communication: Relationship between ultrasonic vocalizations in mice and the effects of ultrasonic listening in humans (Ichikawa, Saitoh, Yamada, and Asakura)

In FY2021, we examined the relationship between ultrasonic vocalizations and emotional states in mice to clarify the relationship between vocal communication and emotion. Rodents are known to communicate with each other using sounds outside the human auditory range in response to pleasant or unpleasant stimuli or the approach of a predator. In a previous study, we found that the number of ultrasonic vocalizations was decreased by anxiolytic treatment in mice under the condition that they vocalized ultrasonic sounds associated with unpleasant emotional states. The reduction in ultrasonic vocalizations was not observed with the administration of antidepressants or schizophrenia medications. Furthermore, this test can be repeated, indicating its potential use as a novel screening system for anxiolytic drugs. The results have already been published in an international journal (right figure, Yamauchi et al., Biol Pharm Bull. 2022; 45: 268.). In FY2022, we recorded live gamelan music, which contains a large number of ultrasonic components, as an auditory stimulus to start ultrasonic listening experiments on human subjects. In addition, the experimental paradigm of a previous study that evaluated physiological and psychological indices by listening to music was tested. It was confirmed that psychological changes by listening to music could be measured using existing psychological indices. In the future, we will use this paradigm to examine how the psychological and physiological states of humans are altered by music with and without ultrasonic components.

In the future, we will expose the collected ultrasonic sounds to animal models of depression, and proceed to elucidate the changes in emotional behavior and their mechanisms of action. At the same time, we will examine changes in brain activity, psychological state, and endocrine system when humans are exposed to ultrasound. The unique feature of this study is to examine the effects of ultrasound listening from the perspective of both experiments using model animals and experiments using human subjects. We will elucidate the detailed mechanisms in animal model studies and demonstrate their applicability in human studies.



Cold-restraint stress-induced vocalizations
could be used to assess anxiolytics as screening system

3. 1. 3. Analysis of stress-induced depression-like state (Saitoh, Yamada, Takemura, and Yamamoto)

Recently, it has been shown that ultrasound exposure can noninvasively alter brain activity, and its application to the treatment of psychiatric disorders has been sought. In FY2022, we exposed olfactory bulbectomized (OB) rat models of depression to various ultrasound waves and examined changes in emotional state behavior in order to clarify changes in an emotional state induced by ultrasound exposure using animal models. The results showed that ultrasonic vocalizations accompanying pleasant emotions and exposure to 50 kHz artificial ultrasound improved depressive and anxiety-like behaviors in OB rats. These results have been published in an international journal (Yamauchi et al., NeuroReport, 2022). Additional studies revealed that exposure to artificial sound at 100 kHz, which is in the non-auditory range of rats, also improved depressive and anxiety-like behaviors and blood stress marker levels.

In the future, we will use OB rats to identify relevant brain regions, neural circuits, and neurotransmitters in order to elucidate the neural mechanisms of ultrasound exposure-induced changes in emotional behavior.

3. 1. 4. Study on the relationship between human gait behavior and personality traits: Extraction and evaluation of gait characteristics derived from human internal state (Ichikawa, Takemura, and Yamamoto)

Human gait behavior reflects personality traits such as extroversion/introversion as well as age and gender. Personality traits include autistic personality (autistic traits), which is a developmental disorder, and it has been repeatedly reported that the walking movements of autistic individuals are awkward. We measured walking movements in 2018 in a situation in which two people approach each other face to face and then walk to avoid a collision and showed that the norm of the angular acceleration of the hips when passing each other is larger for those with higher autistic traits (Shigeta et al., 2018).

In FY2022, we finally elucidated why higher autistic traits are associated with awkwardness in walking past each other by measuring EEG during walking. An approaching pedestrian was created as a virtual character and presented as life-size. We measured the electroencephalograms of the participants while they were observing the character, and examined whether the delay in perceiving the approach of another person was observed on the electroencephalograms. As a result, it was observed that the positive event-related brain potential (P200) seen 200 milliseconds after the other person started walking in the posterior temporal cortex had a longer latency and smaller amplitude in participants with higher autistic traits. These results have been published in an international journal (Inokuchi et al., Frontiers in Human Neuroscience, 2023).

3. 1. 5. Biomechanical analysis of age-dependent gait deficiency in cerebellar neural transmission deficient mice (Hagiwara, Takemura, and Y. Yamamoto)

The cerebellum is important for balance control in locomotion, and plastic changes in neurotransmission have been revealed the mechanism of motor learning. However, the involvement of the cerebellum in the decline of gait function due to aging and frailty and its neural mechanisms remain largely unknown. To establish the appropriate treatment and rehabilitation methods, we investigate the newly developed conditional knockout (cKO) mice, in which a cerebellar granule cell-specific deletion of LKB1, a phosphatase of the AMPK family involved in cell metabolism and morphogenesis. Hagiwara et al. have been found the age-dependent gait defect in this mouse.

Conventional cooperative locomotion has been evaluated by the time a mouse can move (stay) on a rotating thin rod. However, because mild symptoms are covered by the mouse's locomotor ability, this method has not been able to evaluate indices related to body posture, such as the maintenance of balance. Therefore, we developed a system to measure the walking locomotion of freely behaving mice by applying the machine learning technology for moving images developed by Takemura and Yamamoto et al. As a result, it has been found that the stride length of 8-9 weeks-old cKO mice is significantly smaller than that of wild-type mice. This research has been adopted by the 2022-2023 Soikinome-project, and the promotion of interdisciplinary research has greatly contributed to the formation of practical skills of the students. In the future, we will proceed with more detailed analysis of the skeletal musculature, including age-dependent changes, and evaluate them in combination with morphological analysis of the brain and skeletal muscles, for the publication in an international academic journal.

3. 1. 6. 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 thought to be a factor that causes organic and functional changes in the brain, which increases the incidence of mental disorders. In other words, understanding of the neural basis is essential to solve stress-related mental problems. At the site of neuronal transmission, called synapse, information is transmitted via transmitters, and various proteins modify synaptic functions in a plastic manner. In mice lacking the presynaptic protein CAST, which Hagiwara has shown the 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.

CAST-deficient mice were subjected to physical restraint stress and depression-like symptoms were assessed by the sugar preference test (SPT) and the tail suspension test (TST). The TST results showed that CAST-deficient mice showed increased immobility time, suggesting that stress sensitivity is enhanced. In the future, we will examine the pharmacological effects of antidepressants and other drugs to further elucidate the mechanism. In addition, since there is concern that the current experimental method may result in a blurring of judgment criteria by the experimenter. Therefore, we will develop a video analysis program to measure immobility time. This program is expected to unify the judgment criteria and significantly shorten the analysis time.

3. 1. 7. 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 syndromes among ASD. Furthermore, RNA-seq analysis of JAKMIP1-deficient mice suggests that JAKMIP1 is involved in the regulation of cytokine signaling, and more detailed analysis will be conducted. This research was selected for the Daiichi Sankyo TaNeDS program in 2022 and will be pursued as an industry-academia collaborative project over the next two years to develop a novel therapeutic agent for ASD. Oguro and Hagiwara will conduct morphological analysis, such as maturation of dendritic spine of neurons. In addition, Yamada and Saitoh will evaluate the response of calcium signaling as a function of neurons, and one graduate student from the Oguro lab will join the Saitoh lab to conduct the analysis. In addition, Saitoh, Yamada, and Hagiwara will evaluate behavioral deficits in mice and pharmacological effects of various drugs.

3. 1. 8. DNA methylation analysis in various mouse models (Oguro-Ando, Segi-Nishida, Saitoh, Hagiwara, and Yamada)

The neural circuits change diversely depending on the environment, and neuronal activities undergo epigenetic changes that regulate gene expression. The transcriptome technology has been in hot competition for development 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 hub 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). By comparing the results of comprehensive analysis in humans with those in various mouse models, it is possible to explore new developments in the elucidation of the pathogenesis of psychiatric disorders for which the causes have not yet been clarified, as well as for clinical applications.

3. 2. Public Events

3. 2. 1. 2nd Public symposium "Think synch brain dynamics"

- **Saturday, December 17, 2022 10:00-17:30**
- **Tokyo University of Science, Noda Campus Lecture Building K401**
- **Two invited lectures from academic researchers, three invited lectures from researchers in the companies, four lectures from the division members, and 55 student posters.**
- **Participants: 115 (including 23 general participants)**

It was a great successful event 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 six great lecturers who are conducting cutting-edge research in their respective fields in JY2022. 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.

3. 2. 3. EEG brain training competition "b-sports" tournament held at TUS 2022 (July 22, 2022)

We held a brain training game experience session that utilizes BMI (brain-machine interface) technology that directly connects the brain and machines, which is the research theme of Dr. Hasegawa, a visiting professor of this division. Despite the COVID-19 situation, there were many participants from within the university, including Dr. Nishihara, the director of RIST, and five people from outside the university who also participated in the trial session. This event was a great success.

4. Challenges and Prospects

This division is composed of interdisciplinary researchers who specialize in multiple fields and different fields inside and outside the university in order 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 are going to conduct “Parallel Brain” research unique to TUS. In addition, we will strengthen cooperation with researchers outside TUS through symposiums, workshops, and seminars, and 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

In order to develop brain research unique to TUS, this division integrates the promotion of collaborative research and individual original research, and develops innovative academic fields originating from TUS, such as “Connecting Brain” and “Parallel Brain”. We will continue to work to build by pursuing 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 (FY 2022)

Academic Papers

1. Verification of gait analysis method fusing camera-based pose estimation and an IMU sensor in various gait conditions.Yamamoto, M., Shimatani, K., Ishige, Y., Takemura, H., ***Scientific Reports***. 17719, 2022. (Peer-reviewed)
2. Characterization of astrocytes in the minocycline-administered mouse photothrombotic ischemic stroke model. Kondo, M., Okazaki, H., Nakayama, K., Hohjoh, H., Nakagawa, K., Segi-Nishida, E., Hasegawa, H., ***Neurochem. Res.*** 47(9) 2839-2855. 2022. (Peer-reviewed)
3. Noradrenaline activation of hippocampal dopamine D1 receptors promotes antidepressant effects.Kob ayashi, K., Shikano, K., Kuroiwa, M., Horikawa, M., Ito, W., Nishi, A., Segi-Nishida, E., Suzuki, H., ***Proc. Natl. Acad. Sci. USA*** 119(33), 2022. (Peer-reviewed)
4. Regulation of adult-born and mature neurons in stress response and antidepressant action in the dentate gyrus of the hippocampus. Segi-Nishida E., Suzuki K., ***Neuroscience Res.*** 10.1016/j.neures.2022.08.010, 2022. (Peer-reviewed)
5. Bridging rapid and sustained antidepressant effects of ketamine. Kim JW*, Suzuki K*, Kavalali ET, Monteggia LM. ***Trends Mol. Med.***, 29(5):364-375, 2023. *contributed equally (Peer-reviewed)
6. Optical analysis of AMPAR-mediated synaptic scaling in mouse hippocampus. Suzuki K, Kavalali ET, Monteggia LM, ***STAR Protoc.***, 3(2):101443, 2022. (Peer-reviewed)
7. KNT-127, a selective delta opioid receptor agonist, shows beneficial effects in the hippocampal dentate gyrus of a chronic vicarious social defeat stress mouse model. Yoshioka T., Yamada D., Segi-Nishida E., Nagase H., Saitoh A. ***Neuropharmacol.*** 232, 109511, 2023. (Peer-reviewed)
8. Repeated psychological stress, chronic vicarious social defeat stress, evokes irritable bowel syndrome-like symptoms in mice. Yoshioka T, Ohashi M, Matsumoto K., Omata T., Hamano T., Yamazaki M., Kimiki S., Okano K., Kobayashi R., Yamada D., Hada N., Kato S., Saitoh A., ***Front Neurosci.*** 16, 993132, 2022. (Peer-reviewed)
9. High-frequency ultrasound exposure improves depressive-like behavior in an olfactory bulbectomized rat model of depression. Yamauchi T., Yoshioka Y., Yamada D., Hamano T., Ikeda M., Kamei M., Otsuki T., Sato Y., Nii K., Suzuki M., Iriyama S., Yoshizawa K., Nishino S., Ichikawa H., Miyazaki S., Saitoh A. ***NeuroReport.*** 33, 445-449, 2022. (Peer-reviewed)
10. Decoding cellular deformation from psudo-simultaneousy observed Rho GTPase activities. Kunida K., Takagi N., Aoki K., Ikeda K., Nakamura T., Sakumura Y., ***Cell Rep***. doi: 10.1016/j.celrep.2023.112071, 2022. (Peer-reviewed)
11. Effects of exposure to magnetic fields on small laboratory animals for wireless power transmission to an implantable locomotion meter, Yuno NAKADA (Stu. Mem.), Takahiko YAMAMOTO (Mem.), Daisuke YAMADA, Akiyoshi SAITOH, ***Journal of the Japan Society of Applied Electromagnetics***, 30(2), 150-154, 2022. (Peer-reviewed)
12. Development of Train-Boarding Assistance Device for Wheelchair; K. Kim, H. Kobayashi, K. Matsumoto, and T. Hashimoto, ***Journal of Robotics and Mechatronics***, 34(1), 167-176, 2022. (Peer-reviewed)

Invited Lectures

1. Regulation of hippocampal neuronal changes in mouse ECT model, Eri Segi-Nishida, 118th Annual Meeting of The Japanese Society of Psychiatry and Neurology (Symposium), Hakata, 2022.
2. Synaptic mechanisms underlying rapid antidepressant action, Kanzo Suzuki, Joint Symposium of 2nd International Symposium of Multiscale Brain/Molecular and Cellular Cognition Society Asia, Tokyo, 2022.
3. Synaptic mechanisms underlying rapid antidepressant action, Kanzo Suzuki, Ji-Woon Kim, Elena Nosyreva, Ege T. Kavalali, Lisa M. Monteggia, NEURO2022, Okinawa, 2022.

Public Relations

1. Hiroshi Takemura and Eri Segi-Nishida, Future of the Brain, TUS Journal, No. 224, 2022.
2. Eri Segi-Nishida, Toward the future beyond "rikejo" (girls with science background), Asahi Education Conference, 2022.

Award

1. Tsuruda, Y., Akita, S., Yamanaka, K., Yamamoto, M., Sano, Y., Furuichi, T., and Takemura, H., SICE International Young Authors Award, *IEEE/SICE International Symposium on System Integrations,* 2023.

Individual Research Topics

Hiroshi Takemura

"Research on 3D gait Measurement of mice"

In this research, the combined measurement method that RGB-D video shooting from below using Azure Kinect DK and body part tracking by deep learning using DeepLabCut is proposed for measuring three-dimensional limb movements with a single RGB-D camera. As a result, the proposed method can measure the 3D gait of a mouse with sufficient accuracy by improving the accuracy of existing limb tracking methods. In addition, a model that predicts the position of the mouse after 1 second from the time-series data of the nose and front paws was developed. 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"

In FY2021, we aim to create a FRET sensor that can monitor the activity of Rab39B, a risk factor for mental retardation, autism, and juvenile Parkinson's disease, and to elucidate the molecular mechanisms that enable Rab39B to realize its diverse functions. In FY2021, we were able to create a Rab39B sensor with a dynamic range of about 100% by trial and error for the linker portion. In the future, we will compare Rab39B activity in neurons, mainly in the degradation pathway and the recycling pathway.

Eri Segi-Nishida and Kanzo Suzuki

"Research on emotional responses focusing on hippocampal functions"

This study focuses on changes in hippocampal function related to stress-induced depression and antidepressant effects, and aims to clarify what molecules affect emotional function and what changes occur in the hippocampus during these changes. This year, we made progress in the following two areas: 1) We examined the relationship between changes in emotional behavior and neurogenesis in the hippocampus under chronic social frustration stress in a mouse model of depression, and found a high correlation between the proliferative response of neurogenesis and anxiety-like behavior in the hippocampus. In the future, we will examine how changes in neurogenesis are involved in the induction of stress-induced anxiety-like behavior. 2) We examined changes in hippocampal function using electroconvulsive stimulation (ECS) as an antidepressant treatment model and found that the activity-dependent transcription factor SRF (serum response factor) is important in promoting gene expression and neurogenesis induced by ECS. We found that the activity-dependent transcription factor SRF is important for promoting gene expression and neurogenesis induced by ECS. In the future, we will examine whether SRF is necessary for the induction of antidepressant-like behavior.

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 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 brain-peripheral organ linkage"

Negative emotions such as depression, anxiety, and fear are known to be affected not only by the brain but also by the intercommunication between peripheral organs and the brain, the so-called brain-gut correlation. In FY2022, we will clarify how the autonomic nervous system and neural circuits in the brain, which are thought to be important for the brain-gut correlation, are affected by stress and will show that animals subjected to social defeat stress by proxy show diarrhea-like symptoms as well as visceral hyperalgesia, and that the Chinese herbal medicine, Gui Ji Ka Peony Tang, improves these symptoms. and that the Chinese herbal medicine "Katsurajika Peony Tang" ameliorates these symptoms.

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. With Takemura, Yamamoto, and colleagues, we will examine the relationship between the perception of approaching pedestrians and the physical reaction of avoiding 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. 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 non-contact 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 the 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, detailed clustering analysis revealed that the EEG energy in the alpha region decreased in the case of the 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 sound exposure may be influenced by the impression of different sounds depending on the individual. This suggests the possibility that biological responses to sound exposure may be affected by the impression of sound that differs from one individual to another.

Masataka Yamamoto

“Human augmentation by rehabilitation”

This study proposes ankle-foot orthosis stiffness magnitude selection support system for individuals with strolke and clinicians using markerless motion capture system. Markerless motion capture system was used a single RGB camera, and this system accurately measure primary gait parameters. We are measuring post-stroke gait with various ankle-foot orhthosis stiffness in hosptals. The results of this measurement are suggested that small changes in the stiffness magnitude of ankle-foot orthosis have a significant effect on the symmetry of lower limb joint angles and stance duration during gait in individuals with stroke.

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 and 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 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 nonverbal 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. Especially, the sites of information transmission, called synapses, would be essential to reveal 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 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 feedbacks between machine learning systems and statistical analyses of their results, based on mathematical foundations in various levels. They include mathematically redesigning machine learning systems and implementing high accurate and safe A.I. Eventually, they achieve high 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

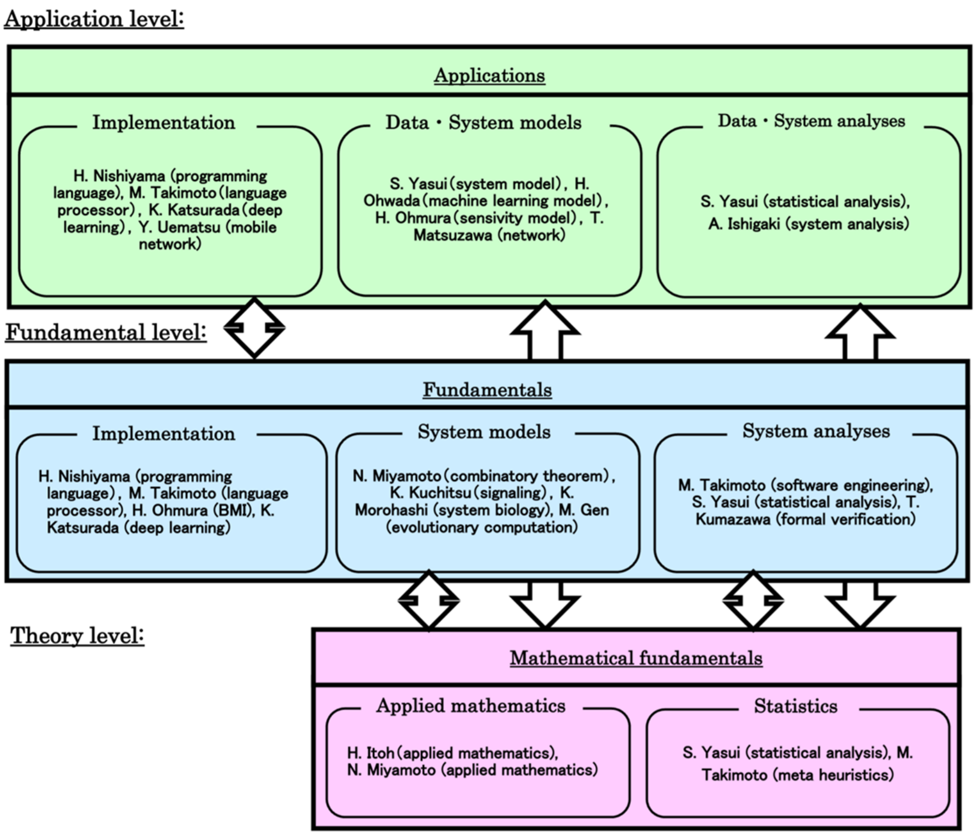


Fig. 1. Relations between research areas.

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

In this level, members who are specialists of each applications investigate issues of the applications based on their expertise, propose approaches to solve the issues, and check validity of results given by the solution. In the process, they give new models based on 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

In this level, members directly improve performance of fundamental techniques such as A.I. and machine learning, and propose new approaches of them. The improvement of performance includes network performance in distributed systems and sensor networks, and learning performance of A.I. through parallel and distributed techniques. The new approaches includes improvements of parallelism in instruction level on GPU, improvement of accuracy of existing machine learning, and development of new machine learning model based on biological systems. The fundamental techniques and systems developed in the level are validated in mathematical methods.

2. 1. 3. Theories

In 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. Divion Facilities

● GPGPU parallel computing servers

We introduced them to analyze the relations between calves for milk cows and manners of suckling. They consists of high performance GPGPU machines x5, Pascal Tesla P100 (GPU：P100 x 1， CPU：6Core x 2) x 3, Pascal Titan X (GPU：Titan X， CPU：6Core 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 2022's achievements of the division members and have made proceedings at March 2023, as shown in Fig. 3. The achievements include ones of the projects with National Cancer Center (NCC) and the projects in NEDO. They are based on research achieving effective prevention or prediction of course through associating advanced data sciences with medical care.

Fig. 3. 2022's DX proceedings.

3. 1. "Medical Care Based on Cancer Genomics and Data Science"（Collaboration with NCC）Group

This group is progressing multi-grain collaborations with NCC in manners that make surgery accurate and efficient, and methods that enable data mining to analyze high dimensional big data bases. Currently, ethical reviews for the members and discussions of the access condition to the data base are performed.

3. 2. "Implementation of A Smart Society through Applications of A.I./ The Area of Health, Medical and Nursing / Implementation of A Cerebral Apoplexy Prevention System"（NEDO）Group

This group has implemented a high accurate cerebral apoplexy prevention system based on an A.I. analysis of the medical information such as medical image data, patient personal data and medical records, and the engineering information such as results of simulation of blood flows in a brain.

4. Challenges and Prospects

This division has conducted research activities for two years. Regarding the NEDO project, its activities have been completed. On the other hand, regarding the collaboration with NCC, the agreement about treatment of clinical data has just been achieved. Therefore, the actual investigations in the collaboration starts from 2023. In order to succeed them, we have to progress them in closer relationship.

5. Conclusion

Through each activity in problems for application, members belonging to the application level, the fundamental level and the theory level are integrated to implement safe and reliable data mining systems. In 2023, we have to make the systems available for more practical use, and we need to investigate a manner where to verify each result generated by them.

Major Research Achievements (FY 2022)

Academic Papers

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2. Evaluation of PSO Algorithm Considering Obstacle Avoidance in Evacuation Guidance, Tomofumi Matsuzawa, Akiyoshi Ishii, Advances in the Theory of Nonlinear Analysis and its Application, Vol. 6, No. 3, pp. 318-335, 2022 (Peer-reviewed)
3. Proposal and Evaluation of a Dynamic Path Finding Method Using Potential Values Considering Time Series in Automatic Driving, Tomofumi Matsuzawa, Akito Fukai, Advances in the Theory of Nonlinear Analysis and its Application, Vol. 6, No. 4, pp. 460-475, 2022 (Peer-reviewed)
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9. 丹治 涼, 澤田 隼, 大村英史, 桂田浩一：“RtMRI データからの調音-音響変換における転置畳み込みニューラルネットワークの利用”, 日本音響学会音声研究会, 電子情報通信学会技術報告 EA2022-27, pp.69-74 (2022-7).
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11. 藤田大介, 桂田浩一, 澤田 隼, 大村英史, “インタラクションにおける相互性に着目した複合現実を用いた遠隔コミュニケーションシステム,” 第 201 回 ヒューマンコンピュータインタラクション研究会, Vol.2023-HCI-201, No. 33, pp. 1-7, 2023.
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31. Uncertainty Aware Model Integration on Reinforcement Learning, Takashi Nagata, Jinwei Xing, Tsutomu Kumazawa, Emre Neftci, 2022 International Joint Conference on Neural Networks (IJCNN), pp 1-7, 2022 (Peer-reviewed)
32. A safety checking algorithm with multi-swarm particle swarm optimization, Tsutomu Kumazawa, Munehiro Takimoto, Yasushi Kambayashi, In Proceedings of the Genetic and Evolutionary Computation Conference Companion (GECCO '22), pp 786–789, 2022 (Peer-reviewed)
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Invited Lectures

1. ROS and Ca^{2+}-mediated regulation of development and stress responses in Marchantia polymorpha, Kuchitsu K, Julius von Sachs Colloquium, Würzburg, Germany, 2022
2. ゼニゴケをモデルとした植物における活性種の役割と低温プラズマの作用機構の解析, 坪山祥子, 朽津和幸, プラズマ種子科学研究会, 名古屋大学, 2023 (in Japanese)
3. 植物の生き方・人との共生: 植物を理解し、環境・食料・エネルギー問題解決に向けてその力を活かす, 朽津和幸, 東京理科大学オープンカレッジ, 2022 (in Japanese)
4. 植物が生きるしくみの不思議: 植物に神経や免疫はあるか？, 朽津和幸, 東京理科大学オープンカレッジ, 2022 (in Japanese)
5. 里山の自然･人と植物の共生を考える, 朽津和幸, 野田市自然学習･生物多様性講座, 2022 (in Japanese)
6. 生産・物流分野における先端技術の利活用と新たな課題, 石垣 綾, 三菱電機株式会社メディア技術部会講演会, オンライン, 2023 (in Japanese)
7. Secure Computing and DX With IoT Data, 植松幸生, 第 8 回米国電気電子学会, World Forum on Internet of Things, 横浜, 2022

Public Relations

1. 朽津和幸, 東京理科大学プレスリリース
2. リグニン合成にはたらく活性酸素種生成酵素 RBOH の制御機構は種子植物間で広く保存されている～活性酸素種を利用した, 植物の物質生産への第一歩～
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https://www.eurekalert.org/news-releases/985640
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3. 熊澤 努, 群知能でソフトウェアの不具合を発見する, 科学フォーラム, 通巻 431 号 pp.4-8, 2022 (in Japanese)

Awards

1. 松澤智史, 髙口奨一郎, 下野将暉, 濱田恭輔, 小林潤子, 桃崎智隆, 鈴木海友, 藤澤健吾, 小林正弘, 中川智之, 田畑耕治, 敢闘賞, 日本 OR 学会, 2023.
2. 長﨑健太郎, 小林潤子, 松澤智史, 小林正弘, 藤澤健吾, 優秀賞, 日本統計学会, 2023.
3. 伊藤浩樹, 澤田 隼, 大村英史, 桂田浩一： "Creative Adversarial Networks を用いた新たな楽音の生成", 情報処理学会研究報告 2023-MUS-136, pp.1-7 (2023-3). 学生奨励賞, SIG-MUS 研究会，2023
4. 朽津和幸, 橋本研志, ベストイメージング賞, 日本バイオイメージング学会, 2022
5. Sawada, T., Uchino, T., Martono, N. P., & Ohwada, H.,Best Paper 賞, EAI AICON 2022 - 4th EAI International Conference on Artificial Intelligence for Communications and Networks, 2022
6. Hazuki Shibayama, Aya Ishigaki, Best Paper Award, The 22nd Asia Pacific Industrial Engineering and Management Systems, 2022
7. Kirika Matsuda, Aya Ishigaki, Outstanding Paper Award, IIAI International Congress on Advanced Applied Informatics, 2022
8. 熊澤 努, 地嵜頌子, 中川智之, 室井浩明, 渡邉卓也, 最優秀論文賞, ソフトウェア技術者協会ソフトウェア・シンポジウム 2022, 2022

Individual Research Topics

Nobuko Miyamoto

"A study on construction and optimality of spanning bipartite block designs"

We proposed a block design called Spanning Bipartite Block Design (SBBD), in which the edge set of a complete bipartite graph is a treatment set and a spanning subgraph is a block, and studied its construction method and optimality. SBBD is a combinatorial structure applicable to the drop-connect method to improve generalization performance in deep learning.

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.

Kouichi Katsurada

"Articulation - acoustic conversion from RtMRI movies"

We developped a speech synthesis model from rtMRI videos of the midsagittal plane of the vocal tract. It has been generally believed that speech sounds are produced based on a principle called the source-filter model, in which a source is created by the vibration of the vocal folds and various phonemes are produced by changing the resonance frequency according to the shape of the vocal tract. In contrast, in this study, we succeeded in generating speech sounds from rtMRI data in which vocal fold vibration was not captured, by using a deep learning model.

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 combing virtual reality and reality, which solves the discord in remote communication.

Munehiro Takimoto

"Parallelized inductive logic programming based on swarm intelligence"

In this study, I redesign Inductive Logic Programming (ILP), which is a kind of logical A.I., based on Particle Swarm Optimization (PSO), which is a kind of Swarm Intelligence, and implement a practical ILP system through parallelizing particles in PSO.

Hiroyuki Ito

"Research on algebraic geometry and singularity theory in positive characteristic and its application to high performance pseudorandom number generator"

Studied on quotient algebraic varieties and quotient singularities by finite group schemes of typical types in positive characteristic. Furthermore, studied for trying to construct general theory combining Artin-Schreier externsions and purely inseparable extensions of Frobenius type which includes many pathological phenomena in positive characteristics. Also trying to improve the performance of pseudorandom number generator using Artin-Screier tower of huge finite fields which I invented before.

Kazuyuki Kuchitsu

"Elucidation of the mechanism of action of a putative plant defense activator through 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.

Hayato Ohwada

"Applications of machine learning in agriculture and medicine"

Research focused on the application of machine learning to agriculture and medicine. Specifically, in the development of a system for predicting cardiac disease from sensor data, we introduced a method for representing time-series data as two-dimensional images, called a Recurrence Plot, and developed a method for classifying and predicting cardiac disease from the original time-series data using machine learning image classification techniques. A method was also developed to automatically extract the vertical relationship between individual dairy cows from their activity data. Furthermore, an efficient algorithm was developed to detect the position of individual dairy cows in real time.

Aya Ishigaki

"Design and implementation of human-centric production and logistics system"

In production and logistics, it is difficult to automate tasks that require human experience and flexibility. It is necessary to implement automation systems with high intelligence and autonomy, taking advantage of the abilities of both humans and machines. The goal of this research is to develop human-centric production and logistics systems by focusing on the following two issues: (1) modeling of psychologically and physically friendly behavior for workers and design of optimal environments, and (2) development of e-learning materials to promote workers' growth.

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

"Development of an experiential learning method for statistical problem solving including analysis between cause data and effect data"

Using putt golf as a theme, we develop an experiential learning method for learning statistical problem solving with a focus on analysis between cause data and effect data. The distance rolled by putting is a characteristic (effect data), however, the cause data for the characteristic are generated by the putting motion. We develop a system to convert the swing speed and other data by capturing that motion. In addition, the curriculum will be created based on educational technology which is the instructional design, and the experiential learning method with a high degree of understanding and retention is developed.

Mitsuo Gen

"Development of high-speed algorithm by advanced evolutionary algorithm with machine learning and its application to real-time production systems"

Tsutomu Kumazawa

"Lightweight model checking based on swarm intelligence with multiple swarms"

Model checking is one of the formal verification techniques of software systems. The aim of this research is 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. Particle Swarm Optimization is a swarm intelligence optimization algorithm for solving complex optimization problems efficiently. We decompose the whole space of model checking into small subspaces and apply each swarm into one of the decomposed subspaces. We expect that this strategy highly contributes to realize efficient model checking since each swarm explores only a small subspace. We combine Particle Swarm Optimization with effective heuristic techniques that make model checking more lightweight and compute comprehensible check results. We finally conduct the performance evaluation of the developed technique by applying it to benchmark problems.

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.

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 and etc. Our research focuses on AI technologies such as anomaly detection that contribute to the digital transformation of such mobile networks and implements them end-to-end from end-user equipment to backbone networks.

Modern Algebra and Cooperation with Engineering

Modern Algebra and Cooperation with Engineering

1. Overview

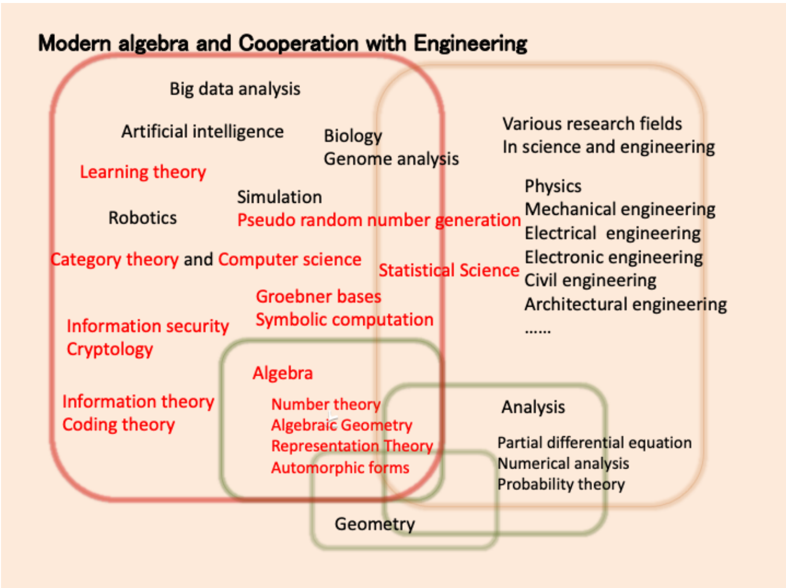
It is important for mathematics, which has more than 2000 years history for research, to interact with other research fields outside mathematics. Research area of pure mathematics is roughly divided into three parts, algebra, geometry and analysis. One can think that algebra and analysis are two wheels of a cart, via geometry and geometric objects. In its long history, analysis, which treat mainly continuous objects, has been developed in interaction with various engineering technology. On the other hand, algebra, which treat mainly discrete objects, has been started to make interaction with information science, information technology, electrical and mechanical engineering, etc., after 20th century, and produce many useful results and effects which are indispensable for modern human life. Our division based on algebra are going to cooperate with another division "Research Alliance for Mathematical Analysis", and are going to be a basis of science and technology to cooperate with various research areas. And finally, to be a center of research on algebra and algebra based engineering.

2. Organization and Facilities

The division consists of various researchers inside 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 relationship 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 groups for applied research. Pure mathematics groups are managed by holding seminars, workshops and symposiums on algebra, algebraic geometry, number theory, and so on. Engineering groups are also managed by making a place for engagement of researchers of pure mathematics and engineering, and by proposing and developing many research plans for both sides, mathematics and engineering. Furthermore, the division do cooperative research under continuously pursuing the deep cooperation with Research Alliance Center for Mathematical Sciences, Tohoku University.



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

3. Activity Reports

The research promotion style of this research division is

a) A method in which reseachers 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) A method of solving problems by intensively discussing a single problem or theme and cooperating.

Both the pure mathematics group and the applied research group use both research styles. In 2022, we will continue to conduct research in a) and b) styles as before, and although it was a corona disaster, we tried to gradually return to the situation before the corona disaster by combining face-to-face and online.

For a), we held a total of 7 algebra seminars, lectures, and ring theory lectures in both Kagurazaka campus and Noda campus throughout the year, with content related to both research group. On the other hand, in method b), we invited collaborators from outside the university to give lectures on the central topics, and we also took time for discussion and conducted intensive research exchanges. In particular, the algebraic geometry/commutative algebra group is making great progress in studying singularities by group scheme quotients. In addition, although we were unable to hold a research meeting co-sponsored with the Collaborative Research Center for Mathematical Sciences at Tohoku University for various reasons this year, we will continue to maintain an ongoing relationship.

4. Challenges and Prospects

After all, it has not been able to act as an active research base like before the corona disaster. This is partly due to the restrictions imposed by the COVID-19 pandemic, but it is also thought that the peculiarity of mathematics research centered on dialogue and discussion has worked in a negative direction due to the pandemic. On the other hand, although the burden on the organizers has increased due to the new form of combined use of online, it seems that the obstacles to holding the workshop itself have decreased. Activation is expected by holding research meetings. In addition, it is considered necessary to proceed to the stage of human resource exchange such as cross-appointment, starting with substantial joint research in the collaborative agreement with Tohoku University's Collaborative Research Center for Mathematical Sciences.

5. Conclusion

The integration of research and research exchanges, which had been stagnating due to the corona crisis, are gradually showing signs of revival as new styles are adopted. Due to the need to devote a great deal of effort to daily work in order to deal with the coronavirus, there is a delay in the research of contents like this research division, but I feel that the situation is gradually returning to the previous situation. I have high hopes for the method that incorporates new changes. Although the department will be established for three years from 2021, we would like to actively engage in activities in the next fiscal year in anticipation of future development.

Major Research Achievements (FY 2022)

Academic Papers

1. Hiroki Aoki: On the upper bound of the orders of Jacobi forms. INTERNATIONAL JOURNAL OF MATHEMATICS, 33-8(2022), Refereed, Online Journal (No page numbers)
2. Katayama, Yuta and Kida, Masanari: Coincidence of L-functions. Acta Arith. 204 (2022) 369-385. (Peer-reviewed)
3. Kida, Masanari: On nondegerate CM-types. Rocky Mountain Journal of Math., 52 (2022) 547-566. (Peer-reviewed)
4. Ryosuke Amano, Akira Ishimaru, and Kida, Masanari: Galois realization of Schur covers of dihedral groups of 2-power order. Funct. Approx. Comment. Math., 67 (2022) 47-67. (Peer-reviewed)
5. Aoki, Misato and Kida, Masanari: Constructing unramified extensions of quadratic fields. Involve, a Journal of Mathematics 15 (2022) 55-68. (Peer-reviewed)
6. Kida, Masanari and Yanai, Hiromichi: The index of degeneracy of a CM abelian variety can be arbitrarily large. Acta Arithmetica 202 (2022) 55-66. (Peer-reviewed)
7. Ayako Itaba, Yuta Shiba and Katsunori Sanada:Symmetric cohomology and symmetric Hochschild cohomology of cocommutative Hopf algebras, 第 54 回 環論および表現論シンポジウム報告集, pp. 40-45, 2022.
8. Naoko Kunugi and Kyoichi Suzuki: Relative stable equivalences of Morita type for the principal blocks of finite groups, Proceedings of the 54th Symposium on Ring Theory and Representation Theory, (2023) 64-69.
9. 自然数の最大限に細分化した分割について，関川浩，数式処理, Vol. 28, No. 1, pp. 24-27, 2022.
10. 合成で表現可能な最近接多項式，関川浩，数式処理, Vol. 29, No. 1, pp. 37-40, 2023.
11. ガンマ関数の関数等式と CM 周期の単項関係式の対応とその応用 (in Japanese), 加塩朋和，第 67 回代数学シンポジウム報告集, pp. 73-84, 2023.
12. T. Nakamura, "Bounds for the Tornheim double zeta function", Proceedings of the American Mathematical Society. Ser.B 10 (2023), 1-12. (Peer-reviewed)
13. T. Nakamura, "Functional equation and zeros on the critical line of the quadrilateral zeta function", J. Number Theory.233 (2022), 432-455. (Peer-reviewed)
14. Unknottability of spatial graphs by region crossing changes, Yukari Funakoshi, Kenta Noguchi, Ayaka Shimizu, Osaka Journal of Mathematics, in press. (2022/8 accept) (Peer-reviewed) (https://arxiv.org/abs/2009.12119)
15. Cubic graphs having only k-cycles in each 2-factor, Naoki Matsumoto,_Kenta Noguchi, Takamasa Yashima, Discussiones Mathematicae Graph Theory, in press. (2022/2/5 published online) (Peer-reviewed) (DOI: 10.7151/dmgt.2447)
16. Yuya Matsumoto, Purely inseparable coverings of rational double points in positive characteristic, Journal of Singularities 24 (2022), 79-95. (Peer-reviewed)
17. Yuya Matsumoto, Canonical coverings of Enriques surfaces in characteristic 2, J. Math. Soc. Japan 74 (2022), no. 3, 849-872. (Peer-reviewed)
18. Yuya Matsumoto, On μ_n-actions on K3 surfaces in positive characteristic, Nagoya Mathematical Journal, 249 (2023), 11-49. (Peer-reviewed)
19. Yuya Matsumoto, μ_p- and α_p-actions on K3 surfaces in characteristic p, J. Algebraic Geom. 32 (2023) 271-322. (Peer-reviewed)
20. A. Itaba and I. Mori, Quantum projective planes finite over their centers, Canad. Math. Bull., Vol. 66 (2023) Issue 1, 53-67. (Peer-reviewed)
21. Y. Shiba, K. Sanada and A. Itaba, Symmetric cohomology and symmetric Hochschild cohomology of cocommutative Hopf algebras, (2022) submitted, arXiv: 2203.17043. (submitted, in minor revisioning stage)
22. A. Itaba, Quantum projective planes and Beilinson algebras of 3-dimensional quantum polynomial algebras for Type S', (2023) arXiv:2304.02242. preprint.

23. A. Itaba, AS-regular algebras and Frobenius algebras, Winter School on Koszul algebras and Koszul duality, 55-60, OCAMI Reports Vol. 3 (2022). (July 4, 2022) doi: 10.24544/ocu.20220624-001 (Peer-reviewed)
24. A. Itaba, Y. Shiba and K. Sanada, Symmetric cohomology and symmetric Hochschild cohomology of cocommutative Hopf algebras, Proceedings of the 54th Symposium on Ring Theory and Representation Theory, 40-45, Symp. Ring Theory Represent. Theory Organ. Comm., Tokyo, (2023).
25. 板場綾子, 中心上有限生成な非可換射影平面の特徴付け, 研究集会「第 15 回数論女性の集まり (WINJ2022)」 (東京工業大学) 報告集 17-25, 2022 年 10 月 (in Japanese).

Books

1. 特集「有限群からその先へ」：「モジュラー群」, 青木宏樹, 数学セミナー（日本評論社）62 (2023-3), 30-33. (in Japanese)
2. 特集「平行線が交わる世界」：射影空間と代数幾何, 射影平面を例に」, 伊藤浩行, 数学セミナー(日本評論社) 61(2023-2), 30-34. (in Japanese)
3. 木田雅成: 連分数. ISBN 978-4-7649-0643-3. 近代科学社. 2022. (in Japanese)
4. 木田雅成: 線形代数講義［増補版］. ISBN 978-4-563-01251-9. 培風館. 2023. (in Japanese)

Invited Lectures

1. 木田雅成 : ひとつのデデキント・ゼータ関数を共有する代数体について 三角函数研究会. 神戸大学六甲台キャンパス. 2022 年 9 月 7 日 (in Japanese)
2. 木田雅成： CM タイプをめぐる冒険 愛知数論セミナー, 名古屋工業大学御器所キャンパス. 2022 年 12 月 10 日(in Japanese)
3. ガンマ関数の関数等式と CM 周期の単項関係式の対応とその応用, 第 67 回代数学シンポジウム, 京都大学数理解析研究所, 2022 年 (in Japanese)
4. フェルマー曲線上のフロベニウス行列の公式とその一般化に関して, 加塩朋和, プロジェクト研究集会 2022, 長野県佐久市, 2023 年 (in Japanese)
5. 「双子単数について」小松 亨, 愛知数論セミナー, 名古屋工業大学(御器所キャンパス), 2022 年 10 月 (in Japanese)
6. 「多胎単数について」小松 亨, 北陸数論セミナー, 金沢大学(サテライトプラザ), 2022 年 11 月 (in Japanese)
7. 「3 次巡回体における単数方程式の強有限性について」小松 亨, 新潟代数セミナー, 新潟大学(五十嵐キャンパス), 2022 年 11 月 (in Japanese)
8. Spanning bipartite quadrangulations of triangulations of the projective plane, Kenta Noguchi, Joint Mathematics Meetings 2023, Boston, USA, 2023 (Jan. 4)
9. 閉曲面上のグラフ, とくに三角形分割と四角形分割, 野口健太, 日本数学会 2023 年度年会特別講演, 中央大学, 2023 年 3 月 15 日 (in Japanese)
10. Yuya Matsumoto, Inseparable analogue of Kummer K3 surfaces, 正標数体上の代数多様体, および連接層の導来圏に関するワークショップ, Tokyo Metropolitan University, 2023. (in Japanese)
11. Yuya Matsumoto, Inseparable analogue of Kummer K3 surfaces, K3, Enriques Surfaces, and Related Topics, Nagoya University, 2023.
12. Yuya Matsumoto, K3 曲面への有限群作用と μ_p, α_p 作用, 慶應・理科大数理オンラインセミナー, 東京理科大学, 2022. (in Japanese)
13. Yuya Matsumoto, Inseparable analogue of Kummer K3 surfaces, p-adic cohomology and arithmetic geometry 2022, Tohoku University, 2022.

Individual Research Topics

Hiroyuki Ito

“Research on algebraic geometry and singularity theory in positive characteristic and its application to high performance pseudorandom number generator. ”

Studied on quotient algebraic varieties and quotient singularities by finite group schemes of typical types in positive characteristic.

Furthermore, studied for trying to construct general theory combining Artin-Schreier externsions and purely inseparable extensions of Frobenius type which includes many pathological phenomena in positive characteristics.

Also trying to improve the performance of pseudorandom number generator using Artin-Screier tower of huge finite fields which I invented before.

Katsunori Sanada

“Study on the Lie algebraic structure of complete Hochschild cohomology rings”

Introducing the BV (Batalin-Vilkovisky) structure to the complete Hochschild cohomology of Frobenius algebras, which is an extension of the ordinary Hochschild cohomology to negative dimension, we study on defining the Lie bracket product by Gerstenhaber.

Masanari Kida

“Studies on isoclinism classes of Galois groups”

I investigated the arithmetic of number fields base on isoclinism classes of Galois groups and obtained the results on construction of isoclinic fields and on L-functions.

Naoko Kunugi

When constructing derived equivalences and Morita equivalences between blocks of finite groups, there is a technique to construct stable equivalences of Motira type and lift them. I considered relative stable equivalences of Motira type, which is a generalization of stable equivalences of Morita type, and studied a method to lift them to Morita equivalences.

Hiroshi Sekigawa

“Research on symbolic-numeric computation”

We conduct research on the composition of polynomials. If a univariate polynomial f can be represented by the composition as f=g(h), where g and h are polynomials of degree more than one, then we can evaluate f at a given point with smaller number of arithmetic operations. However, almost all polynomials cannot be represented as the composition of polynomials. In terms of application, it is enough that there is a “near” polynomial g(h) to f in some cases. Thus, we propose an algorithm to compute a near polynomial to f that can be represented as the composition of polynomials.

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 collaborate with my graduate students on related topics on number theory.

Kouji Tahata

“Study of modeling on square contingency tables”

A contingency table is one of the essential tools for analyzing categorical data. Especially for the analysis of the square contingency table, which has the same row and column classifications, we are interested in considering the symmetry structure than the independence structure. This research aims to assess the modeling of symmetry and asymmetry. Additionally, we reveal the interpretation of the model concerning information theory and properties of goodness-of-fit test statistics. Moreover, we apply the proposed models to a real data set.

Nobuko Miyamoto

“A study on construction and optimality of spanning bipartite block designs”

We proposed a block design called Spanning Bipartite Block Design (SBBD), in which the edge set of a complete bipartite graph is a treatment set and a spanning subgraph is a block, and studied its construction method and optimality.

SBBD is a combinatorial structure applicable to the drop-connect method to improve generalization performance in deep learning.

Takao Satoh

“Study of twisted first cohomology groups of the automorphism groups of free groups”

We studied twisted first cohomology groups of the automorphism groups of free groups with coefficients in the abelianizations of certain verbal subgroups of the free groups. We obtained several linearly independent cohomology classes, and studied relations to the Morita cocycles of the automorphism groups of free groups.

“Study of the images of the Johnson homomorphisms of the basis-conjugating automorphism groups”

Let F be a finitely generated free group with a given basis. The group of automorphisms of F which maps each element of the basis to its conjugate is called the basis-conjugating automorphism group of F. By a joint work with Naoya Enomoto, we studied the Johnson images of the basis-conjugating automorphism group by using combinatorial group theory and representation theory.

Yoshitaka Hachimori

I studied a problem whether there exists always a prime p for which the Iwasawa invariant λ_p is greater than or equal to 2 for a fixed imaginary quadratic K. For this, I tried to generalize a result of M. Stokes. Specifically, I conjectured and examined a formula for the value of the derivative mod p^2 of the p-adic L-function for a prime p decomposing in K, using a linear sum of the values of the Bernoulli polynomial.

Toru Komatsu

“Study on the unit equations over cyclic cubic field”

We study pairs of units in cyclic cubic fields of which differences are positive integers, and determine such pairs of units completely. Let N be the set of positive integers. For a cyclic cubic field K let O_K denote the ring of algebraic integers in K, and U_K the group of units in O_K. Considering unit equation u-v=s for each s¥in N, we prove that the union of the solutions with running s is finite, and determine all the solutions for every cyclic cubic field.

Tomokazu Kashio

“Research on Frobenius actions on algebraic curves’”

Coleman explicitly calculated the Frobenius action on Fermat curves and obtained its formula. This formula was generalized in many settings and led to Dasgupta-Kakde's work on the Hilbert 12 problem. In 2022, we showed that the formula follows semi-automatically, without explicit computation. Furthermore, we aim to adapt this method to generalized versions.

Takashi Nakamura

“Bounds for the Tornheim double zeta function”

In 2022, I researched “1. Riemann's function equation” and “2. Analytical behavior of multiple zeta functions”. Proceedings of the American Mathematical Society. Ser.B 10 (2023), 1--12., is the former study, and T. Nakamura, “Functional equation and zeros on the critical line of the quadrilateral zeta function”, J. Number Theory. 233 (2022), 432-455., is the latter study. There are other accepted papers besides [R1] and [R2], but they are omitted here.

Yuya Matsumoto

“Inseparable analogue of Kummer K3 surfaces”

Kummer surfaces are classical examples of K3 surfaces. They are defined as the resolution of the quotient of an abelian surface by inversion. In characteristic p>0, there exists a supersingular K3 surface that is Kummer if and only if p>2. We introduce the notion of inseparable version of Kummer surfaces, and study their properties.

Kenta Noguchi

'“A study on bipartite spanning quadrangulation of triangulations on closed surfaces”

Summary: Continuing from the last year, I have been doing research for a bipartite spanning quadrangulation subgraph H of a triangulation G on closed surfaces. In particular, on the projective plane, I could give a necessary and sufficient condition for G to have H and I submitted a paper.

Ayako Itaba

“Quantum projective planes finite over its center for Type S'”

By direct calculation, we find generators of the center of 3-dimensional Koszul AS-regular algebra for Type S’. In previous research by the author and Matsuno, they prove that, for any 3-dimensional Koszul AS-regular algebra, there exists a 3-dimensional Koszul Calabi-Yau AS-regular algebra such that these algebras are graded Morita equivalent. Using these consequences, we obtain the representation theoretic result about quantum projective planes finite over its center for Type S’. Note that, in 2015, Mori prove the same result for Type S’. In present, we uploaded the preprint of this result for Type S’, and we are in the process of preparing this preprint for submission.

“Constructions the rigid family of path algebras obtained by Euclidean quiver”

We are conducting joint research to apply the methods of axiomatic set theory to the representation theory of algebras. Gobel-Simson proved that Kronecker algebra are "WILD" by constructing the rigid family of Kronecker algebra, which is the path algebra obtained by Kronecker quiver. In this research, our aim is to construct the rigid family of the path algebra by Euclidean quiver except for Kronecker quiver. From now on, we have succeeded in construct the rigid family of the path algebra by quivers of D_4-tilde, E_6-tilde, E_7-tilde, but, the next challenge is to construct the rigid family for the quiver of E_8-tilde.

Division of Medical Data Sciences

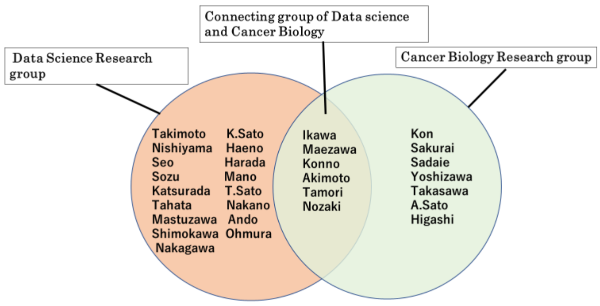
Division of Medical Data Sciences

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., Sozu T., Katsurada K., Tahata K., Matsuzawa T., Ohmura H., Sato K., Haeno H. Harada T., Mano Y., Sato T., Nakano Y., Shimokawa A., Ando S., Nakagawa T.

(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., Konno M., Akimoto K., Tamori S., Nozaki Y.

We used the common facilities of the departments to which each member belongs. In addition, a new laboratory was set up in Laboratory 8 on the 3rd floor of Building No. 10 in the Noda campus, and a partition was constructed between the experimental space and the data analysis space. In order to handle highly confidential data in the data analysis space, independent electronic locks were installed at the entrances and exits of both spaces. In the data analysis space, a PC for taking out to the National Cancer Center was installed. The experimental space was equipped with a freezer, etc., and equipment owned by members was brought in as shared equipment. Furthermore, a server for data analysis was set up in the server room on the 2nd floor of Building No. 19, and Dr. Haeno was appointed as the administrator. In this way, this year was the first year, so we focused on improving common facilities.

3. Activity Reports

In each research group, division members with initiatives in their research fields gathered and worked on basic research from the aspect of Medical Data Sciences to promote the “global TUS”. In addition to creating a division website to disseminate overall research activities, a joint symposium between the division of Medical Data Sciences and the division of Nucleic Acid Drug Development was held on September 24, 2022, aiming for a synergistic effect between data science and nucleic acid drug discovery. It was an excited opportunity to conduct full face-to-face, and it could be the seeds of the interdisciplinary research that this research division is aiming for.

3. 1. Data Science Research Section

I) Establishment and verification of specific data science research methods

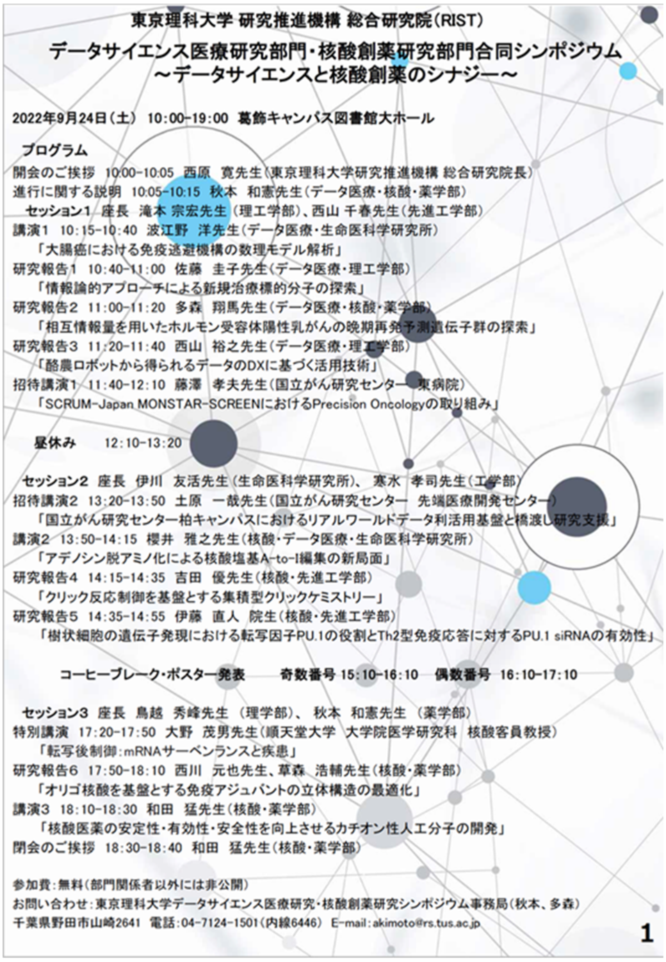
The group proceeded with the stratification of patients by statistical methods and unique information science methods (AI, high-speed logical machine learning, mutual information, PRV (proportional reduction in variation) measure) for public cancer genomics databases to isolate biomarkers of poor clinical outcome and therapeutic target.

II) Introduction of new data science methods to this research division

We introduced methods such as enrichment analysis and Bayesian network to estimate networks among genes.

III) Collaboration with the National Cancer Center (NCC)

"Utilization platform for surgical video database, development of AI equipment" We started to analyze the gaze and voice recognition of the surgeon during surgery, analyze the endoscopic surgery database for the liver, gallbladder, pancreas, large intestine, and urology, and develop AI equipment. "Large-scale clinical data, SCRUM-Japan MONSTER SCREEN utilization platform" We have finished preparing data handling security guidelines and checklists (May 2022), and a draft research plan (November 2022). The draft research plan has been submitting.



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 tried to build the academic foundation for that purpose.

3. 3. Connecting Section of Data Science and Cancer Biology

We aim to integrate data science methods that are unconventional in order to elucidate the mechanism of action in cancer progression in the natural history of cancer and to identify new biomarkers. In this year, we introduced the Shannon-Weiner multiplicity index for the analysis of cancer heterogeneity, and the mutual information of information theory and the person-years method of medical statistics for the isolation of late recurrence biomarker gene clusters of breast cancer. Thus, we built an academic foundation of Medical Data Sciences at TUS.

4. Challenges and Prospects

Despite the expansion of COVID-19, we were able to conduct cross-sectional joint research and exchange information by holding a face-to-face symposium. However, in order to widely appeal to the world the significance of research in this field at TUS, since members are biased toward the Noda Campus, it is necessary to collaborate with new members on the Katsushika and Kagurazaka Campuses, and collaborate with external institutions. It is also important to strengthen international cooperation. In addition, we aim to acquire a large budget starting from the research division, and to present the results of joint research among division members more than ever in academic conferences and academic papers.

5. Conclusion

Based on this year's research results, 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 (FY 2022)

Academic Papers

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Books

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Invited Lectures

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Individual Research Topics

Dr. Shoma Tamori and Dr. Kazunori Akimoto

"Identification of cancer prognostic biomarkers for late recurrence of breast cancer by the analysis of cancer genomics databases"

To identify the biomarkers of the early prediction for late recurrence of breast cancer, we have analyzed cancer genomics databases by data science techniques. In 2022, we isolated SLC20A1 and 63 genes signature as candidate genes for biomarker of late recurrence. In 2023, we will try to isolate new candidates of other cancer types and advance the functional analysis of genes that have already been isolated.

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.

Yasunari Mano

"Development of cancer preventive agents from existing drugs using medical big data"

Using medical big data such as claim data, we verified the cancer preventive effect of statins, which are therapeutic drugs for dyslipidemia. The study design was a retrospective cohort study. As a result of comparing the cancer incidence rates between the statin group and the non-statin group, the risk of developing cancer was significantly lower in the statin group than in the non-statin group. In addition, as a result of examining the cancer preventive effect of leukotriene receptor blocker (LTRA), an anti-asthma drug, the risk of developing cancer was significantly lower in the LTRA group than in the non-administered group.

Kazumi Yoshizawa

"Survey of prescribing trends for strong opioid analgesics using NDB open data"

In this study, we used the NDB open data (https://www.mhlw.go.jp/stf/seisakunitsuite /bunya/0000177182.html) for fiscal years 2014 through 2019. From this data, prescription data for strong opioid analgesics were extracted and trends were investigated by calculating total prescriptions per year and percentages per drug. Total prescriptions for strong opioid analgesics tended to increase, with oxycodone accounting for half of the doses. Upon closer examination, morphine decreased, while tapentadol and hydromorphone increased. These findings may provide useful information for appropriate use of opioid analgesics.

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.

The practical application of the proposed methods will shorten the study duration for each situation.

Munehiro Takimoto

“Parallelized inductive logic programming based on swarm intelligence”

In this study, I redesign Inductive Logic Programming (ILP), which is a kind of logical A.I., based on Particle Swarm Optimization (PSO), which is a kind of Swarm Intelligence, and implement a practical ILP system through parallelizing particles in PSO.

Kouichi Katsurada

“Articulation – acoustic conversion from RtMRI movies”

We developped a speech synthesis model from rtMRI videos of the midsagittal plane of the vocal tract. It has been generally believed that speech sounds are produced based on a principle called the source-filter model, in which a source is created by the vibration of the vocal folds and various phonemes are produced by changing the resonance frequency according to the shape of the vocal tract. In contrast, in this study, we succeeded in generating speech sounds from rtMRI data in which vocal fold vibration was not captured, by using a deep learning model.

Kouji Tahata

“Modeling for square contingency tables”

A contingency table is one of the essential tools for analyzing categorical data. Especially for the analysis of the square contingency table, which has the same row and column classifications, we are interested in considering the symmetry structure than the independence structure. This research aims to assess the modeling of symmetry and asymmetry. Additionally, we reveal the interpretation of the model concerning information theory and properties of goodness-of-fit test statistics. Moreover, we apply the proposed models to a real data set.

Hiroyuki Nishiyama

“Estimating potential biomarkers of late recurrence in breast cancer using machine learning”

We propose a machine learning model designed to estimate potential biomarkers of late recurrence in breast cancer. First, we constructed machine learning models, including those for survival time analysis. We then trained these models using a gene expression dataset of breast cancer patients for each subtype. We evaluated the inner product, defined as the ordinal score, of the SHAP values and Principal Component Analysis’s loadings. This ordinal score enables us to estimate the potential biomarker genes for late breast cancer recurrence more continuously.

Tomokatsu Ikawa

“Molecular mechanisms of B-ALL development using induced leukocyte stem cells.”

B-precursor acute lymphoblastic leukemia (B-ALL) is most common childhood tumors and the leading cause of cancer-related death in children and young adults. We have previously established multipotent hematopoietic progenitors that have self-renewal activities and multilineage differentiation potential. The iLS cells transduced with fusion genes efficiently induced B-ALL. We will determine the molecular mechanisms that control B-ALL development using the iLS system.

Akira Sato

"Analysis of anticancer drug resistance mechanisms in refractory cancer cells"

We examined the anticancer resistance in 5-FU-resistant colorectal cancer. We showed that the trapping of FdUMP by TS confers resistance to 5-FU. We reported that the regulation of FdUMP-TS by autophagy contributes to 5-FU resistance.

Tsugumichi Sato

"Pharmacoepidemiological reseach using big data in healthcare"

We performed following pharmacoepidemiological studies using a claims database: 1) Association between drug use during pregnancy and autism spectrum disorder in children, 2) Drug utilization study of antiepileptic drugs, 3) Drug utilization study of antiparkinsonian drugs, 4) Drug utilization study of anti-allergic drugs in children. Results of the studies were presented at a conference and the English papers will be published in the near future.

Ryoko Takasawa

"Development of novel inhibitors of human glyoxalase I (GLO I)"

We have tried to identify the compounds that inhibit the metabolic enzyme GLO I, which is involved in the detoxification of methylglyoxal (MG), a toxic metabolic byproduct of glycolysis, and is highly expressed in cancer cells. We performed X-ray crystallographic analysis of the GLO I inhibitory compound TLSC702 and the GLO I complex and clarified the binding mode. We found triphenylbismuth dichloride as a novel GLO I inhibitory compound.

Kyohei Higashi

"Elucidation of the mechanism of structural change of glycosaminoglycans under inflammation"

Glycosaminoglycans (GAGs) including heparan sulfate (HS), heparin (HP), chondroitin sulfate (CS), dermatan sulfate (DS), and hyaluronan (HA) are linear and acidic polysaccharides are major component of extracellular matrices. We aimed to elucidate the mechanism of structural change of GAGs caused by ischemic stroke and malignant tumors.

Keiko Sato

"Key genes associated with the development and clinical outcome of triple negative breast cancer"

Triple-negative breast cancer (TNBC) progression is attributed to higher aggressiveness, molecular heterogeneity, and resistance to chemotherapy. An information-theoretic approach was applied to define gene expression signatures that could distinguish TNBC from non-TNBC and could lead to a better understanding of the pathogenesis of TNBC. Furthermore, to explore novel biomarkers for prognosis and possible therapeutic targets for TNBC, we identify specific genes associated with recurrence and death in TNBC.

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.

Taku Harada

"Distributed traffic signal control using deep reinforcement learning"

Appropriate control of traffic signals is important to realize smooth vehicle travel on the whole traffic network. We proposed a distributed control method for traffic signals using deep reinforcement learning, which is one of the machine learning algorithms. The effectiveness of the proposed method was shown by simulation experiments.

So Maezawa

"Multi-omics approaches for revealing mammalian gametogenesis"

Recent advances in developmental biology hold great promise for organ regeneration, stem cell-based therapy, and tissue engineering. In vitro gametogenesis from pluripotent stem cells is currently being developed to overcome infertility, particularly germ cell aplasia. However, the induction efficiency to create functional sperm and egg cells is still low by the existing method. 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.

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.

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

"Mathematical analysis about subclonal accumulation of immune escape mechanisms in microsatellite instability-high colorectal cancers"

We constructed a computational mode of immune escape evolution in Microsatellite instability high Colorectal cancers (MSI-H CRCs) to show that MSI-H CRCs exhibit higher variant allele frequencies of subclonal mutations than microsatellite-stable CRCs, suggesting that subclonal mutations are subjected to selective sweep. This study showed that MSI-H CRCs acquire immune escape mechanisms even in the relatively late phase of tumor progression, suggesting the effectiveness of early application of immune checkpoint inhibitor-based treatment for patients with MSI-H CRCs.

Shunsuke Kon

"Elucidation for elimination of transformed cells by cell competition"

This year we studied the mechanism whereby transformed cells are eliminated by cell competition, and factors which cause dysfunction of cell competition. First, we uncovered that transformed cells surrounded by normal epithelial cells exhibit low activity of lysosomes associated with accumulation of autophagic vacuoles, which positively regulate the process of cell competition. Secondly, we revealed that multi-sequential accumulation of gene mutations causes malfunction of cell competition, and leads to diffuse invasion of transformed cells into basal lamina.

Asanao Shimokawa

"Research on prediction of survival time"

I am studying on the analysis of survival time which treating the time from a certain start point to the occurrence of an event. The goal of my research is to establish a method for constructing an optimal tree-structure-based model for predicting survival time.

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.

Hidefumi Ohmura

"Searching for applied research using sound in medicine"

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 in medicine.

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.

Yuka Nozaki

"Age-related transition of adipose-specific mitochondrial stress"

Mitochondrial intermediate peptidase (MIPEP) plays an important role for mitochondrial matrix proteostasis by processing certain mitochondrial matrix proteins. Therefore, MIPEP dysfunction may cause mitochondrial matrix proteostasis disorder. However, studies investigating the difference between short-term and long-term mitochondrial stress responses. Therefore, to evaluate the differences, we generate and analyze adipose-specific Mipep knockout (aMKO) mice.

Division of Smart Healthcare Engineering

Division of Smart Healthcare Engineering

1. Overview

The Division of Smart Healthcare Engineering originated in the Biosystems Research Division, which was established in April 1983, and was succeeded in April 1988 by the Intelligent Systems Engineering Division, which aims to conduct research on a wide range of themes from basic to applied fields, based on the principle of “adding intelligence to engineering systems. In April 1988, the Intelligent Systems Engineering Division was established to carry out research on a wide range of topics from basic to applied fields. 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 as the Intelligent Systems Engineering Division, 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. human-like intelligent systems” and “conduct research and development for medical and space applications of human-like, autonomous, and human-friendly intelligent systems” as its principles, and after 15 years of activity, the division was temporarily dissolved after achieving many results. Subsequently, in April 2022, the division 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 (20 members as of March 31, 2023). 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.

In FY2022, the first year of its establishment, a workshop on measuring instruments was held jointly with Tokyo Denki Sangyo Co., Ltd. and Yokogawa Test & Measurement Co. on Wednesday, April 27 and Thursday, May 19, mainly for students who had just joined the laboratory. In addition, the Division Workshop was held on July 22 (Friday) and September 20 (Tuesday) to promote research exchanges among Division researchers and provide them with learning opportunities. In addition, the current status and challenges of the division were presented through posters at the General Research Institute Forum 2022 on Monday, November 28, 2022. In addition, on Thursday, March 9, 2023, the Intelligent Systems Engineering Division also held what has become an annual face-to-face research report meeting with Dr. C. Umeda, Chief Clinical Engineer, Saitama Medical Center, Jichi Medical University, presented “Approaching Medical Care from an Engineering Perspective from the Standpoint of a Clinical Engineering Technologist.” In addition to two special lectures by Professor S. Yokobori of Nippon Medical School on “Medical-Scientific Cooperation Required for With Corona and Post Corona,” and seven presentations by representatives of research groups, 41 student-led poster sessions were also held. Poster presentations were evaluated and voted on by all participants, and awards were given to the most outstanding presentations. Through these activities, we further promoted student enlightenment and research exchange among members of the division, and identified future research topics. It can be said that we were able to hold a meaningful debriefing session that will lead to the future development of the field and bridge the gap 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 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.

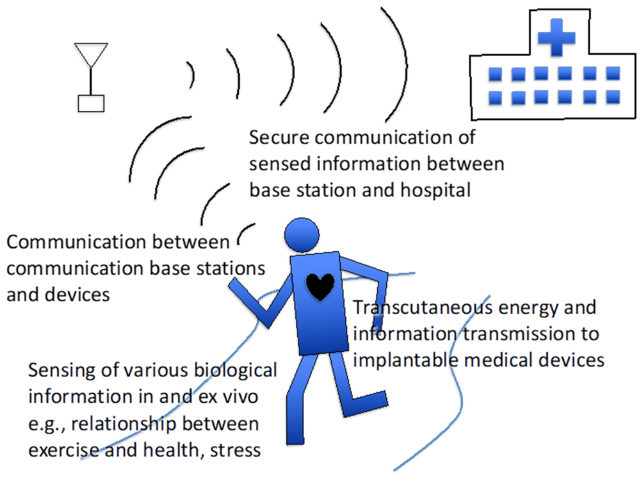

Fig. 1. Examples of research topics in the division.

(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 measurement 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, 2023, this division has 11 members: Faculty of Science and Technology (T. Yamamoto, S. Akashi, K. Higuchi, A. Hyogo, T. Hara), 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 (Masaki Kobayashi), Toyama Prefectural University (Ryo Kishida), Tokyo Institute of Technology (H. Sato), and Zenkigen (I. Hashimoto), a total of 20 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.

Fig. 2. Analog integrated circuit chip analysis facility. (Left: Voltage and current detection section, Right: Measurement analysis section)

Fig. 3. Vector signal generator.

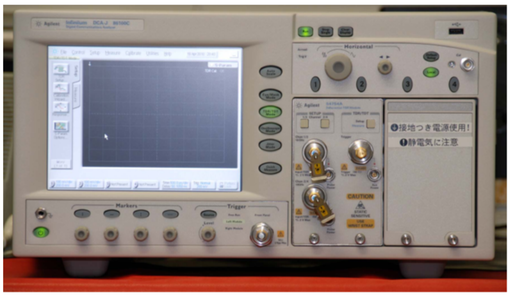

Fig. 4. Oscilloscope with TDR.

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).

(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).

(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).

(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.

3. Activity Reports

Four groups (Sensing group, Integrated circuits and signal processing group, Device operation and control group, and Information and communication group) conduct individual elementary technology research and interdisciplinary research among the groups. The status of activities and major research topics in each group are described below. The research results of each research topic are published in the Proceedings of the Research Achievement Report Conference of the Smart Healthcare System Research Division in FY2022, major academic conferences, and international conferences.

3. 1. Sensing Group

3. 1. 1. Umezawa group

The main research subject of the Umezawa group is listed below.

- Machine learning-based extraction of long non-coding RNAs related to nanoparticle-induced Brain Pathology.

3. 1. 2. Yanagita group

The main research subject of the Yanagita group is listed below.

- The mechanism of health promotion and longevity through physical activity: a challenge to elucidate.

3. 1. 3. Ota group

Ota et al. worked on the estimation of speech content in phoneme units based on mouth movement information captured by a camera, and on the construction of a simple human body movement measurement system. First, for the estimation of speech content based on mouth movements, we searched for a structure suitable for our purpose in deep neural networks, which are also used in ordinary speech recognition, and conducted an evaluation under the condition that the speakers of the evaluation data were not included in the speakers of the training data. As a result, we achieved a phoneme error rate of about 30%. Next, for a simple human body motion measurement system, we performed skeletal detection using openpose on video images captured by two web cameras and realized a three-dimensional motion analysis system using the direct linear transformation (DLT) method. The main research subjects of the Ota Group are listed below.

- Research on object measurement using the DLT method and distance sensors
- Verification of the accuracy of video motion capture using two web cameras
- A study of the relationship between electromyograms, joint angles, and playing motion during guitar playing, and a method for estimating muscle tension
- Effects of the positional relationship between the lips and the flute on the sound of the flute
- Investigation of the effect of WaveGAN data augmentation and distance index on anomaly detection performance
- Investigation of the effect of Conformer on semi-supervised sound event detection
- Investigating the impact of Inception and data augmentation on accuracy in acoustic event localization and detection.
- The impact of data augmentation on word identification accuracy in machine lipreading
- The effect of data augmentation with a three-dimensional model on phoneme recognition accuracy in machine lipreading.

3. 1. 4. Hashimoto group

The main research subjects of the Hashimoto group are listed below.

- An analysis of dialogue in the process of performing creativity tasks
- What do people use as a clue to infer the stress state of others?
- Correlation analysis of filler and personality traits in conversations

3. 2. Integrated Circuits and Signal Processing Group

3. 2. 1. Hyogo, Matsuura, Kishida group

The main research topics of the Hyogo, Matsuura, Kishida group are listed below.

- Improvement of output power by adding a current injection stage to a class E amplifier
- Measured evaluation of aging degradation using a switched inverter-type ring oscillator
- Improving power conversion efficiency at low input signal in a cross-coupled differential CMOS rectifier circuit for RFID
- Ultra-low voltage ring oscillator using an inverter configuration
- Proposed aging evaluation circuit using a switched current starved oscillator
- Low power LC-VCO using transformer feedback and capacitance division

3. 3. Device Operation and Control Group

3. 3. 1. K. Koshiji group

Research and development of transcutaneous power transmission technology for body implantable devices and construction of systems compatible with electromagnetic environment.

3. 3. 2. Yamamoto, K. Koshiji group

Yamamoto and K. Koshiji research transcutaneous energy transmission for implantable devices and its efficiency improvement, information transmission between inside and outside the body, the effect of magnetic fields generated by energy transmission on the body, and development of a phantom that mimic the electrical characteristics of a living body.

The main research topics of the T. Yamamoto and K. Koshiji group are listed below.

- Study on improvement of transmission efficiency of transcutaneous energy Transmission system using two-wire archimedes spiral coil for totally-implantable artificial heart
- transcutaneous energy transmission system for artificial heart using alpha wound coil
- Development of a liver equivalent phantom for hyperthermia using ATO/TiO_2
- Research on the effects of exposure to magnetic fields on small laboratory animals
- Wireless power transmission system for implantable momentum analyzers for experimental animals - Trial transmission coil considering angular change between transmitter and receiver
- Information transmission from an implantable kinetic monitor for small laboratory animals under exposure to magnetic fields
- Wireless power transmission for implantable locomotion meters for laboratory animals
- Circuit using stabilized DC power supply for wireless power transmission to an implantable locomotion meter for laboratory animals
- Piezoelectric element for a foot pressure measurement device
- Low-temperature cooking using dielectric heating

3. 4. Information and Communication Group

3. 4. 1. Higuchi group

The main research subjects of the Higuchi group are listed below.

- Investigation of NOMA-Based Random Access for Massive Machine-Type Communications
- Investigation of Repetition-Based NOMA-HARQ with Adaptive Termination for Ultra-Reliable Low Latency Communications
- Investigation of Peak Power Reduction of OFDM Signals Using Null Space in MIMO Channel for Massive MIMO-OFDM Transmission

- Investigation of Autonomous Decentralized Activation Control of Base Stations Based on Machine Learning for Heterogeneous Networks
- Investigation of Autonomous Decentralized User Association Method to Maximize Integrated System Throughput for Multi-service Coexistence

3. 4. 2. F. Koshiji group

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. The main research subjects of the F. Koshiji group are listed below.

- Study of the superiority of human body communication over radio propagation communication
- Interactive communication system using human body communication
- Transmission characteristics of spiral coils for communication placed on the arm against misalignment
- Transmission characteristics of a coil for transcutaneous energy transmission against deformation of a cylindrical curved surface
- Transmission characteristics of microstrip line formed by ITO transparent conductive film
- Improvement of antenna radiation efficiency by annealing ITO transparent conductive film for transparent antennas
- Semi-trapezoidal unbalanced dipole antenna formed by ITO transparent conductive film

4. Challenges and Prospects

An interdisciplinary research system is essential to the division's goal of “creating a society in which all people can enjoy a high quality of life as a matter of course,” and the division is composed of researchers from various fields within and outside the university. To strengthen the division’s research capabilities, six researchers have joined the division since its establishment, and two research meetings, workshops on measuring instruments for students, and research results reporting meetings have been held to promote research exchanges within the division and to further disseminate research results within and outside the university. In the future, a new joint research system will be established to integrate the results of elementary technologies in each field and enable further collaboration.

5. Conclusion

The division started in FY2022 with research on elementary technologies and fusion research on biological information sensing, miniaturization and low power consumption of integrated circuits, power transmission to devices, antennas for communication, and wireless communication methods. In FY2022, the first year of activities, research exchanges among members of the division were conducted through research meetings centered on lectures by departmental faculty and research results reporting meetings to which students and outsiders were invited, with the aim of accelerating collaborative research and “planting seeds”. The importance of the department's research has increased and will receive renewed attention as the global pandemic of new coronavirus infections has forced people to rapidly change their behavior. Over the next year, the Division will seek to develop the results of its activities in tangible ways, such as accelerating collaborative research and attracting external funding through newly formed collaborations.

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Major Research Achievements (FY 2022)

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Book

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2. 人体通信を利用したインタラクティブコミュニケーションシステム, 漆館竜吾, 越地福朗, エレクトロニクス実装学会システム設計研究会 2022 年度第 2 回公開研究会, Online, Japan, November 2022. (in Japanese)
3. 脂肪組織特異的ミトコンドリアストレスが惹起する全身性抗炎症反応, 野崎優香, 第 45 回日本分子生物学会, 千葉, 2022 (in Japanese)
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5. Endogenous extracellular vesicles (nanoparticles) sensitive to temperature of biological deep tissues, M. Umezawa, *Exchange Academic Seminar "Frontier in Biomedical Engineering"*, University of Science and Technology of Hanoi (USTH; Vietnam France University), Viet Nam, 2022

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4. D. Kato (Supervisor: K. Higuchi), IEEE VTS Tokyo/Japan Chapter 2022 Young Researcher's Encouragement Award, October 2022
5. G. Takita (Supervisor: K. Higuchi), IEEE VTS Tokyo/Japan Chapter 2022 Young Researcher's Encouragement Award, October 2022
6. K. Matsumoto (Supervisor: K. Higuchi), IEEE VTS Tokyo/Japan Chapter 2022 Young Researcher's Encouragement Award, October 2022
7. K. Yanai (Supervisor: K. Higuchi), IEEE VTS Tokyo/Japan Chapter 2022 Young Researcher's Encouragement Award, October 2022
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Individual Research Topics

Shinya Yanagita

“Optimal physical activity levels to promote brain-organ crosstalk”

We have been clarifying the relationship between physical activity and brain functions (especially antidepressant and anxiolytic effects) using animal models. However, the optimal amount of physical activity for brain function is not well understood. In addition, the effect of physical activity on the relationship between skeletal muscles, which are the effector of exercise, and the brain is not known at all. Therefore, we are conducting an experimental study to clarify the optimal amount of physical activity and the mechanism by which an increase in the amount of physical (lifestyle) activity induces adaptive changes in brain function.

Masakazu Umezawa

“Optical and computational analysis of nanoparticle-biological interactions”

Changes in the secondary structure and aggregation of proteins on the surface of inorganic nanomaterials dispersed in an aqueous environment are investigated by optical (FT-IR) and computational (molecular dynamics analysis) methods. The affinity strength between the nanomaterial surface and the protein alters the aggregation tendency of amyloid β-peptide, and among the coexisting ions, ammonium ion promotes aggregation while nitrate ion inhibits it.

“Changes in secretory nanoparticles (extracellular particulate ADMs) induced by heating of adipocytes”

Heating 3T3-L1-derived adipocytes to 42°C for 3 hours caused an increase in the number of secreted adipocyte-derived microvesicles (ADMs) and a significant increase in the amount of total RNA, especially leptin mRNA. The results of this study showed that physical activity caused a significant increase in the number of ADMs. It is suggested that a transient increase in adipocyte temperature caused by local changes in body temperature due to physical activity may alter ADMs, which may serve as novel markers of metabolism and carriers of information to other organs.

Yuka Nozaki

“Time-dependent mitochondrial stress response in white adipose tissue”

Our originally developed mice lacking adipocyte-specific mitochondrial intermediate peptidase (MIPEP) (aMKO mice) survived mitochondrial stress and showed resistance to LPS-induced systemic inflammation at 30 weeks of age, but their lifespan was short. These results suggest that short-term mitochondrial stress in adipose tissue is beneficial for the organism, whereas long-term mitochondrial stress may have significant adverse effects. Therefore, this study aims to clarify the time-dependent mitochondrial stress response in aMKO mice by analyzing the effects on metabolism and various organs over time.

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.

Kenichi Higuchi

“Research on high-capacity and high-reliability wireless communication 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.

Koji Koshiji, Takahiko Yamamoto

“Development of a liver-equivalent electromagnetic phantom”

An electromagnetic phantom that simulates the electrical characteristics of the human body is useful for testing the electromagnetic compatibility of medical devices that are implanted or attached to the body under conditions similar to those in actual use, taking into account the effects of the human body. In this study, as part of the development of phantoms for various tissues, we are developing a phantom in the 8 MHz band that simulates hyperthermia treatment.

“Research on percutaneous energy and information transmission system for implantable artificial heart”

Non-invasive transmission of driving energy and control information is essential for improving the quality of life of patients with implanted artificial hearts. In order to realize a transcutaneous energy transmission system with an information transmission function, we are investigating the application of a figure-eight information transmission coil with a double-wound outer circumference that is partially cut off from the outer circumference.

“Wireless energy transmission and its biological effects on small laboratory animal tracking systems”

A small locomotion meter is used to measure the locomotion of small laboratory animals. Wireless power transmission to this device is expected to further reduce the size of the device and make it battery-free for long-term measurement. In this study, we are conducting research and development of such a non-contact power transmission device, as well as investigating the effects of exposing living organisms to electromagnetic waves.

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.

Kenko Ota

“A Study on speech estimation and measurement of human body movements based on image information”

In recent years, Japan's population has been aging rapidly, and the number of domestic workers is expected to decline. To solve this problem, there is a need for technology to support workers by estimating their psychological state, physical movements, and speech content using various sensors. In this study, we investigated the prospects for new estimation technologies based on image processing and deep learning, mainly using images acquired by cameras.

The Kao "Kirei" Future Open Innovation Project

The Kao "Kirei" Future Open Innovation Project

1. Overview

Based on the educational philosophy of TUS, "Innovation in Science and Technology for Sustainable Development", TUS aims to solve various problems in society through education and research. In addition, Kao Group Mid-term Plan 2025 (K25) outlines the company's direction to "Become a company that saves future lives" and Kao conducts research and development to contribute to a sustainable society and the realization of a rich lifestyle culture. Thus, Kao and TUS expect significant synergy effects from the collaboration for Kirei—Making Life Beautiful.

Therefore, we have established "The Kao "Kirei" Future Open Innovation Project" and started joint research. We are promoting the development of innovative technologies to enrich people's lives on our respective social missions and roles.

The following four initial joint research themes are in progress. We will contribute to the areas of "Ecology", "Life" and "Everyday lives" through the research and development of each research theme.

Theme 1: Research on biofuel cells and biosensors
Theme 2: Research on foaming control and functionalization
Theme 3: Research on neural and molecular mechanisms of pain
Theme 4: Research on application of cellulose nanofiber reinforced resin composites to structural materials

2. Organization and Facilities

Associate Professor, Isao Shitanda, Department of Pure and Applied Chemistry, Faculty of Science and Technology (Project leader)
Professor Hiroharu Yui, Department of Chemistry, Faculty of Science Division I
Professor Eri Segi, Department of Biological Science and Technology, Faculty of Advanced Engineering
Professor Shinji Ogihara, Department of Mechanical Engineering, Faculty of Science and Technology
Visiting Professor Keiko Matsuo, Research Institute of Science and Technology (Kao Corporation, responsible for the project)

3. Activity Reports

Theme 1: Research on biofuel cells and biosensors

We investigated methods to control the orientation of bilirubin oxidase (BOD) during electrode modification to improve the performance of self-powered paper-based biocathodes. The electrode modification method with small molecule compounds such as bilirubin was also investigated. The chemical structural modification of the compounds improved the molecular orientation on electrodes and the performance of the cathode.

Theme 2: Research on foaming control and functionalization

The scope of Theme 2 is understanding and controlling foam for the efficient use of surfactant to keep our enriched and hygienic life. Particularly, we aim to reduce surfactant usage for foaming while maintaining their cleaning ability and pleasant touch. To achieve this purpose, we clarify the role of the additive polymers in the foam films from the viewpoint of physical chemistry using newly developed measurement techniques. In the 2022 fiscal year, we succeeded in measuring the viscoelastic properties of foam films with a high-speed camera and heterodyne light scattering measurements. In addition, we established fluorescent imaging techniques to visualize the fluidic dynamics in the lateral direction of a foam film. In the next year, we will clarify the local structure and environments of the additive polymers in a foam film to control the mechanical properties and the lifetime of the film and design their molecular structures for further reduction of surfactant usage.

Theme 3: Research on neural and molecular mechanisms of pain

The goal of this theme is to elucidate pathological mechanisms of chronic low-back pain at the neuronal circuit and molecular level and to clarify the influence of stress on the onset and progression of low back pain. First, we attempted to develop an animal model of low-back pain by administering nerve growth factor or an inflammation-inducing substance to the back muscles of mice and evaluated their walking behaviors. Both models developed persistent gait impairment and disturbance 4 weeks after the stimulation, suggesting a prolonged elicitation of symptoms similar to back pain. Then, we evaluated signal changes in the brain, which controls pain, memory, and emotion, and found a significant signal change in a certain brain area. Next, we examined the influence of social defeat stress on the onset of low back pain. We found that the onset of low back pain-like symptoms was accelerated in the chronically stressed group. Furthermore, the disturbance of social behavior in the stressed group was exacerbated in the low back pain-induced group. This indicates that chronic stress and low back pain interact with each other's phenotypes.

Theme 4: Research on application of cellulose nanofiber reinforced resin composites to structural materials

In this theme, we are investigating the applicability of cellulose nanofiber (CNF) reinforced resin composites as new structural materials (e.g., high interlaminar toughness materials and adhesive materials) for carbon fiber reinforced plastic (CFRP) laminates. Kao Corporation is currently developing CNF for CFRP and composites with resin, while TUS is developing technology for localizing CNF-reinforced resin composites in CFRP laminates and evaluation methods of interlaminar fracture toughness of CFRP. In addition, a detailed evaluation of the fracture toughness and strength of CNF-reinforced resin composites as adhesive materials is also being conducted. We are currently searching for optimal conditions to improve the interlaminar fracture toughness of CFRP by adding CNF-reinforced resin composites. We have clarified the optimal amount of CNF-reinforced resin composite in the CFRP interlayer. We will investigate the optimal CNF fiber length and concentration.

Major Research Achievements (FY2022)

Conference Presentations

1. "Investigation of BOD orientation control method to improve the performance of paper substrate biocathodes", Chika Miura, Mitsuyoshi Okuda, Yuto Yasuda, Noya Loew, Hikari Watanabe, Isao Shitanda, Masayuki Itagaki, 32nd Annual Meeting of MRSJ, Yokohama, 2022
2. "Alkyl conformation and supported lipid bilayer formation of double chain cationic surfactant vesicle", Atsushi Miyazaki, Kotaro Ichimaru, Haruna Shibasaki, Shu-hei Urashima, Takaya Sakai, Hiroharu Yui, The 73rd Divisional Meeting of Division of Colloid and Surface Chemistry, Hiroshima, 2022
3. "Dynamics of foamability improvement by cationic polymer", Shunsuke Urabe, Atsushi Miyazaki, Takaya Sakai, The 73rd Divisional Meeting of Division of Colloid and Surface Chemistry, Hiroshima, 2022
4. "Establishment of a mouse model of low back pain and search for central pain signals", Yasuhito Yamaji, Seiji Kanazawa, Sena Washigashira, Kazunari Mori, Hiroaki Motohashi, Yoshihiko Minegishi, Nobuyasu Ota, Eri Segi-Nishida, Division of Parallel Brain Sensing Research 2nd Open Symposium, Poster Presentation, Tokyo, 2022
5. "Application of cellulose nanofiber (CNF) reinforced resin to suppress damages in CFRP laminate", M. J. Mohammad Fikry, Issei Hori, Tooru Hatano, Rinako Hano, Yuki Yoshikawa, Yutaka Yoshida, Yoshiaki Kumamoto, Akira Takenaka, Masashi Nojima, Shinji Ogihara, JSPS-DST Japan–India Workshop 2023, Tokyo, 2023
6. "Enhancement of interlaminar fracture toughness of CFRP composite laminates using cellulose nanofiber-reinforced resin and its application as an adhesive", Issei Hori, M. J. Mohammad Fikry, Tooru Hatano, Rinako Hano, Yuki Yoshikawa, Yoshiaki Kumamoto, Akira Takenaka, Shinji Ogihara, The 14th Japan Conference on Composite Materials (JCCM-14), Tokyo, 2023

Research & Development Platform of Functional Green Building Materials

Research & Development Platform of Functional Green Building Materials

1. Overview

On 1 June 2022, Tokyo University of Science and Shimizu Corporation established and launched "Research & Development Platform of Functional Green Building Materials", an "Open Innovation Project" of TUS Research Institute for Science and Technology. This project focuses on the environmental load of non-structural components in buildings.

To realize the social implementation of environmental-friendly buildings, this project will construct a system for evaluating and visualizing CO_2 emissions related to non-structural components which still requires further research, taking life stages into consideration. We will also promote research and development of high-functionality materials such as exterior materials, interior materials, entrance components, and foundation materials, as well as construction methods that help to reduce CO_2 emissions during manufacturing and construction.

Activity for decarbonization is now demanded all around the world. In order to reduce the environmental loads of buildings, it is essential to establish an academic foundation for achieving environmentally friendly construction at a high level and to develop a comprehensive platform for encouraging the implementation of those goals in society. In particular, non-structural components occupy approximately 20% of the CO_2 emission as embodied carbon during the construction. Individual non-structural components and methods have been studied and implemented in society in light of an environmental protection. However, there has been little attempt to optimize the overall environmental impact of whole buildings.

In order to reduce the environmental impact of non-structural components, we need to consider whole life carbon, i.e. the total amount of CO_2 emissions produced during a building's life cycle, including embodied carbon as well as operational carbon, which is the amount of CO_2 emitted during the operational stage of a building. However, at present, there is no established method for assessing whole life carbon.

Another issue is that the database of non-structural materials still requires further progress compared with structural materials. Such a database is necessary for making precise calculations of embodied carbon, taking into account the effect of differences in material processing treatments on environmental impact, the effects of reducing environmental impact through the use of recycled materials, and other such factors.

In this project, we will develop a system for evaluating and visualizing the CO_2 emissions of non-structural components for each life stage, and we will promote research and development of materials and construction methods that achieve a high degree of compatibility between environmental performance and functionality with regard to exterior materials, interior materials, entrance components, and foundation materials, which are items that have a high level of impact on whole life carbon. We will also encourage research and development directed toward high-functionality and high-performance interior and exterior building materials that also promotes resource conservation and recycling.

2. Organization and Facilities

Tokyo University of Science has established an interdisciplinary research framework in which professors from the Department of Architecture, the Department of Pure and Applied Chemistry, and the Department of Industrial and Systems Engineering in the Faculty of Science and Technology, and the Department of Global Fire Science and Technology in the Graduate school of Science and Technology collaborate with each other. By promoting this industry-academia collaboration project as a comprehensive initiative based on open innovation, the project's members intend to create pioneering examples in a wide range of boundary regions and lead the way in environmental conservation efforts within the construction industry.

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	Lecturer Kozo TAKASE

Graduate School of Science and Technology	
Department of Global Fire Science and Technology	Professor Yoshifumi OHMIYA

Research Achievements by Researcher

Hiroshi Nishihara ---

Original Papers

1. Superior Multielectron-Transferring Energy Storage by π-d Conjugated Frameworks. D. Xia, K. Sakaushi, A. Lyalin, K. Wada, S. Kumar, M. Amores, H. Maeda, S. Sasaki, T. Taketsugu, H. Nishihara, *Small* **2022**, 2202861. (Peer-reviewed)
2. Conductive coordination nanosheets: Sailing to electronics, energy storage, and catalysis. H. Maeda, K. Takada, N. Fukui, S. Nagashima, H. Nishihara, *Coord. Chem. Rev.* **2022**, *470*, 214693. (Peer-reviewed)
3. A Series of D-A-D Structured Disilane-Bridged Triads: Structure and Stimuli-Responsive Luminescence Studies. H. Miyabe, M. Ujita, M. Nishio, T. Nakae, T. Usuki, M. Ikeya, C. Nishimoto, S. Ito, M. Hattori, S. Takeya, S. Hayashi, D. Saito, M. Kato, H. Nishihara, T. Yamada, Y. Yamanoi, *J. Org. Chem.* **2022**, *87*, 8928 - 8938. (Peer-reviewed)
4. Chemically Laminated 2D Bis(terpyridine)metal Polymer Films: Formation Mechanism at the Liquid-Liquid Interface and Redox Rectification. J. Komeda, K. Takada, H. Maeda, N. Fukui, T. Tsuji, H. Nishihara, *Chem. Eur. J.* **2022**, e20220131650. (Peer-reviewed)
5. Layered metal-organic frameworks and metal-organic nanosheets as functional materials. R. Sakamoto, N. Fukui, *Coord. Chem. Rev.* **2022**, *472*, 214787. (Peer-reviewed)
6. Near-Infrared Light-Emitting Diodes from Organic Radicals with Charge Control. N. C. Greenham, Y. Tani, R. Matsuoka, H.iroshi Nishihara, R. H. Friend, T. Kusamoto, E. W. Evans, *Adv. Opt. Mater.* **2022**, 2200628. (Peer-reviewed)
7. Terpyridine-zinc(II) coordination nanosheets as modulators of perovskite crystallization to enhance solar cell efficiency, Y.-C. Wang, C.-H. Chiang, C.-J. Su, J.-W. Chang, C.-Y. Lin, C.-C. Wei, S.-K. Huang, H. Maeda, W.-B. Jian, U-S. Jeng, K. Tsukagoshi, C.-W. Chen, H. Nishihara, *J. Mater. Chem. A* **2023**, DOI: 10.1039/D3TA00505D16. (Peer-reviewed)

Books

1. Chemistry in Education: Life, Environment and Energy, Hiroshi Nishihara, Munetaka Nakata, Tokyo Kagaku Doujin, 228 pages, 2023. (in Japanese)
2. Photochromic Materials. H. Maeda, M. Nishikawa, R. Sakamoto and H. Nishihara, in Inorganic Photochemistry; Yam, V. W. W.; in Comprehensive Inorganic Chemistry III; Reedijk, J., Poeppelmeier, K. R., Eds.; Vol. 8, pp 356–416. Oxford: Elsevier, 2023.

Invited Lectures

1. Coordination Nanosheets - Functional 2D Material Consisting of Metal Complexes, Hiroshi Nishihara, Osaka Metropolitan University · Materials Science Colloquia, 2022/6/23.
2. Two-dimensional material “coordination nanosheets” with metal complex motifs, Hiroshi Nishihara, 35th Autumn Symposium of The Ceramic Society of Japan, Tokushima University, Josanshima Campus, 2022/9/15. (in Japanese)
3. Functional Coordination Nanosheets, Hiroshi Nishihara, Seventh International Conference on Multifunctional, Hybrid and Nanomaterials, Genoa, Italy, 2022/10/22.
4. Creation and properties/functions of coordination nanosheets, Hiroshi Nishihara, The Society of Polymer Science 22-1 Polymer Surface Study Group, Morito Memorial Hall, Tokyo University of Science, Tokyo, October 28, 2022. (in Japanese)
5. Creation and functional application of metal complex two-dimensional materials “coordination nanosheets”, 2022 Kato Memorial Award Commemorative Lecture, Ginza Blossom, Tokyo, 2022/11/18. (in Japanese)
6. Overview of Coordination Nanosheets, 2023 JSPS-EPSRC workshop on coordination nanosheets, Maxwell Centre, Cavendish Laboratory, UK, 2023/3/8.

Patents

1. Hiroshi Nishihara, Mariko Miyachi, Masaharu Sato, Anode comprising silicon, secondary battery, and their manufacturing methods, Japan Patent number 7170330, 2022/11/14.

Public Relations

1. Hiroshi Nishihara, At the Water's Edge: Self-assembling 2D Materials at a Liquid–Liquid Interface: Scientists find a simple way to produce heterolayer coordination nanosheets, expanding the diversity of 2D materials, Tokyo University of Science, Press Releases, 2022/7/22

Awards

1. Hiroshi Nishihara, Kato Memorial Award, Kato Foundation for Promotion of Science, 2022

Jaw-Shen Tsai --

Original Papers

1. Elucidation of Spin-Correlations, Fermi Surface and Preudogap in a Copper Oxide Superconductor, Hiroshi Kamimura, Masaaki Araidai, Kunio Ishida, Shunichi Matsuno, Hideaki Sakata, Kenji Sasaoka, Kenji Shiraishi, Osamu Sugino, Jaw-Shen Tsai, and Kazuyoshi Yamada, Condens. Matter 2023, 8, 33, 2023. (Peer-reviewed)
2. Motigation of noise in Josephson parametric oscillator by injection locking, Gopika Lakshmi Bhai, Hiroto Mukai, and Jaw-Shen Tsai, Appl. Phys. Lett. 122, 054002, 2023. (Peer-reviewed)
3. Noise Properties of a Josephson Parametric Oscillator, Gopika Lakshmi Bhai, Hiroto Mukai, Tsuyoshi Yamamoto, and Jaw-Shen Tsai, Physical Review Applied 19, 014065, 2023 (Peer-reviewed)
4. Autonomous quantum error correction in a four-photon Kerr parametric oscillator, Sangil Kwon, Shohei Watabe, and Jaw-Shen Tsai, npj Quantum Information, 8:40, 2022. (Peer-reviewed)
5. Deterministic one-way logic gates on a cloud quantum computer, Zhi-Peng Yang, Huan-Yu Ku, Alakesh Baishya, Yu-Ran Zhang, Anton Frisk Kockum, Yuch-Nan Chen, Fu-Li Li, Jaw-Shen Tsai, and Franco Nori, Physical Review A, 105, 042610, 2022. (Peer-reviewed)

Invited Lectures

1. Superconducting quantum computer and its future issure, Jaw-Shen Tsai, QPQIS2022, Dec. 1, 2022, Online
2. Superconducting quantum computer and its future issure, Jaw-Shen Tsai, The First International Conference on Axion Physics and Experiment (Axion 2022), Nov. 22, 2022, Online
3. Recent progress in superconducting quantum information, Jaw-Shen Tsai, The virtual QBIC Workshop 2022, Oct. 13, 2022, Online
4. Superconducting Quantum Circuit, Jaw-Shen Tsai, EAIFR Conference, Sep. 12, 2022, Online
5. 超伝導量子ビットの平面集積化，蔡 兆申，第 70 回応用物理学会春季学術講演会，上智大学四谷キャンパス, 3/6/2023 (in Japanese)
6. 超伝導量子コンピュータの展望, 蔡 兆申，応用物理学会 2022 年度第 2 回講演会, Online、1/20/2023 (in Japanese)

Awards

1. Yasunobu Nakamura & Jaw-Shen Tsai，Japan Academy Prize，The Japan Academy, 2023

Ichiro Hagiwara --

Original articles

1. Study on effective arrangement of evacuation equipment Part 3 Usage of evacuation equipment based on fire report data: I. Hagiwara, S.Takagi, *Proceedings of JAFSE Annual Symposium*, pp59-60, **2022** (no review)
2. Study on effective arrangement of evacuation equipment Part 4 Proposal of evaluation methods and installation criteria: S.Takagi, I. Hagiwara, *Proceedings of JAFSE Annual Symposium*, pp61-61, **2022**
3. Study on effective arrangement of evacuation equipment Part 2 Usage of evacuation equipment based on fire report data: I. Hagiwara, S.Takagi, *Summaries of Technical Papers of Annual Meeting (Fire Safety)*, pp233-234, **2022**
4. Study on effective arrangement of evacuation equipment Part 3 Proposal of evaluation methods and installation criteria: S.Takagi, I. Hagiwara, *Summaries of Technical Papers of Annual Meeting (Fire Safety)*, pp235-236, **2022**

Books
1. 建築避難安全計画指針, 2.4 延焼防止計画, 萩原一郎, 日本建築センター, pp63-71, 2022 (in Japanese)

Public Relations
1. 萩原一郎, 千日デパート火災から 50 年についてコメント, 読売新聞, 2022. 5 (in Japanese)
2. 萩原一郎, 大阪北新地火災の報告書公表に関するコメント, 毎日新聞, 2022. 6 (in Japanese)
3. 萩原一郎, 熊本大洋デパート火災から 50 年についてコメント, 毎日新聞, 2022. 12. 18 (in Japanese)
4. 萩原一郎, 仙台駅前の火災についてインタビュー対応, 仙台放送, 2022. 12. 21 (in Japanese)
5. 萩原一郎, 講演「火災時に命を守るための避難計画」, シンポジウム「ガソリン散布を伴う放火火災に備える」, 火災科学研究所, 2022. 11. 25 (in Japanese)

Masashi Nojima ---

Original Papers
1. X-ray photo electron diffraction and X-ray specrto-holography from the contributions of our instruments, Masashi Nojima, Yoshimasa Nihei, Journal of Electron Spectroscopy and Related Phenomena, Vol. 257 **147187** p.1-9 (2022) (Peer-reviewed)
2. Development of Mass-controlled Ion Beam through a Vacuum Electrospray Method, Masashi Nojima, e-Journal of Surface Science and Nanotechnology, Vol. 20 3 p.155-160 (2022) (Peer-reviewed)

Books
1. A revolution in materials-driven fabrication processes, Masashi Nojima, Impact publishing, Volume 2022, Number 3, April 2022, pp. 46-47(2) (2022)

Awards
1. 野島 雅, 令和 4 年度 公益財団法人 新素材情報財団助成制度に採択

Sayoko Nagashima ---

Original Papers
1. Conductive coordination nanosheets: Sailing to electronics, energy storage, and catalysis. H. Maeda, K. Takada, N. Fukui, S. Nagashima, H. Nishihara, *Coord. Chem. Rev.* **2022**, 470, 214693. (Peer-reviewed)

Yoshiki Niihori ---

Academic Paper
1. "Pt_{17} Nanocluster Electrocatalysts: Preparation and Origin of High Oxygen Reduction Reaction Activity", T. Kawawaki, Y. Mitomi, N. Nishi, R. Kurosaki, K. Oiwa, T. Tanaka, H. Hirase, S. Miyajima, Y. Niihori, D. J. Osborn, T. Koitaya, G. F Metha, T. Yokoyama, K. Iida, Y. Negishi, *Nanoscale, in press*. (Peer-reviewed)
2. "Vertex-Shared Linear Superatomic Molecules: Stepping Stones to Novel Materials Composed of Noble Metal Clusters", Y. Niihori, S. Miyajima, A. Ikeda, T. Kosaka, Y. Negishi, *Small Sci., in press*. (Peer-reviewed)
3. "Key Factors for Connecting Silver-based Icosahedral Superatoms by Vertex Sharing", S. Miyajima, S. Hossain, A. Ikeda, T. Kosaka, T. Kawawaki, Y. Niihori, T. Iwasa, T. Taketsugu, Y. Negishi, *Commun. Chem*. 6, 57, 2023. (Peer-reviewed)
4. "Improved Activity for the Oxygen Evolution Reaction using a Tiara-like Thiolate-protected Nickel Nanocluster", S. Funaki,a T. Kawawaki, T. Okada, K. Takemae, S. Hossain, Y. Niihori, T. Naitoh, M. Takagi, T. Shimazaki, S. Kikkawa, S. Yamazoe, Tachikawa, Y. Negishi, *Nanoscale*, 15, 5201-5208, 2023. (Peer-reviewed)
5. "Charge-Transfer-Mediated Mechanism Dominates Oxygen Quenching of Ligand-Protected Noble-Metal Cluster Photoluminescence", M. Mitsui, D. Arima, A. Uchida, K. Yoshida, Y. Arai, K. Kawasaki, Y. Niihori, *J. Phys. Chem. Lett*., 13, 9272-9278, 2022. (Peer-reviewed)

6. “On the Origin of Photoluminescence Enhancement in Biicosahedral AgxAu25-x Nanoclusters (x = 0-13) and Their Application to Triplet-Triplet Annihilation Photon Upconversion”, M. Mitsui, D. Arima, Y. Kobayashi, E. Lee, Y. Niihori, *Adv. Optical Mater.*, 10, 2200864, 2022. (Peer-reviewed)
7. “Evidence for Triplet-State-Dominated Luminescence in Biicosahedral Superatomic Molecular Au25 Clusters”, M. Mitsui, Y. Wada, R. Kishii, D. Arima, Y. Niihori, *Nanoscale*, 14, 7974-7979, 2022. (Peer-reviewed)

Invited Lectures

1. “Triplet Sensitizability of Thiolate-Protected Metal Clusters”, Y. Niihori, 95th Anniversary Conference of the Japan Society of Color Material (JSCM), Tokyo, 2022.

Awards

1. Y. Niihori, CSI Medallion award, The Japan Society of Color Material, 2022.
2. Y. Niihori, The Chemical Society of Japan Award for Young Chemists for 2022, The Chemical Society of Japan, 2022.

Kenji Takada --

Original Papers

1. “Chemically laminated 2D bis(terpyridine)metal polymer films: Formation mechanism at the liquid-liquid interface and redox rectification”
   Joe Komeda, Kenji Takada, Hiroaki Maeda, Naoya Fukui, Takuya Tsuji, Hiroshi Nishihara.
   Chemistry A European Journal, 2022, 28, e202201316. (DOI: 10.1002/chem.202201316) (Peer-reviewed)
2. “Conductive Coordination Nanosheets: Sailing to Electronics, Energy Storage, and Catalysis”
   Hiroaki Maeda, Kenji Takada, Naoya Fukui, Sayoko Nagashima, Hiroshi Nishihara.
   Coordination Chemistry Review 2022, 470, 219643. (DOI: 10.1016/j.ccr.2022.214693) (Peer-reviewed)

Public Relations

1. Joe Komeda, Kenji Takada, Hiroaki Maeda, Naoya Fukui, Takuya Tsuji, Hiroshi Nishihara.
   “Chemically laminated 2D bis(terpyridine)metal polymer films: Formation mechanism at the liquid-liquid interface and redox rectification”
   Chem. Eur. J. **2022**, *28*, e202202128. (DOI: 10.1002/chem.202202128)
2. Joe Komeda, Kenji Takada, Hiroaki Maeda, Naoya Fukui, Takuya Tsuji, Hiroshi Nishihara.
   “At the Water’s Edge: Self-assembling 2D Materials at a Liquid–Liquid Interface: Scientists find a simple way to produce heterolayer coordination nanosheets, expanding the diversity of 2D materials” Tokyo University of Science, Press Releases, 2022/7/22

Naoya Fukui --

Original Papers

1. Two-Dimensional Metal-Organic Framework Acts as a Hydrogen Evolution Cocatalyst for Overall Photocatalytic Water Splitting. Jingyan Guan, Tigmansu Pal, Kazuhide Kamiya, Naoya Fukui, Hiroaki Maeda, Tetsu Sato, Hajime Suzuki, Osamu Tomita, Hiroshi Nishihara, Ryu Abe, Ryota Sakamoto, *ACS Catal.*, **2022**, 12, 3881-3889. (Peer-reviewed)
2. Chemically Laminated 2D Bis(terpyridine)metal Polymer Films: Formation Mechanism at the Liquid-Liquid Interface and Redox Rectification. J. Komeda, K. Takada, H. Maeda, N. Fukui, T. Tsuji, H. Nishihara, *Chem. Eur. J.* **2022**, e20220131650. (Peer-reviewed)

Invited Lectures

1. The smallest fraction of coordination nanosheet visualized by scanning tunneling microscopy under ultrahigh vacuum., 2023 JSPS-EPSRC workshop on coordination nanosheets, Maxwell Centre, Cavendish Laboratory, UK, 2023/3/8.

Hiroaki Maeda --

Original articles

1. “Terpyridine-zinc (II) coordination nanosheets as modulators of perovskite crystallization to enhance solar cell efficiency”, Ying-Chiao Wang, Chun-Hao Chiang, Chun-Jen Su, Je-wei Chang, Chi-Ying Lin, Chia-Chun Wei, Shao-Ku Huang, Hiroaki Maeda, Wen-Bin Jian, U-Ser Jeng, Kazuhito Tsukagoshi, Chun-Wei Chen, Hiroshi Nishihara, J. Mater. Chem. A, 2022, Accepted, DOI: 10.1039/D3TA00505D (Peer-reviewed)
2. “Chemically laminated 2D bis(terpyridine)metal polymer films: Formation mechanism at the liquid-liquid interface and redox rectification”, Joe Komeda, Kenji Takada, Hiroaki Maeda, Naoya Fukui, Takuya Tsuji, Hiroshi Nishihara, Chem. Eur. J., vol. 28, e202201316, 2022 (Peer-reviewed)
3. “Superior Multielectron-Transferring Energy Storage by π-d Conjugated Frameworks”, Dong Xia, Ken Sakaushi, Andrey Lyalin, Keisuke Wada, Sonu Kumar, Marco Amores, Hiroaki Maeda, Sono Sasaki, Tetsuya Taketsugu, Hiroshi Nishihara, Small, vol. 18, 2202861, 2022 (Peer-reviewed)

Review articles

1. “Layered Metal-Organic Frameworks and Metal-Organic Nanosheets as Functional Materials”, Ryota Sakamoto, Naoya Fukui, Hiroaki Maeda, Ryojun Toyoda, Shinya Takaishi, Tappei Tanabe, Joe Komeda, Pilar Amo-Ochoa, Félix Zamora, Hiroshi Nishihara, Coord. Chem. Rev., vol. 472, 214787, 2022 (Peer-reviewed)
2. “Conductive Coordination Nanosheets: Sailing to Electronics, Energy Storage, and Catalysis”, Hiroaki Maeda, Kenji Takada, Naoya Fukui, Sayoko Nagashima, Hiroshi Nishihara, Coord. Chem. Rev., vol. 470, 214693, 2022 (Peer-reviewed）

Books

1. “Comprehensive Inorganic Chemistry III (Third Edition)” Chapter8.09, Hiroaki Maeda, Michihiro Nishikawa, Ryota Sakamoto, Hiroshi Nishihara, Elsevier, pp 356-416, 2023, DOI: 10.1016/B978-0-12-823144-9.00089-3 (Published online)

Patents

1. 鵜飼順三, 本間信孝, 西原 寛, 前田啓明, 国内優先出願, 金属錯体ナノシート及びその製造方法, 特願 2022-066738, 2022 (in Japanese)
2. 西原 寛, 田寺（長島）佐代子, 前田啓明, 国内優先出願, 配位高分子膜, 配位高分子膜の製造方法, 水素発生用電極及び水素発生装置, 特願 2022-195136, 2022 (in Japanese)

Public Relations

1. 西原 寛, 米田 丈, 髙田健司, 前田啓明, 福居直哉, 「ユニークな酸化還元特性と整流作用を示すヘテロ積層体のワンポット合成法を開発 ～液液界面反応を利用して複数の異なる層を段階的に積層～」, 東京理科大学プレスリリース, 2022 (in Japanese)
2. Hiroshi Nishihara, Joe Komeda, Kenji Takada, Hiroaki Maeda, Naoya Fukui, “At the Water’s Edge: Self-assembling 2D Materials at a Liquid-Liquid Interface”, TUS Press release, 2022

Takahiro Yamazaki --

Original Papers

1. Tuning the Temperature Range of Superelastic Ni-Ti Alloys for Elastocaloric Cooling via Thermal Processing, T. Yamazaki, A. Montagnoli, M. L. Young, and I. Takeuchi, *Journal of Physics: Energy* **2023**, accepted. (Peer-reviewed)

Invited Lectures

1. Design of large and sensitive magnetostrictive composites for vibration energy harvesters, Takahiro Yamazaki, Integrated Nanocomposites for Thermal and Kinetic Energy Harvesting (INTAKE) Seminar 2022, Tohoku University, 2022/11/22.

Tomooki Hosaka

Original Papers

1. Fluorosulfonamide-type electrolyte additives for long-life K-ion batteries, Zachary T. Gossage, Tomooki Hosaka, Tatsuo Matsuyama, Ryoichi Tatara, Shinichi Komaba, Journal of Materials Chemistry A, 11(2) 914-925 (2023). (Peer-reviewed)
2. Effect of non-stoichiometry of $K_xFe[Fe(CN)_6]$ as inner solid-contact layer on the potential response of all-solid-state potassium ion-selective electrodes, Ryoichi Tatara, Kenta Ishihara, Tomooki Hosaka, Kazuma Aoki, Yuko Takei, Takahiro Matsui, Toshiharu Takayama, Shinichi Komaba, Electrochimica Acta, 439 141561-141561 (2023). (Peer-reviewed)
3. Mg-Doped $KFeSO_4F$ as a High-Performance Cathode Material for Potassium-Ion Batteries, Petla Ramesh Kumar, Tomooki Hosaka, Tomoaki Shimamura, Daisuke Igarashi, Shinichi Komaba, ACS Applied Energy Materials, 5(11) 13470-13479 (2022). (Peer-reviewed)
4. Origin of enhanced capacity retention of aqueous potassium-ion batteries using monohydrate-melt electrolyte, Tomooki Hosaka, Rie Takahashi, Kei Kubota, Ryoichi Tatara, Yuki Matsuda, Kazuhiko Ida, Kanji Kuba, Shinichi Komaba, Journal of Power Sources, 548 232096-232096 (2022). (Peer-reviewed)
5. Effect of Cu Substitution in P'2- and P2-Type Sodium Manganese-Based Oxides, Eun Jeong Kim, Tomooki Hosaka, Kei Kubota, Ryoichi Tatara, Shinichi Kumakura, Shinichi Komaba, ACS Applied Energy Materials, 5(10) 12999-13010 (2022). (Peer-reviewed)
6. Superconcentrated NaFSA–KFSA Aqueous Electrolytes for 2 V-Class Dual-Ion Batteries, Tomooki Hosaka, Ayumi Noda, Kei Kubota, Kento Chiguchi, Yuki Matsuda, Kazuhiko Ida, Satoshi Yasuno, Shinichi Komaba, ACS Applied Materials & Interfaces, 14(20) 23507-23517 (2022). (Peer-reviewed)

Patents

1. Shinichi Komaba, Ryoichi Tatara, Tomooki Hosaka, Daisuke Igarashi, Ryusei Fujimoto, Air Batteries, Application Number:2023-39116, 2023.

Yutaka Oya

Original Papers

1. Effect of Electrostatic Interactions on the Interfacial Energy between Thermoplastic Polymers and Graphene Oxide: A Molecular Dynamics Study. M. Morita, Y. Oya, N. Kato, K. Mori, J. Koyanagi, Polymers **2022**, *14 (13)*, 2579. (Peer-reviewed)
2. Evaluation of Microscopic Damage of PEEK Polymers under Cyclic Loadings Using Molecular Dynamics Simulations. S. Iwamoto, Y. Oya, J. Koyanagi, *Polymers.* **2022**, *14 (22)*, 4955. (Peer-reviewed)
3. A Molecular Dynamics Simulation for Thermal Activation Process in Covalent Bond Dissociation of a Crosslinked Thermosetting Polymer. N. Yamada, Y. Oya, N. Kato, K. Mori, J. Koyanagi, *Molecules.* **2023**, *28 (6)*, 2736. (Peer-reviewed)

Awards

1. Takenobu Sakai, Yutaka Oya, Jun Koyanagi, Technology Award, The Japanese Society for Experimental Mechanics, 2022

Koji Tsuchiya

Original Papers

1. Effect of polyol type on the structure and properties of lecithin liposomes prepared using the polyol dilution method, Kaoru Ohishi, Koji Tsuchiya, Taku Ogura, Aya Ebisawa, Aika Sekine, Yuji Masubuchi, Masaaki Akamatsu, Kenichi Sakai, Masahiko Abe, Hideki Sakai, Colloids and Surfaces, A: Physicochemical and Engineering Aspects, Vol. 656, pp. 130509 (2023). (Peer-reviewed)

2. Effect of polyols on membrane structures of liposomes: A study using small-angle X-ray scattering data and generalized indirect Fourier transformation, Aika Sekine, Taku Ogura, Koji Tsuchiya, Kaoru Ohishi, Yuji Masubuchi, Masaaki Akamatsu, Kenichi Sakai, Masahiko Abe, Hideki Sakai, Chemistry and Physics of Lipids, Vol. 249, pp. 105253 (2022). (Peer-reviewed)
3. Characterization of lecithin liposomes prepared by polyol dilution method using 1,3-butylene glycol, Kaoru Ohishi, Koji Tsuchiya, Taku Ogura, Aya Ebisawa, Aika Sekine, Yuji Masubuchi, Masaaki Akamatsu, Kenichi Sakai, Masahiko Abe, Hideki Sakai, Colloids and Surfaces, A: Physicochemical and Engineering Aspects, Vol. 650, pp. 129592 (2022). (Peer-reviewed)
4. Key factor of sponge phase formation in commercial polyethoxylated nonionic surfactant/cosurfactant/water systems and its unique feature at interface, Kei Watanabe, Yuki Watanabe, Kazuki Masuda, Zhang Yang, Ami Kaneshima, Akira Motoyama, Takaaki Shima, Koji Tsuchiya, Hideki Sakai, Colloids and Surfaces, A: Physicochemical and Engineering Aspects, Vol. 641, pp. 128405 (2022). (Peer-reviewed)
5. Design, Synthesis, and Anticancer Activity of Triptycene-Peptide Hybrids that Induce Paraptotic Cell Death in Cancer Cells, Kohei Yamaguchi, Kenta Yokoi, Masakazu Umezawa, Koji Tsuchiya, Yasuyuki Yamada, Shin Aoki, Bioconjugate Chemistry, Vol. 33, No. 4, pp. 691-717 (2022). (Peer-reviewed)
6. Induction of paraptosis by cyclometalated iridium complex-peptide hybrids and CGP37157 via a mitochondrial Ca^{2+} overload triggered by membrane fusion between mitochondria and the endoplasmic reticulum, Kenta Yokoi, Kohei Yamaguchi, Masakazu Umezawa, Koji Tsuchiya, Shin Aoki, Biochemistry, Vol. 61, No. 8, pp. 639-655 (2022). (Peer-reviewed)
7. Preparation of highly stable oil-in-water emulsions with high ethanol content using polyglycerol monofatty acid esters as emulsifiers, Takumi Motoyama, Yuka Katsuumi, Hiromu Sasakura, Tetsuya Nakamura, Hisashi Suzuki, Koji Tsuchiya, Masaaki Akamatsu, Kenichi Sakai, Hideki Sakai, Journal of Oleo Science, Vol. 71, No. 6, pp. 829-837 (2022). (Peer-reviewed)

Awards

1. Kei Watanabe, Namiko Sakurai, Takashi Meno, Chihiro Yasuda, Shigeo Takahashi, Ayaka Hori, Koji Tsuchiya, Hideki Sakai, The 23rd Honorary Mention Award, The Society of Cosmetic Chemists of Japan (SCCJ), 2022

Report of Research Institute for Science and Technology Forum

Report of “Research Institute for Science and Technology Forum 2022” (11/28)

On November 28 (Mon), 2022, Research Institute for Science and Technology Forum 2022 −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 179 participants (66 participants in the venue and 113 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.** Yasuo Kogo (Director, Organization of Research Promotion)
2. **Research of Metal Complex Two-dimensional Materials “Coordination Nanosheets” at TUS.** Hiroshi Nishihara (Director, Research Institute for Science and Technology)

Oral Presentations of Research Centers and Research Divisions

[Fundamentals]

3. **Superconducting Quantum Computers and Their Current Issues**. Jaw Shen Tsai (Director, Nano Quantum Information Research Division)
4. **The forefront of research in Division of Research Alliance for Mathematical Analysis.** Hiromichi Itou (Director, Division of Research Alliance for Mathematical Analysis)

[Functional Materials]

5. **The Challenge of Water Research in TUS.** Masahiro Motosuke (Director, Water Frontier Research Center (WaTUS))
6. **Creation of Functional Interfaces Responsive to Various External Stimuli.** Hideki Sakai (Director, Division of Colloid and Interface Science)
7. **Science and Technology Contributing to Carbon Neutral**. Akihiko Kudo (Director, Carbon Value Research Center)

[Bio and Pharmacy]

8. **Biological Effects of Chemicals Present in the Environment.** Shinichi Miyagawa (Division of Biological Environment Innovation)
9. **Development of Highly Functional Cell Medicine Applying DDS Technology.** Makiya Nishikawa (Director, Development of Superior Cell and DDS for Regenerative Medicine)
10. **Drug Discovery Research Using Tokyo University of Science Original Compounds.** Isamu Shiina (Director, Chemical Biology Division Supported by Practical Organic Synthesis)

[Information and Societal]

11. **Modeling of Fire and Explosion Phenomena.** Kazunori Kuwana (Center for Fire Science and Technology), Base for Fire-Safety Science
12. **Development of Ground/Space Dual Development and Application to Ground**. Shinichi Kimura (Director, Research Center for Space System Innovation)

13. **Divergence-Based Modeling and Its Properties.** Koji Tabata (Statistical Science Research Division)
14. **From FESI, Assessment Abilities and DAAE, and the Digital Archipelago Evolutionary Theory.** Hideki Wakabayashi (Director, The Technology Management Strategy and Financial Engineering Social Implementation Research Department)

<u>Poster Session</u>

15. **Poster presentations of 14 Research Divisions**

<u>Panel Discussion</u>

16. **Expectations and Recommendations for Research Institute for Science and Technology**
    [Moderator] Shin Aoki (Vice Director, Research Institute for Science and Technology)
    [Panelists] Yasuo Kogo (Director, Organization of Research Promotion)
    Yoshikazu Homma (Director, Organization for Innovation and Social Collaboration)
    Atsushi Ochiai (Director, Research Institute for Biomedical Sciences)
    Hiroshi Nishihara (Director, Research Institute for Science and Technology)

17. **Closing Remarks**. Hiroshi Nishihara (Director, Research Institute for Science and Technology)