RIST TUS

Research Institute for Science & Technology

2022 / 2023

The Edge of Cross Disciplines

Information and Societal

Center for Fire Science and Technology
Research Center for Space System
Research Division for Advanced
Statistical Science Research Division
Department of MOT Strategy & Financial
Parallel Brain Interaction Sensing
Division of Digital Transformation
Medical Data Sciences
Division of Smart Healthcare Engineering

Bio and Pharmacy

Chemical Biology Division Supported by Practical Organic Synthesis
Division of Nucleic Acid Drug Development
Division of Synthetic Biology
Division of Biological Environment Innovation
Development of superior cell and DDS for regenerative medicine

RIST TUS
Research Institute for Science & Technology

Structural Materials

CAE Advanced Composite Materials and Structures Research Division

Fundamentals

Research Alliance for
Division of Nano-quantum
Modern Algebra and

Functional Materials

Water Frontier Research Center
Carbon Value Research Center
Division of Nanocarbon Research
Division of Colloid and Interface Science
Renewable Energy Science & Technology Research Division
Division of Ambient Devices Research
Research Group for Advanced Energy Conversion

Research Centers

These are research organizations that obtain the research funding needed for their activities from the national government, from local governments, and from industry and other sources, and that carry out initiatives that are strategically important for their research.

Research Divisions

These are core research organizations comprised of researchers selected from within TUS and from outside the TUS in order to provide a synergistic effect. They develop interdisciplinary and cross-disciplinary "Only at TUS" research activities.

Joint Usage / Research Center

A nationally selected organization for joint use / joint research open to public and funded partially by MEXT.

The Open Innovation Projects

These are research organizations that promote the co-creation of new value with the aim of contributing to society through both TUS and corporations.

Building a better future with

Innovation [SSI]

Disaster Prevention on cities

Engineering for Social Implementation

Division

Mathematical analysis

Information Science and Technology

Cooperation with Engineering

Message from the Director

The Research Institute of Science and Technology (RIST) is a cross-disciplinary research organization belonging to the Organization for Research Advancement, originally established in 1981. Education and research, the two pillars of the university, are synergistically related, and many cutting-edge, integrated research projects conducted at RIST provide students with a broad perspective.

As of April 2022, 27 research centers, research divisions, joint-usage research centers, and open innovation projects are active in RIST. In all activities, as well as actively pursuing basic science in each academic field, we promote close cooperation between disciplines, removing bureaucratic barriers inside and outside the university, and carrying out innovative research. We began promoting research focused on environmental and energy issues even before the United Nations established its SDGs (Sustainable Development Goals) in 2015.

In April 2021, two Research Centers and an Open Innovation Project were launched, and in January 2022, a new Research Center was started. The Water Frontier Research Center (Wa TUS) succeeded the Water Frontier Science & Technology Research Center (WFST) established by the Branding Project of the Ministry of Education, Culture, Sports, Science and Technology in 2016, and is now positioned at the cutting edge of studying "water interfaces", the behavior of water on material surfaces. The purpose of the Wa TUS is to establish a research center that offers one-stop services and solutions by considering both promotion of research and issues facing industry.

The Space System Creation Research Center resulted from a merger of the Photocatalyst International Research Center (established in 2013) and the Space Colony Research Center (established in 2017), and is tasked with solving energy and environmental problems. Research projects are expanding to create the personnel foundation of next-generation space science and technology, including engineers who can contribute internationally to development of technologies required for space residence, such as water, air, food, and energy. The objective is development of a virtual cycle between the ground and space based on photocatalysts, development of technology necessary for humans to stay for prolonged periods in extremely closed environments, and development of integrated systems encompassing the science and technology necessary to create the space plane of the future and legislation to govern commercial space transportation.

The "Open Innovation Project" is a research endeavor that could be called "co-creation of knowledge", in which research results fulfilling medium-term R & D strategies of companies create new value by disseminating results of joint research by our faculty members and corporate researchers. In the "Kao 'Kirei' Future Open Innovation Project", companies and universities will promote innovative technological development to enrich people's lives while discharging their respective social missions and roles.

At the Carbon Value Research Center, we will develop basic science and technology that contributes to carbon neutrality, such as artificial photosynthesis, through collaborative research with external institutions, making full use of the scientific and technological expertise of our faculty members.

At the Research Institute for Science and Technology, we will enhance fluidity and mobility of faculty appointments and strengthen our ties with society by collaborating across centers and departments. In addition, we will foster highly creative, diverse human resources that will lead to the future of society, creating novel academic processes and research results that are unique to Tokyo University of Science.

Dr.Hiroshi Nishihara

Director

Research Institute for Science and Technology

Tokyo University of Science

Science

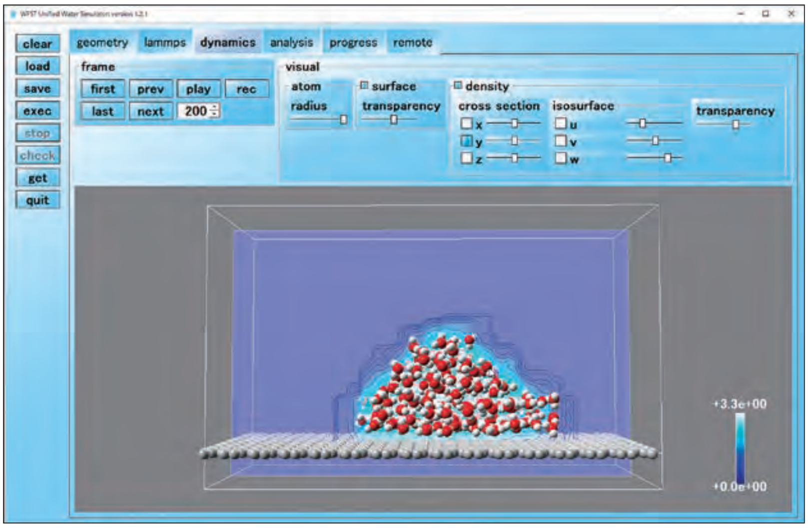
FOCUS①

Water Frontier Research Center

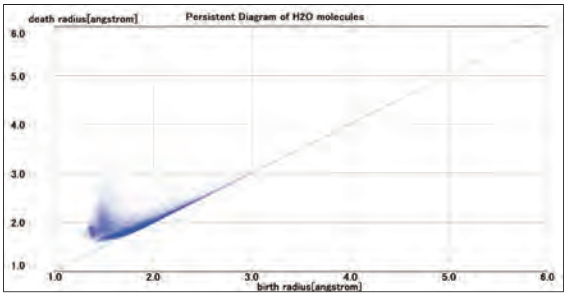
Development of a Multi-level Water Simulator

Connections Between Quantum Mechanics, Molecular Dynamics, and Fluid Dynamics Calculations for Water on Material Interfaces

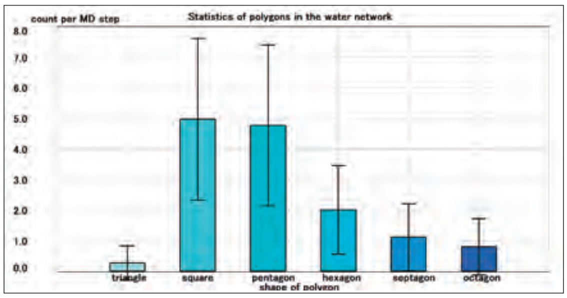
We have developed a multi-level water simulator that allows users who are not experts in computational science to easily perform numerical simulations and analysis for the motion and structure of water on material surfaces and interfaces. With this simulator, you can perform molecular dynamics simulations of water molecules on the surface of graphene, silica, boron nitride, and other solid substrates. The simulation results are then analyzed to calculate various physical quantities, such as water density distribution, hydrogen-bond networks, persistent homology, and contact angle in this simulator, which are not handled by conventional simulation softwares. The simulator can generate an input file for quantum chemistry software to calculate vibrational spectra of the water molecules on the surface obtained by the molecular dynamics simulations. Contact angle, viscosity, and surface tension of water/solvent are important parameters in computational fluid dynamics calculations; the simulator provides a file containing these physical quantities calculated from the molecular dynamics simulations for computational fluid dynamics software. They are unique features of our simulator that covers from nano- to macro-level properties of water. This simulator and a series of its training programs will be open to the researchers in the university.



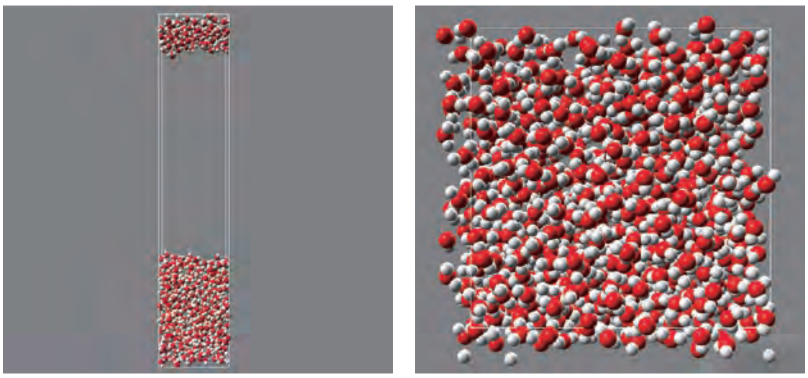
The graphical user interface of the multi-level water simulator, showing water molecules and their density on a substrate



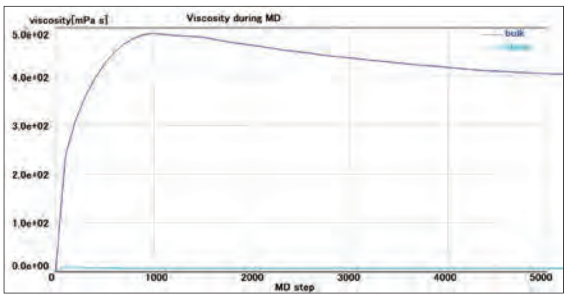
Persistent homology analysis



Hydrogen-bond network (polygon) analysis



Simulation models for calculating surface tension (left) and viscosity (right) of water



Viscosity calculation

FOCUS②

Research Center for Space System Innovation

A Giant First Step Toward Living in Space

Two On-Orbit Demonstrations and Cross-Disciplinary Collaboration at Gundam Open Innovation

Humanity's space-related advancement has accelerated sharply in recent years, but in order for humans to expand their sphere of activity in space, we need rapid development of space habitat technology that will enable healthy and comfortable living in space, both mentally and physically. The technologies that will enable comfortable and sustainable living in space, an environment with limited resources, are closely related to technologies that will enable sustainable development on the ground. There is a direct link between these technologies and solutions to our earth-based problems, as represented by the SDGs. The Research Center for Space System Innovation is engaged in research to make the connection between space and various earth-based technologies under the concept of "dual earth-space development" and the belief that the goal of living in space is to bring happiness to earth. As such, we have been focusing our effort toward on-orbit demonstrations of related technologies, and in FY2021, we were pleased to successfully demonstrate two technologies on the International Space Station (ISS).

The first technology involved the world's first demonstration of plastic culture bag technology in space. It was carried out in collaboration with the Japanese Aerospace Exploration Agency (JAXA), Takenaka Corporation, Kirin Holdings Company, Limited, and Chiba University. Its purpose was to demonstrate a technology for producing food during future long-term sojourns in space. The experiment was conducted for a duration of 48 days, from Friday, August 27 to Wednesday, October 13, 2021. On Friday, September 10, true lettuce leaves were confirmed, and this was followed by steady growth and eventual harvest.

The second was a technology demonstration of a photocatalytic air purification system developed in collaboration with Japan Manned Space Systems Corporation (JAMSS) and Tokyo University of Agriculture and Technology. It was launched at 12:17 a.m. (Japan time) on April 9 from Kennedy Space Center in Florida, USA and transported to ISS as part of Axiom Mission 1, the first private crewed space flight mission by the American company Axiom Space.

These accomplishments did not go unnoticed, and in March 2022, Research Center for Space System Innovation (Tokyo University of Science) was selected as the public partner for Gundam Open innovation, a cross-disciplinary initiative promoted by Bandai Namco Group in order to usher in the space age. By actively utilizing this framework, the Research Center for Space System Innovation is working toward even broader collaboration in the future.

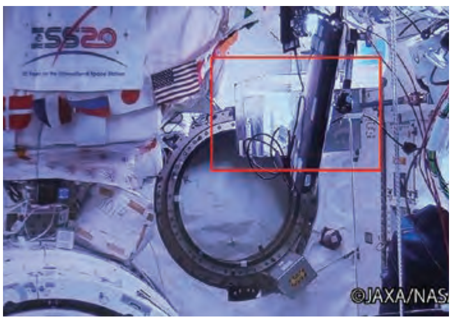


Figure 1. The plastic bag culture technology demonstration equipment aboard the Kibo module

Figure 2. The photocatalytic air purification device experiment

Joint Usage/Research Center

Established: July, 2009 kasaianzen-ml@tusml.tus.ac.jp

Research Center for Fire Safety Science

Director
Professor,
Graduate School of Science and Technology, Department of Global Fire Science and Technology
Ken Matsuyama
Dr.Eng.

Research Center for Fire Safety Science is currently promoting formation of research and education center, and produced two major outcomes, one is the development of "theory" pertaining to performance-based fire safety design, and the other is the development in "practice" through experimental research utilizing the full-scale experimental facilities. Upon these two pillars, the Center will further research and deepen our knowledge of how to control the potential fire risks that are increasing along with the emergence of new spatial configurations (high-rise or underground) and use of new materials (e.g. aluminum and plastics). These are inevitable changes brought about by modernization, industrialization and increased need of energy conservation.

Open Call Schedule

The Center invites and accepts research plans from public basically once a year research activities of the selected plans start at the beginning of each academic year. However, research of urgency may be accepted at any point of an academic year as needed.

The rough schedule of the application is as follows:

- Announcement of the theme : early February
- Application period : February to mid-March
- Notification of acceptance : March to April
- Conducting collaborative research : April to next March
- Briefing report of achievement : by next April

Reference Research Theme

[General Category, A～F]

A. Fundamental research on building fire safety
(Examples from the past)

- An experimental study on measurement method and estimation algorithm of radiant heat flux from large scale facade fire

B. Fundamental research on material combustion science

- Measures for controlling fire propagation at the surface of wooden linings
- An investigation of the measurement methods of lateral flame spread rate over wall lining materials
- FT-IR/Thermal Decomposition Analysis of Surface Combustion Characteristics in Flame Retardant Cross-Laminated Timber with Intumescent Nano-Clay Composites

C. Fundamental research on fire safety and disaster prevention

- An Experimental Study on Fire Prevention Effect with High Viscosity Liquid on A Wood Board

D. Fundamental research on large-scale fire

E. Research on technology and measures pertaining to fire safety

F. R & D issues that can be expected for technological innovation to reduce fire risk

[Emphasis Category, G] (※)

G. Experimental Research on Building Structural Fire Resistance

(※) Large-scale experimental challenge to use Structural Fire Resistance Furnace, or Multiple Full-scale Furnace

Management Structure and Assessment Procedure

The Research Center for Fire Safety Science Committee "(the Committee"), playing the central role in the Center, consists of a chairperson and 10 members (5 from inside and 5 from outside of TUS).

The Committee is the supreme decision-making body of the Center that develops a research and operation policy, formulates a management policy (including budget drafting), and plans research projects such as deciding a theme to call for entries.

Aiming to support smooth operation of the Center, the Research Theme Selection Committee and two special committees (called Working Groups or WG) are placed under the Committee. The Research Theme Selection Committee and two special committees function as follows respectively:

The Research Theme Selection Committee

This committee makes judgment on acceptance or rejection of applications received. Judgment will be made considering whether the research objective is defined clearly, the plan and the methodology are appropriate, proposed budget is reasonable, and whether the research outcome has potential for further development.

Facilities and Equipment Control Committee (WG)

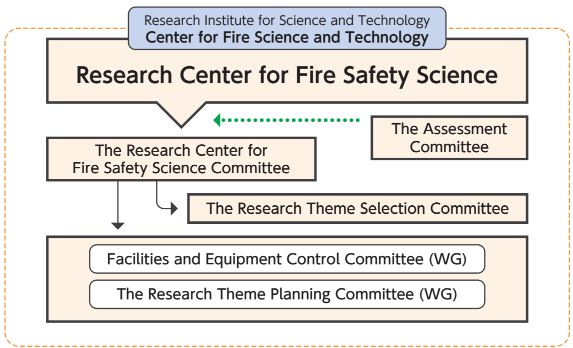
This committee (WG) is primarily involved in the operation planning of the full-scale experimental facilities. It is also responsible for the maintenance of facilities and equipment installed in the institution. In addition, it gives users instruction on how to use these facilities and equipment and on safety control.

The Research Theme Planning Committee (WG)

This committee (WG) draws out research themes and projects that are appropriate for the collaborative use or research and that serve the purpose of the Center and fulfill a social need.

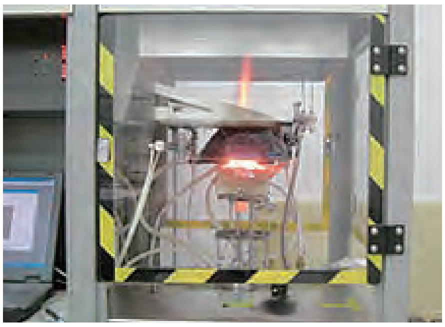
The Assessment Committee

This committee functions as an assessing body of the Center by providing interim and ex-post evaluation on the progress and outcome of research projects.



(Management Structure)

Example of Available Facilities/Equipment

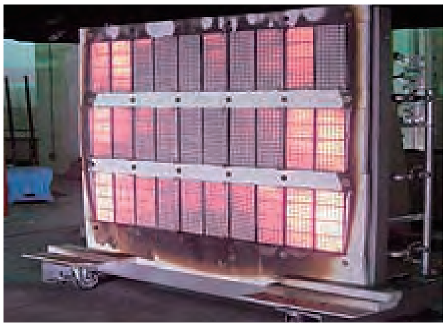


Cone Calorimeter Testing Device (ISO 5660)

This device is used to examine ignitability and the exothermal properties of construction materials using thermal radiation. A test object is placed under the conical-shape electric heater, which controls the thermal radiation to the object, and a pilot flame, is applied to the object 10mm from its surface. The ignition time and the heat release rate can be measured per thermal radiation that can be set in the range of 0 to 50 kW//m^2.

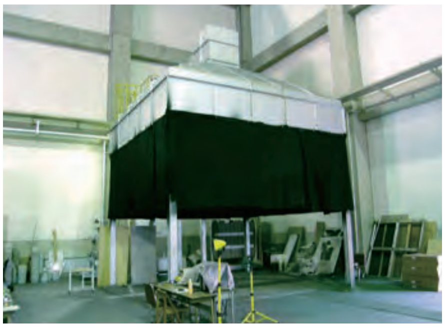
FTIR Gas Analyzer

This unit is designed to be connected to the combustion and smoke generation tester and enables high-speed and continuous analysis of combustion gas. A measured value can be updated at short intervals (five to ten seconds). This unit specializes in measuring certain types of gas that is result from combustion in fire.



ICAL Testing Unit (Heat Radiation Panel)

This unit is designed to elucidate the burning behavior of combustible materials under the condition where a certain heat flux was given through radiative heat transfer. The unit can also be used to investigate the behavior of members exposed to radiative heat. The panel heater has a heating area of 1.75 m (W) × 1.38 m (H). Members can be exposed experimentally to surface temperatures up to 950 and a heat flux of 50 kW/m2.



Calorimetry Hoods (5 m × 5 m)

This unit is used to analyze the burning characteristics of furniture and equipment in a room by burning them and collecting the burning gas. The duct is equipped with devices for flow measurement and sampling. The design heat release rate is 2 MW at maximum, and the smoke suction power is 600 m^3/min at maximum. A movable unit (4 m × 4 m) is also available.

Full-Scale Compartment for Fire Experiment (with Water Pump)

This fire compartment is 6 m (W) × 6 m (D) × 2.7 m (H) in actual size, and the sprinkler system can be attached to the ceiling. The compartment is mainly used to evaluate the fire extinguishing performance of sprinkler systems and also has used for experiments on smoke movement during sprinkler system activation.

Room Corner Testing Unit (ISO 9705)

This unit is comprised of a space of 2.4 m (W) × 3.6 m (D) × 2.4 m (H) (approximately, the size of a 6-tatamimat room) and an opening 0.8 m (W) × 2 m (H). It can be used to recreate a fire in a room with furniture and dry walls, which can be developed into a fully developed fire.

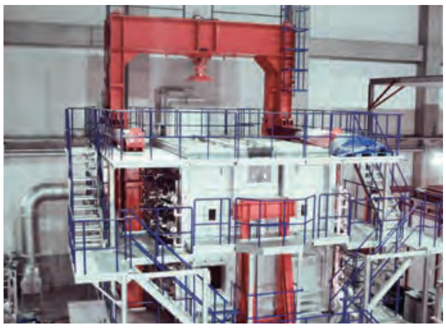
In addition, flashover experiments can be performed with this unit by recreating fires that spread to entire rooms in a short time period, and then combustible gas concentration and temperature distribution data can be collected. The development of the fire can be captured by video camera.

Structural Fire Testing Furnace (Medium scale)

This unit is used to evaluate the fire-resistive performance of various structural members such as columns, beams, floors and walls. The unit can control the heat to the standard heating temperature and furnace pressure set by ISO 834.The heating furnace, with dimensions of 1.5 m (W) × 1.5 m (D) × 1.5 m (H), can also provide immediate heating.

Structural Fire Testing Furnace (Large scale, for Walls)

This unit is used to evaluate the fire-resistive performance of an exterior wall under fire and can control the heat to the standard heating temperature and furnace pressure set by ISO 834. There are 20 burners on the lateral side, and this can heat up to a 3.5 m × 3.5 m area. The unit is also suitable for performing heat tests.



Multiple Full-scale Furnace

This device is used to measure the fire-resistive duration of horizontal materials of buildings including beams, floors and roofs by using the standard heating test (ISO834). Fire-resistive performance of any kind of horizontal materials can be evaluated by the heating test using this device. Put a full-scale model of 3 m (W) × 4 m (D) on the top the heater like covering it and then turn on the burner to heat the model from beneath.

INDEX

Only at TUS

Established: April, 2021
watus@rs.tus.ac.jp

Water Frontier Research Center (WaTUS)

Director
Professor,
Department of Mechanical Engineering,
Faculty of Engineering
Masahiro Motosuke
Ph.D

Objectives	To discover principles and mechanisms of interaction between water and materials surface including how to control them by interdisciplinary research collaboration.
Future Development Goals	To promote advanced researches on water interface by collaboration, and to form a research organization offering one-stop service for water science and technology.

Water is one of the most familiar substances but there are many unexplained issues, especially around the interface with materials surface. We, WaTUS, tackle these researches relating to “water interface” by interdisciplinary approaches and aim to provide practical solutions to industries as well.

Core of excellence for research and development of “Water Interface”

Background

“Water” is one of the most essential substances which supports our basis of lives in various forms, and we, not only the human being but also all the life cannot survive without the benefit of water. It plays crucial roles to transfer oxygen, nutrition and waste, and to assist structuring and fulfilling cells, tissues and organs. Additionally, in industrial fields, it is of importance in drinking, cleaning, immersion, coating and so on. So, it is no exaggeration to say that water is the longest and most frequently used substance in our history. However, there are still plenty of unexplained issues in its properties, performance and function; especially, interaction between water and materials’ surface, namely “water interface” , is generally very complicated and particularly difficult to be fully understood (Fig. 1).

To tackle these issues, a former research center, Water Frontier Science and Technology Research Center (W-FST) was launched on November 2016. Through research activities of W-FST, it is found that the topic of “water interface” is crucial and is highly needed both for academics and industries. Then we concluded to keep our continuous challenges and progresses to these issues by expanding and deepening the fields. Then, the successive research center “Water Frontier Research Center (WaTUS)” has been established after the reorganization on April 2021 to highly promote our research activities.The logotype of our center (Fig. 2) represents “water” encompassing its molecule, nature of continuum, and interfacical behavior.

Our mission

We, WaTUS, aims to pursue leading-edge researches and developments relating to “Water Interface” with multi-disciplinarily collaborative researches. Our mission is to perform following missions (Fig. 3);

(i) Pursuit of state-of-the-art science and technologies of water interface by collaboration and technical excellence
(i i) Establishment of international research core of excellence
(i i i) Provision of “one-stop service” of water researches for industries
(i v) Visualization of TUS through our research activities

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

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

Research organization of WaTUS

WaTUS promotes interdisciplinary collaborative researches to achieve our goals. We consist of matrix-based research units with approaches (Materials development, Measurement & Analysis, and Theory & Simulation) and targets (Materials & Water, Life & Water, and Environment & Water). In this 3 x 3 matrix-based research unit (Fig. 4), our center encourages researchers who develop novel materials with high functionality, ones who develop cutting-edge measurement and analysis techniques, and ones who perform advanced theoretical consideration and simulation, to perform intensively flexible collaborative studies expecting synergetic effects. Also, more flexible style of collaboration involving ones outside of the center are appreciated in this center.

Materials and Water : this unit pursues research and development considering relation between water and materials from atomic to macroscale.

Life and Water : this unit pursues research and development contributing to human beings and medical diagnostics or medical and biological engineering.

Environment and Water : this unit pursues research and development for environment and industries. Earth science and energy conservation is also included in this unit.

In addition, events such as the Water Frontier Symposium and evening seminars are held to promote the output of research activities and enhance mutual exchange among related researchers.

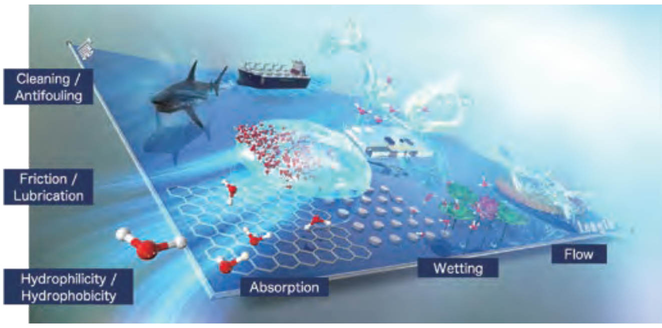


Fig. 1 Various phenomena and applications of “Water Interface” from atomic/ molecular scale to macroscale

Fig. 2 Logo of Water Frontier Research Center (WaTUS)

Fig. 3 Strategies of WaTUS

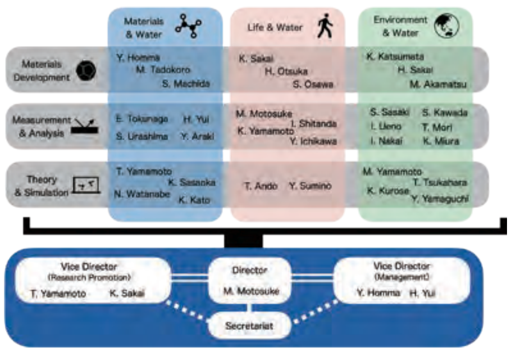


Fig. 4 Matrix-based research units in WaTUS

a-kudo@rs.tus.ac.jp

Carbon Value Research Center

Director
Professor,
Department of Applied Chemistry, Faculty of Science Division I
Akihiko Kudo
Ph.D. (Science)

Objectives	We aim at developing technologies based on basic researches for green H_2 production and CO_2 utilization by converting it into valuable products.
Future Development Goals	We will contribute to achievement of carbon neutral and solution of resource, energy and environmental issues we are globally facing.

For a carbon neutral society, it is indispensable to develop technologies utilizing CO_2 as a carbon source for production of valuable compounds. Our CV center study science and technology using photocatalysts and batteries that are our strong research fields for the CARBON VALUE that contributes to the solution of resource, energy, and environmental issues.

Carbon value beyond carbon neutral ~ Green H_2 production and CO_2 utilization ~

Background of the establishment

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 discussion done here, "University Coalition for Carbon Neutrality" was established.

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.

Aims of our CV center

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.

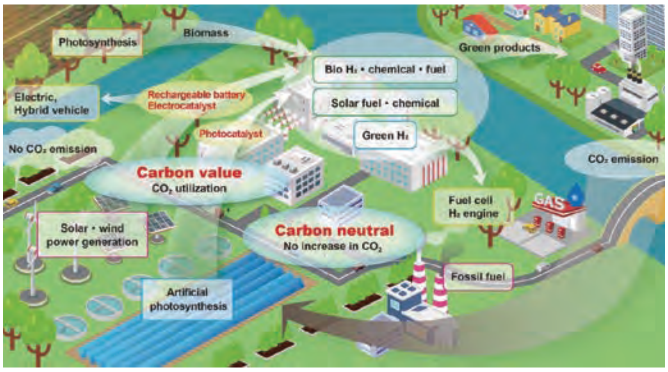


Fig. 1 Future vision that our CV center aims

Research system of CV center

About 10 researchers from Tokyo University of Science 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 also studied. The collaboration will be expanded to accelerate the research in the future.

Main research topics in our center

- **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.

- **Green hydrogen production with renewable energy**

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

- **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. Our 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 view point of stable supply of the alkaline metal resource. The secondary battery contributes to carbon neutral in an electric vehicle.

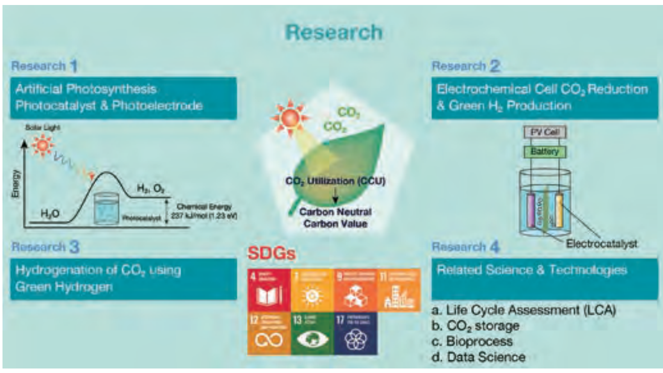


Fig. 2 Research topics in our center

Functional Materials

Established: October, 2012

takahiro@rs.tus.ac.jp

Division of Nanocarbon Research

Objectives	To investigate novel properties relating to carbon nanotubes and graphene, and to develop material sciences utilizing the nanospace of nanotubes and the interaction between nanotubes and various molecules.
Future Development Goals	To promote advanced researches on nanocarbons based on tight and highly active collaborations of division members.

Director
Professor,
Department of Physics,
Faculty of Science Division I

Takahiro Yamamoto

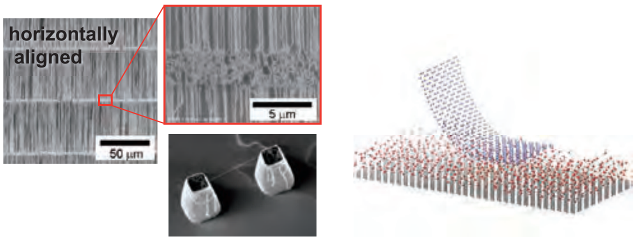
Ph.D.

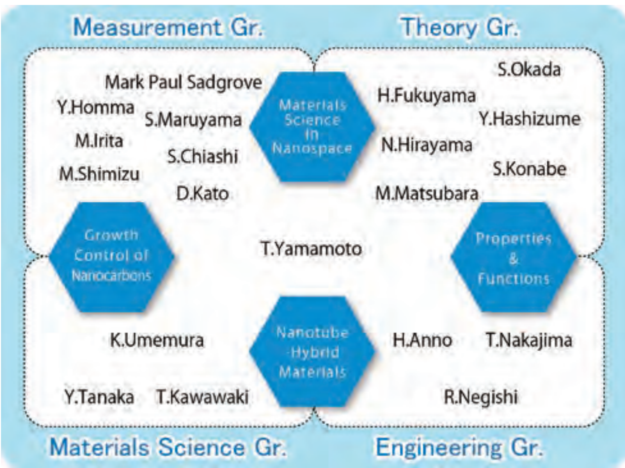
Nanocarbon is an active research field with increasing publications. Our research division is unique in that advanced researchers of nanocarbons are getting together and perform researches with wide scopes. In particular, tight collaborations between theorists and experimentalists are our strength. We are aiming at creating new fields and technologies based on our researches.

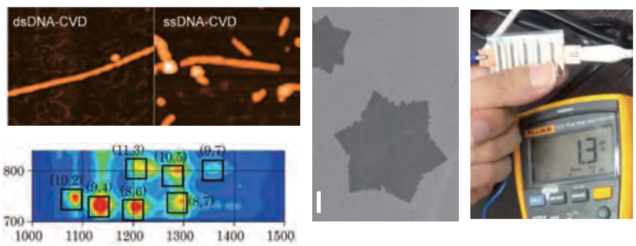
Research and development on carbon nanotubes and graphene.

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 researches 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.







Research topics

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.

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.

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 substarte.
- 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.

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.

hisakai@rs.tus.ac.jp

Division of Colloid and Interface Science

Objectives	To play a leading role in colloid and interface science both in Japan and the world.
Future Development Goals	We afford a deep understanding of surface phenomena from fundamental aspects and the practical aspects by the assist of exchanges of information and closer collaboration between interdisciplinary researches. In particular, we give intensively attentions to "static and dynamic surface behaviors" and "dimension of target-objects".

Director
Professor,
Department of Pure and Applied Chemistry, Faculty of Science and Technology
Hideki Sakai
Ph.D.

Research objective of Division of Colloid and Interface Science (DCIS) is to understand various phenomena occurring emerged from restricted spaces at interfaces or boundaries and to develop novel functional interfaces, by collaboration of TUS researches who specialize in chemistry, physics, life science, mechanical engineering, and theoretical science. We sincerely hope that outcomes of our project will contribute to the progress of many research fields and also the improvement of our quality of life (QOL).

Basic and applied researches on phenomena at various interfaces

All physical objects have surfaces. A boundary surface (interface) also exists between two mutually contiguous objects. Interface science is a discipline that researches surfaces and interfaces.

Let us take, for example, a coarse spherical particle with a radius of 1cm. By crushing this particle, we can create a cluster of microparticles with a radius of 1 μ m. Since the total volume of the entire cluster of microparticles is the same as that of the coarse particle (4.2cm^3), it is easy to calculate that we can create 10^{12} microparticles in this way (see the diagram below). The surface area of the coarse particle, however, is 12cm^2 or 3cm by 4cm, about the same size as the palm of your hand. But when the coarse particle is crushed, the total surface area increases 10,000 times to 12m^3 or 3m by 4m. In other words, the cluster of microparticles has an unbelievably large surface area. With such a large total surface area, the properties and behavior of the cluster of microparticles (colloid particles and nanoparticles) are determined by the properties of their surface area.

Interface science has a broad range of application, and is related to a variety of fields including surface active agents (surfactants), microparticle (colloid particle and nanoparticle) dispersed systems, microcapsules, gel, solid surfaces, powders, bio-interfaces and environmental colloids.

The Division of Colloid and Interface Science was established in January 1981. The first Director, Professor Kenjiro Meguro (Department of Applied Chemistry, Faculty of Science) was succeeded by Professor Tamotsu Kondo (Department of Medicinal and Life Science, Faculty of Pharmaceutical Sciences), Professor Minoru Ueno (Department of Applied Chemistry, Faculty of Science), Professor Kijiro Konno (Department of Industrial Chemistry, Faculty of Engineering), Hiroyuki Ohshima (Department of Medicinal and Life Science, Faculty of Pharmaceutical Sciences), and Professor Takeshi Kawai (Department of Industrial Chemistry, Faculty of Engineering) leading up to the present incumbent. The members come from all faculties of TUS, and have played a leading role in interface and colloid science both in Japan and internationally.

The Division of Colloid and Interface Science had been shifted to the Center for Colloid and Interface Science during 2008~2013, because a project application was accepted as the MEXT Program for the Development of Strategic Research Bases. The project theme was "Creation and Application of Nano/Biointerface Technologies," and the research unit consisted of 5 groups: biointerfaces, biomaterials, nanomaterials, nanospace, and interface theory/analysis. In this project, we approached the interface as the locus of temporospatial expression of function, and our goal was to create temporospatially controllable nano/biointerface technologies.

Now, we restarted the division of colloid and interface science with new members from April 2013. The main research project is the deeper understanding of dynamic surface phenomena of "soft interface" and "hard interface". Here, "soft interface" is referred to a dynamic ineteface where molecules and atoms are continually going in and out thorugh the interface, whereas "hard interface" means a static interface where no exhange of molecules and atoms take place at the interface. The representative materials of the former are spherical and worm-like micelles, emulsions, vesicles and Gibbes monolayers, while the latter are metal nanoparticles and nanowires, nanoporous materilas made of organic complexes, self-assembled monolayers on solid substrates. "Soft interface" and "hard interface" can also be called "dynamic interface" and "static interface", respectively, and the both interfaces are classified into three basic groups according to dimesions, namely, zero and three dimesion, one dimension and two dimension. We aggressively pursue the fully understanding of the fundamental phenomema and the fuctions at the both interfaces, and hope to achieve the development of novel functional materilas.

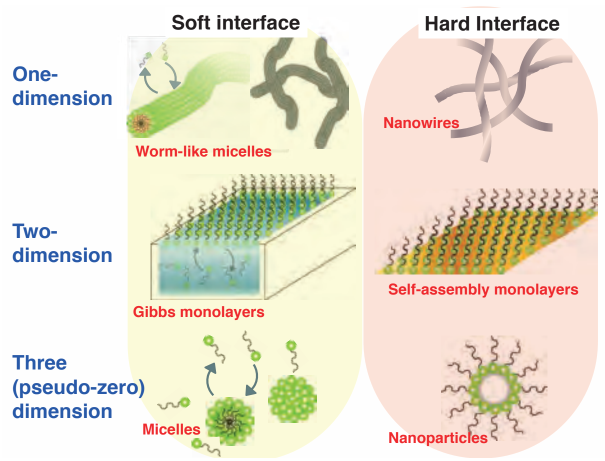


Figure 1

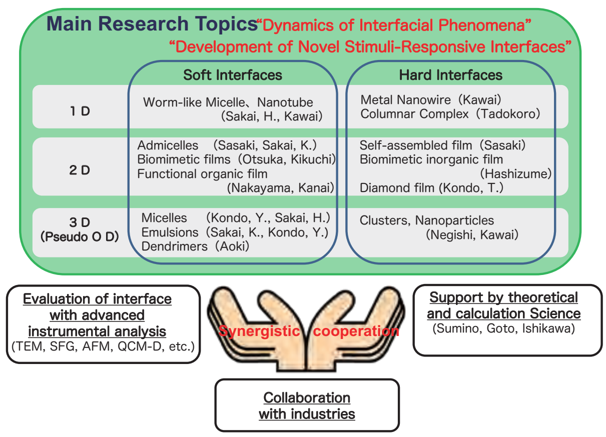


Figure 2

Functional Materials

Established: April, 2020

solar@rs.tus.ac.jp

Renewable Energy Science & Technology Research Division

Director
Professor,
Department of Electrical Engineering,
Faculty of Science and Technology
Mutsumi Sugiyama
Ph.D.

Objectives	To propose a foundation for stable and low-cost power supply/management, and to activate and promote research, development and education of renewable energy utilization technology at TUS.
Future Development Goals	Through active interaction among the Division members from different backgrounds, we will promote both internal and external joint research to create novel concepts for renewable energy technology.

In response to the trend of times, this division is created by reorganizing the Photovoltaic Sci & Tech Division established in 2010. We are composed of members from different fields of expertise in various renewable energy devices and systems. We will develop unique renewable energy and integrated systems/infrastructures such as solar-wind-biomass power generation.

Research and development on renewable energy and systems such as solar, wind, biomass etc.

To solve the global warming problem, the biggest issue for humankind in the 21st century, it is necessary to substantially shift the energy sources from fossil energy such as coal, oil and natural gas to renewable energy. With this background, the predecessor Solar Power Generation Technology Division had worked to promote research of the University on solar power generation by disseminating the research results in Japan and worldwide, tackling the global warming problem. Meanwhile, in today world, there is a wide variety of research and development ongoing on "renewable energy" beyond solar, such as wind power, biomass power generation and fuel cells. In addition, at the time of the establishment of the predecessor Division, the power supply was simply based on nuclear power to provide a stable base power and thermal power generation to supplement the fluctuation of demand. However, nowadays many types of renewable energy are connected to the grid and the operation of the system infrastructures for stable power supply has become highly difficult and critical. We have therefore reorganized the Division, which previously focused only on solar, to include the entire "renewable energy", and defined the purpose of the new Division as following:

(i) Development of power generation materials that reduce the installation and operation costs to the same level as power generation by fossil fuels.
(ii) Development of highly efficient management technology for electric power from various power generation methods.
(iii) Development of new materials and new system technologies.
(iv) Collaborations between our research division and external research institutes.

Members of the Division

The Division consists of 18 members listed as follows, who all have different fields of expertise in physics, chemistry, electrical power, electronics, materials and management. We are gathered together to deepen the discussion on the development of renewable energy utilization technology and aim for major developments through synergistic effects.

Table Members of Renewable Energy Science & Technology Research Division

Name	Job title	Affiliation of key role	Main research field
Mutsumi Sugiyama	Professor/ Director	Faculty of Science and Engineering Department of Electrical Engineering	Semiconductor material engineering / Thin film solar cell
Zhao Xinwei	Professor	Faculty of Science Division II Department of Physics	Semiconductor nano-material engineering / Thin film photovoltaic cell
Takashiro Akitsu	Professor	Faculty of Science Division II Department of Chemistry	Coordination chemistry / Photofunctional fuel cells of organic/ inorganic hybrid materials
Yuzuru Ueda	Professor	Faculty of Engineering Department of Electrical Engineering	Electricity and energy engineering / Photovoltaic system
Morio Nagata	Associate Professor	Faculty of Engineering Department of Industrial Chemistry	Organic photovoltaic cell / Artificial photosynthesis
Junji Kondoh	Associate Professor	Faculty of Science and Engineering Department of Electrical Engineering	Photovoltaic power system / Wind power generation / Power conditioning system
Noboru Katayama	Associate Professor	Faculty of Science and Engineering Department of Electrical Engineering	Fuel cells / Hydrogen storage / Diagnosis for energy devices
Takashi Ikuno	Associate Professor	Faculty of Advanced Engineering Department of Applied Electronics	Surface and interfaces / Photovoltaic devices / Nanogenerators
Tomoyuki Haraguchi	Junior Associate Professor	Faculty of Science Division II Department of Chemistry	Coordination chemistry / Dye sensitized solar cell
Daisuke Nakane	Assistant Professor	Faculty of Science Division II Department of Chemistry	Coordination chemistry / Bioinorganic chemistry / Catalytic chemistry
Cui Jindan	Assistant Professor	Faculty of Engineering Department of Electrical Engineering	Photovoltaic system / Energy management system
Kim Joonam	Assistant Professor	Faculty of Science and Engineering Department of Electrical Engineering	Semiconductor material engineering / Nano energy harvest
Yoichi Hirata	Visiting Researcher	Suwa University of Science, Faculty of Engineering	Photovoltaic power generation system / Wind-power generation / Micro grid
Yasuyuki Watanabe	Visiting Researcher	Suwa University of Science, Faculty of Engineering	Molecular electronics & Bioelectronics / Photosynthetic engineering
Sho Shirakata	Visiting Researcher	Ehime University	Semiconductor material engineering / Thin film photovoltaic cell, CIGS solar cell
Satoshi Ohnishi	Visiting Researcher	National Institute for Environmental Studies	Energy economics / Low carbon city management
Daisuke Kodaira	Visiting Researcher	University of Tsukuba	Smart grid / Energy storage system management / PV generation forecasting
Ayaka Kanai	Visiting Researcher	Nagaoka University of Technology	Thin film photovoltaic cell / Optical Properties of Semiconductor

Research Activities

As a research and development hub for renewable energy technology, we will realize novel renewable energy materials and power generation systems through vertical integration of technologies, as well as educate the next generation of researchers and disseminate the technology to society. Specifically, the following activities will be carried out:

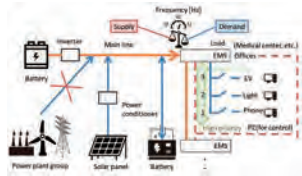
• Renewable energy materials group:

(i) Proposal of ultra-high efficiency power generation device by tandem configuration of thin film solar cells/thermoelectric generation elements.
(ii) Establishment of hydrogen production technology using solar cell thin films and charging technology such as supercapacitors.
(iii) Development of ultra-low-cost solar and fuel cell materials and manufacturing methods, and examination of their common basic technology.

• Energy management group:

(i) Development of technologies of failure diagnosis, remote diagnosis, power generation prediction and AI utilization for energy loss control.
(ii) Integration of smoothing technology development for wind × solar power generation and power storage technology such as batteries and flywheels.
(iii) Solar matching for agriculture and application of renewable energy technologies to smart houses.

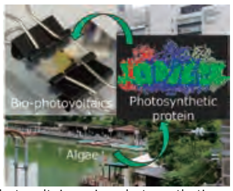
Design and evaluation on renewable energy system utilizing regional characteristics



Renewable energy recovery system assuming a blackout due to a disaster

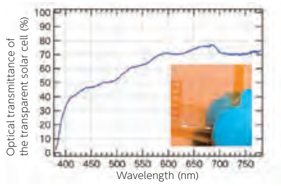
Monitoring of output power from multiple small wind turbines, and a prototype of a flywheel energy storage system

Polymer electrolyte membrane fuel cell and automatic humidity control system for supply air

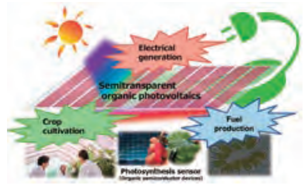


Bio-photovoltaics using photosynthetic proteins from algae

Photofunctional metal complex and catalytic enzyme for biofuel cell



Transparent solar cells fabricated on bio-derived transparent film substrates



Solar matching (Co-developing technology both photovoltaics and photosynthesis)

Figs. Research theme of Renewable Energy Science & Technology Research Division

Functional Materials

Established: April, 2020

kkinosita@rs.tus.ac.jp

Division of Ambient Devices Research

Director
Professor,
Department of Applied Physics,
Faculty of Science

Kentaro Kinoshita

Ph.D.

Objectives	We aim to create an innovative standalone RFID tag with high-sensitivity sensors consisting of organic or organic/inorganic hybrid semiconductor devices, which are environment-friendly. We also aim to establish new automatic data collection and analysis technology using the data collected.
Future Development Goals	We believe that synergies through collaboration with other departments are indispensable to step through the rugged road to device creation and social implementation.

As a research base of organic or organic/inorganic hybrid devices at Tokyo University of Science, experts who are active in various fields such as physical property experiments and theory, semiconductor devices, organic electronics, energy conversion, etc. We will work on a series of research and development from material research, device application, and to social implementation.

Creation of ambient devices and establishment of technology for collecting and analyzing extracted big data.

Background to establishing the department

In 2013, the "Trillion sensor concept" was proposed in the United States, in which sensor nodes are attached to all trillions of objects, information is collected, and information science is used to realize a prosperous and safe society. At present, in Japan, "convenience store electronic tag 100 billion pieces declaration" (Ministry of Economy, Trade and Industry) is being promoted to attach electronic tags to all convenience store products by 2025 in order to improve the efficiency of logistics. Such a stick-on type/dispersion type sensor node is called an “ambient device” in the sense that it can be integrated into the environment, and it is expected to form a large market as a post-smartphone. Since the ambient device needs to be lightweight, flexible, and inexpensive, it is necessary to compose all materials including the substrate with organic materials or organic/inorganic hybrid materials. With a view to the mass diffusion of ambient devices, we conduct research on material property control, device creation, and acquired data analysis related to ambient devices, aiming at social implementation.

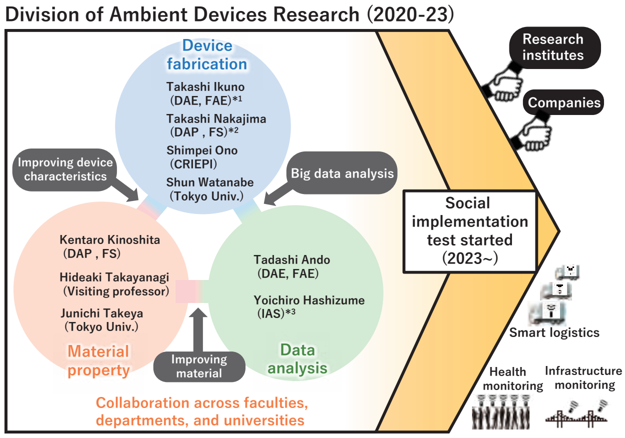
Contents of our research and development

As an example for the application of an ambient device, we envision a radio frequency identifier (RFID) tag with a sensor for next-generation logistics. With the recent rapid increase in large-scale commercial facilities, expansion of e-commerce, and expansion of logistics services due to globalization, the failure of the conventional logistics system is beginning to become apparent, so there is an urgent need to develop a mechanism for next-generation logistics. There is a wide variety of needs regarding transportation modes, and in order to realize transportation that does not impair the quality and value of food, chemicals, precision equipment, etc., there is an increasing demand for logistics technology in low-temperature and shock-free environments. If an RFID tag with a sensor using an innovative organic semiconductor device is created and a new automatic data collection technology using it is established, a highly efficient, safe and secure logistics service will be realized, and its impact on society will be extremely large. In order to "realize a sensor node with low environmental load and low cost," we construct a sensor node constituent device by precisely controlling the material properties. The devices mounted on the sensor node depend on the purpose, and for example, the sensor node used for future logistics require an acceleration sensor, a temperature sensor, an RF transceiver antenna, a transistor, a memory, and a power supply. A sensor node with low environmental load is realized by constructing the device, including the substrate of each device, with organic materials or organic/inorganic hybrid materials. In addition, the manufacturing cost cannot be ignored for the diffusion of technology. In order to achieve a price of 1/100 of the conventional sensor node (1 yen/sensor node), and we will pursue a low-cost manufacturing process and low-cost material.

System for research and development

Researchers involved in the field of semiconductor devices, functional materials, molecular simulations, and information science who belong to Tokyo University of Science collaborate to realize the concept such as “100 billion tags for convenience store electronic tags” and “1 trillion IoT devices per year” by the creation of innovative ambient devices. Each group actively interacts with each other to search for physical properties, improve device characteristics, and analyze big data. Figure 1 shows the interrelationship among researchers inside and outside Tokyo University of Science and the image of research promotion. In collaboration with the Takeya Group of the University of Tokyo, which possesses the edge technology for producing ultra-thin single-crystal organic semiconductor films that exhibit outstanding device operation speed, we will search physical property from both sides of calculations and experiments, aiming at further improvement of device characteristics. Research can be carried out in the state-of-the-art equipment environment owned by Professor Takeya at The University of Tokyo. Specifically, there are states of the art equipments for forming single crystal organic monomolecular film that is essential to this theme, for forming various organic and inorganic thin film forming devices (both wet and dry processes), for microfabrication (photolithography, laser lithography, wet process), for large screen printing, various electron microscopes, spectroscopes, electrical-, mechanical-, and optical-property analyzers. By using them, we can conduct all the processes for manufacturing ambient devices from organic semiconductor molecule synthesis to device fabrication, evaluation, and large-scale printing process.

Division of Ambient Devices Research (2020-23)



*1: Department of Applied Electronics, Faculty of Advanced Engineering
*2: Department of Applied Physics, Faculty of Science
*3: Institute of Arts and Sciences

Fig1. An image of correlation and research promotion among researchers who belong to Research Division of Ambient Devices inside and outside the Tokyo University of Science.

gunji@rs.tus.ac.jp

Research Group for Advanced Energy Conversion

Director
Professor,
Department of Pure and Applied Chemistry,
Faculty of Science and Technology
Takahiro Gunji
Dr. Eng.

Objectives	This research aims at the development of novel "Only at TUS" energy systems based on SDGs by establishing elemental know-how of the systematic material-to-system research.
Future Development Goals	Practical use of secondary cells and fuel cell systems, building of efficient thermoelectric conversion systems, and the development of new light-reactive materials.

An efficient, new energy system based on Sustainable Development Goals (SDGs) is needed. In this group, specialists in chemistry, mechanical engineering, electronic engineering, and system engineering come together to develop and test a new, efficient system for the generation, storage, and utilization of clean energy by "Only at TUS".

The development of a system for the generation, transformation, storage, and utilization of energy by "Only at TUS"

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 in order to achieve the goal of this research group early.

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.

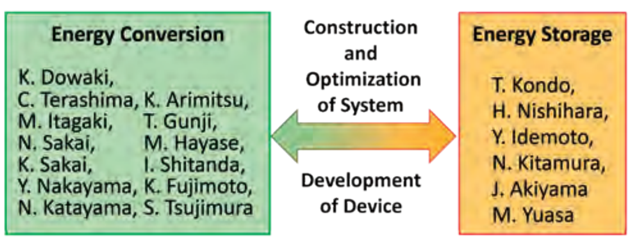
We will manufacture a printable wearable biofuel cell with paper and transfer sheet. For example, a fuel cell that uses organic material in urine as fuel can be used for urine detection (Elderly care, health maintenance). By using lactic acid in sweat as fuel, one can monitor the health of athletes. 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.



Structural Materials

Established: April, 2018

koyanagi@rs.tus.ac.jp

CAE Advanced Composite Materials and Structures Research Division

Objectives	The main objective of our research division is to create deeper relations between academia and industry and to boost the number of industry-ready CAE engineers significantly through engineering research using CAE technology with a focus on advanced composite materials, including carbon-fiber-reinforced plastic (CFRP) and their structures.
Future Development Goals	The aim is to further the academia–industry partnership through collaborative research on the subject of advanced composite materials and structures conducted individually by our faculty members, while also cultivating more CAE engineers. We also intend to expand this development greatly from the second year onward.

Director
Professor,
Department of Materials Science and Technology, Faculty of Industrial Science and Technology
Jun Koyanagi
Ph.D.

The CAE Advanced Composite Materials and Structures Research Division aims to:

- Conduct research focused on composite materials, which are undeniably the material of the 21st century;
- Build strong relations with industry through engineering research utilizing CAE technology (which has become mainstream in recent years);
- Apply the motto " be equipped " when cultivating CAE engineers, the demand for whom has grown in recent years, and preparing them for industry support.

Engineering research was conducted on advanced composite materials and their structures using computer-aided engineering (CAE) software to achieve partnership between industry and academia.

Here at the CAE Advanced Composite Materials and Structures Research Division, we aim to establish strong academic—industry collaboration by effectively utilizing computer-aided engineering (CAE) software to (1) conduct engineering research through the development of materials at the molecular level (via the molecular orbital theory and molecular dynamics method) and (2) design actual structures or execute molding simulations and fracture analysis from destruction simulators (which employ the finite-element method and particle method). Because the members of our research division can cover a wide range of materials and structures, as shown in the figure below, it is possible to increase their suitability for the needs of the industry. In other words, the division will become a major receiver to entrust with and take on collaborative research. Through this research, the division will improve the brand recognition of Tokyo University of Science in Japan by deploying a large number of well-trained, well-equipped CAE engineers for the industry where they will make great contributions.

Until now, CFRP has been primarily used in aerospace applications, but, in recent years, it is starting to become widely incorporated into the automotive industry as well. Our engineering research division aims to provide solutions to the issues/needs of the industry. More specifically, to make CFRP more widely used by the automotive industry, at the very least, the following three points require improvement:

1. Moldability of CFRP: be able to cast parts made from CFRP in 1 min while maintaining its high quality;
2. Impact characteristics of CFRP: doubling its current impact energy absorption;
3. Its unique design: not all metallic parts need to be replaced with CFRP, but, rather, new automotive parts unique to CFRP, while taking its moldability and impact characteristics into account, need to be designed.

However, with the recent advancements in computer capabilities, the use of numerical analysis tools is becoming more familiar. By utilizing CAE software, it has become normal in recent years to reduce the costs of experiments and speed up developments. Our research division makes use of CAE software to approach and solve a variety of research issues, such as the aforementioned improvements to CFRP. One of the major features of our research division is the way in which we cultivate our students so that they are ready to contribute to society right away. This is highlighted by allowing the students to conduct research through their graduate/master' s/doctoral theses that meets the needs of the industry. Also, through the work of our experienced, talented alumni, we intend to create a synergistic partnership with industry that allows the Tokyo University of Science to obtain funding from its commissioned research. To educate and conduct research based on a strong relationship with industry is another major characteristic of our research division.

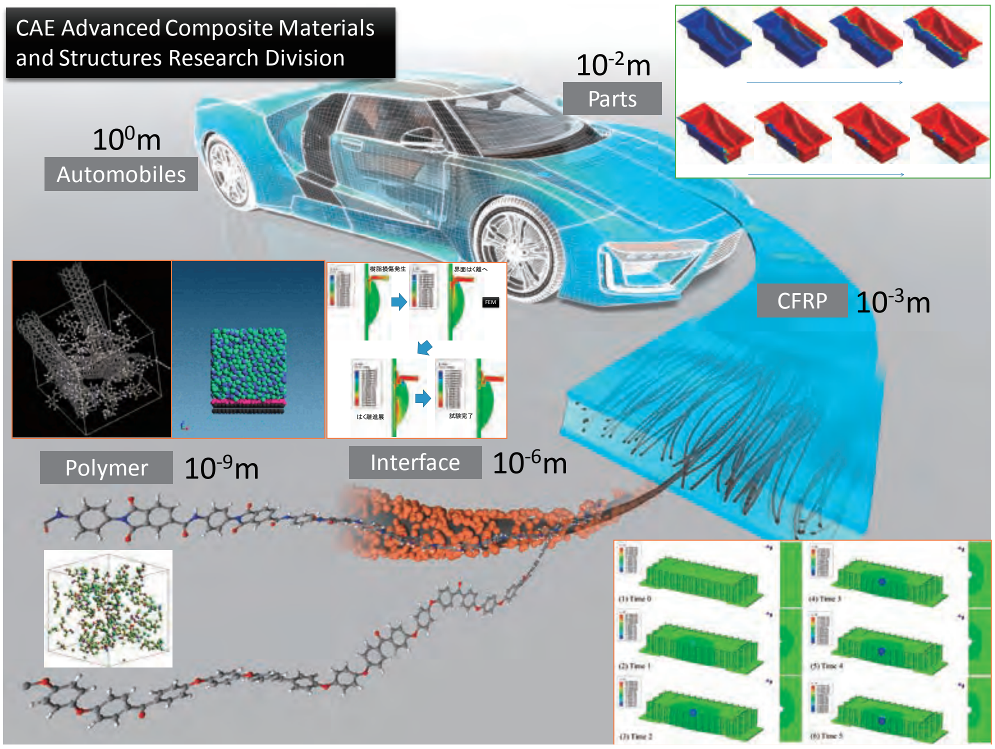


Fig. 1 Overview of research range covered by our group

Established: April, 2018

shiina@rs.tus.ac.jp

Chemical Biology Division Supported by Practical Organic Synthesis

Objectives	Our goals include the efficient production of pharmaceutical products from natural and/or artificial compounds. In our research department, our team will collaborate with researchers within the campus, as well as outside, who have made considerable achievements in the field of molecular biology, thereby completely exploiting synthetic organic technologies from which the representative research can derive its strength.
Future Development Goals	Recently, the discovery of new medicines originating from academia via industry–university collaboration from an industrial viewpoint has attracted a significant amount of attention. Results obtained from such researches provide a methodology for solving various issues associated with the development of drugs derived from natural sources.

Director
Professor,
Department of Applied Chemistry,
Faculty of Science Division Ⅰ

Isamu Shiina
Ph.D.

In this project, novel biological research will be conducted by completely exploiting organic synthesis technology, referred to as the “total synthesis of naturally occurring products,” which has been scarcely used so far for the discovery of new drugs. Synthetic studies based on natural product-derived compounds lead to the production of novel drugs with a unique mechanistic MOA and pave the way for the treatment of intractable diseases that have not been treated thus far.

Structure–Activity Relationship (SAR) and Mode of Action (MOA) Studies Using New Compounds Developed at the Tokyo University of Science

Development of New Synthetic Methods for the Effective Transformations in Organic Chemistry

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

Our synthetic team is conducting research on reaction methods that can improve the synthetic yield of pharmaceutical products to the maximum. Hence, in 2002, our team developed a new dehydration condensation agent, namely 2-methyl-6-nitrobenzoic anhydride (MNBA), which can drastically enhance the production efficiency of antibiotics and anticancer drugs.

Dehydration condensation is a structural transformation where two hydrogen atoms and one oxygen atom are simultaneously removed from organic molecules, and two compounds are ligated using a reagent such as a dehydrating condensation agent. For decades, dehydration condensation has been employed to construct the basic skeleton of pharmaceuticals. However, as conventional methods require harsh reaction conditions, including the use of an acid catalyst or high temperatures, issues related to the destruction of reagents or compounds that serve as the raw materials were noted.

With the establishment of the Shiina laboratory in 1999, compounds and reaction conditions for the invention of the fastest dehydration condensation reaction in the world were thoroughly analyzed, which finally led to the development of MNBA.

After the establishment of this new technology, MNBA has been widely used to synthesize new antibiotics, molecular target anticancer drugs, and drugs for diabetes treatment, and more than 2000 successful results have been reported worldwide (Please check YouTube using “YouTube MNBA Shiina” as the keyword, (Fig. 1).

Fig. 1 Efficient Synthesis of Various Compounds Using MNBA
(The Shiina Research Group) (https://www.youtube.com/watch?v=Dw1ajJchujw)

A New Method for the Inhibition of Cancer Cells
(Total Synthesis of Vesicle Protein Transport Blocker, M-COPA)

In this chemical biology division, research on the “Development of New Reactions” and “Total Synthesis of Natural Products” is interconnected as major research topics. Total synthesis involves the artificial synthesis of natural-derived chemical substances with complex molecular structures using a minimum amount of raw materials. For example, some rare chemical compounds extracted from soil-borne bacteria exhibit anticancer properties. If these compounds can be artificially synthesized, not only the stable production of medicines can be achieved but also the chemical structures that are optimum for pharmaceuticals, including the suppression of side effects, can be designed.

In the total synthesis research, MNBA is predominantly used for the synthesis of organic compounds exhibiting anticancer properties.

Our team completed the total synthesis of M-COPA, which limits the function of the Golgi apparatus that is responsible for the transport of intracellular proteins. Both domestic and international research groups have attempted to apply this compound to cancer cells activated by the Golgi apparatus to block transportation pathways and to suppress the growth of cancer (Fig. 2). At the Shiina laboratory, our team has worked toward the development of a large-scale method to prepare M-COPA for use in animal experiments.

Each reaction step was analyzed to ensure gram-scale production, or higher, of M-COPA with seven consecutive stereogenic carbons. Our team established large-scale synthesis by effectively employing organic reactions, such as asymmetric aldol reaction, intramolecular Diels–Alder reaction, and MNBA dehydration condensation reaction. Experiments to verify the effect on cancer cells using M-COPA via total synthesis have been conducted, and even the inhibition of proliferation of cancer, which has been thought to not be cured using the current anticancer drugs, has been observed. In addition, other outstanding achievements have been consistently reported in articles. The design of a synthetic method in the anticipation of the development up to industrial use has played an important role in successfully achieving this objective.

In addition, these results have also been presented on YouTube. These can be viewed on the YouTube handle “YouTube M-COPA Shiina” or “YouTube Shiina Laboratory TUS.”

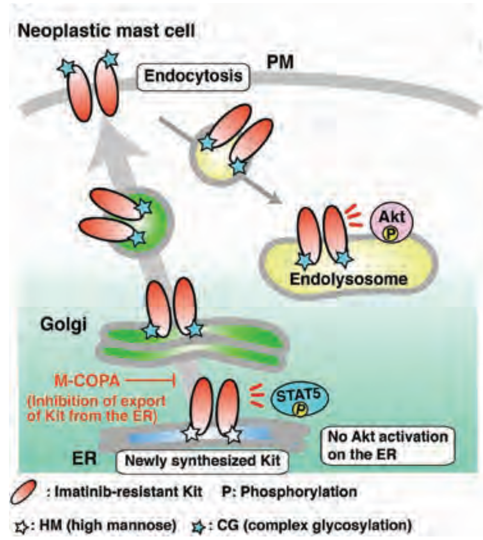


Fig. 2 Proliferation Suppression Mechanism of Cancer Cells Using M-COPA
(Fig. 2 was created by Dr. Yuuki Obata who collaborates with Prof. Shiina: *PLOS ONE*, 12(4), e0175514 (2017))

Bio and Pharmacy
Established: April, 2019

twada@rs.tus.ac.jp

Division of Nucleic Acid Drug Development

Director
Professor,
Department of Medicinal and Life Sciences
Faculty of Pharmaceutical Sciences
Takeshi Wada
Doctor of Science

Objectives	We aim to create nucleic acid drugs to treat unprecedented target diseases through the synthesis of novel chemically-modified nucleic acids and the establishment of DDS and formulation methods
Future Development Goals	Our goal is to make a breakthrough in the field of nucleic acid drugs through the collaboration of in-house researchers

This division was established by the cross-departmental team of in-house researchers working on the nucleic acid or other related research fields. By succession of networks and joint researches created through the activity of the TR center, we aim to develop innovative nucleic acid drugs from TUS.

Development of nucleic acid-based drugs that are expected to be a next-generation drug

History of This Division

The TR (Translational Research) center, which was the former organization of this division and lasted until 2018, got notable results in the field of nucleic acid drug. Also, nucleic acid-based drugs have recently attracted much attention as a next generation type drug. There are a plenty of researchers who work on nucleic acids at TUS, and the most of them took part the activity of TR center. Then, "round-table conference on nucleic acid drugs and DDS" was established in 2017 (representative: Prof. Makiya Nishikawa), and we have active discussions on nucleic acid drugs. Under these circumstances, the Division of Nucleic Acid Drug Development was established as a subsequent organization of TR center in April 2019.

Research Objectives

The development of nucleic acid drugs requires a knowledge from wide range of research field. There are many prominent researchers who work on nucleic acid or related research at TUS, thus innovative and unique results are highly anticipated through their collaborations. In this division, one of our mission is the development of novel nucleic acid derivatives which overwhelm conventional ones in the viewpoint of efficacy, stability and safety. Also, we aim at establishing the cationic molecules and formulation technology which stabilize and improve pharmacokinetics of nucleic acid drugs. We chose immune system, metabolic system related diseases and cancer as targets. As just described, the development of original nucleic acid drugs targeting unique diseases are highly expected by gathering of in-house competent researchers in this division.

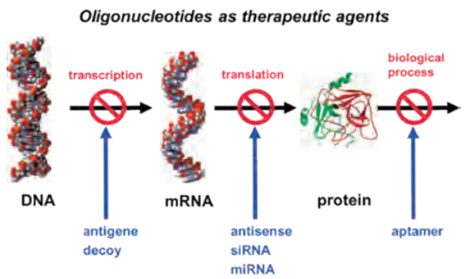


Figure 1

Members

In-house Members

Faculty of Pharmaceutical Sciences
Takeshi Wada, Kazuki Sato (Organic chemistry)
Makiya Nishikawa, Kosuke Kusamori (Drug delivery system)
Takehisa Hanawa, Chihiro Ozawa (Medicinal formulation)
Yoshikazu Higami, Masaki Kobayashi, Yuka Nozaki (Molecular pathology and metabolic diseases)
Kazunori Akimoto, Shoma Tamori (Molecular pathology)
Chikamasa Yamashita (Physical pharmacy)
Yosuke Harada (Immunology)

Faculty of Science
Satoru Miyazaki, Yoshio Nakano (Bioinformatics)
Hidetaka Torigoe (Biophysical chemistry)
Hidenori Otsuka (Polymer chemistry)

Faculty of Advanced Engineering
Chiharu Nishiyama, Masakazu Hachisu (Immunology, allergy and molecular biology)
Suguru Yoshida (Organic synthesis)

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

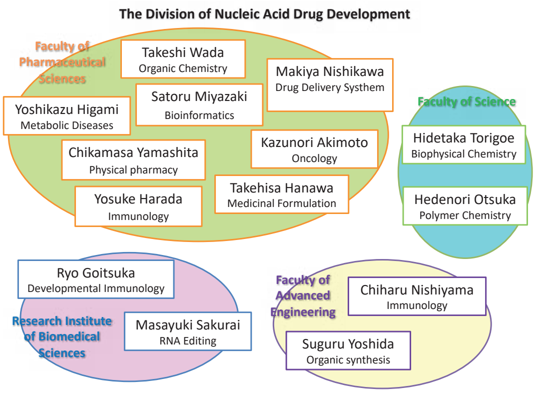


Figure 2

Current Situation of Nucleic Acid Drugs and Our Research Topics

Nucleic acid-based drugs are anticipated to be an epoch-making remedy for the treatment of intractable hereditary diseases. The global market size of nucleic acid-based drugs is predicted to expand to 19 billion dollars in 2030 from 2 billion dollars in 2018, according to the estimation of Seed Planning Inc., a marketing research and consulting enterprise. Although much efforts have been devoted to the research of nucleic acid-based drugs, only 16 drugs have been approved so far. There are a lot of challenges to overcome for the development of potent nucleic acid drugs, and a break-through is required for the further progress of this area. To address this issue, we are dealing with following topics;

1. Development of an efficient method to synthesize boranophosphate oligonucleotides which is anticipated as an alternative candidate of phosphorothioate
2. Establishment of a scalable synthetic method of artificial cationic oligosaccharides and peptides that bind to and stabilize nucleic acids.
3. Construction of a highly target selective drug delivery system through the elucidation of interaction between nano-structured nucleic acid and cells
4. Development of antisense drugs that target such as wound and bladder cancer remedy
5. Development of a novel formulation method of nucleic acid drug
6. Research on the control of aging, aging related diseases and metabolic abnormalities by nucleic acid drugs
7. Development of nucleic acid drugs which regulate autoimmune response and rejection reaction during an organ transplantation
8. Development of effective breast cancer drugs using novel artificial cationic molecules and siRNAs
9. Establishment of investigation technology via bioinformatics and AI to determine the sequence of a mRNA that codes disease-related protein

ikawa@rs.tus.ac.jp

Division of Synthetic Biology

Director
Professor,
Division of Immunology
and Allergy

Tomokatsu Ikawa
Ph.D.

Objectives	Using informatics analysis and modern biotechnology such as DNA synthesis, cell fusion, microinjection and microscopic laser technology, we create genetically transplanted cells.
Future Development Goals	Emphasis on ethical, legal and social impacts, we aim to establish genome transplantation technology with sufficient safety measures.

We will promote our synthetic biology projects that create cells with our frontier spirits. This research division can become a platform for joint research, information sharing and technology exchange with synthetic biology researchers.

We create genetically transplanted cells, which will contribute to useful substance production and medical technology.

Synthetic biology is the study to elucidate the biological principle through artificial cells with DNA synthesis. Pet animals such as dogs and cats, horticultural crops such as orchids, livestock such as mules and chickens, and multiple species of agricultural products such as wheat and fruits are hybrids by crosses of related species. Since ancient times, we have created and used such genomic hybrid organisms. Current technological innovations have also enabled crosses and transfer of genomes other than closely related species. In order to create a frontier area from the modern biotechnology, we will promote departmental research. Our research is conducted with strict awareness of ethical, legal and social issues. With a view to the development of useful substance production technology and medical technology in the future, we will promote the following three research subjects with the aim of establishing a genome transfer technology with sufficient safety measures.

Strategy 1: Plant genome transplantation

There are many modules in the plant genome that are not found in animal genome, such as photosynthetic modules, pigment modules, and metabolic pathway modules that produce medicine materials. By transplanting these plant modules into the animal genome, we aim to impart new functions to animal cells. We call artificially photosynthetic animal cells “planimal cells” (Figure 1).

Strategy 2: Genome transfer beyond the species barrier

Even close relatives, there is a "species barrier" in genome crossing between organisms. Therefore, we aim to create ascomycete hybrid cells that enable useful substance production by genome engineering and cell fusion.

Strategy 3: Cell creation leading to regenerative medicine

Methods to control cell proliferation and cell metabolism are needed to promote the production of spheroids and organoids. We aim to develop technologies that can be safely applied to medical technology by incorporating a regulatory system with epigenetic and optogenetic techniques.

Through this department, the fields of biology divided into microbiology, botany, zoology and medical science can be fused to make it possible to elucidate the basic principles of life.

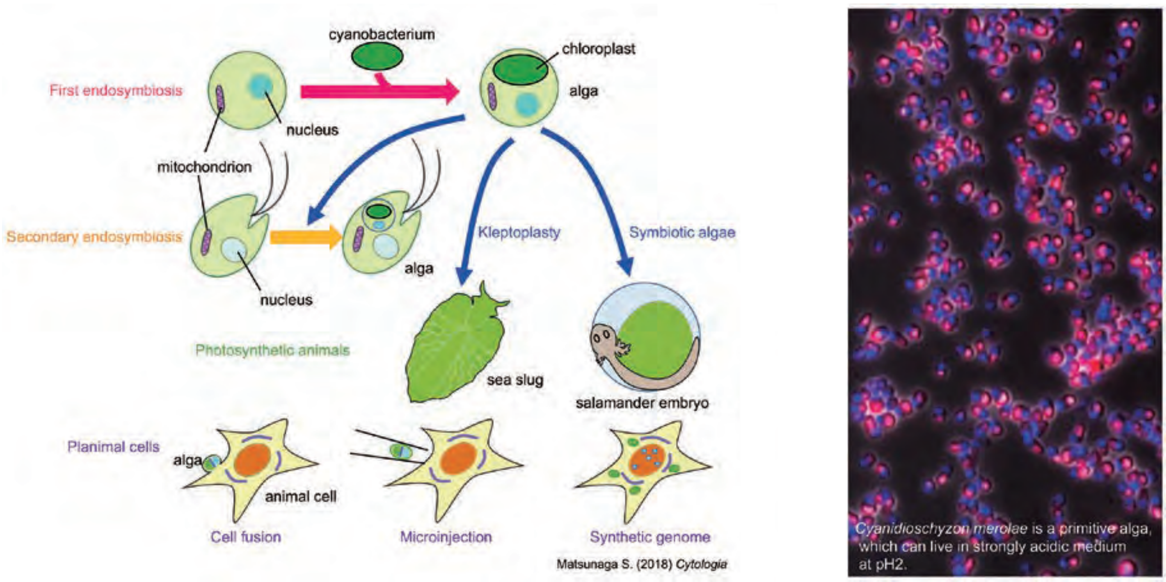


Figure 1　Creation of artificially photosynthetic animal cells “planimal cells”

garimura@rs.tus.ac.jp

Division of Biological Environment Innovation

Objectives	We 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.
Future Development Goals	We will create a new revolutionary academic field that has never existed by fusing individually developed research areas such as environmental biology and ecology.

Director
Professor,
Department of Biological Science and Technology,
Faculty of Advanced Engineering
Gen-ichiro Arimura
Ph.D.

With the theme of "environment," we will elucidate the environmental adaptability and molecular evolution mechanisms of various species, such as plants, mammals, reptiles, amphibians, fish, insects, and fungi species. We will explore applications of novel discoveries to aid the preservation of natural ecosystems and biological diversity.

Bioenvironmental research with the aim of creation of synergy between academic fields and technological seeds in an environmentally changing society.

Summary

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 produce new technological seeds that will contribute to protecting our lives in a global environment that is always changing.

<Section of Environmental Adaption>

We explore 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 biologial 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 (Univ. of Tokyo)

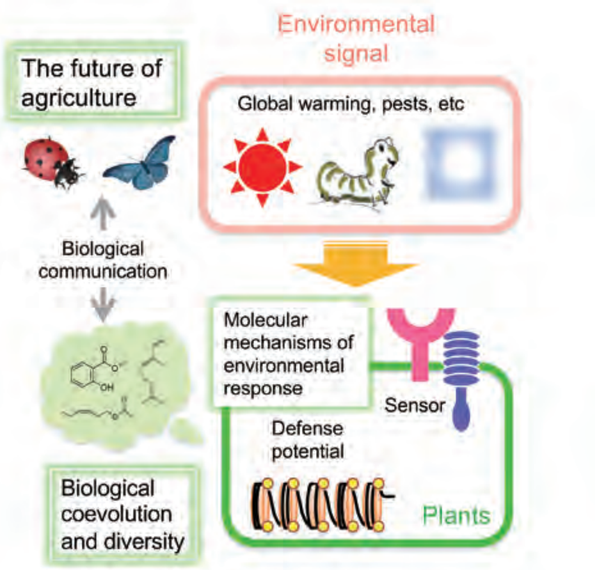


Figure 1

<Section of Molecular Evolution>

We analyze the mechanisms of genomic evolution and biology' s central dogma that enable adaptation and diversification of life from the viewpoint of evolution, which has been overlooked in the past. We also aim 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 (Univ. of Tokyo), Akiko Soma (Chiba Univ.)

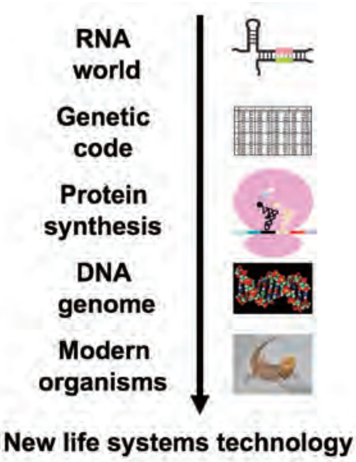


Figure 2

<Section of Nature Symbiosis>

We advance 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 (NIEFS)

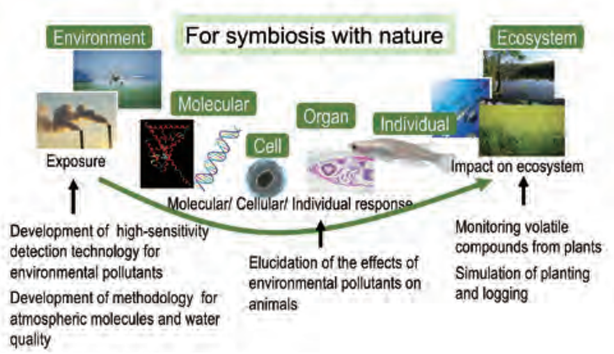


Figure 3

Established: April, 2021

makiya@rs.tus.ac.jp

Development of superior cell and DDS for regenerative medicine

Director
Professor,
Department of Pharmacy,
Faculty of Pharmaceutical Sciences

Makiya Nishikawa
Ph.D.

Objectives	To develop “superior cells” and DDS that can precisely control the function and in vivo fate of the cells for accelerating regenerative medicine
Future Development Goals	To create a novel and unique research field focusing on “superior cells” by collaboration of researchers with a variety of expertise

Cell-based therapy and regenerative medicine can be greatly accelerated by applying the concept of drug delivery system (DDS), i.e., drug delivery at the right time, at the right site of action, and in the right amount, to cells that are administered to patients for disease treatment. This division aims at developing “superior cells” whose functions are extremely upregulated and DDS that improves their functions.

Development of superior cells and DDS for accelerating regenerative medicine

History and Background of This Division

This division has a root in the DDS Research Division established in the Research Institutes for Science and Technology, Tokyo University of Science in 2003. In “Fusion of Regenerative Medicine with DDS Division” started from 2015, researchers headed by Professor Kimiko Makino have conducted collaborative researches focusing on regenerative medicine and the development of DDS for intractable diseases. To continue these activities, a predecessor round-table conference on Superior Cells and DDS Development for Regenerative Medicine was founded on 2020, which has been re-established as a division in April 2021.

Research Purposes and Goals of This Division

Under the overall goal of accelerating cell-based therapy and regenerative medicine, this division is focusing on (1) the development of “superior cells” by functionalizing the cells administered to patients for therapeutic purposes, and (2) the development of DDS that can precisely manipulate the in vivo distribution of cells and other functional molecules. The research purposes also include the development of therapeutic modalities against respiratory, brain, immune, cancer, and bone diseases.

Members and Their Roles in This Division

The four groups below cooperate with one another to accelerate the group research.

(1) Superior cell/DDS development group
This group designs and constructs superior cells, and develops DDS aiming at controlling the function and in vivo distribution of cells and other functional bioactive molecules. A goal is to develop “superior cells” that super-exceed the existing cells in terms of cellular functions through (1) the addition of novel functions, (2) the development of multicellular spheroids/organoids, and (3) the use of exosomes and other extracellular vesicles. In addition, various delivery systems are developed and applied to the superior cells and their usefulness is examined in animal models.

(2) Cell function regulation system development group
This group creates novel compounds that regulate cellular functions, and functional materials that can be used in cell-based therapy and regenerative medicine. These compounds and materials are supplied to other groups for applications and analysis. The data obtained using them are used for the development of more functional compounds/materials.

(3) Physical property control/analysis group
This group evaluates the physical properties of the items developed by the superior cell/DDS development group and the cell function regulation system development group, including superior cells, delivery systems, and functional compounds/materials. This group supports the optimization of these items by data feedback to the corresponding groups.

(4) Cell/tissue regeneration group
This group investigates the mechanisms of the regeneration of the lung, bone and other tissues, and treat the diseases of these tissues/organs. The interaction of superior cells/DDS and the immune systems is also analyzed.

Figure 1 summarizes the members and roles of each group. This division develops superior cells and DDS regenerative medicine by constructing organic interrelationships among the members of the division in pursuit of a new-stage collaboration.

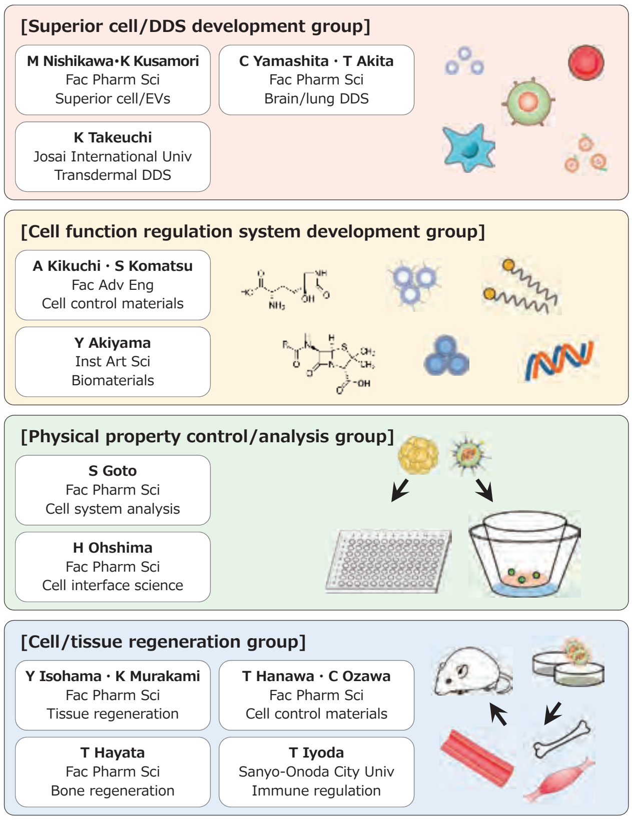


Figure 1 Members and roles of each group.

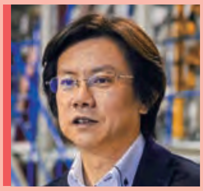
Information and Societal

Established: April, 2004

kmatsu@rs.tus.ac.jp

Center for Fire Science and Technology

Objectives	To promote the development of fire science and fire safety engineering, as well as the training of young researchers and specialist professionals.
Future Development Goals	To establish an education and research center at the highest level of the world, to meet various social demands concerning fire safety, and to contribute to society.



Director
Professor,
Department of Global Fire Science and Technology,Graduate School of Science and Technology
Ken Matsuyama
Dr. Eng.

Safety and security play pivotal roles in social development. TUS has, as a core of the fire safety engineering community both domestically and internationally, contributed to their advancement. In recent years, major cities in East Asia in particular have been undergoing marked development at a speed that no other Asian countries, including Japan, have ever experienced. We have a duty to mitigate this urgent situation sufficiently and, at the same time, to develop the innovative educational research system to prevent the occurrence of such fire accidents.

Research on the safety technology to protect human life and property from fires, and research on the fire science to support it.

Fire science at TUS

In 1981, Tokyo University of Science established Department of Fire Science and Technology in its Institute for Science and Technology. The aim was to set up a research center that would promote research on the safety technology to protect human life and property from fires, and research on the fire science that supports the technology. This development was initially started by the inauguration of a course on Architectural Fire Safety Engineering when the Department of Architecture, TUS was founded some 50 years ago. In this way, TUS laid the foundations of research and education on fire science ahead of the times, when such developments were unknown in other universities. These foundations have yielded a strong record of accomplishment of achievements since then, as amply illustrated in the fact that we have received two prestigious awards from the International Association for Fire Safety Science, the highest authority body of its kind in the world. The first of these was awarded for "Meritorious achievements in research contributing to the advancement of fire safety science", and the second was for "Meritorious achievements in education producing numerous researchers in fire science". In the past, Japan has suffered many fires in large buildings, which have claimed a large number of human lives. Members of the Department of Fire Science and Technology, TUS have been involved in appraising the majority of these serious building fires since 1968.

In recognition of this record of accomplishment, the Department was included in the 21st Century COE Program of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in fiscal 2003, as a "Center of Advanced Fire Safety Science and Technology for Buildings". It is currently engaged in activities aimed at establishing itself as a research and education center on fire science and fire safety engineering at the world' s highest level. Other aims are to promote the advancement of fire safety engineering and the training of young researchers and specialist professionals. We will continue our efforts in offering innovative education and research to protect human lives and properties from fires. Following the 21st Century COE Program, which concluded in 2007, the Global COE Program 2008, which would conclude in 2012, further adopted the "Center for Education and Research on Advanced Fire Safety Science and Technology in East Asia". Now, the Center restarted as a five-year project after having been selected as a 2013 recipient of the Private University Strategic Research Formation Assistance Grant from the MEXT. "Fire Safety Information Center in Asia based on Sharing Expertise-New Fire Safety in Information Society" was started. Fire Safety Information in Asia as a research base that focuses on building a network of networks, and works together to reduce fire risk in Asian cities, we have realized the global development of science, which is an issue for the 21st century.

Since April 2018, it has been playing a role as permanent organization of "Fire Science Research Center", as a center for fire science and fire safety engineering that represents East Asia.

Fire Research and Test Laboratory

Taking the opportunity of being adopted as the 21st Century COE Program, this laboratory was built in March 2005. It is one of the largest and most functional laboratories in the world meant solely for fire science. Built at Noda campus, it has a building area of 1,500 m^2, and gross floor area of 1,900 m^2, and a height of 20 m (Photo1). Members of the Center constructed a basic plan and did the designing utilizing their wealth of experiences, so that the laboratory would enable us to promote world-leading researches on fire sciences.

In March 2006, a large-scale fire furnace was added. Other large-scale experimental facilities to be included in the laboratory are composite furnace, fire resistance assessment machines for exterior wall materials, and combustion performance testing facilities, which are needed internationally, to contribute to the advancement of innovative researches.

Graduate School of Global Fire Science and Technology

The Master's Course in Fire Science & Technology at the Tokyo University of Science' s Graduate School of Global Fire Science & Technology was established in April 2010 is the first postgraduate fire science course in Asia, and is aimed at those employed in the area of fire science and safety (such as the construction, firefighting, and non-life insurance industries) as well as students from Japan and overseas who want to become fire safety technicians and fire officers.

The graduate school represents one aspect of the MEXTs Center of Excellence (COE) program, "Center for Education and Research on Advanced Fire Safety Science & Technology in East Asia", being promoted by the Center for Fire Science and Technology, and aims to establish Asia' s first definitive fire science education facility. The school to familiarize students with basic theory in a practical setting uses the Fire Research Test Laboratory.

In addition to the Master' s Course, students also have the opportunity to continue their studies, such as Doctoral Course in Fire Science & Technology established in April 2012. The Department of Global Fire Science and Technology is scheduled to be set up in April 2018 under the Graduate School of Science and Technology by reorganization of the Graduate School.

Designated Performance Evaluation

In order to improve fire safety technology and improve reliability at the Fire Science Research Center, the Building Standard Law has been applied to the construction method of buildings as a designated performance evaluation body designated by a designated performance evaluation body of the Ministry of Land, Infrastructure and Transport. Carry out performance evaluations required to obtain Minister of Land, Infrastructure, Transport and Tourism approval.

Performance evaluation is conducted by an evaluator who has expert knowledge of the field of performance evaluation based on the business method approved by the Minister of Land, Infrastructure, Transport and Tourism.

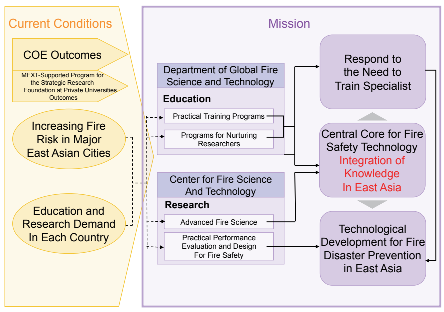


Fig. 1 Perspective of the Center for Fire Science and Technology

Photo 1 Fire Research and Test Laboratory

Fig. 2 Home Page
[Center for Fire Science and Technology]
https://gcoe.tus-fire.com/

Information and Societal

Established: April, 2021

ssi@rs.tus.ac.jp

Research Center for Space System Innovation

Objectives	To develop a virtuous cycle between earth and space research and solve various problems common to both.
Future Development Goals	Through technology transfer to collaborative private companies, RCSC aims to enhance state-of-the-art technologies that can improve life on earth and are usable in space.

Director
Professor,
Department of Electrical Engineering,
Faculty of Science and Technology

Shinichi Kimura

Ph.D.

The goal of the center is to become an innovation-driven hub for outer space and earth research through collaboration with various entities. These collaborations will allow innovation by fostering excellent human resources. Researchers, businesspersons, and students can explore the frontiers of space.

Living in space, bringing benefits to earth!
−Trial for Space-Terrestrial Dual Development on Space Living and Spacecraft−

Background of SSI Establishment

In recent years, space research has gained considerable attention. Space systems are multidisciplinary, and in addition to aerospace engineering, require expertise of various domains. As exemplified by recycling-based living in the closed environment of space, technologies required for humanity to reach into space are closely related to solving various earth-related problems, such as sustainable development and a recycling society.

About the Center

By pooling research and education activities related to space development and space environment utilization at Tokyo University of Science, the research center can be used for comprehensive analyses of various technological challenges, including research related to space travel.

The aim to is to develop a creation hub in which cross-disciplinary technologies and human resources can be pooled to form a virtuous cycle to solve problems common to both space and earth.

- By utilizing photocatalytic technology, which is the specialty of our university, we aim to develop life-support technologies in space and realize a safe and comfortable living environment on earth.
- We will demonstrate suborbital spaceplanes under development, and develop a new "space" market in partnership with the 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 strategic development.
- We will provide a place for education based on space research opportunities, secure and foster PhD students and young researchers, and develop an environment where they can experience "real" research.

Research Organization of SSI

▪ Education Unit
−Education based on "real" technology and experience that can be used in space−

Utilizing Tokyo University of Science research, such as flight missions, rocket launches, theoretical research in astrophysics, and astronomical observations, for the purpose of education can be an incentive for both researchers and students. In addition to participating in numerous missions, we will cooperate with domestic and international space development organizations, space venture companies, and space development companies and actively use the results for education.

▪ Photocatalysis International Unit
−Solving resource and environmental problems by using photocatalysis−

Photocatalysts, such as titanium dioxide, can effectively decompose organic pollutants and exhibit antibacterial and disinfecting properties because of their strong oxidative decomposition. Considerable research is being conducted on artificial photosynthesis using photocatalysts (hydrogen production by water decomposition and generation of valuable substances by carbon dioxide reduction). By advancing these studies, we can address existing issues, such as environmental purification and energy production, on earth and implement solutions in space.

▪ Space Colony Unit
−Advancement of space-stay technologies and promotion of their use, with a focus on space habituation−

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

▪ Spaceplane Unit
−Development of spaceplanes that can facilitate easy space travel−

The Spaceplane Unit is focused on the integration of technologies including system optimization technology, fault-tolerant systems, LOX/LNG engine operation, autonomous navigation technology, composite airframes and propellant tanks, and legalization of commercial space transportation. This integration is necessary to allow travel to and from space using spaceplanes in a manner similar to airplanes under the motto "Space is for everyone."

Established: April, 2014

o.taka@rs.tus.ac.jp

Research Division for Advanced Disaster Prevention on cities

Objectives	Building up theories for city environment plan with sustainability and resilience by updating modern architectures and infrastructures.
Future Development Goals	Building up theories for city planning with the sustainability and resilience against disasters and renewal of infrastructures in cities by merging various perspectives and knowledge of the architectural fields: materials, structures, planning, design, and history, into the primal purpose, disaster prevention.

Director
Professor,
Department of architecture,
Faculty of engineering

Osamu Takahashi
Dr.Eng.

This research division is composed of experts of architecture, city planning and civil engineering. Stuffs belong to Faculty of Engineering and to Faculty of Science and Engineering, and School of International Fire Science. For many years, researchers in this division continue to develop regional researches, contributions to local communities, and regional exchanges with thick accumulation of their researches. We aim to create results to contribute the areal development of Kagurazaka and Sotobori area where is the home of Tokyo University of Science.

Comprehensive research consists of three research fields: city culture, city performances, and city planning. The contribution of the results of research to the regions studied as academic knowledge that contributes to the formulation of city planning.

Characteristics of the Research Division

Nowadays, numerous issues regarding life in highly modernized and industrialized cities are caused by multiple and interrelated factors. Therefore, it is no longer sufficient to form, maintain, and operate a sustainable, resilient, and comfortable urban environment that overcomes these challenges only with the results of specialized and segmented research. However, among those challenges, there is one that has continued since long before the modern era and continues to face us, changing its form in various periods. -Disaster Prevention in Cities.

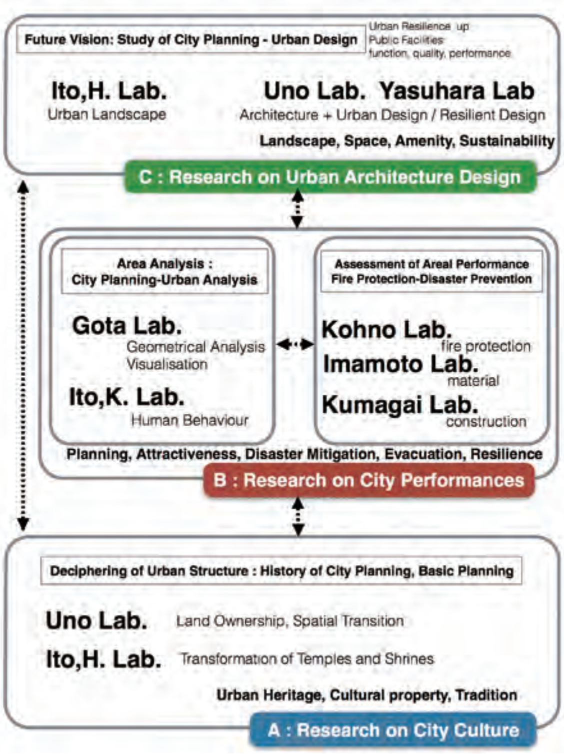
Even in recent years, the Tohoku and Kanto regions have experienced house collapses, tsunamis, and liquefaction following the Great Eastern Japan Earthquake in 2011; the Kyushu region experienced landslides and disruption of transportation networks following the Kumamoto Earthquake in 2016 and torrential rains at Northern Kyushu region in 2017 and 2020, and the Kansai region experienced the collapse of concrete walls following the Northern Osaka Earthquake in 2018.

Planning for disaster prevention from a more significant point of view, such as disaster risk in cities located in mountainous and coastal areas, has been discussed for some time.

However, unfortunately, the city planning comprehended micro perspectives, for example, examining and managing risks for human and material damages by collapsed or damaged facilities, and malfunctions of urban functions such as infrastructures have not yet sufficiently done.

Therefore, we have re-launched this research division as the "Research Division for Advanced Disaster Prevention on cities" to integrate the perspectives and knowledge of various fields of architecture.

In addition, this research has an aspect of social engineering in the study of political science and is expected by organizations such as governments, companies, and NPOs, in terms of the contribution by Tokyo University of Science of its results to societies.



Tbl. 1 Research field and partners

Fig. 1 Historical Changes of Kagurazaka "Outside of Sotobori" , Lecture of Professor Akihisa ITO, April 2014

Fig. 2 "Sotobori-Kagurazaka 7 images" , CKARD_TUS, April 2014

Fig. 3 "Brought Close between Town and Sotobori" Proposal to connect town and Sotobori with a barrier-free deck, Sotobori Reconstruction Plan Symposium, CKARD_TUS, May 2014

Established: April, 2020

seo@rs.tus.ac.jp

Statistical Science Research Division

Objectives	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.
Future Development Goals	This research division contributes to the study of mathematical data science with the aim of working closely with the Data Science Center, conducting joint research with companies, and becoming a base for the international research on statistical science.

Director
Professor,
Department of Applied Mathematics,
Faculty of Science
Takashi Seo
D.Sc.

Many professors involved in statistics are enrolled in our university, across campuses and undergraduate departments. In this research division, these professors from the field of statistical science come together and actively interact with each other to conduct a research which is unique to Tokyo University of Science. In the future, we would like to establish a "Statistical Science Research Center" and "AI and Data Science Theory Research Center."

Development of mathematical and applied statistics and their fusion

Background and Purpose of the Research Department

"Statistical science" is a field of study that uses the concept of probability to provide optimality theory and statistical methods to estimate the characteristics of the population behind the data obtained. In the recent years, "data science," which is associated with big data, as well as artificial intelligence (AI), has attracted significant attention. Furthermore, the core of these theories is "statistical science (statistical theory)," which has gained considerable prominence.

Accordingly, our university must build a research system that will lead not only Japan but also the rest of the world in the domain of AI and data science research. However, research in AI and data science is significantly extensive. Tokyo University of Science has been planning to conduct research in this field, intending to make the world proud. The university has many faculty members who specialize in "statistics," and these members are present across all its campuses. In particular, it is no exaggeration to say that our university is the only one in Japan with a huge number of researchers that specialize in mathematical statistics, which handles statistical inference logic mathematically. Tokyo University of Science also has the distinction of being strong in medical statistics, as it used to host a medical statistics program for the working members of society. Therefore, we aim to create a research stronghold where the researchers in these fields can come together and actively interact with members from across all campuses and departments to conduct research "unique to Tokyo University of Science." Furthermore, establishing this department will bring together researchers with specialties in different research topics but with a shared interest in a common theory. Our goal is to increase the level of research on essential theories and methods, and to create new theories and introduce new fields in the era of data science.

Members of Statistical Science Research Division

Name	Job title
HASHIGUCHI Hiroki	Professor, Faculty of Science Division I, Department of Applied Mathematics
MATSUZAKI Takuya	Professor, Faculty of Science Division I, Department of Applied Mathematics
MIYAOKA Etsuo	Professor, Faculty of Science Division II, Department of Mathematics
NISHIYAMA Takahiro **	Professor, Senshu University, Department of Business Administration
SEO Takashi *	Professor, Faculty of Science Division I, Department of Applied Mathematics
SHIOHAMA Takayuki **	Professor, Nanzan University, Department of Data Science
SOZU Takashi	Professor, Faculty of Engineering, Department of Information and Computer Technology
TAHATA Kouji	Professor, Faculty of Science and Technology, Department of Information Sciences
TERUI Nobuhiko	Professor, School of Management, Department of Business Economics
TOMIZAWA Sadao	Professor, Faculty of Science and Technology, Department of Information Sciences
TSUBAKI Michiko	Professor, School of Management, Department of Management
WATANABE Yuki	Professor, Organization for Education Advancement, Center for Teacher Education
YABE Hiroshi	Professor, Center for Data Science
ANDO Shin	Associate Professor, School of Management, Department of Business Economics
KAWASAKI Tamae ***	Associate Professor, Aoyama Gakuin University, College of Economics
KOIZUMI Kazuyuki ***	Associate Professor, Juntendo University, Faculty of Health Data Science
KUROSAWA Takeshi	Associate Professor, Faculty of Science Division I, Department of Applied Mathematics
MURAKAMI Hidetoshi	Associate Professor, Faculty of Science Division I, Department of Applied Mathematics
ANDO Shuji	Junior Associate Professor, Faculty of Science and Technology, Department of Information Sciences
HU Yannan	Junior Associate Professor, Faculty of Science Division I, Department of Applied Mathematics
ISHII Aki	Junior Associate Professor, Faculty of Science and Technology, Department of Information Sciences
NAKAGAWA Tomoyuki	Junior Associate Professor, Faculty of Science and Technology, Department of Information Sciences
SHIMOKAWA Asanao	Junior Associate Professor, Faculty of Science Division II, Department of Mathematics
SHINOZAKI Tomohiro	Junior Associate Professor, Faculty of Engineering, Department of Information and Computer Technology
FUJISAWA Kengo	Assistant Professor, Faculty of Science and Technology, Department of Information Sciences
KITANI Masato	Assistant Professor, Faculty of Science Division I, Department of Applied Mathematics
TEI Wanwan	Assistant Professor, Faculty of Engineering, Department of Information and Computer Technology
YAGI Ayaka	Assistant Professor, Faculty of Science Division I, Department of Applied Mathematics

*Director, **Visiting Professor, ***Visiting Associate Professor

Research Group

This research department is roughly divided into two groups that conducts research in the following fields.

1. Mathematical Statistics Basis Group
(Leader: Hiroki Hashiguchi (Department of Applied Mathematics, Faculty of Science Division I))

The "multivariate analysis group" comprises faculty members from Kagurazaka, Katsushika, and Noda Campuses and visiting associate professors. Focusing on the existing research themes of each faculty member, "multidimensional missing data analysis," "high-dimensional data analysis," "random matrix theory," and "dimension reduction method," we will conduct research with a view to developing the Applied Statistics Research Group. The "statistical model group" comprises faculty members from Kagurazaka and Noda Campuses and conducts research on topics such as "statistical modeling and model selection," "nonparametric methods," and "contingency table analysis." The method, handled by the Mathematical Statistics Basis Group, has a clear theoretical background and acts as a white box. However, the method of solving a "real-world problem" has a black-box aspect, such as in heuristics and deep learning. In constructing the theory of AI and data science, how to clarify the black-box-like solution of the latter using the methodologies of the former, as well as other methodologies, will be asked.

2. Applied Statistics Research Group
(Leader: Takashi Sozu (Department of Information and Computer Technology, Faculty of Engineering))

In the field of "medical statistics (biostatistics)," the faculty members of Katsushika Campus will conduct research activities related to the methodology of research design and data analysis, focusing on medical research. In particular, the Department of Information and Computer Technology, Faculty of Engineering, has an excellent and internationally acclaimed research track record, and new research is expected through intra and inter-group interactions. Research on the development of educational methods and systems via quantitative analysis in "educational engineering" will be conducted mainly by the faculty members from Kagurazaka Campus. Additionally, in recent years, the field of "sports statistics" has been gaining attention, and the faculty members from Noda Campus and visiting associate professors are actively conducting research in this field. Moreover, we plan to conduct joint research involving student exchange programs. Regarding the "statistical machine learning/mathematical optimization field," research on "natural-language processing that integrates statistical/machine learning and symbolic modeling," "large-scale nonlinear optimization problems related to big-data analysis and machine learning," and "statistical methods for computer-based data mining and pattern recognition" will be conducted mainly by the faculty members from Kagurazaka Campus.

Moreover, regarding one of the objectives of this research department, "collaboration with external institutions, such as companies, through a Data Science Center," a "data analysis team," which comprises research coordinators appropriate for each research content, will be formed, and joint research will be conducted.

Information and Societal

Established: April, 2020

wakabayashi.hideki@rs.tus.ac.jp

Department of MOT Strategy & Financial Engineering for Social Implementation “MOT-FESI”

Objectives	Contribute to systematization and database construction, social implementation, selection of research themes, and investment in venture companies.
Future Development Goals	Creation of a database on know-how in evaluation will make it possible to increase the success rate of research theme selection, new business creation, M&As, etc.

Director
Professor,
Department of Management of Technology, Graduate School of Management
Hideki Wakabayashi
Master of Engineering

There will be a coming together of top economists, top analysts, and venture capitalists who have conducted field surveys for many years for the purpose of fusing technology with finance, and social science approaches with science and engineering approaches. They will transform the tacit knowledge of their analysis know-how into explicit knowledge using the latest technologies such as AI.

Implement the practical knowledge accumulated in MOT in society by utilizing the theory of financial engineering

"Think Tank" with technology and management, theory and practice, MOT, TUSIM and TUSIC

The purpose of this project is for MOT—which conducts practical education fusing theory with practice in technology management—and TUS IC/TUS IM—which leads financial engineering—to interact with each other including the networks surrounding their organizations and personal connections, and to try various theoretical tools. The aim is to develop products utilizing advanced technologies and knowledge information, to conduct empirical research on new services, and to implement them in society. This can be called a think tank for the new Reiwa era, "TUS Research Institute."

In Management of Technology (MOT), many theoretical studies and case studies relating to innovation have been accumulated from large enterprises to venture companies. Various kinds of know-how, such as successful and failed cases of such technology strategies and investments in venture companies, are hidden as tacit knowledge in the field, including MOT, TUSIM/TUSIC, and VB investment track records of TUS. Some of them have been identified as case studies in papers and reports, although they are superficial, not transformed into explicit knowledge or practical knowledge, and nor are they related. They will become useful only when experts' knowledge is available. However, such know-how has not been passed on to the next generation, nor has it been shared within TUS and society. On the macro side, on the other hand, not only statistical data but also a lot of big data will be accumulated in the future. However, such macro data is explicit knowledge and is not linked to tacit knowledge and practical knowledge on a micro basis that is the background to making decisions in management strategy and conducting evaluations in VB investment. This may be due to the vertical division of expertise in each field, as well as insufficient exchange between macro and micro experts, technical and financial experts, and academic and business experts. In the future, many documents and kinds of know-how will be digitized and patterned by the development of AI. In addition, Center for Data Science of TUS has been established to enable knowledge sharing. Utilizing such AI, fintech, and ICT technologies, it will become possible to share and digitize kinds of know-how, accumulated at the micro level such as those within MOT and IM/IC, link with macro statistical data, and fuse them.

From FY2020, in connection with this, as a concrete application example, we are also working on theorizing the DAAE concept advocated by SHIFT Inc. and the company.

Currently, there are the following research groups.

① Connoisseur
② DAAE concept (by SHIFT) Theorized
③ Survey on the construction of a venture ecosystem and construction of a startup database (IM/IC)
④ Survey and research on domestic and overseas venture investment and support (IM/IC)

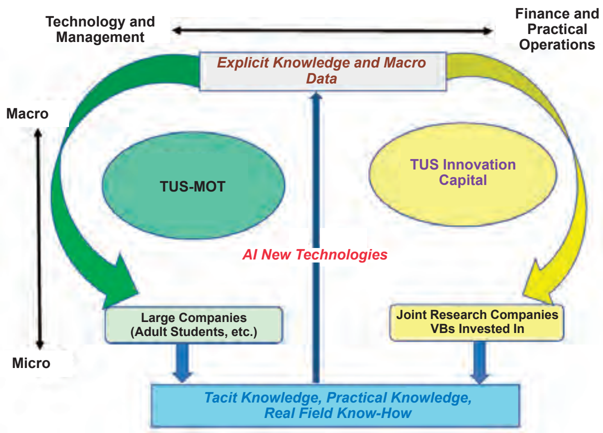
In-depth learning of tacit knowledge accumulated in hop, KPI extraction in step, and digitization in jump

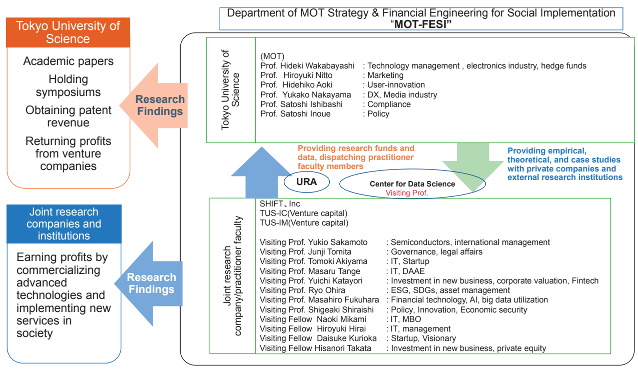
The first step is to extract keywords and KPIs that have been selected to the extent possible with respect to past MOT papers, and success/failure of published technical strategies and VB investments. Analysis is then performed on the relationship between these keywords/KPIs and data published externally, such as macro statistical data and annual securities reports. For example, we will analyze the correlation among the age and background of the manager, the mobility of employees, technology strategy, earnings, and VB investment.

As the second step, we will conduct interviews with corporate managers and VB investors who have many successful cases. In this way, we will analyze what are the key points for evaluation and investment decisions, and what decisions are made based on explanatory materials and questions and answers; and if necessary, we will conduct a questionnaire survey. We will then examine the relationship between this and the sample analysis described above.

For the third step, we will extract KPIs and keywords using AI, analyze the correlation with the macro-statistical data and the published data of annual securities reports, expand N, and make a database.

The figure shows the correlation analysis and mutual feedback between the real field know-how and practical knowledge of enterprises and VB investments at the micro level and macro statistical data. The horizontal axis shows the sharing of the cases and corporate strategies in MOT and the know-how in IM as a VC. On the Management of Technology side, it will become science and technology policy at the macro level while corporate strategy at the micro level; and on the IM and financial side, it will become portfolio construction in GPIF and policy of public and private funds at the macro level, while criteria for individual VCs to decide at the micro level.





Established: April, 2021

takemura@rs.tus.ac.jp

Parallel Brain Interaction Sensing Division

Director
Professor,
Department of Mechanical Engineering,
Faculty of Science and Technology
Hiroshi Takemura
Doctor of Engineering

Objectives	Our goal is to proceed from the conventional brain research and technology development focused on a single individual, creating a new brain research area analyzing the multiple brain interaction.
Future Development Goals	We will have several open seminars and workshops to find a common language for researchers in multiple dimensions, educate the young investigator and students, increasing the integration of researchers.

This division brings together researchers from both inside and outside the university in the field of the brain and neural information and systems to create an innovative academic field, "Parallel Brain," originating from the Tokyo University of Science. We aim to reveal how the brain activity of multiple individuals interacts with each other.

Toward Next-generation Brain Project: enter a new era of IoB (Internet of Brains)

Background and purpose of the division

Neuroscience (brain science) is a field of life science that is dramatically developing in the 21st century. People expect that, the maintenance of brain health will improve the quality of life in an aging society, and the application of information processing mechanisms in the brain lead to the creation of innovative technologies. In recent years, most thing 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 without even realizing 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, and by collaborating with related researchers outside of the university. We aim to create an innovative academic field of brain science, "Parallel Brain," which will be developed at the Tokyo University of Science in preparation for the coming era of the Internet of the Brain.

Research Organization and Members

We will 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 will become our original interdisciplinary brain research field. This division aims to elucidate and support the mechanisms of group formation and symbiosis in online space, and to build a theoretical background to describe the interaction between multiple brains common to social animals by using the common sensing technology in both mouse and human experiments through mathematical models. 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, to elucidate related mechanisms, and to create seeds for improvement drugs and diagnostic agents. We aim to create the seeds for new drugs and diagnostics.

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 aims to develop models and theories of brain information processing systems based on the results of multidimensional studies of functional brain imaging, cognitive psychology experiments, brain-type algorithms, etc., with a focus on human visual perception.

The division consists of 17 researchers in interdisciplinary neuroscience-related fields, including the Faculty of Science and Technology (Hiroshi Takemura, Takeo Ushijima, Takahiko Yamamoto, Akari Hagiwara, Takumi Asakura, Masataka Yamamoto), the Faculty of Pharmaceutical Sciences (Akiyoshi Saito, Daisuke Yamada), the Research Institute for Biomedical Sciences (Takeshi Nakamura, Shingo Koinuma), the Faculty of Engineering (Osamu Sakata, Takuya Hashimoto), the Faculty of Advanced Engineering (Eri Segi (Nishida), Kanzo Suzuki), the Institute of Arts and Sciences (Hiroko Ichikawa), and two visiting researchers: Ryohei Hasegawa from the National Institute of Advanced Industrial Science and Technology (AIST) and Asami Oguro-Ando from the University of Exeter Medical School.

We are mainly engaged in collaborative and 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. For details, please see the division's website.

Elucidation of brain functions controlling social behavior
(Prof. Segi and Prof. Oguro-Ando [University of Exeter])
～Elucidation of social behavior and brain development using 3p deletion syndrome mouse model

Investigation of cross-species vocal communication
(Prof. Ichikawa, Prof. Saito, and Prof. Yamada)
～Relationship between ultrasonic vocalizations in mice and the ultrasonic effect in humans

Study on the relationship between human gait behavior and personality traits
(Prof. Ichikawa and Prof. Takemura)
～Extraction and evaluation of gait characteristics derived from personal internal states in humans

Information and Societal
Established: April, 2021
mune@rs.tus.ac.jp

Division of Digital Transformation

Director
Professor,
Department of Information Sciences,
Faculty of Science and Technology
Munehiro Takimoto
Ph.D.

Objectives	Development of new integrated big data processing manners through breakthrough on mathematical theories in theory level, modeling methods in fundamental level, and statistical analyses of results in application level.
Future Development Goals	Development of big data processing manners that give accurate predictions for practical missions through mutually and spirally reflecting feedbacks between machine learning systems and statistical analyses of their results.

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. The processing manners include redesign from theory and implementation of systems and analyses. We believe that the challenges of this division will open new horizons for big data processing.

R&D on integrated big data processing manners based on new theory and implementation. They include mathematically redesigning machine learning systems and implementing high accurate and safe A.I. In addition, they achieve high confidential big data processing, through statistically analyzing the results generated by the systems.

Introduction and Background

In most science areas, which include DNA & molecule designs in micron level and earth environment sciences in macro level, it is so important to extract meaningful information from big data, which is superficially useless data with huge size. The extraction techniques are called data mining. Data mining is so costly that it is difficult to process it in traditional ways. To achieve much more efficient and accurate data mining and result in innovative science technologies, we have to propose new approaches based on mathematical theorems in algorithms and execution styles.

Division of Super Distributed Intelligent Systems, which is the previous division, especially focuses attention to medical and bio-systems, and has developed next generation data mining softwares together with researchers in artificial intelligence and statistics areas. In the process of that, we have found that we have to not only enhance parallelization/distribution and propose new approaches based on mathematical theorems to achieve new innovative technologies. In Division of Digital Transformation, we will improve the results of the previous division, and develop new big data processing manners based on performance and accuracy issues that the results have exposed. For example, we will continuingly enhance execution efficiency in the low level that is related with programming languages, parallel/distributed algorithms, and network protocols. In addition, we will design new deep learning manners based on adjusting their super-parameters based on combinatory theorem. Eventually, we will apply these techniques and models to several areas such as image processing, power systems, machine learning, robot systems, software engineering tools and so on, including data mining.

Research Hierarchy

We address the issues of big data processing in three hierarchical levels, “applications”, “fundamentals”, and “theories” as follows:

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.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 include 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.

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.

Research Topics

We currently have two main projects as follows:

① Genomix Data Science Medical Care of Cancer

It is a project that is advanced with National Cancer Center Exploratory Oncology Research & Clinical Trial Center (NCC-EPOC) as a cooperative research (Fig. 1). In this project, the purposes in the applicative level are cancer prevention, lengthening the time of a healthy life, improvement of quality of life and rehabilitation. Also, we are developing methods special to each applicative level purpose through fusing data sciences such as mathematical statistics, machine learning, information processing and statistical analysis, and cancer biological experiments.

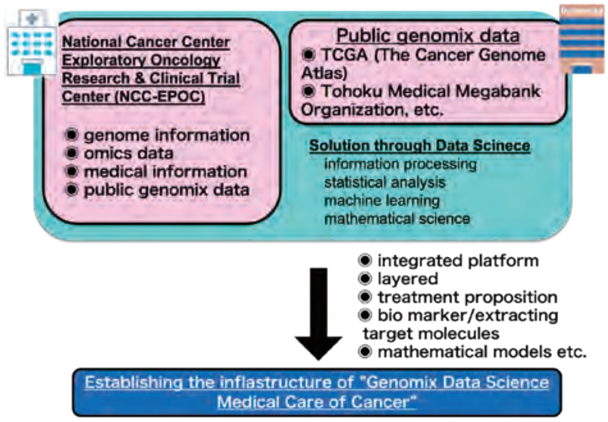


Fig. 1 Genomix Data Science Medical Care of Cancer.

② Implementation and Practical Realization of Cerebral Apoplexy Prevention by AI

We are developing the system that enables AI to support a doctor medically examining or treating patients of cerebral apoplexy using medical big data and engineering big data.

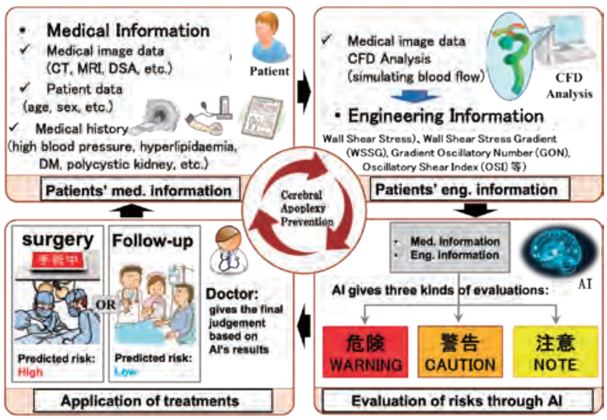
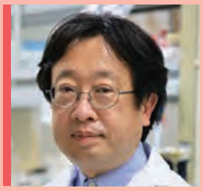


Fig. 2 Cerebral Apoplexy Prevention by AI.

akimoto@rs.tus.ac.jp

Medical Data Sciences

Objectives	Toward the realization of "Medical Data Sciences" based on digital medical data, we aim to solve the needs of clinical sites using data science methods and identify novel biomarkers for stratification.
Future Development Goals	In addition to the multifaceted analyses of global public medical data, it is expected that the unique "Medical Data Sciences" will be established by promoting cooperation with the National Cancer Center.



Director
Professor,
Department of Pharmaceutical Sciences

Kazunori Akimoto
Ph.D.

This division has been launched by a group of researchers specializing in data sciences and cancer biology, crossing the boundaries of the faculties and campuses of TUS. We aim to construct "Medical Data Sciences" at TUS by forming a network both inside and outside TUS, such as in collaboration with the National Cancer Center.

Construction of "Medical Data Sciences" establishing novel preventive and therapeutic methods for diseases at TUS

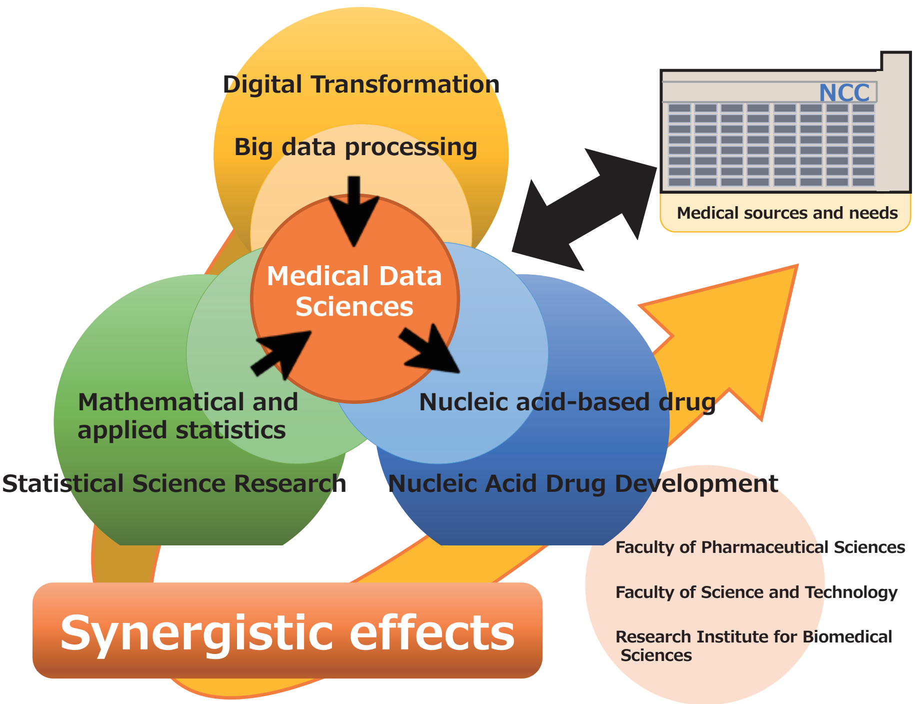
Objectives

The realization of "Medical Data Sciences" is becoming indispensable for establishing preventive and therapeutic methods for the cure of diseases. In medical care, Precision Medicine is being established: patients are stratified into specific groups by analyzing various medical big data, and the appropriate treatment is precisely selected for each patient group. However, at present, there are various problems pose barriers and is a limit to the provision of precise medical care. The purpose of launching this division is combined with data science methods and cancer biological methods to solve the medical problems by the collaboration between NCC-EPOC and TUS. The outcomes are expected to prevent cancer progression, extend healthy life expectancy, and realize high QOL and rehabilitation of cancer patients.

This division will promote new patient stratification and proposals for treatment methods by using data science research on medical big data as a starting point. There are various challenges to be overcome in the realization of "Medical Data Sciences". Therefore, we will make full use of data science methods accumulated in TUS to solve the problem and develop the theoretical foundation for proposing new therapeutic agents and treatments. A series of research will enable the creation of new academic fields and the establishment for the theoretical foundation of "Medical Data Sciences". Furthermore, we will promote next-generation education and the development of researchers who will adapt and develop "Medical Data Sciences" based on medical big data.

Current Situation of "Medical Data Sciences"

Attempts to solve medical problems with data science methods have become a global trend. Such efforts are also being actively carried out in Japan. This division uses NCC and global medical databases as medical sources and needs, but is characterized by using the data science methods accumulated at TUS. This is made possible by gathering specialists highly specialized data science and cancer biology of TUS. Although the network scale of researchers is smaller than the global networks by other groups, it secures the diversity of researchers' specialties and enables them to cooperate closely and flexibly carry out research activities.



Information and Societal

Established: April, 2022

t_yamamoto@rs.tus.ac.jp

Division of Smart Healthcare Engineering

Objectives	This division aims to conduct interdisciplinary research that contributes to the creation of a smart, healthy, and longevity society by researchers in a wide range of fields, including physiology, materials engineering, metabolism, integrated circuit engineering, radio frequency systems, and wireless communication engineering.
Future Development Goals	We are promoting active interactions among division members covering a wide range of specific fields, to emphasize joint research within and outside TUS, and to encourage young researchers.

Director
Associate Professor,
Department of Electrical Engineering,
Faculty of Science and Technology
Takahiko Yamamoto
Ph.D.

This division conducts elemental and interdisciplinary research on elemental technology and cross-disciplinary related to biometric sensing for health diagnosis to telemedicine, and high-quality, secure wireless communications, with the aim of supporting a smart, healthy, and longevity society in which people can lead healthy and high quality of life.

Creation of a Smart, Healthy, and Long-Lived Society that Supports People's Daily Life with High Quality of Life

The stresses that people may experience in daily life in society, even if they look minor and small, increase the risk of various diseases. Research is required to create a society where people can have daily healthy life with a high quality of life, even when their physiological functions are impaired or lost due to diseases. This division advocates the value of smart healthcare systems that support to realize such a society and conducts research on the development of elemental technologies and their effective integrations.

Research Structure and Members of this Division

This division is divided into four major groups, and some of their research activities are introduced below.

○ Sensing Group

・Elucidation of the mechanisms of health promotion and longevity through physical activity

Based on exercise physiology, behavioral physiology, material science, and metabolism, this group uses non-contact methods to quantify the amount of physical activity using animal models and explore the optimal amount of physical activity for physical and mental health in order to elucidate the mechanisms of health promotion and longevity from daily physical activity.

・Analysis of Message Nanoscale Materials Derived from Skeletal Muscle/Fat Tissue on Physical Function and Mental Health

Quantitative visualization of various mental and physical functions in humans is being attempted. In particular, Yanagita, Umezawa, and Kobayashi in our members have collaborated on a health promotion/longevity mechanism through exercise that is opened up by brain-organ communication, and are currently working on a research project to reveal the mechanism of brain-peripheral organ communication associated with changes in the amount of physical activity. Physicochemical and biological characteristics of nanoscale structures produced and released from the muscle and fat cells respond to environmental stimuli are also being investigated, aiming to visualize the brain-organ communications.

○ Device Operation and Control Group

・Transcutaneous energy transmission for electronic devices implanted in the body

Transcutaneous energy transmission and information transmission systems for medical electronic devices implanted inside the body are studied. This system completely reduces the risk of infection when supplying the drive energy essential for device operation. and achieves miniaturization and weight reduction through battery-less operation (Figure 1).

・Development of a Electromagnetic Phantom

When conducting wireless power or information transmission between

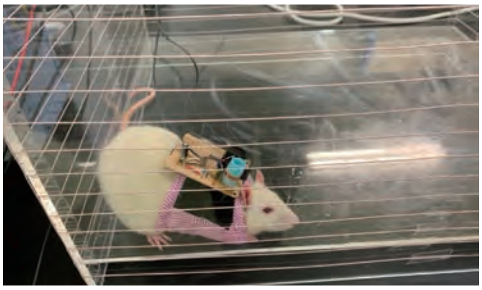


Fig. 1 Wireless power transmission to an implantable momentum meter

inside and outside living organisms, it is essential to investigate the effects of the presence of living bodies on the operation of the equipment and electromagnetic radiation from the equipment to ensure stable operation of the equipment. By using materials that mimic the electromagnetic properties of living bodies, these studies can be performed without animal experiments. In this research, we are developing various types of simulated living organisms.

○ Integrated Circuits and Signal Processing Group

The Transmission Group and the Information and Communication Group conduct research on high-frequency and high-speed signal processing circuits, low-voltage and low-power circuits, and their miniaturization, which are indispensable in the process of hardware implementation. We are developing high-performance amplifiers (low noise, high input impedance), analog-to-digital conversion circuits (ADC) and digital-to-analog conversion circuits (DAC) with high resolution and low power consumption, which are essential for measuring minute bioelectric potentials. In addition, as sensing devices become increasingly popular, we are analyzing device variation and studying variation-resistant circuits in order to realize robust circuits that are low-cost and highly resistant to variation.

○ Information and Communication Group

・Small antennas installed in the vicinity of living bodies

We are researching and developing compact, high-gain biometric antennas that can be used in the vicinity of living bodies and are not easily affected by them.

・Low power consumption, high quality, and secure wireless communication

This group is researching communication methods that achieve high speed, large capacity, high quality/low latency, multiple simultaneous connections, and low power consumption without degrading transmission quality. These are envisioned to transmit biometric and other information measured by the sensing group to medical facilities using wireless communications. Furthermore, research conduct on the promotion of secure, safe, and secure use of radio waves by defending information and communications against unauthorized access and malicious attacks.

Table 1 Member and Main Research Field

Affiliation	Job title	Name	Main research field	Group
Department of Electrical Engineering, Faculty of Science and Engineering	Associate Professor, Director	Takahiko Yamamoto	Medical Electronic Systems	Device Operation and Control
Department of Electrical Engineering, Faculty of Science and Engineering	Professor	Kenichi Higuchi	Wireless Communications	Information and Communication
Department of Electrical Engineering, Faculty of Science and Engineering	Professor	Akira Hyogo	Electronic Circuits and Integrated Circuits	Integrated Circuits and Signal Processing
Department of Information Science, Faculty of Science and Engineering	Professor	Shigeo Akashi	Information Theory	Information and Communication
Noda Division, Institute of Arts and Sciences, Institute of Arts and Sciences	Professor	Shinya Yanagita	Neurology and Exercise Physiology	Sensing
Department of Materials Science and Technology, Faculty of Advanced Engineering	Junior Associate Professor	Masakazu Umezawa	Pharmaceutical Science and Materials Engineering	Sensing
Department of Medicinal and Life Sciences, Faculty of Pharmaceutical Sciences	Junior Associate Professor	Masaki Kobayashi	Metabolism	Sensing
Department of Electrical Engineering, Faculty of Science and Engineering	Assistant Professor	Ryo Kishida	Integrated Systems and Reliability	Integrated Circuits and Signal Processing
Department of Electrical Engineering, Faculty of Science and Engineering	Visiting Professor	Kohji Koshiji	Radio systems and medical electronics	Device Operation and Control
Tokyo City University	Visiting Professor	Tatsuji Matsuura	Integrated Circuits and Signal Processing	Integrated Circuits and Signal Processing
Tokyo Polytechnic University	Visiting Associate Professor	Fukuro Koshiji	Bio-Communication	Information and Communication
Nippon Institute of Technology	Visiting Researcher	Kenko Ohta	Emotion Analysis	Sensing
Tokyo International University	Visiting Researcher	Natsuko Kubota	Physiology	Sensing
Tokyo Institute of Technology	Visiting Researcher	Hiroki Sato	Integrated Circuits and Signal Processing	Integrated Circuits and Signal Processing
ZENKIGEN	Visiting Researcher	Issei Hashimoto	Sensitivity Engineering	Sensing

Fundamentals

Established: April, 2020

kato@rs.tus.ac.jp

Research Alliance for Mathematical analysis

Objectives	To make interdisciplinary researches with researchers of mathematical analysis, numerical analysis, physics, chemistry, biology and engineering
Future Development Goals	We make research alliance with other divisions in our research institute and institutes outside the university

Director
Professor,
Department of Mathematics,
Faculty of Science

Keiichi Kato

Mathematical Sciences

This division has been established on the April of 2020, as the succession of Division of Mathematical modeling and mathematical analysis. Our aim is to make interdisciplinary researches between mathematical analysis, numerical analysis, physics, chemistry, biology and technology. The members of our division are willing to cooperate to those who need to techniques of mathematical analysis, numerical analysis or theoretical physics.

Interdisciplinary researches between mathematical analysis, science and engineering

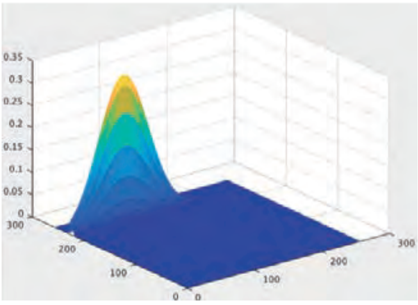
This division has been established on the April of 2020, as the succession of Division of Mathematical modeling and mathematical analysis. The aim of our division is to make alliance research over mathematical analysis, numerical analysis, physics, chemistry, biology and engineering.

Alliance inside the division

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

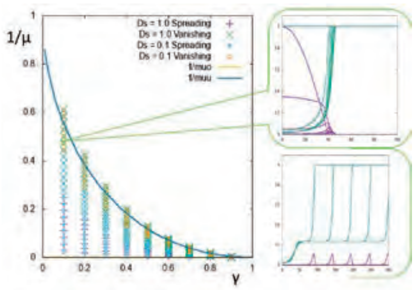
• Group of mathematical physics

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



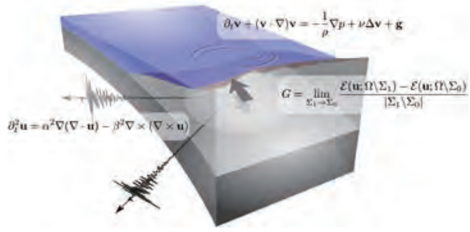
• Group of mathematical biology

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.



• 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.



Alliance with other divisions in RIST

From the beginning of the 21st century, the importance of mathematics has been known more and more even in our country. In the research institute for Science and technology(RIST), we have two mathematical division: this division and the division of modern algebra and cooperation of engineering(DMACE). We will make research alliance with other divisions such as divisions of condensed matter physics, divisions of chemistry, divisions of biology and divisions of engineering with cooperation of DMACE.

Alliance with other institutes

On the January of 2020, we have concluded the agreement for research alliance between RIST and Research Alliance Center for Mathematical Sciences(RACMaS) in Tohoku University. We will promote research alliance between this division and RACMaS based on the agreement. We also try to make research alliance with other institutes.

Fundamentals

Established: April, 2020

tsai@rs.tus.ac.jp

Division of Nano-quantum Information Science and Technology

Objectives	Our research division aims at optimization of the operation condition for superconducting, optical and spin qubits.
Future Development Goals	This division will contribute to the practical realization of the quantum computer thirty years later.

Director
Professor,
Research Institute for Science and Technology

Tsai Jaw-Shen
Ph.D.

The research of quantum computer has been very active during the recent years. One of the reasons of the rapid progress is the improvement in coherence time of the qubit due to the advancement of nanotechnology. However, the current status of the quantum circuit is still far from the real implementation. We must accelerate the pace of research and development toward the truly fault-tolerant quantum computer.

Nanotechnology and its applications to quantum information and electronics

Background

In recent years, demonstrations of quantum supremacy by Google and later the University of Science and Technology of China, the establishment of IBM's commercial quantum computer, and the D-Wave System's 4,000-bit quantum annealing machines, quantum information processing has made remarkable progress. All of the above systems are based on superconducting qubits, but quantum computing systems based on other systems such as light, semiconductors, and ions are also being actively researched around the world.

Our targets

Our division mainly investigate the superconducting qubit. Qubit cause errors like ordinary classical semiconductor circuits. Malfunction of the qubit also would come from the breakdown of the quantum superposition state. Such phenomenon is called decoherence. The fault-tolerant quantum computer would be realized by employing a quantum error correction procedure, and it would deliver truly practical applications. The division plans to carry out research of several kinds of fault-tolerant quantum circuits with superconducting qubits. It is expected that the fault-tolerant quantum computer would appear by 2050, and we would try to contribute to its realization.

Superconducting qubit is considered as the most suitable platform for the quantum computers. However, it also has its problems. The coherence time of superconducting qubit is still short, for example. Beside the superconducting qubit, qubits based on other physical systems, like photon, ion, atom and electron spin in quantum dot have been investigated earlier. In our division, spin qubit and optical qubit will also be investigated, along with the superconducting qubit.

Moonshot Research & Development Program

The research subject “Developing bosonic code using superconducting resonator” was adopted to the government moonshot research & development program in 2020. The program leader is Dr. Tsai and Drs. Yoshihara, Takayanagi, Watabe and Hashizume join this program.

This program continues until 2025 (https://ms-iscqc.jp).

Collaboration with the University of Tokyo

Other research activity of the division is the collaborated one with the University of Tokyo. The partner organizations are the Institute for Nano Quantum Information Electronics (http://www.nanoquine.iis.u-tokyo.ac.jp/) and Quantum Innovation Co-creation Center. The research subject is quantum optics utilizing single photon. Drs. Sanaka, Sadgrove, and Tkachenko join this activity.

Members

Affiliation	Name
Tokyo University of Science	Jaw-Shen Tsai
Tokyo University of Science	Kaoru Sanaka
Tokyo University of Science	Mark Paul Sadgrove
Tokyo University of Science	Fumiki Yoshihara (June, 2022 -)
Tokyo University of Science	Noboru Watanabe
Tokyo University of Science	Satoshi Iriyama
Tokyo University of Science	Takeo Kamizawa
Tokyo University of Science	Yoichiro Hashizume
Tokyo University of Science	Georgiy Tkachenko (July, 2022 -)
The University of Tokyo	Hideaki Takayanagi
Shibaura Institute of Technology	Shohei Watabe
The University of Tokyo	Yasuhiko Arakawa
Riken	Seigo Tarucha
NEC	Tsuyoshi Yamamoto
NTT	Shiro Saito

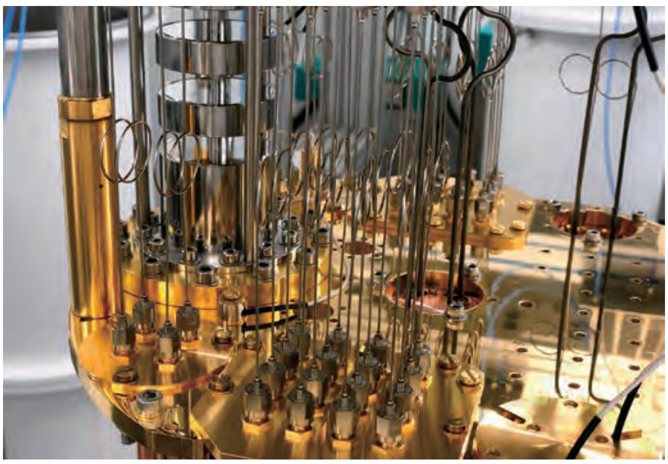


Fig. 1 Heart of the dilution refrigerator for superconducting qubits’ evaluation. Multiple wideband signal lines can be seen.

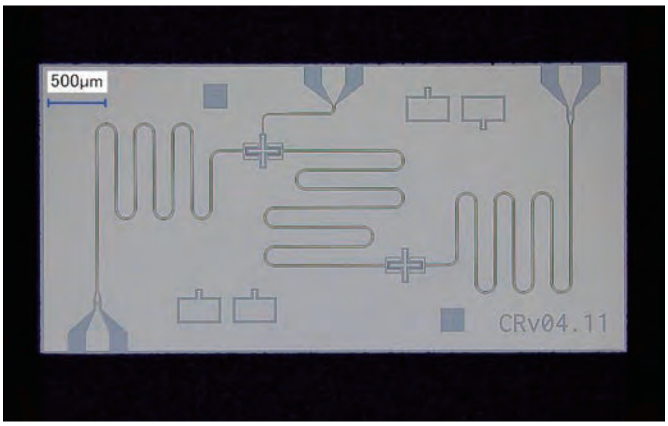


Fig. 2 2-bit quantum logic gate. Two transmon-type qubits (cross-shaped structures) are connected by a superconducting resonator.

(Tokyo University of Science, Tsai Laboratory)

Established: April, 2021

ito_hiroyuki@rs.tus.ac.jp

Modern Algebra and Cooperation with Engineering

Director
Professor,
Department of Mathematics,
Faculty of Science and Technology

Hiroyuki Ito

Doctor of Science

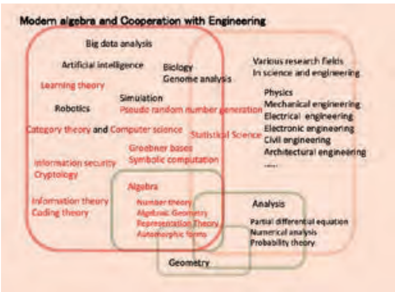
This division do research from purely theoretical mathematics to experimental engineering, and make cooperative environment between mathematicians and researchers in algebra based engineering. Furthermore, the division will contribute to make cooperative research between algebra and engineering which induces mathematical innovation. The division continue to play an important role as the international hub for research on algebras.

Objectives	To research and develop algebra itself and algebra based engineering, also to make cooperative research on algebra and engineering, thereby to make a contribution to mathematics and engineering.
Future Development Goals	To make contribution to mathematics and engineering, and to continue to be the center of research on algebra and its applications to engineering.

Theoretical research on algebra and its applications on engineering

Background and purpose of the division

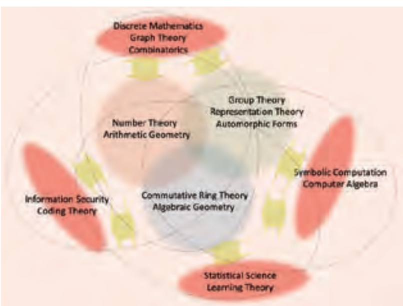
It is important for mathematics, which has more than 2000 years history for research, to interact with other research fields outside mathematics. Research area of pure mathematics is roughly divided into three parts, algebra, geometry and analysis. One can think that algebra and analysis are two wheels 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 technology, information science, 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.



Research on Modern Algebra and Cooperation with Engineering

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 cooperative research between pure mathematics and engineering.

More precisely, 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.



There are three special features of this division. 1) The generations of researchers are widely distributed. 2) They have enough experiences of joint research not only for domestic but also for international. 3) The researchers have been managed continuously various seminars and symposiums inside Tokyo University of Science.

About the Future of Modern Algebra and Cooperation with Engineering

Since making relationship between person and person in various research fields has already done, the next step is expanding the relationship between person and person to the cooperative relationship between person and group, group and group. Furthermore, develop a new cooperative research fields based on algebra. Also keep to play an role as an international research hub cooperate 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

Open Innovation Project

Established: April, 2022 ✉ koho@admin.tus.ac.jp

The Kao “Kirei” Future Open Innovation Project

Director
Associate Professor,
Department of Pure and Applied Chemistry,
Faculty of Science and Technology
Isao Shitanda

Objectives	Kao will promote the development of innovative technologies to enrich people's lives by collaborating with Kao's technologies and the TUS's knowledges in biochemical science, interface science, and brain science.
Future Development Goals	We will work not only on research and development, but also on contributions to the SDGs and human resource development. Details of these efforts can be found in the movie※ at TUS Forum 2021 (Japanese only). ※ URL: https://www.tus.ac.jp/tusforum/2021/archive.html#point03

This open innovation project is a joint research project between Kao Corporation ("Kao") and the Tokyo University of Science (TUS). This is the first project designated under the "Open Innovation Projects" system of the RIST. Kao and TUS are both working to solve social problems through science and technology, and we expect significant synergy effects through collaborative research and development.

Develop innovative technologies to enrich people's lives

Based on 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 sustainable society and 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 "The Kao “Kirei” Future Open Innovation Project" and started joint research. While recognizing their respective social missions and roles, both parties are promoting the development of innovative technologies to enrich people's lives.

The following three initial joint research themes are in progress. We aim to 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 1
Research on Biofuel Cells and Biosensors

Innovative development of bio-devices

1) Investigation of the practical application of health monitoring devices that generate power from the human body
2) We will study the realization of an ultimate health care device that allows anyone to manage health information at any time by incorporating biofuel cells, which provide clean and safe power supply regardless of location, into wearable devices.

テーマ１：バイオデバイスの革新的開発

人体から発電するヘルスモニタリングデバイスの実用化に向けた検討

Theme 2
Research on Foaming Control and Functionalization

Innovative development of foaming control technology

1) Maximize surfactant performance using small amounts of polymers to achieve comfortable and rich foam with a minimum of materials
2) Understand the synergistic effects of mixing surfactants and polymers to create technologies that can control various foam performances

テーマ２：泡立ち制御技術の革新的開発

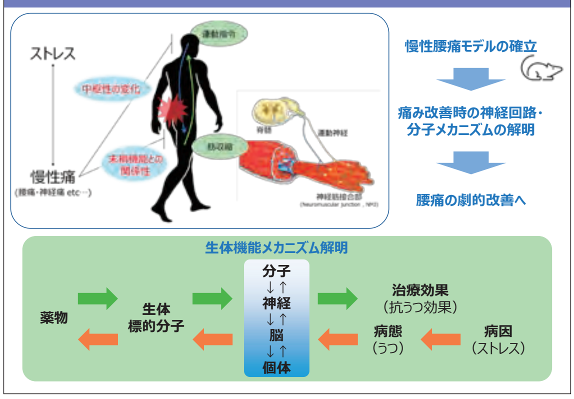
Theme 3
Research on Neural and Molecular Mechanisms of Pain

Innovative development for improvement of low back pain

1) Elucidation of neural and molecular mechanisms of chronic low back pain
2) Elucidation of the mechanism of stress-induced aggravation of low back pain and search for treatment methods by modulating brain functions

Through the above, we aim to clarify the relationship between the onset of low back pain and stress, and to improve low back pain by regulating brain functions.

テーマ３：腰痛改善のための革新的開発



In addition to research and development on the above existing themes, discussions are held on the establishment of new themes. In order to discuss new themes, we will hold a new technology presentation to introduce the TUS's technological seeds. Brainstorming sessions are also planned to discuss the expansion and development of research and development into new areas. In addition, we also offer special lectures for undergraduate and graduate students and other human resource development programs to expand organization-to-organization collaboration.

RIST Organization Chart

Chairman of the Board of Governors

President

Organization for Research Advancement

Research Institute for Science & Technology

Research Institute for Science & Technology

Research Institute for Science & Technology Steering Committee

Research Divisions

- Carbon Value Research Center
- Division of Nanocarbon Research
- Division of Colloid and Interface Science
- Chemical Biology Division Supported by Practical Organic Synthesis
- CAE Advanced Composite Materials and Structures Research Division
- Division of Nucleic Acid Drug Development
- Research Division for Advanced Disaster Prevention on cities
- Division of Synthetic Biology
- Renewable Energy Science & Technology Research Division
- Division of Ambient Devices Research
- Division of Biological Environment Innovation
- Statistical Science Research Division
- Department of MOT Strategy & Financial Engineering for Social Implementation
- Research Alliance for Mathematical analysis
- Division of Nano-quantum Information Science and Technology
- Research Group for Advanced Energy Conversion
- Development of superior cell and DDS for regenerative medicine
- Parallel Brain Interaction Sensing Division
- Division of Digital Transformation
- Modern Algebra and Cooperation with Engineering
- Medical Data Sciences
- Division of Smart Healthcare Engineering

Research Centers

- Center for Fire Science and Technology
- Water Frontier Research Center
- Research Center for Space System Innovation [SSI]

Joint Usage / Research Center

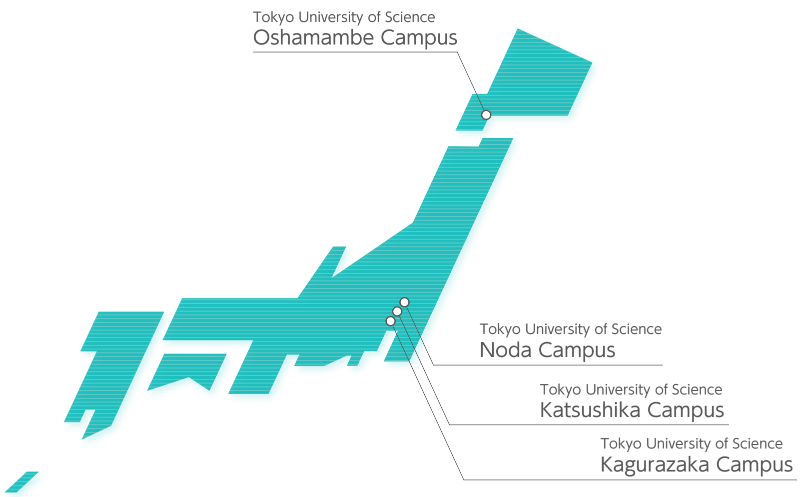
- Research Center for Fire Safety Science

The Open Innovation Projects

- The Kao “Kirei” Future Open Innovation Project

2022.4.1

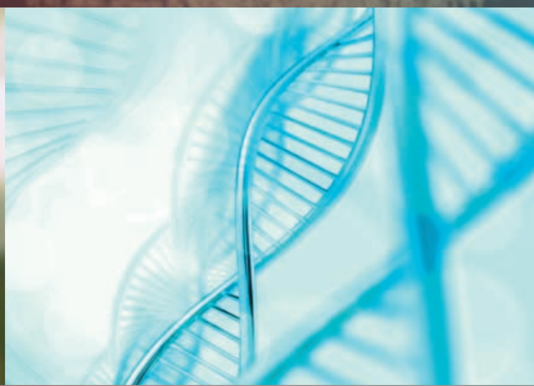
Campus Map



Tokyo University of Science
Research Support Division

Noda Campus 2641 Yamazaki, Noda-shi, Chiba-ken, 278-8510 JAPAN
[TEL] +81-4-7122-9151 [FAX] +81-4-7123-9763 [URL] https://rist.tus.ac.jp/en/

Kagurazaka Campus 1-3 Kagurazaka, Shinjuku-ku, Tokyo, 162-8601 JAPAN
Katsushika Campus 6-3-1, Niijuku, Katsushika-ku, Tokyo, 125-8585 JAPAN



Tokyo University of Science
2022 / 2023

RIST creates new directions in science and technology achievable"Only at TUS".