RIST TUS

Research Institute for Science & Technology

2016/2017

Information and Societal

Center for Fire Science and Technology
Division of Advanced Communication
Division of Advanced Urbanism and
Division of Things and Systems
Atmospheric Science Research Division
Division of Super Distributed Intelligent
Division of Intelligent System Engineering

Bio and Pharmacy

Research Center for Chirality
Translational Research Center
Division of Bio-organometallics
Academic Detailing Database Division
Division of Medical-Science-Engineering Cooperation
Fusion of Regenerative Medicine with DDS
Division of Agri-biotechnology
Brain Interdisciplinary Reseach Division

RIST TUS

Research Institute for Science & Technology

Structural Materials

International Research Division of Interfacial Thermo-fluid Dynamics

Fundamentals

IR FEL Research Center
Imaging Frontier Center
Division of Mathematical
Division of Modern Algebra

Functional Materials

Photocatalysis International Research Center
Division of Nanocarbon Research
Division of Thermoelectrics for Waste Heat Recovery
Division of Colloid and Interface Science
Division of Synergetic Supramolecular Coordination Systems in Multiphase
Water Frontier Science Research Division
Photovoltaic Science and Technology Research Division
Advanced EC Device Research Division
Advanced Agricultural Energy Science and Technology Research Division

Center

Funded jointly by TUS and MEXT-Supported Program for the Strategic Research Foundation at Private Universities. Expected to form a strategic research organization after termination.

Division

Funded exclusively by a core of a Center.

Building a better future with

Researches

Architecture

Systems

Modeling and its Mathematical Analysis

and Cooperation with Engineering

TUS and expected to be

Joint Usage / Research Center

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

Science

Message from the Director

Within the university, education and research are inseparably linked to one another and have a synergistic relationship which contributes to significant growth and development.
Education represents the built-in culture which is the foundation of each academic area, and it is driven by the undergraduate and graduate schools; while, research requires activities which transcend the boundaries of those academic areas. If education is the longitudinal axis, then research is the horizontal axis.
The Research Institute for Science and Technology plays the role of that horizontal axis within the Tokyo University of Science and is an organization which exists to support outstanding and original research.
On April 1, 2015, a newly reorganized Research Institute for Science and Technology was established. Research within the Institute is carried out by different research divisions, research centers and joint usage research centers which are organized within a full-scale, comprehensive research promotion framework.
The foundations of the Research Institute for Science and Technology were laid by its first Director General, Dr. Hidetoshi Fukuyama.
The specific aims of the Research Institute for Science and Technology are to transcend categories of basic and applied science in pursuing substantive, cross-field cooperation between different academic areas based upon a thorough, fundamental knowledge of each area; to eliminate barriers between those inside and outside of academia and between those inside and outside of Japan to actively carry out research; to strengthen the fluidity and mobility of faculty and staff within the university; and to achieve a greater connection between the university and society. The expectation for the Institute is that it will capitalize on the terrific research environment full of vitality and unity which has been created and will produce tangible results via outstanding, highly diverse graduates amply equipped with the creativity needed for the future.
It is towards this end that we seek to do away with the barriers between research centers and divisions, foster mutual cooperation, create new research clusters and produce new academic trends and results.

Director,
Research Institute for Science and Technology

Dr. Makoto Asashima

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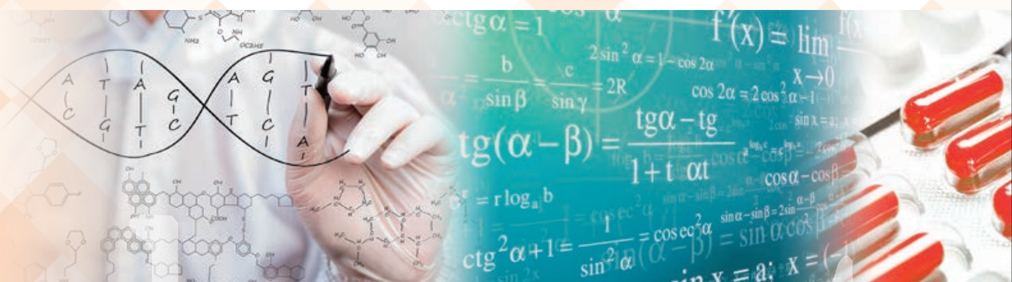


Only at

Joint Usage / Research Center

Rist Organization Chart

The Edge of Cross Disciplines

Research Centers / Research Divisions

2016/2017

TUS

Functional Materials

Photocatalysis International Research Center

Established: April 2013
pirc@rs.tus.ac.jp

Director
President,
Tokyo University of Science
Akira Fujishima

Objectives	To advance the photocatalysis to the next-stage by integrating technology with self-cleaning, artificial photosynthesis and environmental cleanup.
Future Development Goals	To establish top-level center for photocatalysis, as well as to transmit remarkable achievement towards the world in order to expand the field of photocatalysis.

Innovation of science and technology for solving energy and environmental issues in a global scale and a life style is urged. Photocatalysis has been paid attention for that science and technology. Researchers with high potentials in TUS work together on the important topics through collaboration in this center. We push forward with our work for the sustainable future.

To deepen the photocatalysis technology for the construction of practically usable photocatalysis systems

The field of photocatalysis can be traced back more than 80 years to early observations of the chalking of TiO2-based paints and to studies of the darkening of metal oxides in contact with organic compounds in sunlight. During the past 20 years, it has become an extremely well researched field due to practical interest in air and water remediation, self-cleaning surfaces, and self-sterilizing surfaces. During the same period, there has also been a strong effort to use photocatalysis for light-assisted production of hydrogen.

The fundamental aspects of photocatalysis on the most studied photocatalyst, TiO_2, are still being actively researched and have recently become quite well understood. The mechanisms by which certain types of organic compounds are decomposed completely to carbon dioxide and water, for example, have been delineated. However, certain aspects such as the photo-induced wetting phenomenon, remain controversial, with some groups maintaining that the effect is a simple one in which organic contaminants are decomposed, while other groups maintain that there are additional effects in which the intrinsic surface properties are modified by light. During the past several years, powerful tools such as surface spectroscopic techniques and scanning probe techniques performed on single crystals in ultrahigh vacuum, and ultrafast pulsed laser spectroscopic techniques have been brought to bear on these problems, and new insights have become possible. Quantum chemical calculations have also provided new insights. New materials have recently been developed based on TiO_2, and the sensitivity to visible light has improved.

In the Photocatalysis International Research Center, we will develop fundamental and applied research of the photocatalysis. The center provides support for interdisciplinary photocatalytic materials research and education of the highest quality by collaboration with industry, academia, and the government under one roof while addressing fundamental problems in science and engineering that are important to green innovation.

Research on the Energy Photocatalysis

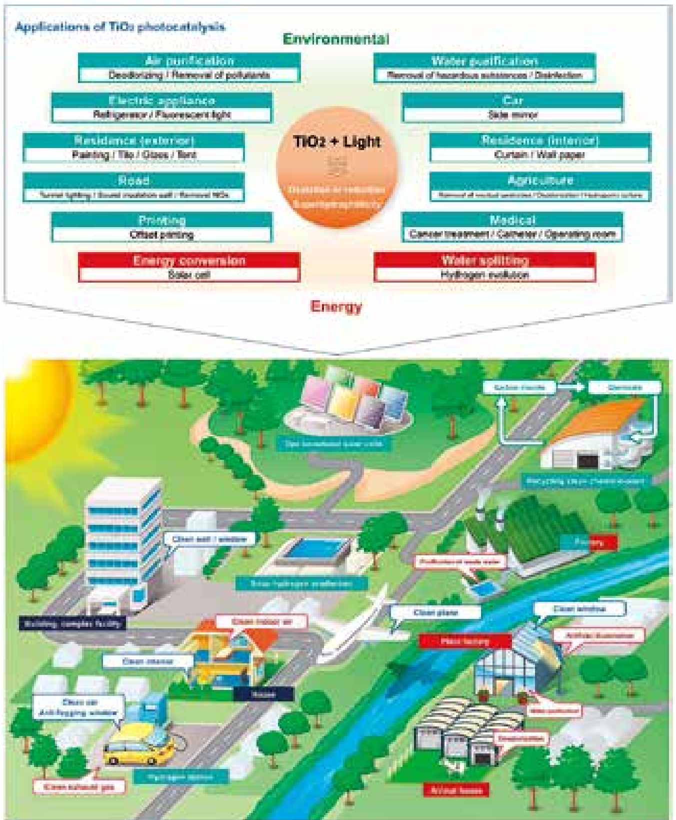
Utilization and conversion of solar energy to fuels and electric energy are an urgent issue in the world. It is indispensable to construct clean energy systems in order to solve the issues.

Hydrogen will play an important role in the system because it is an ultimate clean energy. It can be used for a fuel cell. Moreover, hydrogen is used in chemical industries. Hydrogen has to be produced from water using natural energies such as sunlight if one thinks energy and environmental issues. Therefore, achievement of solar hydrogen production from water has been urged. Photocatalytic water splitting is an attractive reaction and will contribute to an ultimate green sustainable chemistry and solving energy and environmental issues resulting in bringing an energy revolution. We are working on the development of new photocatalyst materials for solar water splitting and CO_2 fixation based on the original strategy for the design of photocatalyst materials. Moreover, science to understand photocatalytic processes is studied.

Research on the Environmental Photocatalysis

As the single most important effect of TiO_2 photocatalysis, its bactericidal activity has been studied in various microorganisms, as well as in fungi. In addition, the mechanism of this antimicrobial photocatalysis has been revealed as the loss of cell membrane integrity caused by electrons/holes or by reactive oxygen species. While photocatalysis for air-purification has been scientifically studied for more than two decades, and the bactericidal activity of TiO_2 photocatalysts is thus well known, in-depth studies of selective applications of TiO_2 photocatalysts are still required. Therefore, we are mainly engaged in research in the following themes for development of novel photocatalytic air-purification units.

- ○Developing test methods for tracing quantitative decrease of airborne bacteria in the fields based on the JIS and ISO standard test methods for antibacterial performance.
- ○Fabrication of prototype air-purification unit using a novel photocatalytic filter, titanium-mesh sheet modified with TiO_2.
- ○Evaluation of antibacterial performance of prototype air-purification unit together with other tests for decomposition of gaseous pollutants.



Vision of future community based on photocatalysis

We push forward with our work, as plants grow toward the light.

Established: October 2012 takahiro@rs.tus.ac.jp

Functional Materials

Division of Nanocarbon Research

Director
Associate Professor,
Department of Liberal Arts,
Faculty of Engineering
Takahiro Yamamoto

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 biomolecules.
Future Development Goals	To promote advanced researches on nanocarbons based on tight and highly active collaborations of division members.

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 a new field 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

Material 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-Biomolecule Interaction

○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.

Theoretical Study on Novel Properties

○We investigate the friction property of surface of nanocarbons.

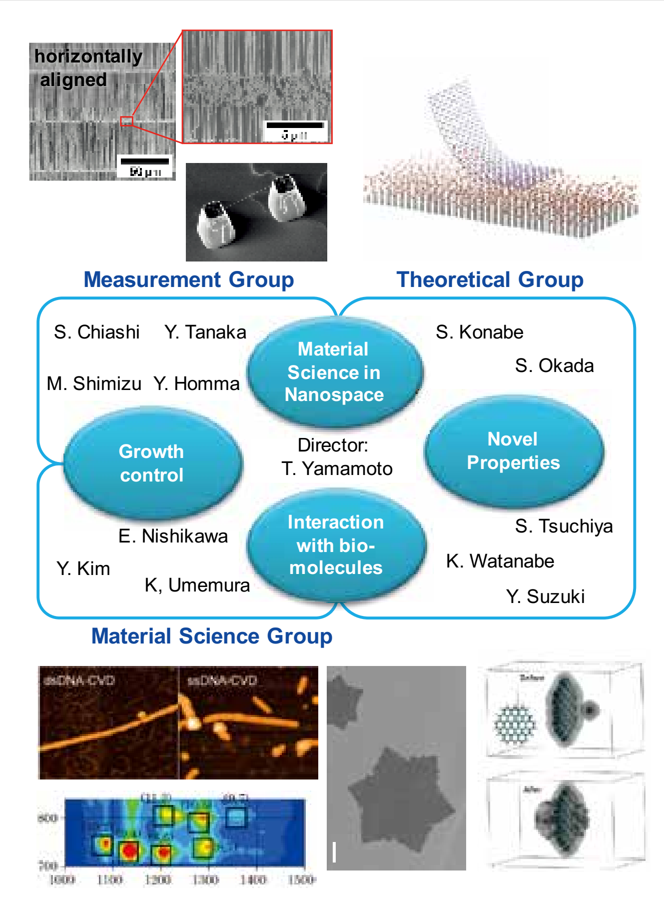
○We aim to clarify the mechanism of secondary electron emission from nanocarbons.

○We perform first principles or semi-empirical simulations in order to clarify the responses of electrons or atoms in nanocarbons to laser or high electric field. We are aiming at theoretical descriptions of experimentally observed phenomena such as field electron emission, laser induced electron emission, laser stimulated coherent phonon generation/plasma oscillation excitation, etc.

○We analyze the electric transport in nanocarbons by using simulation techniques in order to understand the interactions between nanotube/graphene and high speed electrons.

○We theoretically study the super conductivity of nanotube and graphene, and predict the basic properties.

○We analyze the electronic structure of nanotube composites in their ground states, and also the phenomena relating to their excited states.



Established: April 2013 ✉ k-nishio@rs.noda.tus.ac.jp

Division of Thermoelectrics for Waste Heat Recovery

Director
Professor,
Department of Materials Science and Technology, Faculty of Industrial Science & Technology
Keishi Nishio

Objectives	To research and develop materials and power generation systems which is used for the waste heat recovery for the automotive and industrial application fields.
Future Development Goals	To research and develop appropriate thermoelectric materials and thermoelectric power generation systems which is installed to the automotive exhaust line and the industrial furnaces, in order to obtain fuel-efficient system.

In this Division, we have been developing thermoelectric materials and systems for energy conversion to tackle the global warming that is being caused by the mass consumption of fossil fuels. Using our state-of-the-art thermoelectric technology, heat energy, which is the final phase of energy consumption, can be recycled into electrical energy. Concurrently, we have also been pursuing environmentally friendly semiconductor energy conversion materials, while studying environmentally "low-load" production processes.

R&D on waste heat recovery systems using solid-state thermoelectric energy conversion technique

The earth's environment will undergo great changes within our own lifetime if we keep consuming fossil energy on such a massive scale as we are doing now. The earth's environment could drastically change in our children's era due to global warming. "What about the generation of atomic power?" We worry that we are dumping atomic waste caused by our wastefulness on to our children or our grandchildren, or even that we are passing the problem on to their descendents some thousands of years in the future. Although an individual person possesses only limited power, we feel that the time has arrived when we must start moving towards a "sustainable society for the future."

Human beings are really just creatures who are supported by the ecological food chain, although we supposedly possess higher intelligence compared with the other creatures that inhabit the earth. Thus, we must start to think more seriously about the global environment···.

Improvements in energy and environmental problems cannot progress at a sufficiently high pace to make a difference sometime today or tomorrow. Therefore, proactive studies that look ahead for some tens of years are necessary. From a material's standpoint, not only steps to ensure future resources, but also studies of materials that could maximize energy conversion efficiency are required. From the view point of environmental conservation, studies of materials that represent a low environmental burden are needed. There is now a trend towards the prohibition of some poisonous materials that were previously permitted to be used in small amounts, irrespective of how desirable their performance is.

In this Division, we have been developing materials for energy conversion to tackle the global warming that is being caused by the mass consumption of fossil fuels. In particular, considerable weight is currently being placed on the study of materials for power generation from waste heat. Using these materials, heat energy, which is the final phase of energy consumption, can be recycled into electrical energy. Concurrently, we have also been pursuing environmentally friendly semiconductor energy conversion materials, while studying environmentally "low-load" production processes. Environmental semiconductors are semiconductor materials that are abundant on the earth and which comprise of materials that are friendly to living creatures and to the environment.

The main advantage of thermoelectric conversion as compared to thermodynamic conversion results from the absence of any moving parts. Being entirely static, the device is vibrationless and is not affected by wear. In the context of increasing energy prices and climate change, thermo-electric conversion is of the highest interest for producing electric power from waste heat. It has also attractive applications for low and near ambient temperature refrigeration.

Especially, the automotive industry is anxious for the installation of thermoelectric generators (TEG) because of the strict fuel consumption regulation in EU. As is shown in the figure, almost all current models could not pass the regulation at 2020, except for some hybrid system or next generation of diesel engines. Since ~70 % of initial gasoline is emitted as waste heat when we drive, if some percentages of discarded heat can be reused, then fuel consumption is improved. An on-board TEG system is one possible technique to conserve fuels and supply electricity. In our research division, we are currently working corresponding research issues listed below to proceed appropriate thermoelectric materials and TEG adopted for the automotive application and the industrial furnaces.

Thermoelectric material development and fabrication

Synthesis of powders and bulk materials using methods of

- High energy ball milling (synthesis/mechanical alloy/doping)
- Combined process of vibration ball milling and spark plasma sintering (synthesis & doping)
- All molten synthesis (synthesis & doping)
- Manufacture-oriented all molten synthesis
- Mechanochemical and self-flux synthesis

Fabrication of nano-structures with enhanced functionality as post process of the materials developed with fabrication methods of

- High energy ball milling (nanostructurization)
- Melt spin synthesis (nanostructurization)
- Direct nanostructure-formation during spark plasma sintering process

Powder compaction and sintering for thermoelectric chip fabrication

- Standard Material Consolidation (thermoelectric chip fabrication)
- Spark plasma sintering (thermoelectric chip fabrication)
- Plasma activated sintering (thermoelectric chip fabrication)

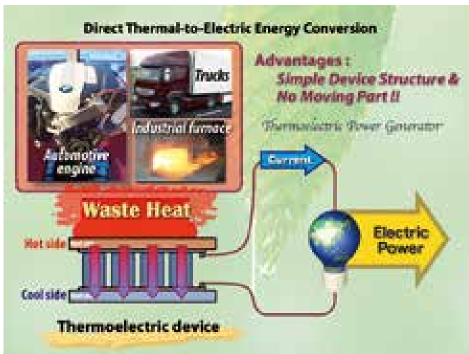
Application and development of advanced characterization and measurement methods for thermoelectrics

- Physical properties of thermoelectrics
- Structure of thermoelectrics from meso- to atomic scale
- Combined approach of XRD, SEM and TEM
- Chemistry and structure at the nanoscale by advanced electron microscopy
- Electronic band structural analysis using synchrotron based techniques
- In-situ analyses for durability enhancement

Computational thermoelectric material and power generation module structure design

Modeling and rational design of thermoelectric material.

- Identifying fundamental properties, including temperature dependence of thermoelectric power, and optimal uses of the material classes delivered by the first principles calculations using the all electron FLAPW/LDA (Code:ABCAP)
- Designing the optimal nanostructures from lattice thermal conductivity perspective using the mulitscale phonon transport calculations based on first principles.
- Finite elemental



Division of Colloid and Interface Science

Established: April 2013 kawai@ci.kagu.tus.ac.jp

Director
Professor,
Department of Industrial Chemistry,
Faculty of Engineering
Takeshi Kawai

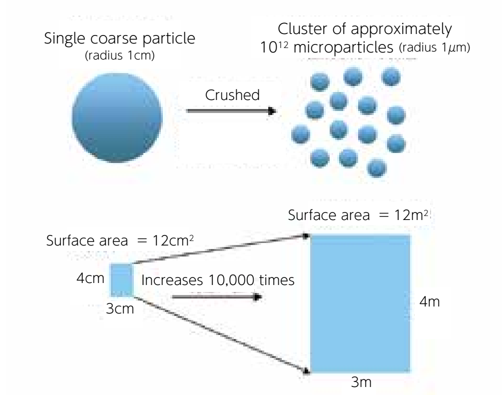
Objectives	To play a leading role in colloid and interface science both in Japan and internationally.
Future Development Goals	We afford a deep understanding of surface phenomena from fundamental aspects and the practical aspects by the assist of exchanges of information and closer collaboration between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

Every objects have surfaces, and there are interfaces between objects. Surface science is a science which studies surface phenomena emerged from restricted spaces at interfaces or boundaries, and covers a wide interdisciplinary research fields. Further, surface science has an interest side and some surface science researches pursuit conceptual understanding of the phenomena, although it is one of materials science. We sincerely hope that outcomes of our project will contribute to the progress of many other fields.

General research on surfaces and 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 1μm. 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^2 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.



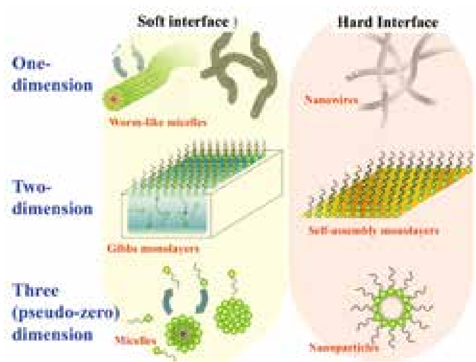
Interface science has a broad range of application, and is related to a variety of fields including surface active agents (surfactants), microparticle (colloid particle and nanoparticle) dispersed systems, microcapsules, gel, solid surfaces, powders, bio-interfaces and environmental colloids.

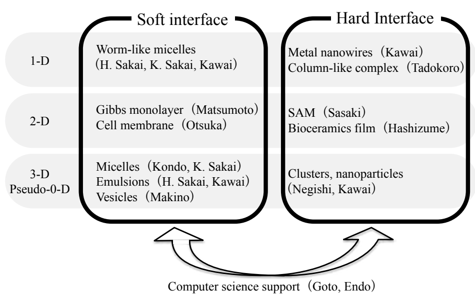
The Division of Colloid and Interface Science was established in January 1981. The first Director, Professor Kenjiro Meguro (Department of Applied Chemistry, Faculty of Science) was succeeded by Professor Tamotsu Kondo (Department of Medicinal and Life Science, Faculty of Pharmaceutical Sciences), Professor 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 phenonema and the fuctions at the both interfaces, and hope to achieve the development of novel functional materials.

In this project, we are going to investigate intensively the role of water molecules present at interfaces such as solid-liquid, liquid-gas and solid-gas interfaces. It is general known that water molecules at interfaces play a crucial role in performances of various functional materials including biomaterials, however, the detailed functions and structure of water, and interactions beween substrate molecules and water remain unsolved.





Established: April 2013

tadokoro@rs.kagu.tus.ac.jp

Division of Synergetic Supramolecular Coordination Systems in Multiphase

Director
Professor,
Department of Chemistry,
Faculty of Science Division I
Makoto Tadokoro

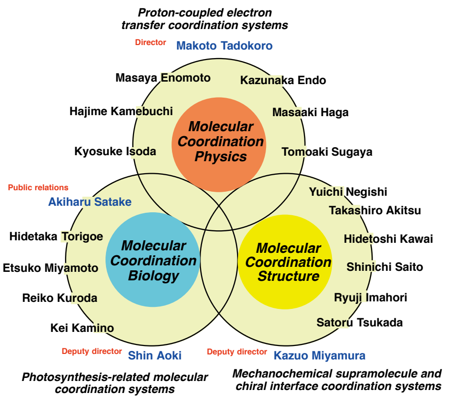
Objectives	The Division of Synergetic Supramolecular Coordination Systems in Multiphase joins together synthesized complex molecules (organic-inorganic complex molecular devices) to create complex functionality that would be difficult for a single molecule to attain, and aims to produce novel synergistic effects.
Future Development Goals	A scientific field is needed that attempts to control molecular arrangement and proactively utilizes intermolecular interactions. In particular, possible future advancements include biological functions, proton-coupled electron transfer systems, and mechanical-photochemical energy conversion that are governed by intermolecular interactions.

Almost all researchers who work on molecular coordination systems focus on molecules. Although molecular design and molecular synthesis have become possible following previous scientific advances, challenges still exist in making these molecules self-organizing and harnessing the intermolecular interactions between them. Biological molecules represent the only known "complete molecular devices" to achieve this feat, and we plan to continue with our research on mimicking the intermolecular interactions of these molecules.

Performing structural, physical, and functional evaluation of organic, inorganic, and biological complex molecular systems

Research Aims

Researchers who target molecules such as inorganic-organic complex molecules perform molecular design to study the synthesis of target molecules with new functionality. For example, useful new molecular systems that do not exist in nature are being constructed one after another, such as artificial proteins, molecular machines, molecular superconductors, multiferroic molecular crystals, photomolecular catalysts, Grätzel solar cells, and organic thin film field effect transistors. Furthermore, in addition to the rapid pace at which functional molecules are being developed by these ideas, a trend has recently appeared toward the development of "molecular coordination systems," which join together different functionalized molecules. Synergistic complex supramolecular systems that join together these different functionalized molecules are characterized not only by the combination of their existing functions, but also by the appearance of synergistic effects. At the Division of Synergetic Supramolecular Coordination Systems in Multiphase, several molecules synthesized by different members of the group are mutually interacted to create complex functionality that is difficult to obtain from a single molecule, in an attempt to produce novel synergistic effects. When building this kind of molecular system, although virtually all of the molecules can be synthesized at the current scientific level, controlling the arrangement of these molecules in order to harness their intermolecular interactions has become an extremely important problem. Accordingly, this research attempts to bring together various strategies for controlling crystal structure, surface organization, molecular arrangement, and molecular structure.



For example, the ultimate ensemble that uses synergistic complex systems with these kinds of functionalized molecules is a photosynthesis system. In such a system, the individual molecules on a thin film including many biological molecules appear to function together in an overall uniform interaction (Figure 1), allowing photosynthesis to convert 70% of solar energy into chemical energy, stored in the form of high-energy molecules such as ATP and NADPH. In this kind of complex system, molecules that have several roles interact on the thin film to create the target functionality.

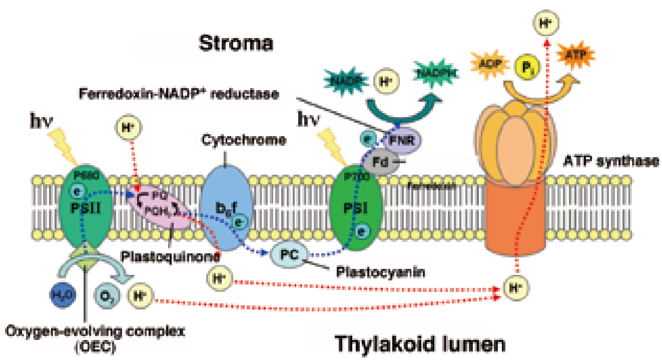


Fig. 1 Biological photosynthesis system (by Wikipedia)

Three supramolecular coordination themes

In our research division, the first goal is to develop the individual functionalized molecules. The next goal is mutually to interact different molecules in supramolecular and crystallographic assemblies to develop molecular systems with novel functionality to produce synergistic effects (even under a scanning tunneling microscope). Our research is therefore divided into the following three themes, the aim of which is to mutually construct molecules and induce intermolecular interactions using systems that are controlled in an advanced way.

1. Molecular coordination physics: This theme focuses on solid-state physical properties such as optics, magnetism, and conductivity. The synthesis in this research theme focuses on controlling the electron system by giving degrees of freedom to the molecules and ions. We are striving to build molecular coordination systems with a proton-coupled electron transfer in particular.
2. Molecular coordination structure: This theme conducts research into interlocking compounds that act as mechano-chemical supramolecules, metallic clusters that have limited to novel structures and numbers, and the chirality of interface structures and crystals. We create molecular machines that exhibit supramolecular motion and chirality that controls on the interfaces and in the crystals, metal cluster catalysts that exhibit physical properties for controlling structures and numbers.
3. Molecular coordination biology: This theme involves molecular design based on biological energy conversion such as photosynthesis. We aim for energy conversion, such as from light energy to chemical energy or chemical energy to mechanical energy, through the use of molecular complexes based on biological mimic systems such as porphyrin complexes, electron transfer complexes, and luminescent complexes.

Establishment of the Division of Synergetic Supramolecular Coordination Systems in Multiphase

Over the last several years, many academic staff members specializing in coordination chemistry have been employed at the Tokyo University of Science, particularly in the Faculty of Science. For this reason, the " Supramolecular Coordination Chemistry Research Group in Tokyo University of Science " was established in 2010 with the aim of bringing together capabilities (molecular design, molecular synthesis, and molecular analysis) from the various schools within the Tokyo University of Science (January 18, 2011). In other words, an attempt was begun to create a place for academic exchange and cooperative research between academic staff and students who belong to the physically separated Kagurazaka area and Noda campuses. The aim was to hold discussions and conduct research in a carefree and innovative way in order to make a major contribution to this field and to have a large impact both domestically and internationally. Research group members applied for funding for our research activities through a 2011 "Grant-in-Aid for Collaborative Research" awarded by the dean for "Chemistry Related To Photosynthesis Using Metal Complexes and Supramolecules." The funds were used to purchase a fluorescence lifetime spectrometer, which is currently being utilized in collaborative research between our members. Our second conference on funding for our collaborative research was held on July 9, 2010, at Building 14 of the Faculty of Pharmaceutical Sciences. After the keynote lecture titled "Chemistry related to photosynthesis using metal complexes and supramolecules," by Professor Akiharu Satake of the Faculty of Science at our university a presentation session was held by the research group members. For our third conference on November 18, 2011, the symposium "Interface Science and Coordination Chemistry—An Approach to Biological-Related Functions" was held. The conference had such main features as a chairman, presentations, and a statement of purpose. Furthermore, on August 23, 2012, the researchers seeking approval to establish the new division gathered and held a Preparatory Meeting on Establishing the Division of Synergetic Supramolecular Coordination Systems in Multiphase.

Functional Materials

Water Frontier Science Research Division

Established: April 2015

homma@rs.tus.ac.jp

Director
Professor,
Department of Physics,
Faculty of Science
Yoshikazu Homma

Objectives	To establish the comprehensive science of water through investigating the properties and structures of water on the material surface and in nanopores, and to develop novel applications of interfacial water.
Future Development Goals	To promote researches on water linking microscopic and macroscopic scales, and to enhance the collaboration through simulations of water in diverse scales.

Water on the surface/interface and in nanospace becomes hot and interdisciplinary research topics. Because water relates to nature, people and society, the topics match the teaching principle of TUS "creating science and technology for nature, people and society and the harmonious development of all three." We promote the researches of water from the microscopic viewpoints based on the collaboration of researchers in various fields.

R&D on water science and applications based on the microscopic viewpoints

Water is the most familiar substance and has been studied for a long time. Recent progresses in measurement and simulation techniques, however, elucidate molecular structures different from those in the free space for water on the material surface and in nanopores. It is highly desired to clarify the role of the new form of water on the surface properties of materials and biological phenomena, and to utilize the functions of the structure.

In this research division, we will conduct studies on water based on both experimental and theoretical approaches under the tight collaboration among experimentalists having original measurement techniques for different sizes of the space and theoreticians performing simulations of water behaviors. Although we focus on the most familiar substance, we make it the target of the most advanced researches. We will not only study the science of water, but also develop novel technologies of interfacial water usage relating to the fields of energy, environment, agriculture, biotechnology, and medical care.

Research themes

We focus on four aspects of interfacial water on materials, namely, “structure” , “wetting” , “flow” , and “reaction” , and implement researches on these topics. For each research theme, researchers of material synthesis, measurements and simulations of water, and applications of water collaborate with each other in linking these four concepts and diverse scales, and aim at establishing the comprehensive science of interfacial water covering micro and microscopic scales.

○T1 “Structure” : Understanding and control of structures and properties of water in 1D and 2D spaces
○T2 “Wetting” : Understanding and establishing advanced utilization of wetting phenomena through multifaceted measurements
○T3 “Flow” : Understanding and control of interfacial water under momentum transfer
○T4 “Reaction” : Creation of novel nano and thin film materials utilizing surface and interface properties of water

Structure

Using hydrophilic molecular zeolites and hydrophobic nanocarbon materials, both of which are size controllable, as the standard materials, we investigate the statistical thermodynamics and solution chemistry of water in nanopores or on material surfaces, and develop nano-fluid dynamics based on material transport. Structure and thermal properties of the water in the pores are strongly affected by the size and hydrophilic-hydrophobic control of the inner wall surface. We can precisely control the both of the conditions by using hydrophilic molecular zeolites and hydrophobic carbon nanotubes, and investigate the microscopic hydrogen-bond network structures and the thermal properties of water in the pores, in particular aiming at establishing the phase diagram.

Wetting

We aim at understanding and application of wetting by highly-precise observations of various aspects of the wetting phenomena. For example, phase-change heat transfer, so-called boiling, is expected to achieve a high density heat removal. As is repeated in the generation, growth and withdrawal of the vapor bubbles, heat and mass transport of fluid near the three-phase (solid, liquid, and vapor) boundary line are elementary processes that are the key to the heat removal mechanism. Here, in order to advance the understanding of the thermal fluid phenomenon due to the movement of the three-phase boundary line on a solid substrate, we are conducting researches by fusing the knowledge of analytical chemistry, non-linear physics, and interface thermal fluid.

Flow

We are conducting studies on understanding and control of the reaction of water in the vicinity of the interface with flow, and aiming at the applications to bio and medical care by making full use of them. Collaborating with each other by taking advantage of the strengths of the members, we will promote researches on such as flow control in the microfluidic device, nano-scale detection of sialic acid distribution in the cell membrane surface, the synthesis of artificial bone material hydroxyapatite crystal, measurement of abnormal Pockels effect on the water surface, high-precision numerical simulation of interface flow, and spectroscopic measurements using infrared free electron laser.

Reaction

We are promoting the research from the viewpoint of material synthesis and environmental analysis. The materials synthesis group builds water plasma reaction fields capable of introducing any of the reaction gas from the outside of plasma; producing fertilizer with highly controlled efficiency, and formation of metal nanoparticles with controlled particle size distribution using plasma in water. Another approach of material synthesis utilizing air-water interface under UV irradiation is a new processing technology of polymer particles with hollow cavity with a spatial size smaller than the diffraction limit of the UV light. The environmental analysis group promotes researches of water in the fields closely relating to human society, from water environment management to the generation of cloud that affects weather.

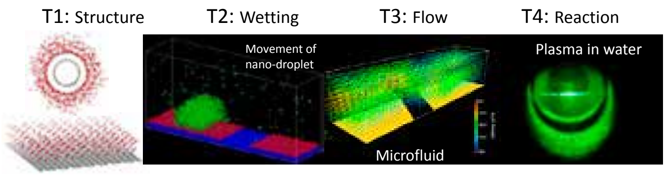


Fig. 1 Water on materials surface

G \ T	T1 Structure (Energy)	T2 Wetting (Environment, Saving energy)	T3 Flow (Biotechnology, Medical care)	T4 Reaction (Agriculture, Material)
G1 Synthesis	Y.Homma M.Tadokoro	Y.Homma **I.Ueno**	**M.Motosuke** K.Tsukiyama	T.Kawai C.Terashima
G2 Measurement	T.Itou M.Kotsugi H.Matsui (Tohoku Univ.)	I.Ueno M.Kotsugi H.Yui	M.Motosuke E.Tokunaga T.Kobayashi (The Univ. of Electro Communications)	I.Nakai **H.Yui**
G3 Simulation	**T.Yamamoto** H.Daiguji (Tokyo Univ.)	T.Tsukahara Y.Sumino Y.Yamaguchi (Osaka Univ.)	T.Tsukahara T.Ando Y.Yamaguchi (Osaka Univ.)	T.Shirafuji (Osaka City Univ.)
G4 Application	M.Tadokoro	Y.Homma I.Ueno	H.Otsuka M.Hashizume	I.Nakai K.Miura T.Kawai C.Terashima

□ Theme leader (boxed in red)

Fig. 2 Organization of Water Frontier Science Division

Photovoltaic Science and Technology Research Division

Established: April 2015
yachi@rs.kagu.tus.ac.jp

Director
Professor,
Department of Electrical Engineering, Faculty of Engineering
Toshiaki Yachi

Objectives	We aim at the development of environmentally friendly technological approaches that can be applied throughout the life cycles of photovoltaic systems, from construction to installation, operation, and disposal.
Future Development Goals	We will facilitate research and development into next-generation photovoltaic systems by utilizing the aggressive synergy of our division members, which were selected from a variety of different specialties.

This division evolved from the previous photovoltaic generation technology research section that was started in 2010. Our current division members were chosen from different specialized fields, from materials and devices science, to circuits, assembly, and system technology. Our overall goal is the development of infrastructure photovoltaic systems having high degrees of environmentally friendliness.

Environmentally friendly photovoltaic systems throughout their life cycle

Background and aims for establishing the division

Anthropogenic global warming is one of the major problems confronting the 21st century. As one potential solution to global warming problems, it is desirable that energy production be shifted from fossil-fueled sources, such as oil and coal, to renewable energy sources such as sunlight, wind, and substantial biomass. Photovoltaic power generation, in particular, is expected to become a leading source of such renewable energy. As of 2014, approximately 177 GW of installed photovoltaic systems were in operation worldwide, which is an amount that is roughly equivalent to the output of 170 nuclear power plants. As this amount is expected to increase in the future, it is becoming increasingly necessary to develop more environmentally friendly technological approaches that can be applied throughout the life cycles of the photovoltaic systems used in electric power infrastructures.

With this background in mind, the previous division was established in April 2010 and tasked with the missions of accelerating research on photovoltaic power generation, sharing its accomplishments at home and abroad, and contributing to solving problems related to global warming. To further contribute to global warming problem solutions, our research division was newly established in April 2015, and charged with focusing on more environmentally friendly technological approaches that could be applied throughout the life cycles of the photovoltaic systems used in electric power infrastructures.

Members and formation

This research division now consists of the 12 people listed in Table 1. These members were selected from a variety of specialties from physics, chemistry, and electrical engineering, to system engineering. Our research system aims at facilitating major developments via synergistic effects, as the division itself focuses on environmentally friendly technological approaches that will lead to the development of solar cells, modules, and total photovoltaic systems that operate in harmony with the natural environment.

Development aims of the photovoltaic science and technology research division

The following research subjects have been taken up as environmentally friendly technological approaches to photovoltaic systems:

- The development of organic and inorganic thin film solar cells created via environmentally friendly and energy efficient processes.
- With the aim of developing products that are gentle to people and the environment at all stages of their life cycles—manufacture, use, and disposal—we are advancing toward the development of solar cells that to not incorporate toxic substance such as cadmium and lead.
- The development of tandem modules with solar and thermal cells, and tandem modules that operate via wavelength splitting technology in order to facilitate solar energy use without waste.
- The development of solar sharing and matching modules that will make possible both power generation and vegetation preservation, thus advancing agriculture.
- The development of a more efficient photovoltaic generation systems that utilize high-performance energy management technology that will allow generated electric power to be used without waste.
- The development of long-life photovoltaic systems with self-check and self-repair technological functions that will utilize generated electricity more efficiently.
- The development of the most suitable photovoltaic system construction and operation technologies based on advanced electric power generation amount prediction techniques.

Table 1 Members of Photovoltaic Science and Technology Research Division

Affiliation of key role	Job title	Name	Academic degree	Main research field
Faculty of Engineering Division II Department of Electrical Engineering	Professor	Toshiaki Yachi	Doctor of Engineering	Energy conversion engineering / photovoltaic power generation system
Faculty of Science Division II Department of Physics	Professor	Zhao Xinwei	Doctor of Engineering	Semiconductor nano-material engineering / thin film photovoltaic cell
Faculty of Engineering Department of Industrial Chemistry	Associate Professor	Morio Nagata	Doctor (engineering)	Organic photovoltaic cell/ Perovskite solar cell, Artificial photosynthesis
Faculty of Engineering Department of Electrical Engineering	Junior associate professor	Yuzuru Ueda	Doctor (engineering)	Electricity and energy engineering / photovoltaic system
Faculty of Science and Engineering Department of Electrical Engineering	Associate professor	Mutsumi Sugiyama	Doctor (engineering)	Semiconductor material engineering / thin film photovoltaic cell
Faculty of Science and Engineering Department of Electrical Engineering	Associate professor	Junji Kondoh	Doctor (engineering)	Photovoltaic power system / grid-connection
Tokyo University of Science, SUWA, Faculty of Engineering, Department of electrical and electronic engineering	Professor	Yoichi Hirata	Doctor (engineering)	Energy conversion engineering / photovoltaic power generation system
Tokyo University of Science, SUWA, Faculty of Engineering, Department of electrical and electronic engineering	Associate professor	Yasuyuki Watanabe	Doctor (engineering)	Organic photovoltaic cell / Dye-sensitized solar cell, solar hydrogen
Faculty of Engineering Department of Industrial chemistry	Professor (part-time)	Hironori Arakawa	Doctor of Engineering	Solar energy conversion technology / Dye-sensitized solar cell, solar hydrogen
Research Institute of Science and Technology	Visiting professor	Tokio Nakada	Doctor of Engineering	Semiconductor material engineering / tin film photovoltaic cell, CIGS solar cell
Ehime University, Graduate School of Science and Engineering	Visiting professor	Sho Shirakata	Doctor of Engineering	Semiconductor material engineering / tin film photovoltaic cell, CIGS solar cell
Research Institute of Science and Technology	Project Fellow	Ishwor Khatri	Ph. D	Semiconductor material engineering / thin film photovoltaic cell

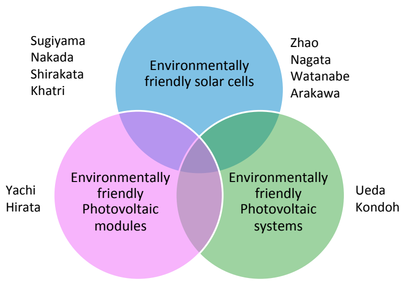
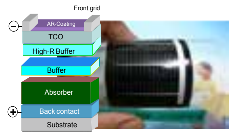


Fig. 1 Formation of Photovoltaic Science and Technology Research Division.

(a) The transparent conductive film with high transmission and low resistivity

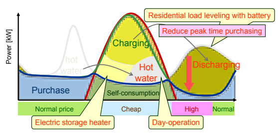


(b) High efficiency CIGS thin film solar cell

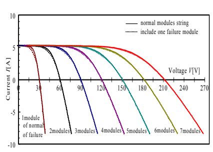
(c) Transparent thin film solar cell

(d) Semi-transparent OPV greenhouse

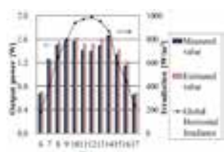
(e) Smart grid field test



(f) Power leveling by the high-performance energy management technology



(g) Photovoltaic array self-check using by I-V characteristics



(h) Power output estimate of cylindrical-shaped flexible photovoltaic module

Fig. 2 Research Issues of Photovoltaic Science and Technology Research Division

Functional Materials

Advanced EC Device Research Division

Established: April 2015 ✉ itagaki@rs.noda.tus.ac.jp

Director
Professor,
Department of Pure and Applied Chemistry, Faculty of Science and Technology
Masayuki Itagaki

Objectives	To develop of novel energy devices by systematic material-to-system researches and establishments of advanced analytical methods specialized for devices
Future Development Goals	To produce EC devices such as the electrochemical capacitor, the fuel cell and the lithium-ion battery based on material design and screening, and device-oriented analyses.

Our division consists from experts on chemistry, biotechnology, mechanical and system engineering with relation to rechargeable battery and electric power generation system. By close cooperation with these professional fields, we aim to develop state-of-art electrochemical energy devices “Only at TUS (Tokyo University of Science)” .

Development of sophisticated EC (Electrochemical) energy device “Only at TUS”

In recent years, rechargeable batteries and electric power generation systems have drawn much attention as vehicle power sources and stationary power sources for the smart grid, backup and so on. From such background, the world market especially of the electrochemical capacitor, the fuel cell and the lithium-ion battery are predicted to grow outstandingly in the next decade. These devices are also still important as small and safe ubiquitous electric power sources, taking diversification and/or downsizing of portable electric devices into account. More recently, a wearable device for health monitoring becomes a hot topic and thus electrochemical sensors are also expected to be used for the application.

As described above, a demand for the electrochemical (EC) devices gets diversified and sophisticated nowadays, and thus it becomes mandatory to have multidisciplinary cooperation for satisfying the demands. In this division, scientists working on materials for the EC devices and experts on the systems collaborate on the same target, i.e. EC device developments. We also try to apply fundamental analytical technique of electrochemistry, atomic and electronic structures for *operando* investigations in order to propose appropriate material and/or system depending on the purpose of use. This division pay special attention on the electrochemical capacitor, the fuel cell and the lithium-ion battery as next-generation energy sources, and the members in difference professional fields supply their technical know-how to the device developments.

Our ultimate goal is to produce novel state-of-art EC devices “Only at TUS (Tokyo University of Science)” which meet the needs of the age.

Research on electrochemical capacitor

In the case of the electrochemical capacitor, a research on the electrodes is a key issue. As one of the most promising candidates, we focus on porous diamond thin film and conductive diamond powder because these diamonds are expected to realize high working voltage due to their wide potential window. We also tailor mesoporous carbons with various porous size for high power density electrodes. For developments of different kinds of capacitors, we synthesize redox polymers and inorganic nanosheets which show pseudo-capacities, and develop microsupercapacitors by multidisciplinary cooperation. Through a collaboration with the lithium-ion battery group, the lithium-ion capacitor with much higher capacity is studied as well.

This collaborative policy will enable us to propose many types of new capacitors with different size, capacities, powers and thus various concepts. These devices can be used for a wide variety of situations.

Research on fuel cell

This research has two main targets: that is, a wearable biofuel cell and a high-power polymer electrolyte fuel cell.

As a novel wearable biofuel cell, we manufacture a printable wearable biofuel cell with paper and transfer sheet. For example, a fuel cell using organic material in urine as fuel can be used for urine detection (senior care, health maintenance). By using lactic acid in sweat as fuel, one can check health of athletes. In order to make the wearable device, we prepare carbon materials with meso pore suitable for an enzyme, and develop a printable paper device using the carbons 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.

We also try to develop a hydrogen generation system, and systems of the solid oxide fuel cell and the direct methanol fuel cell under close collaboration among material scientists and engineering experts. The electrode reactions are analyzed by *in-situ* techniques, and feedbacks are given to designing processes of the materials and the systems in order to realize higher efficiencies and power densities.

Research on lithium-ion battery

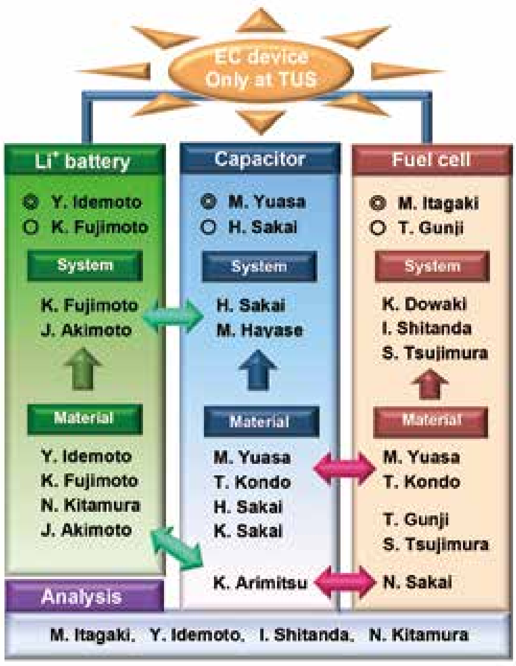
We aim to perform high-throughput material screening, and device-oriented electrochemical and structural analyses in addition to preparation of high-capacity electrodes whose structures are well-controlled at atomic-to-micro levels.

For optimization of nano- and micro-structures of the electrode, we prepare the powder by liquid-phase synthetic methods like a solvothermal method, and perform a surface coating on the pristine powder.

The high-speed material screening will be carried out by a combinatorial method experimentally, and atomic configurations of the materials are also simulated computationally as a theoretical screening.

In addition, we investigate degradation mechanisms of the batteries under various operation conditions by means of some electrochemical techniques such as the *in-situ* electrochemical impedance spectroscopy (EIS) and *in-situ* analyses on the atomic- and electronic-structures using neutron and synchrotron X-ray sources. This strategy enables us to customize an appropriate device design depending on a working condition and a purpose of use.

Throughout these intra- and inter-cooperations in the research groups, we try to produce EC devices only at TUS.



Established: April 2016

watanbey@rs.tus.ac.jp

Advanced Agricultural Energy Science and Technology Research Division

Objectives	Our objective is to solve problems such as local production and consumption of energy, local industry, and TPP issues by having internal and external researchers from departments including the Department of Electrical and Electronic Engineering, the Department of Applied Biological Science, and the Department of Management and Information Science participate in the development of next-generation agricultural technologies.
Future Development Goals	We will develop proprietary Tokyo University of Science technologies to lead the way in deploying next-generation agricultural technologies to the global market by achieving "smart agricultural technologies capable of making electrical and agricultural production self-sufficient."

Director

Associate professor, Department of Electrical and Electronic Engineering,Faculty of Engineering,Tokyo University of Science,SUWA

Yasuyuki Watanabe

Electricity, which is essential to human lives, is used in the form of energy and in the form of information. Plants, on the other hand, do not necessarily use electricity, but use sunlight as energy and information. In this division, we explore the methods by which humans obtain the necessary electricity, and crops simultaneously obtain the necessary light from sunlight energy, from the perspective of science and technology.

Creating next-generation agricultural technology based on semitransparent organic photovoltaics compatible with agricultural production

The idea behind the establishment of this division

The world population is expected to surpass 10 billion people by 2100. To solve global energy, environmental and food problems, changes to agricultural markets and industry structures will need to be predicted, and a forum to provide new value throughout the world will need to be built by leading the way with basic research at universities.

Innovative agricultural engineering based on solar matching

"Solar sharing," in which solar panels are installed in gaps on agricultural land, is gathering interest; however, as shown in Figure 1, the effect of shadows cast by the panels on crops and the high installation costs are a few of the issues. To address these issues, we proposed "solar matching (agricultural OPV)," which allows the light necessary for crop cultivation to permeate, and which stores the remaining light in organic photovoltaic cells capable of generating power, and we demonstrated that this technology allows both crop cultivation and solar power generation. We plan to scientifically verify if this approach can be used to develop further technologies to improve crop yield in horticulture, such as in agricultural fields and in sunlight-using plant factories.

This research division aims to combine the science, engineering and pharmacology technologies of Tokyo University of Science with the agriculture-related engineering technologies of Tokyo University of Science, Suwa, to achieve both agriculture and power generation through "solar matching," to improve agricultural productivity through the use of the Internet of Things (IoT), to provide society with "innovative agricultural engineering" such as labor-saving solutions, and to promote the development of Japanese agriculture and industry.

Members and research fields

■Tokyo University of Science
- Professor Kazuyuki Kuchitsu (plant physiology)
- Professor Tatsuya Tomo (photosynthesis)
- Associate professor Mutsumi Sugiyama (transparent solar cells, agricultural sensors)

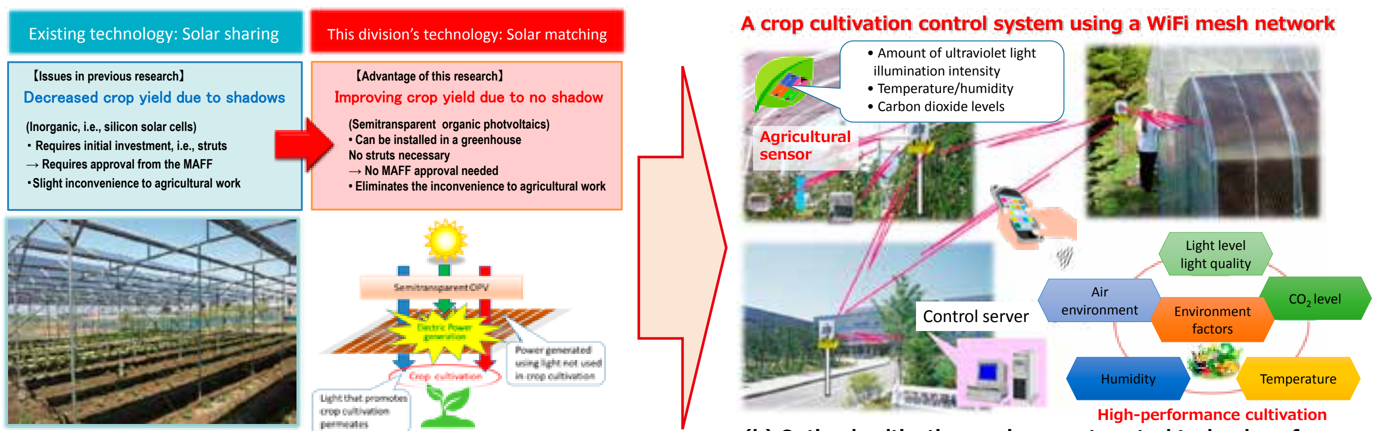
■Tokyo University of Science, Suwa
- Associate professor Yasuyuki Watanabe (agricultural solar cells, photosynthesis measurement)
- Postdoctoral Fellow Noboru Ohashi (organic photovoltaic solar cells, plant cultivation)
- Professor Hideaki Matsue (communication and network engineering, agricultural IoT)
- Assistant professor Kazuhiro Yamaguchi (image and signal processing)
- Professor Takashi Matsuoka (quantum information theory)
- Associate professor Takashi Hirao (product development strategy)

■Yatsugatake Central Agricultural Institute
- Visiting researcher Hisashi Oku (practical agriculture)

■Kyushu University, Chihaya Adachi Laboratory
- Assistant professor Hajime Nakanotani (agricultural organic LED)

Future ideas to pursue

To strengthen the research capabilities of the agricultural and food sectors, which is listed as a priority issue in the medium-term research plan of Tokyo University of Science, we are looking to both expand the scale of and commercialize industry–university collaborative projects and other initiatives.



(a) Existing solar power technology used on agricultural land and the technology proposed by this division

(b) Optimal cultivation environment control technology for crops that makes use of agricultural IoT

Fig. 1 Schematic diagram of the Advanced Agricultural Energy Science and Technology Research Division

Established: April 2012 i2plus@rs.tus.ac.jp

International Research Division of Interfacial Thermo-Fluid Dynamics

Director
Professor,
Department of Mechanical Engineering, Faculty of Science & Technology
Ichiro Ueno

Objectives	We, international and interactive research group, focus on heat/mass transfer phenomena in micro- and nanometer scale to realize high-efficient devices through making full use of interfacial thermo-fluid dynamics.
Future Development Goals	Final goal of our research project is to realize technologies for low consumption of energies and low contamination of environments. Through the research activities, we also focus on educational contributions by embodying international environments for students as well as researchers.

A group of young researchers from various fields of mechanical, electrical and electronics, chemical, and material engineerings started this research division in April 2012. Our goal is to make contributions to scientific and technological issues in order to realize 'earth-friendly' technologies through the international activities on research and education.

Non-linear thermo-fluid dynamics in the vicinity of three-phase boundary line and its application

This research division (nicknamed as 'I^2plus') was established in the Research Institution for Science and Technology (RIST), Tokyo University of Science, in April 2012. This division consists of young researchers from Europe, the United States, and this university, Tokyo University of Science. We set our final goal as to develop high efficient, low consumption of energies and low contamination of environments as 'earth-friendly' devices of heat/mass transfer in micro- and nanometer scale. Typical examples of technologies for applications are techniques of gas/liquid/solid manipulating under low energy input; fluid handling and/or heat transfer with high heat flux in a very small area for fuel-cell or electric vehicles, controlling ultra-fine chemical reaction with a very tiny amount of test fluids for environmental controls, and so on. Such technologies are indispensably required not only for our society after the severe disaster and accident in 2011, but also for fatal issues of global energy problems due to the explosive development of the quality of life in the third world. It is one of the prominent features of this research division that we vigorously promote research and education in collaboration with researchers of the world.

Research

Our final goal is to establish a mesoscopic dynamics of the fluid in the vicinity of the solid-liquid-gas three-phase boundary line (contact line) and to apply it to engineering technologies. In this dynamics, we have to solve the problems in multiscale and multiphase systems; we treat the prime factors such as energy states near the interface due to the chemical and physical barriers, and microscopic movement, deformation and diffusion near the contact line, and their interactions. Target issues in this research division are phenomena emerged near the boundaries of two phases (solid-liquid, liquid-gas, and gas-solid), and phenomena emerged near the three-phase boundaries (Fig. 1); typical examples for former phenomena are such as condensation, generation and collapse of gas/vapor bubbles, and adsorption, and those for latter are such as wetting and dewetting. We especially focus on following topics;
(A) measurement and control of thermal-flow field near the micro- and nanometer-scale movable and deformable interface,
(B) elucidation of thermal-flow field and its near-wall structure in micro- and nanometer-scale channel, and,
(C) elucidation and control of mass transport near the micro- and nanometer-scale movable and deformable interface.

Education

In parallel with the research activities, several workshops (*I^2plus Workshop*) and seminars (*I^2plus Seminar*) open to the public are held in a fiscal year. In the *I^2plus Workshop*, students and faculty members make active discussion through presentations of latest results. In order to accelerate 'cross-cultural' interaction, students are actively encouraged to join the poster sessions. In the *I^2plus Seminar*, we will invite researchers from all over the world to have fruitful discussion and inspirations. We have invited speakers from Lunds Universitet (Lunds University, Sweden), Technische Universität Wien (Vienna University of Technology, Austria), University of Florida (the United States), Univ. Paris-Sud XI (Paris-Sud University, France), Indian Institute of Technology, Ropar (India) and others. Since JFY2013, we have hosted *I^2plus International Symposium on Interfacial Thermo-Fluid Dynamics*. The 1st Symposium was held at Noda-Campus, Tokyo University of Science on 4th April 2013, the 2nd Symposium in March 2014, and the 3rd in Feb. 2015 (Fig. 2). We had fruitful discussion and exchanged ideas with speakers/participants from France, Israel, Sweden, the United States and others as well as the students at Tokyo University of Science.

We also make strong efforts to realize exchange of students between foreign universities in order to accelerate interdisciplinary collaborations, and to provide international environments for researches and daily lives for young students as well as faculty members.

Two master-course students in Dept. Mechanical Engineering, Fac. Science & Technology at TUS stayed to join collaborative research at Dept. Chemical Engineering at University of Florida, and a Ph.D. candidate from that department stayed at Dept. Mechanical Engineering, Fac. Science & Technology at TUS in the JFY2012. Two other master-course students in Dept. Mechanical Engineering, Fac. Science & Technology at TUS stayed at the Microgravity Research Center in Université Libre de Bruxelles (Belgium) in JFY2014 and 2015. A faculty member stayed at Université Lille 1 (France) to prepare the program of the exchange students and faculties for collaborative researches in the JFY2013, and a master-course student stayed at Université Lille 1 to carry out a series of experiments for the collaboration among Technion (Israel), Univ. Lille 1 and TUS. A part of this collaboration between France and our group is financially supported by the Bilateral Joint Research Project of the Japan Society for the Promotion of Science (JSPS) for JFY2015 and 2016.

Based on such international and interdisciplinary collaborations by this Research Division, our university, TUS, have established international partnerships and agreements with Université Lille 1, Technische Universität Wien, and National Chung Hsing University (Taiwan).

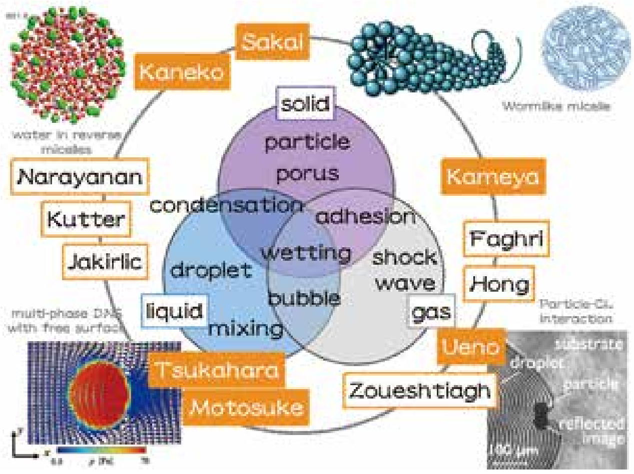


Fig. 1 Prime factors of phenomena within a phase or between/among phases.

Fig. 2 Snapshots at I^2plus 3rd International Symposium on Thermo-Fluid Dynamics (Katsushika Campus, Tokyo University of Science, 25th and 26th Feb., 2015).

Research Center for Chirality

Established: April 2012

shiina@rs.kagu.tus.ac.jp

Director
Professor,
Division of Applied Chemistry,
Faculty of Science Division I
Isamu Shiina

Objectives	The amino acids and other components of living organisms are chiral. Our objectives are to develop methods for the asymmetric synthesis of chiral compounds, to elucidate the origins of molecular chirality and to develop asymmetrical synthesis.
Future Development Goals	On the basis of the fruits of research carried out in the past by our individual members, we aim to further promote research in fields related to chirality, giving consideration to our members' other alliances.

Living creatures including human-being act in the world of three dimensions. In the world of three dimensions, both structures expressed by the coordinates of [x, y, z] and [x, -y, z] are possible, *i. e.*, enantiomers. However, many biologically related compounds are composed with only one enantiomer. We will promote the research on (1) the origin of homochirality of biocompounds and (2) enantioselective synthesis of biologically active compounds.

Research on chirality at levels ranging from the molecular level to that of aggregates

Introduction

Research Center for Chirality was established in April of 2012.

An object is said to be chiral when it is non-superposable on its mirror image, as are the palms of your left and right hands. Biogenic compounds such as L-amino acids and D-sugars could be expected to have 2 possible enantiomers, each of which would differ in action from the other, but we know that in many cases, only one of these actually exists in nature.

This, then, presents one of the important challenges in research: developing methods of asymmetric synthesis that can be used to produce the other, missing enantiomer, which is desired for the properties it would offer. Elucidating the origins of chirality in biogenic compounds, together with the processes by which it is generated and amplified, is one of science's unsolved problems. And because chirality is observed not only at the molecular level, but also at the level of individual organisms (visceral situs, etc.), the elucidation of its origins at the molecular level becomes an important theme in terms of shedding light upon the genesis and differentiation of life. Recently, at our university, a great deal of interest has been focused upon molecular chemical research on such topics as how chirality is generated by chiral autocatalytic reactions and how asymmetrical organocatalysts are produced. Thus far, our university's efforts have steadily born fruit in the form of useful findings in such areas as remote asymmetric induction in diastereoselective and enantioselective asymmetric synthesis.

Objectives

Research Center for Chirality, organized around the concept of chirality, brings together researchers from our university who work in fields of chiral molecular chemistry. The goals of its projects are to elucidate the origins of chirality and the process of its amplification, to develop chiral complexes and asymmetrical catalytic reactions using asymmetrical organocatalysts, and to open up the field of the asymmetric synthesis of useful chiral compounds by diastereoselective and enantioselective reactions. In this way, we aim to produce results in the field of chiral science that will position us at the top global level in terms of the originality of our Research Center.

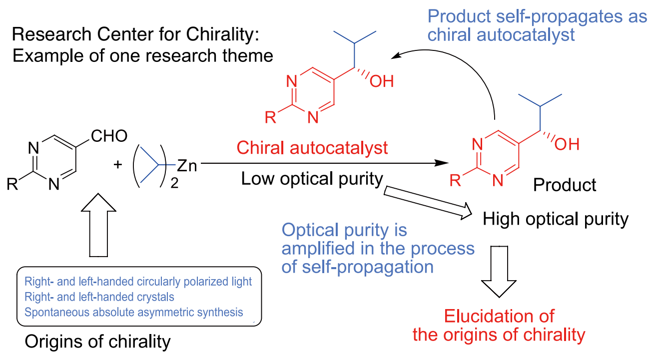
Characteristics

One of the characteristics of Research Center for Chirality is that the level of the research into chirality conducted by our constituent faculty members is high from a global standpoint in terms of both quality and quantity. Our research group bringing together researchers of chiral molecular chemistry has the distinction of being one of the few such units in the world. The elucidation of the origins of chirality has long been regarded as one of the unsolved mysteries of science. The utilization of chiral autocatalytic reactions can be expected to contribute much to the solution of this problem. Trail-blazing activities in asymmetric synthesis using asymmetrical organocatalysts and complex catalysts can also be expected to yield environment-friendly techniques that are applicable to asymmetric synthesis of pharmaceuticals and the like. Through these kinds of research, the center will contribute to the establishment of a deeper appreciation of the profundity of the natural world in relation to chirality, and our work is also significant in that it will provide new techniques for the asymmetric synthesis of chiral substances.

Research on chirality has attracted the attention of many researchers worldwide, and it is an area of intense competition, but our faculty's research on chirality is exceptionally original and ranks top-class globally in terms of both quality and quantity. Almost nowhere else in the world will you find a research center that brings together researchers from wide range of molecular chemistry to devote their main efforts to the study of chirality. This center has produced extremely advanced research results on the topic of chirality, and it is regarded with great expectations for its potential not only to provide valuable asymmetric synthesis methods for chiral substances, but also to provide clues to one of the great unsolved mysteries of science by shedding light upon the origins of the chirality of biogenic compounds.

Research Content

A: Elucidating the origins of chirality through chiral autocatalytic reactions: We endeavor to elucidate the origins of chirality by using chiral inorganic substances and dynamic chiral factors together with chiral autocatalytic reactions that improve enantiomeric excess, in order to obtain chiral compounds with high optical purity.



B: Asymmetric preparation of chiral compounds by kinetic resolution: development of asymmetric kinetic resolution for the preparation of chiral drugs.

C: Synthesis of chiral compounds: Development of manufacturing methods for chiral compounds by the following 2 approaches.

C-1: Development of asymmetrical reactions: These investigations of asymmetrical aldol and other reactions have as their aim the construction of chiral quaternary carbon centers, for which a good method of synthesis has not previously been available. We also are working on chiral transcription synthesis of spiro skeletons and one-pot synthesis of spirocyclic oxindoles. By applying chiral catalysts to chiral hetero Diels-Alder reactions and chiral epoxidation reactions, we also synthesize chiral building blocks. Finally, with an eye toward chiral sulfoxide compounds that can easily be synthesized as optically active starting materials, we are using 1,4-remote concurrent asymmetric induction to synthesize various useful chiral intermediates.

C-2: Development of chiral catalysts: Asymmetrical catalytic reactions that synthesize large quantities of chiral compounds from catalytic amounts of chiral initiators are one of the outstanding methods of synthesizing optically active substances. To this end, the development of superb catalysts is regarded as essential. Our center has developed transition metal catalysts possessing surface chirality or helical chirality, and we have applied these to polymer synthesis reactions (polymerization reactions) to control the main chains (primary structure) of the generated polymers and synthesize optically active polymers. Moreover, we are working on the design of amino acid-derived organic chiral catalysts and the development of practical asymmetric synthesis methods allowing for the synthesis of large quantities of substances. Lastly, we are conducting research on methods of synthesizing chiral compounds that do not use organic solvents, with the goal of discovering exceptional methods of asymmetric synthesis that are environmentally friendly.

Translational Research Center

Established: April 2014

higami@rs.noda.tus.ac.jp

Director
Professor,
Department of Medicinal and Life Science, Faculty of Pharmaceutical Sciences
Yoshikazu Higami

Objectives	To share the benefits of basic research seeds with the medical community through refining scientific innovations, such as new drugs and technologies, developed at Tokyo University of Science (TUS) for successful clinical applications.
Future Development Goals	We expect that ongoing joint research projects between the Translational Research (TR) Center and collaborating medical institutions will bear fruit in the near future. We also plan to conduct more joint research projects based on the discovery of new seeds at TUS and the needs proposed by medical institutions in Japan. Moreover, we will also promote international collaborative research with University of Hawaii Cancer Center.

The TR Center was founded to perform joint research with medical institutions for the purpose of transforming basic research seeds developed at TUS and applying them in clinical practice. Our Center welcomes researchers who are interested in the clinical application of their research seeds.

Our work applies early stage innovations (seeds) obtained in basic science to develop diagnostic, therapeutic and preventive measures for use in clinical practice.

About Translational Research

TR involves reevaluating the clinical application and therapeutic potential of basic research findings and technologies and refining these scientific discoveries for clinical use. In other words, TR serves as a bridge between basic research and clinical practice. This is exemplified by the slogan "From Bench To Bedside!" which is used often in the United States.

History of the TR Center

Although Japanese researchers have produced many outstanding seeds from their basic research, TR—which is needed to bring these research results to life in clinical settings—has not yet gained sufficient ground in Japan and is one of the major obstacles to the development of new drugs and medical technologies. Excellent basic research has been conducted by many departments at TUS, and we have amassed a large number of seeds with the potential to contribute to the medicine of tomorrow. We have a very small number of connections with medical institutions because TUS is not affiliated with hospitals. This has made it difficult for TUS to share the benefits of its basic research achievements with healthcare professionals.

In recent years, universities have begun to develop a TR research system for the clinical application of their basic research seeds by establishing a TR division. At TUS, we also established a TR Division in 2009, to serve as a liaison point for joint research with medical institutions. Thanks to the staff' s dedicated efforts and their major research results, the TR Division was expanded into the TR Center in April 2014. To promote TR further at TUS, we must collaborate with medical institutions to identify clinical applications for our seeds.

Research Objectives

The mission of the TR Center is to help researchers at TUS perform, in collaboration with the Faculty of Medicine and other medical institutions, innovative investigations that bridge basic and clinical research and that subsequently turn the research seeds into novel health care products and other clinical applications.
To succeed in our mission, we take the following three approaches:
(1) Promote the development of novel drugs, drug delivery system (DDS), diagnostic techniques and medical technology for clinical use.
(2) Perform drug repositioning (drug repurposing) by re-profiling the pharmacological properties of known drugs or chemical compounds whose development was previously terminated due to a failure to deliver therapeutic effects.
(3) Promote the clinical application of novel drugs and technologies developed at TUS in collaboration with medical institutions.

Members of the TR Center

As of writing in June 2016, the TR Center houses 26 in-house researchers (19 from the Faculty of Pharmaceutical Science, 3 from the Faculty of Science, 1 each from the Faculty of Engineering, Faculty of Science and Technology, and 2 from Faculty of Industrial Science and Technology) and 30 visiting research fellows from outside the TUS community.

In-house Researchers (26)

Faculty of Pharmaceutical Science: Yoichiro Isohama, Ichiro Horie (Applied Pharmacology); Junichiro Oka, Yayoi Tsuneoka, Sachie Hamada (Neuropsycho-pharmacology); Masayo Komoda (Medical safety sciences); Tsugumichi Sato (Pharm acoepidemiology,Therapeutic risk management); Takehisa Hanawa, Yayoi Kawano (Clinical design); Tatsuya Higashi, Shojiro Ogawa (Bio-analytical chemistry); Yasunari Mano (Clinical Drug Informatics); Kazumi Yoshizawa (Pharmacology and therapeutics); Kazunori Akimoto (Molecular Medical Science); Yoshikazu Higami (Molecular pathology and metabolic disease); Fumio Fukai, Takuya Iyoda (Molecular patho-physiology); Takeshi Wada, Rintaro Hara (organic synthetic chemistry, Life Molecular science), Faculty of Science: Hidetaka Torigoe (Biochemistry), Hidenori Otsuka, Daisuke Matsukuma (Colloid and interface science), Faculty of Engineering: Chikuma Hamada (Statistical science), Faculty of Science and Technology: Keiko Sato (Bioinformatics), Faculty of Industrial Science and Technology: Chiharu Nishiyama, Takuya Yashiro (Immunology, allergy and molecular biology)

Guest Researchers (30)

University of Tsukuba: Ichinosuke Hyodo, Akinori Yanaka, Hideo Suzuki (Gastroenterology); Akira Matsumura, Tetsuya Yamamoto (Neurosurgery); Nobuhiro Ohkohchi (Surgery); Yoshinori Harada (Critical research and education integrated leading center); Masayuki Noguchi (Diagnostic pathology); Hitoshi Shimano, Yoshimi Nakagawa (Endocrinology and metabolism),National Cancer Center Research Institute: Yasuhito Uezono (Cancer Patho-Physiology); Michihiro Muto (Cancer Prevention Basic Research), The Jikei University School of Medicine: Toshifumi Ohkusa (Gastroenterology); Takashi Sasaki (Diabetology), Tokyo Medical Univeristy: Yasushi Matsuzaki (Hepatology), Tokyo Metropolitan Institute of Gerontology: Kazuhiro Shigemoto (Geriatric Medicine), National Institute of Infectious Diseases: Masayoshi Fukasawa (Virology), Juntendo University Hospital: Yoshiya Horimoto (Breast Cancer), Tomonaga Clinic Hospital: Osamu Tomonaga (Diabetes and lifestyle-related diseases), Hokkaido Government, Department of Health and Welfare: Takuya Matsunaga (Hematology), Saga University: Hiroaki Kodama (Chemistry and applied chemistry); Mitsuru Noguchi (Urology), Nagasaki University: Isao Shimokawa, Ryoichi Mori (Pathology); Susumu Eguchi (Transplantational surgery); Tomoshi Tsuchiya (Surgical oncology), Osaka University: Ken Ishii (Immunology); Koji Yamamoto (Translational and clinical research), Sasaki Institute: Takao Sekiya (Pharmaceutical science): Naoyuki Okita (Molecular biology).

Ongoing Projects Conducted in Collaboration with Visiting Research Fellows (Collaborative Institutions)

1. Development of functional foods for the prevention of cancer and lifestyle diseases (University of Tsukuba)
2. Development of glioblastoma treatment targeting the tenascin-C molecule (University of Tsukuba)
3. Development of transplantable regenerative lung by modulation of integrin (Nagasaki University)
4. Discovery of calorie restriction mimetics that extend healthy lifespan (University of Tsukuba, Sasaki Institute, Nagasaki University)
5. Development of antisense oligodeoxynucleotides that accelerate skin wound healing (Nagasaki University)
6. Development of antisense oligodeoxynucleotides that treat bladder carcinoma (University of Hawaii)
7. Development of PARP inhibitor with novel molecular mechanism (Nagasaki University, Saga University, Sasaki Institute, University of Hawaii)
8. Clinical trial of bath therapy using the antiscabietic agent ivermectin
9. Development of preventive medicine for colon cancer using big data analysis (National Cancer Center)
10. Development of science-based kanpo medicine that improves QOL of cancer patients (National Cancer Center)

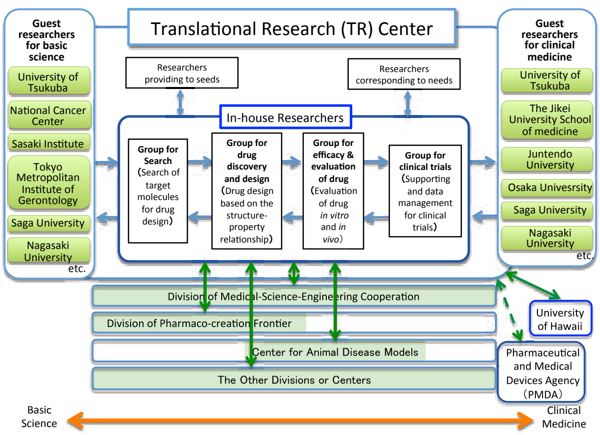


Fig : research organization of TR Center, Cooperation of In-house Researchers and Guest Researchers

Division of Bio-organometallics

Established: October 2012 bio-organometallics@rs.tus.ac.jp

Director
Professor,
Department of Pharmacy,
Faculty of Pharmaceutical Sciences
Toshiyuki Kaji

Objectives	To perform a joint research project by reserchers in the field of chemistry, molecular biology, physics, computational sciences, toxicology, and analytical science of oraganic-inorganic hybrid molecules.
Future Development Goals	Based on the new concept of bio-organometallics, the researchers in various research fields perform a joint research and show the result unrealizable by the conventional sciences.

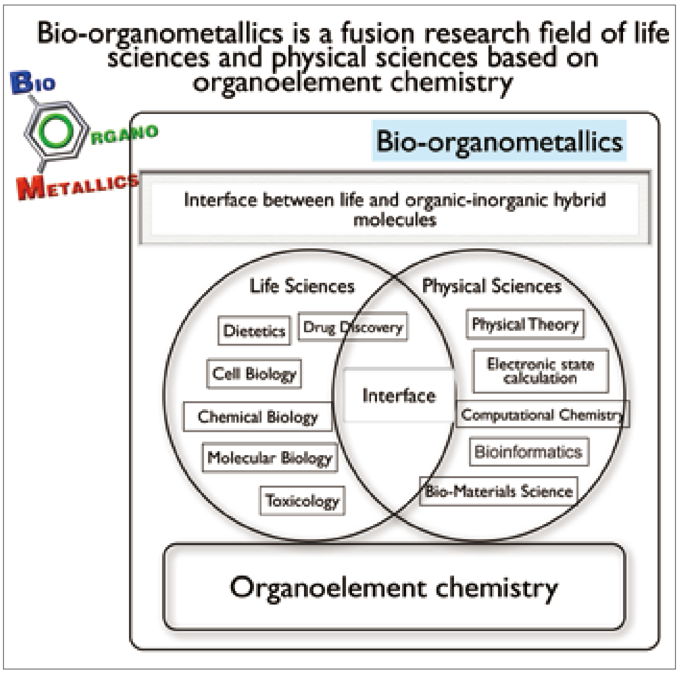
The division of bio-organometallics was founded in October, 2012. It is very significant for bio-organometallics research to obtain a research base in Tokyo University of Science. We will send the research results of bio-organometallics by making full use of organic-inorganic hybrid molecules prior to the world through joint researches among researchers of various research fields.

We perform reserch of Bio-organometallics, a new science field of bilogy using oraganic-inorganic hybrid molecules.

What is bio-organometallics?

Although chemical compounds are classified as organic compounds or inorganic compounds, organic-inorganic hybrid compounds (organometallic compounds and coordination compounds) have both characteristics. Since pioneering researchers, such as Grignard and Wittig, utilized the hybrid molecules in the field of synthetic chemistry, organic element chemistry is splendidly developed. However, in most cases, the usefulness of the hybrid molecules is still evaluated as synthetic reagents, and the contribution to life sciences is in a very insufficient situation.

This division really begins and develops bio-organometallics reseach. Bio-organometallics means biology of organic-inorganic hybrid molecules. Taking advantages of the outstanding characteristics of hybrid molecules, we perform studies to regulate biomolecules and biological systems, those to exhibit the specific biological activities of metals in the target molecules and tissues, and those on organic element chemistry and computational sciences of the hybrid molecules. In addition, these studies variously collaborated and will make a new field of life sciences and technology.



The strategy to use organic-inorganic hybrid molecules

The characteristics of the hybrid molecules from the viewpoint of life sciences are as follows: (1) The metal atm in the hybrid molecules can change the three-dimensional structure of the molecules. (2) The molecular structure can control the dynamic states in the living body and biological activities of the metal atom. (3) The metal atm in the hybrid molecules can change the electronic state of the molecules.

Taking advantages of these characteristics, we use the hybrid molecules as a tool to analyze biological systems, like a molecular probe of chemical biology, and as sead/lead compounds of drug design. Furthermore, we would like to utilize the hybrid molecules as a tool to analyze the interrelationship between the electronic state and biological activity of chemical compounds.

Organization of the division of bio-organometallics

In order to develop bio-organometallics research, researchers in the field of chemistry, molecular biology, physics, computational sciences, toxicology, and analytical science of oraganic-inorganic hybrid molecules are organized from the inside and outside of the university. These researchers not only perform their original bio-organometallics research in their field but also organically collaborate each other, utilizing the mutual research results.

In-house Reseachers

Toshiyuki Kaji (Faculty of Pharmaceutical Sciences), Shinichi Saito (Faculty of Science), Noriaki Hamada (Faculty of Science and Technology), Satoru Miyazaki (Faculty of Pharmaceutical Sciences), Takumi Uchiro (Faculty of Pharmaceutical Sciences), Ryoko Takasawa (Faculty of Pharmaceutical Sciences), Tatsushi Imahori(Faculty of Engineering), Akira Sano (Faculty of Pharmaceutical Sciences), Yo Shinoda (Faculty of Science and Technology)

Guest Researchers

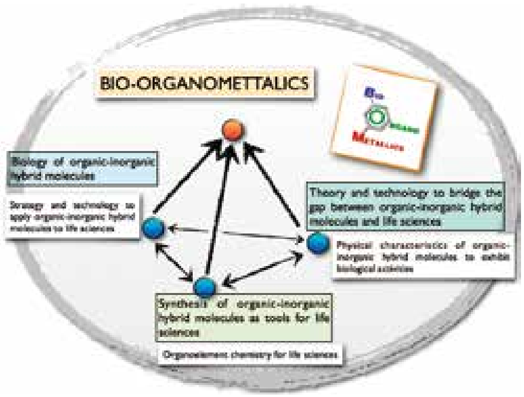
Masanobu Uchiyama (University of Tokyo), Masahiko Satoh (Aichi Gakuin University), Tsuyoshi Miyazaki(National Institute for Materials Science), Chika Yamamoto (Toho University), Shuji Yasuike (Aichi Gakuin University), Yasuyuki Fujiwara (Tokyo University of Pharmacy and Life Sciences), Tomoki Kimura (Setsunan University), Hiroshi Naka (Nagoya University), Hitomi Fujishiro (Tokushima Bunri University)

Desired results of the Division' s research

The division of bio-organometallics accumulates the research results that is difficult or impossible to obtain by traditional ways of thinking.

1. We establish the technology to synthesize organic-inorganic hybrid molecules that have a specific three-dimensional structure necessary for a specific biological activity and send metal ions to a target biomolecules, leading to a criation of new organic element chemistry which cultivates life science.
2. We search and find unique biological activities and toxicities of the hybrid molecules and discover the molecular targets. We also find out about new biological systems, new functional proteins and new sead/lead compounds of drug design. In addition, we establish the technology to analyze the hybrid molecules to support the biological experiments.
3. We establish the methodology to understand the mechanism of biological activities of organic-inorganic hybrid molecules from the three-dimensional structure and the electronic state of the molecules. Furthermore, we develop the methodology to the bridging technology that connects the hybrid molecules to life sciences.

We originate a new research current by developing the above research and show the infinite vitality of bio-organometallics prior to the world.



Academic Detailing Database Division

Established: April 2014 komo1207@rs.noda.tus.ac.jp

Director
Professor,
Department of Pharmacy,
Faculty of Pharmaceutical Sciences
Masayo Komoda

Objectives	Our aim is to integrate these data in order to develop original diversified Academic Detailing Database. Then we would be able to propose a doctor the most appropriate medicine for a patient by using it.
Future Development Goals	We will try to make the database related to breast cancer first. In the future, we hope to expand into several diseases and release the Academic Detailing Database to all pharmacists in Japan.

In this Division, we established in April, 2014. Our pharmacist education program utilizing basic pharmaceutical sciences for patients is still not enough to be a highly qualified clinical pharmacist. Therefore, we focus on utilizing basic pharmaceutical sciences and established division of Academic Detailing Database in our University.

Academic detailing is personalized support for improving both knowledge and clinical decision-making by the latest non-commercial evidence-based data.

How and why academic detailing works to improve clinical decision-making

- **A Government-funded public health improvement program from the pharmacy department of an acute care geriatric teaching hospital**
- **Serving South Australian primary and secondary care practitioners since 1991**
- **Regular visits to ˜1100 doctors every six to nine months**
- **Personalized therapeutic advice services during and between visits**
- **>90% of all Primary Care Doctors in the State**
- **Topics covered include**
- **Disease management issues**
- **Prescribing issues**
- **Preventive care issues**
- **Quality of care issues**

Academic detailing programs are extensively used in other countries, particularly in Australia and Canada. While there are important differences between those healthcare systems and that of the United States, it is important to note that U.S. prescription drugs are generally considerably more costly. That may suggest the potential for even greater savings here. In Australia, the National Prescribing Service program generated net savings of 300 million Australian dollars over ten years. This is largest, longest running program in the world, involved 11,500 individual prescribers in 2006-2007 (a steady increase from 2,500 participants in 1998–99. Over a nearly ten-year period 1997-2005), estimated savings have consistently been greater than budgeted.

Dr. Frank May is one of members who established Academic detailing programs in Australia. We invited him as the speaker in the symposium we held last year.

The First Academic Detailing Conference

Academic detailing is personalized support for improving both knowledge and clinical decision-making by the latest non-commercial evidence-based data. First Academic Detailing Conference was held last 2013 at Boston, USA. Many world's eyes focus on Academic Detailing lately.

Doctors select mainly best medicine through viewpoint of experiences and clinical guidelines to prescribe patients (Fig.1). Pharmacists select mainly best medicine through viewpoint of drug characteristic such as pharmacological action, physical chemistry characteristic and metabolite mechanism. Furthermore, pharmacists also require to provide medical teams with the latest information including molecular pharmacology, genome information and others. Our university is traditionally fulfilling basic pharmaceutical sciences. However, our pharmacist education program utilizing basic pharmaceutical sciences for patients is definitely not enough to be a highly qualified clinical pharmacist. Therefore, we focus on utilizing basic pharmaceutical sciences and established division of Academic Detailing Database in our University. Eight essential fields which are necessary to support Doctor's prescription are Biology, Chemistry, Physics, Pharmacology, Pharmaceutics, Pharmacotherapy, Clinical Guideline and Drug Adverse Reaction (Fig.2).

Our aim is to integrate these data in order to develop original diversified. Academic Detailing Database. Then we would be able to propose a doctor the most appropriate medicine for a patient by using it. First, we focused on breast cancer treatment and started to develop the Pharmaceutics database last year (Fig.3). The new program which is to utilize Academic Detailing Database for patient was also tested. In the future, we will expand into several diseases and release the database to all pharmacists in Japan.

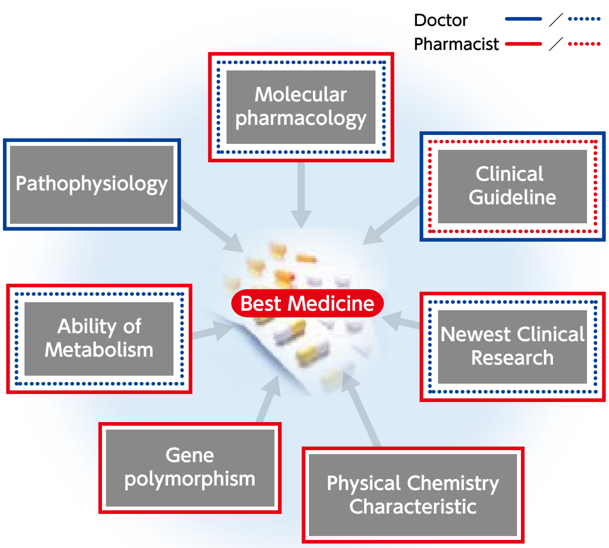


Figure 1. Each point of view to select an appropriate medicine for a patient.

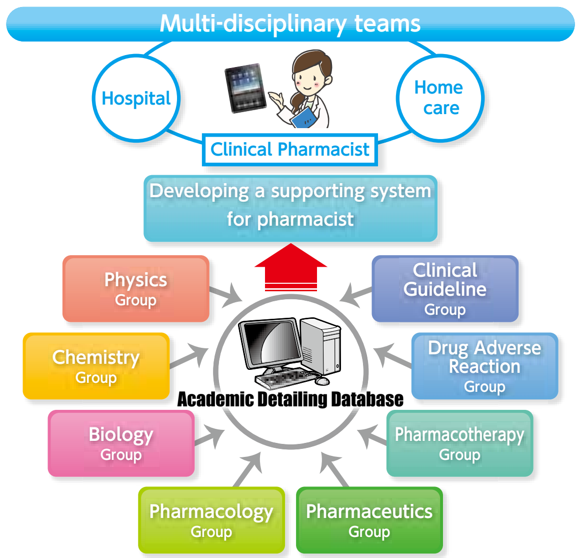


Figure 2. Eight essential fields of the division.

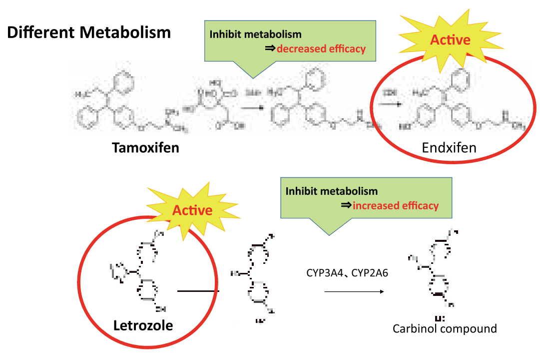


Figure 3. Focused on breast cancer treatment

Established: October 2014 rabe@rs.noda.tus.ac.jp

Bio and Pharmacy

Division of Medical-Science-Engineering Cooperation

Objectives	To realize a society in which people live long healthy lives, advanced science and technology developed at our university will be cross-sectionally integrated with the aims of preventing bed confinement and dementia, and of developing early diagnostic and treatment methods for chronic diseases such as cancer, cardiovascular and cerebral nerve diseases, and allergic diseases.
Future Development Goals	Through the activities of the Researcher Network, we plan to consolidate advanced science and technology available at our university to treat aging-associated diseases and to establish cooperative systems with other medical institutions.

Director
Professor,
Research Institute for Biomedical Science
Ryo Abe

This research division was founded through the collaborative efforts of researchers at our university in the preparation of the Global Center of Excellence (COE) Program application and the research activities at the Center for Technologies against Cancer. I want to make this research division to be an organization that promotes the activities of "Healthcare and Life Innovation", which is one of the university's main research topics.

We aim to prevent aging-associated diseases and develop treatment methods by consolidating the advanced science and technology available at TUS.

Background

Eight years ago, the Tokyo University of Science Researcher Network was founded as a forum for TUS researchers to communicate and interact through their research across the frame of departments and specialties. The network's founding was preceded by multidisciplinary discussions between volunteers working toward the Global COE Program application. The aims of the network were not only to expand the research horizons of individual researchers, but also to discover and create interdisciplinary and new research fields through the understanding of other scientific disciplines. Then, in collaboration with National Cancer Center East Hospital, the Center for Technologies against Cancer (CTC) was founded in 2009 by researchers, including many of the network members. The aim of the center was to develop innovative diagnostic and treatment methods for cancer. Tokyo University of Science does not have a school of medicine, so the founding of the CTC was our first organizational effort to enter the fields of healthcare and medicine. Yet, we were able to make great strides and accomplish much. Notable achievements include hosting a total of 21 lectures by physicians at the National Cancer Center to advance the understanding of cancer treatment among our faculty members and students, and conducting on-campus recruitment of engineering and science faculty members to expand the Researcher Network and get them involved in healthcare or medical research for the first time. Upon the closing of the CTC in 2013, we decided to established the new research division to inherit, maintain, and expand what we have achieved from the CTC activities, such as the cooperative on- and off-campus networks connecting the fields of medicine, science, and technology. Through this division, we will continue ongoing research and development to promote the commercialization of research results, and will prepare for the founding of a new research center that will take over the cooperative projects developed by the CTC.

Significance

With a life expectancy of 86 years for women and 80 years for men, Japan has become the world's leading country in terms of longevity. However, to realize a society with sustainable health and longevity, it is essential to shift from hospital-based care to home healthcare, to prevent bed confinement and dementia, and to develop early diagnostic and treatment methods for chronic diseases such as cancer, cardiovascular and cerebral nerve diseases, allergic diseases, and autoimmune diseases. In collaboration with off-campus medical institutions, this research division integrates cross-sectionally the highly specialized science and technology developed at TUS with the aim of realizing innovative healthcare techniques that contribute to creating a society where people live long, healthy lives.

Research projects, aims, and teams

This research division creates and nurtures the advanced science and technology that serve as a foundation for realizing a society where people live long, healthy lives. This is accomplished through the networks connecting highly motivated scientists and advanced knowledge and technologies at TUS with of-campus facilities for medicine, nursing care, and health maintenance. This research division then functions as an application core for advanced science and technology and as a practical core for multidisciplinary projects like the Researchers Network. At this division, multidisciplinary core projects are developed by experts in electromechanical engineering, including robotics, microfabrication, fluid dynamics, image processing, and electronic control; materials science, including biomedical polymers, inorganic materials, and nanoparticles; information science including machine learning, big data, and bioinformatics; and medical and pharmaceutical sciences, including drug discovery, organic chemistry, health sciences, and medicine.

Advanced preventive and diagnostic technology development team

This team aims to develop techniques for early disease detection that utilize liquid biopsy or a diagnostic tool using ill explored light frequencies, to predict the prognosis of cerebral aneurysm by analyzing factors associated with growth and rupture, and to establish a living environment that prevents diseases.

Novel treatment technique development team

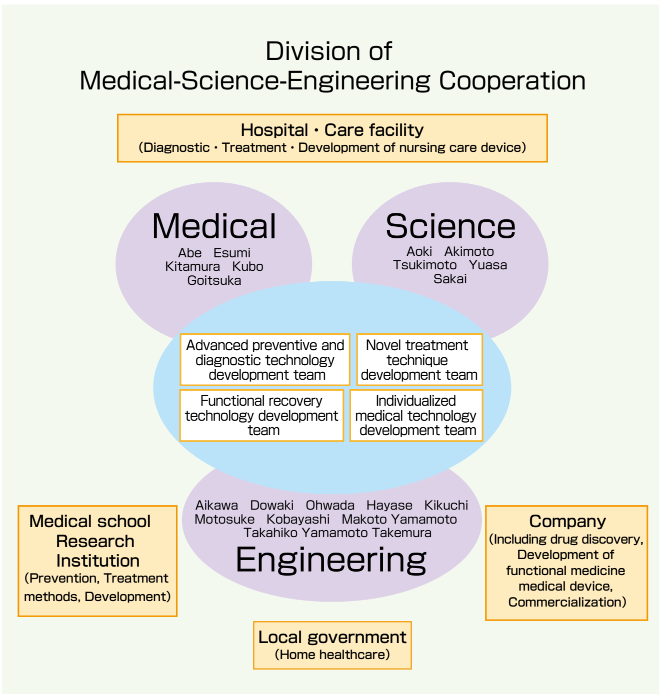
This team aims to 1) discover chemical and biological agents for the treatment of cancer, immune diseases (allergy and rheumatism), and infectious diseases, 2) to develop treatment systems that utilize three-dimensional information from combined diagnostic imaging, and 3) to improve the safety and efficacy of boron neutron capture therapy (BNCT) for patients with intractable cancer toward the therapy's incorporation into clinical practice.

Functional recovery technology development team

This team aims to develop 1) robots for home healthcare and nursing care, to develop 2) artificial organs, treatment devices, and auxiliary systems using new materials and new techniques, and to develop 3) regenerative medicine technology to promote functional recovery and reconstruction.

Individualized medical technology development team

This team aims to develop 1) individualized medical technology using large-scale clinical and omics data, to predict disease prognosis computationally, to create 2) treatment selection algorithms, and to develop 3) a management engineering-based healthcare system, novel influenza vaccines, and tailor-made cancer therapies using antibody-producing cells.



Fusion of Regenerative Medicine with DDS

Established: April 2015
ddsj@rs.noda.tus.ac.jp

Director
Professor,
Department of Pharmacy,
Faculty of Pharmaceutical Sciences
Kimiko Makino

Objectives	With a view to promoting commercially viable regenerative medicine, our aim is to learn the structure of human body and to deliver medicine to the target organ when the medicine is needed.
Future Development Goals	To research and develop more efficient drug delivery systems with lower side effects of drugs.

DDS is an indispensable means of making drugs work more efficiently. We have develop biocompatible and biodegradable particles with nano- or micro-size to deliver bioactive materials to the target organs, such as skin, brain, lungs. For this purpose, new drug molecules and polymers are also developed. Intelligent tablets including oral disintegration system will be developed.

R&D on regenerative medicine with DDS.

DDS

For the effective regenerative therapy, we have studied targeting of medicine.

Nanomedicine

Nanomedicine is medical treatment at the "nano" scale of about 100 nm or less. From 1980's, progress in developing nanosized hybrid therapeutics and drug delivery system has been remarkable and products have been approved for clinical use. Most are anticancer therapies, polymer-coated liposomes (Doxil®/Caelyx®), antibodies (Herceptin®, Avastin™), a nanoparticle containing paclitaxel (Abraxane™). The concepts of antibody-conjugates, liposomes, nanoparticles, polymer micelles stem from the 1970s. Liposomes are biocompatible drug carriers, but easily release drugs quickly or do not release drugs and sometimes captured by the reticuloendothelial system (RES), even when the liposome surfaces are coated by hydrophilic polymer layers. Particles with the diameters larger than 200 nm are easily recognized by RES and digested by macrophages after intravenously administered. To escape from the recognition by RES, many studies have been reported. For this purpose, synthetic biocompatible polymers have been developed.

Preclinical and clinical evidence of this formulation (Doxil®/Caelyx®), Fig. 1, has demonstrated that the nanoparticle, especially pegylated liposome, delivery system leads to greater localization of doxorubicin to tumor site and consequent improved efficacy, as well as, reduced toxicity. For vascularized tumors, the selective accumulation and retention of liposomes is a result of the combination of 'leaky' tumor neovasculature and malfunctioning lymphatics, integrated in enhanced permeability and retention (EPR) effect, as shown in Fig. 2.

Nanosized particles have high surface-to-volume ratio, could be especially dangerous, although they are less effectively taken up by macrophages and can reach brain passing through blood brain barrier (BBB). Any toxicity of nanoparticles depends on the route and frequency of administration, and polymer used to prepare the particles.

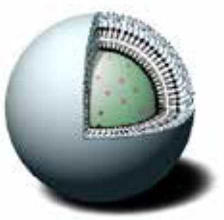


Fig 1. Pegylated liposomal doxorubicin

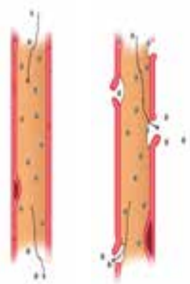


Fig 2. Pegylated liposomal doxorubicin in normal (left) and tumor vessels.

Regenerative medicine

Angiogenesis, the formulation of new blood vessels, is fundamental to development and post-injury tissue repair. Vascular endotherial growth factor (VEGF)-A guides and enhances actin filament formation and endotherial cell migration. Ischemic limb treatment will be improved by nano-DDS systems. Also, nano-DDS systems will be useful for the treatment of Chronic Obstructive Pulmonary Disease (COPD).

Pulmonary drug delivery system

The lung (adjectival form: pulmonary) is the essential respiration organ, and two lungs are located in the chest on either side of the heart. Their principal function is exchange of oxygen and carbon dioxide, transporting oxygen from the atmosphere into bloodstream and releasing carbon dioxide from the bloodstream to atmosphere, by the passage of air through the mouth to the alveoli. The air progresses through the mouth or nose, it travels through the oropharynx, nasopharynx, the larynx, the trachea, the primary bronchiole, the secondary bronchiole, the terminal bronchiole, the respiratory bronchiole, and finally reaches the alveolar duct where the gas exchange of CO_2 and O_2 takes place. Recently, there have been many attempts to improve systemic delivery of peptide and protein drugs by routs of administration other than injection. The drug delivery in these studies have included nasal, rectal, buccal, and respiratory rout of administration. Because of the unique physiological characteristics, lung is an attractive port of entry to the systemic circulation for the administration of drugs. That is, the alveoli present a large surface area for adsorption of about 100 m^2, a very thin diffusion path separates the airspace form the blood stream, i.e., the alveolar epithelium, the vascular endothelium and their respective basal membranes are less than 0.5 μm thick. Also, the high blood flow of about 5 ℓ / min of the pulmonary circulation rapidly distributes molecules throughout the body without first-pass hepatic metabolism, and the metabolic activity locally in the lungs is relatively low. Together with the success of design of new inhalers, pulmonary delivery of small drugs and proteins has reached clinical trials of drugs such as insulin, calcitonin, interferon, and hormone.

The environment in the lungs is very moist, and the humidity in the respiratory tract is almost 100 %. To reach alveolar through the respiratory tract, the medicine should have the proper size and density, shown as an aerodynamic diameter. As shown in Fig. 3, the particles with the aerodynamic diameters between 2 and 5 μm can efficiently reach alveoli. The particles smaller than 1 μm are easily inhaled by respiration but exhausted from lungs without deposition in alveoli, like tabacco smoke. The aerodynamic diameter of the particle, d_{aer}, is defined as equation (1) which is simply derived from Stokes' equation,

$$d_{ae} = d_p \sqrt{\frac{\rho_p}{\rho_0}} \quad (1)$$

where d_p is the diameter of the particle which is usually measured using laser diffraction, ρ_p the density of the particle, ρ_0 the density of water at the same temperature.

As mentioned before, the environment in the lungs is very moist, which makes it hospital for bacteria and it causes infectious diseases in the lungs. For the treatment of these infectious diseases, direct delivery of antimicrobe agents to the lungs through respiratory tract has been considered to be effective. This is included in local injection of medicine to the lungs. Also, this concept has been applied to the treatment of lung carcinoma.

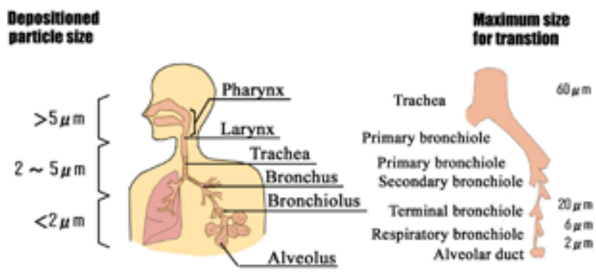


Fig 3. Deposittioned particle size in respiratory tract.

Division of Agri-biotechnology

Established: April 2015
shimadah@rs.noda.tus.ac.jp

Director
Professor,
Department of Biological Science and Technology, Faculty of Industrial Science & Technology
Hiroaki Shimada

Objectives	We hope to establish a steady and sustainable Agri-biotechnology system that leads to an innovation for improvement of the plant biomass productivity.
Future Development Goals	Regulatory elements involved in plant functions are deeply studied on the views of individual plant cells, bodies, and biomass.

This is a first trial on the research project for Agri-biotechnology in Tokyo University of Science. Our objectives are to cultivate a vacant field, sow seeds, let them germinate, and grow to open up a new research area. I hope here will become an arena where hundreds persons come together and discuss for development of a novel Agri-biotechnology.

Basic research for improved biomass production in view of the biotechnology and engineering

Faced to the climate change on earth such as global warming, and the explosive increase of global population. System construction for the steady supply of the food and sustained agricultural production is strongly required. In addition, in Japan, a problem caused by a decrease in population with low birthrate and the change of our lifestyle will occur. We need various types of foods that may satisfy the consumers' demands, and therefore the development of functional foods with good-taste and high quality is required. On the other hand, in the field of the agricultural production, a decrease in the young persons on agriculture ascribes to agriculture by the senior aged persons. In this article we offer a construction of a new system that may take a role to maintain the country and perform a sustainable agricultural production, which may achieve the steady supply of the food. We also propose a plan of agricultural innovation to make up a smart agriculture, so called as the sixth industry. In addition, demand for plant biomass is increase because they are used for the source of biomass energy or bio refinery projects.

In this research project, we plan to build an agricultural innovation to satisfy these demands. We hope to carry out the studies on various view-points and then make up the improvement of the biomass productivity in this purpose. We, in this way, hope to construct an Agri-bio system giving a sustainable cereal production. Therefore, We inspect the improvement of the plant function at a cell level, individual level, the point of view of the group level, and develop new technologies on the key factors. In other words, we look around the environment of the production field ranging from a genetic information (DNA) to the factors in the real farming. The improvement of the gene function involving in photosynthesis, a source function, translocation, distribution, sink functions, gene function control, evolutional engineering, genome editing, sensing, visualization of the material transportation, and the examination of an effective cultivation method, and then we hope to propose the new way for the profit utilization.

We figure out the factors that are important for biomass productivity. They cover the production of carbohydrates caused by the photosynthesis (carbon dioxide assimilation) with the source organs (organization to produce) such as green leaves, the transportation (translocation and distribution) of the material in the individual, the metabolism with the sink organ (organization to store), and production and storage of the stored substances. It is thought that we can maintain the high productivity when these are performed smoothly. I enumerated important points (element) that it was thought that it prescribed cereals productivity on the right side in the figure. We presume that high-level cereal productivity is led to us when these elements are achieved by Agri-biotechnology processes. It is suggested that there is a key gene participating in these elements for efficient productivity, and it is the first step of the improvement of cereals productivity.

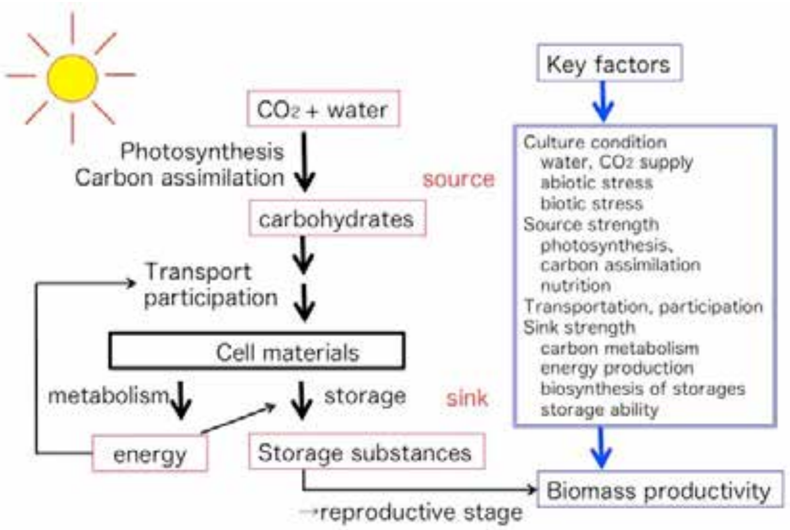
In this research section, we study on the basic research for the following three items, which we focused on the improvement of biomass productivity on the above-mentioned points of view: They include the inspection for the improvement of the plant function on a cell level, individual level, and group level, and development of a new technique for the key factors. We will investigate the studies on the function of the key factors involved in biomass productivity, which cover various scenes including molecular breeding and field examination. We hope they will give us a new technology for the stable and sustainable biomass productivity, and basal knowledge for New Plant Breeding Technology (NBT) such as genome editing, DNA-based plant breeding based on the genome information, and development of the efficient cultivation system.

Followings are our objectives:

①Enhancement of the plant function by the cell level study:
We will identify a useful gene involved in biomass productivity, and develop a technique to utilize this. We analyze DNA, RNA, protein, nucleotide as target materials. In addition, we determine their dynamics in detail using a model system.

②Enhancement of the plant function by the individual level study:
We will clarify the transport of the essential materials in the plant bodies, the transmission of the genetic information, and the interaction between the cells. In addition, we will elucidate the key factors by live imaging analysis, and develop a new technique to visualize the change of productivity during growth process, and the transportation of carbon dioxide assimilation.

③Enhancement of the plant function on the plant population:
We will analyze the influence and cultivation environment (light, flow of the wind) that gives on the growth to obtain a basic data. In addition, We attempt to engineer the production efficiency using a natural enemy.



Established: April 2016

tfuruichi@rs.tus.ac.jp

Brain Interdisciplinary Research Division (BIRD)

Objectives	We create a collaborative platform for interdisciplinary brain research to develop following areas with a focus on brain cognition: (1) Understanding brain health and disorders and the development of new tools for diagnosis and treatment (2) Analyzing and modeling neural activity, and designing brain-inspired ICT (3) The development of measuring and function-assisting devices
Future Development Goals	Using the emergent research infrastructure created by multidisciplinary integration, we aim to establish an R & D base for brain health, brain measurement, modeling, and for the creation of new devices with designs inspired by the brain function.

Director
Professor,
Department of Applied Biological Science, Faculty of Science and Technology

Teiichi Furuichi

Healthy brain function is essential for a richness of mind and a better quality of life. In our modern society of high stress and aging communities, the preservation of a healthy brain is becoming evermore important. Furthermore, the brain is a living energy-saving device that can massively parallel processes, learn, store and retrieve a myriad of information by itself. Therefore, we can expect creation of future technologies and devices inspired by the study of the brain.

Creating an R & D infrastructure for the study of the brain, neural information and neural systems.

The Scope of the Brain and Neuroscience Field

The brain and neuroscience field is a life science highly anticipated to show rapid advancements within the 21st century. The maintenance of good brain health is expected to improve the quality of life (QOL) within the current aging population. In addition, innovative information and communications technologies (ICT) can be created by applying the same information processing mechanisms as discovered in the brain. Therefore, the field has had high expectation from both society and industry.

Healthy Brain, Healthy Mind

The brain, responsible for controlling our thoughts and actions, is a system necessary for any person to live as a human being. Throughout the various stages of life, however, people can be confronted with several impairments of brain health. Developmental disorders of brain can cause autism spectrum disorder and has also been linked to an increased risk of schizophrenia. Furthermore, in today's stressful society, no one is immune to the risk of depression and other stress disorders. With the escalation of aging problem, our society is further burdened with the compounding issues associated with dementia such as Alzheimer's disease. Impairments of the health of brain and mind are directly linked to the loss of individual's QOL and thus a significant national health issue. In turn, such health issues are also linked to critical social issues stemming from the burdens placed on patient families and the financial losses...

Information Processing in the Brain

Brain has also been notably compared to a high-level analog computer with high-speed massive parallel processing. Whilst small in size and energy saving (with the power consumption of a mere 10-30W), the brain can process information equivalent to that of the supercomputer 'K' (9.9 million W). Technological development is currently underway utilizing brain-inspired computers and brain-machine interfaces (BMI). Despite such advancements, the cognitive systems and computational algorithms of the brain have yet to be completely elucidated.

Goals of the Brain Interdisciplinary Research Division

In order to unravel the complex details of the brain that controls human thought and action, and thus apply this knowledge to emergent development, multi-scaled, multimodal and multidimensional research approaches are required. Informatics that allows such integration becomes essential, and thus the focus and cooperation between the various interdisciplinary fields is also vital. In our University, multimodal and multidimensional research is being advanced within a wide range of fields spanning the natural science, engineering, pharmaceutical and medical sciences. The Brain Interdisciplinary Research Division (BIRD) is creating a research and development (R & D) infrastructure allowing for effective collaboration between researchers belonging to the various disciplines distributed throughout the University (e.g. experimental, information, system and developmental courses). By capitalizing the synergism in this collaborative environment, we aim to create some revolutionary results – filled with the creativity afforded by multidisciplinary integration – regarding the brain, neural information or neural system from Tokyo University of Science.

To confront the challenges ahead, the following three interdisciplinary joint research groups will be established:

(1) Brain Health and Disorders Group

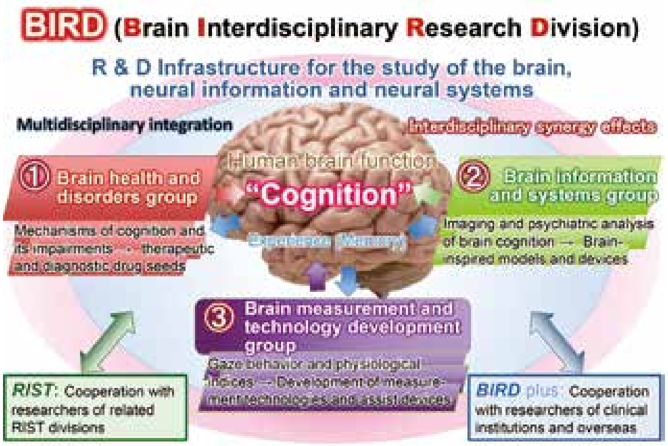
With a focus on cognition, this group aims to elucidate the mechanisms of brain health and disorders (e.g. depression with pessimistic cognitive characteristics; senile dementia that reduces cognitive and memory function; social cognition and communication difficulties caused by autism) and develop therapeutic and diagnostic drug seeds. This will be achieved through multidimensional research studies all aspects from the molecular and neural circuitry to model animals. [Member] Furuichi, Nishiyama (Sci. Tech.), Oka (Pharma. Sci.), Nakamura (Res. Inst. Biomed. Sci.), Segi-Nishida (Ind. Sci. Tech.), Hashimoto (Fukushima Med. Univ.).

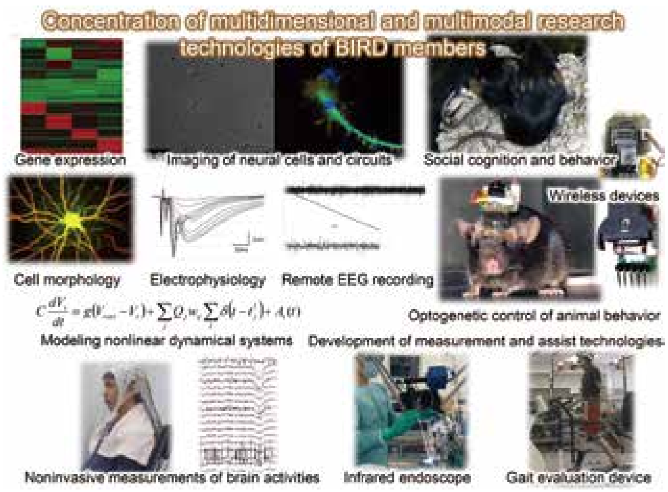
(2) Brain Information and Systems Group

This group aims to elucidate, model and theorize the brain information processing systems with a focus on human visual perception. The group aims to achieve these goals through multidisciplinary studies including brain function imaging, cognitive psychological experiments and brain algorithms. [Member] Araki, Urakawa (Sci. I), Ikeguchi (Eng.), Nishiyama (Sci. Tech.), Nakamura (Res. Inst. Biomed. Sci.), Kimura (Kochi Univ. Tech.).

(3) Brain Measurement and Related Technology Development Group

This group aims to develop measurement technologies and assist devices through multidisciplinary study of both the analysis and evaluation of brain dysfunction. The group studies personality traits observed in developmental disorders and other impairments by analyzing gaze behavior and physiological indices. [Member] Takemura, Ichikawa, Nishiyama, Furuichi (Sci. Tech.), Aikawa (Ind. Sci. Tech.),





Information and Societal

Center for Fire Science and Technology

Established: April 2004 mtsuji@rs.kagu.tus.ac.jp

Director
Professor,
Department of Architecture,
Faculty of Engineering Division Ⅱ
Makoto Tsujimoto

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 make a contribution to society.

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 40 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 track record 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 tarack record, 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.

The aim of this program is to use the research results produced at our institution to contribute to reducing fire risks in Asia, and to protect the safety of the people who live in cities. The main content of this program can be divided into the following two themes.

Theme 1: Fire Risk Analysis by Building and Operation of a Fire Information Network

This program will therefore operate the “Forum on Fire Safety in Asia” website, which is currently being developed, and will collect fire accident information from around Asia.

Theme 2: Analysis of Fire Risk Events

Problems related to the state of combustion of outer walls that use flammable materials and problems related to the processes by which fires spread due to the relationship between the use of a space and the materials used and the generation of toxic gases have been noted in examples of fires in various cities in Asia in recent years.

In this way, we will gather fire accident information, obtain an understanding of the problems related to fire risks through “Fire risk analysis by building and operating a fire information network,” and investigate scientific explanations for these problems and the existence of safety measures based on experiments and analysis in this theme. Thus, by bringing together this information, the Asia Fire Safety Information Center website will be widely used as a source of information where the required information can be obtained immediately by users in the event that a similar fire accident occurs because it will have an explanation of the causative factors and the phenomenon as well as an accumulation of comments by experts about the factors for the spread of damage. This is expected to enhance fire safety in various cities in 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 (Photo 1). 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 refractory furnace was added. Other large scale experimental facilities to be included in the laboratory are composite furnace, fire-resistance assessment machines for outer 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 nonlife insurance industries) as well as students from Japan and overseas who want to become fire prevention 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.

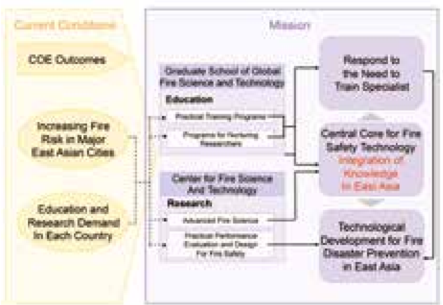


Fig. 1 Perspective of the Center for Fire Science and Technology

Photo 1 Fire Research and Test Laboratory

Fig. 2 Home Page 「Forum on Fire Safety in Asia」

Information and Societal

Division of Advanced Communication Researches

Established: April 2012
itami@te.noda.tus.ac.jp

Director
Professor,
Department of Applied Electronics,
Faculty of Industrial Science & Technology
Makoto Itami

Objectives	Advanced short range communication system and its applications are researched and developed in cooperation of communication, network and device research areas.
Future Development Goals	In order to realize advanced communication systems, developements of elemental technologies and practical systems are performed by cooperation of researchers.

The role of short range communication technology is more and more important to sophisticate ICT in the wide range of applications. In order to realize short range communication systems, not only the advance of elemental technologies but also the integrated system development is required. In this research division, advanced short range communication system is researched and developed.

Research on next generation high-speed and highly-reliable short range communication technology

Recently, advances of wireless communication technologies such as cellar phone, wireless LAN and so on are remarkable and the communication speed beyond 100Mbps can be made available under mobile communication environments. Moreover, the opportunities to use wireless communication in our daily lives are more and more increasing by the rapid diffusion of sophisticated mobile information terminals such as smart phones and tablets. As represented by the word of 'Ubiquitous', the wireless communication technologies hence will be more familiar and they will become more and more important.

In this research division, we target the short range communication technology for research. It is considered that the role of the short range communication technology becomes more and more important among the various communication technologies. For example, in the office environment, the demands for wireless-izing of information equipment, sensor network and so on are increasing and their seamless operation is highly expected. By the wireless office environment, the ICT infrastructure that realizes advanced and comfortable office environment is constructed. Toward the goal, it is necessary to develop a high-speed and highly-reliable short range communication technology. The short range communication technology is the key technology in the wide range of applications such as office, home, medical field, factory, ITS, logistics and so on, and its realization is more and more required in the near future.

In this research division, our primary research target is the short range communication technology. In the realization of a short range communication system, the system requirements that are different from the cases of long range and middle range communication systems such as cellar phone and wireless LAN must be considered and different approaches should be actively performed. Moreover, the short range communication closely depends on the application, the research and development that the total system is considered is necessary. In addition, the early realization of the system is also important in the area of wireless communication that the generation change is very quick. Hence, in this division, the experts of the network technology and the device technology in addition to the experts of the communication technology perform researches together to realize an advanced and feasible system. Cooperation of exports is necessary to realize the practical system. As shown in Fig. 1, this research division currently consists of three research groups: "Communication and Signal Processing Group" , "Network Group" and "ICT Device Group". In each group, the elemental technologies are researched and developed. In addition, the total system is developed in cooperation with these three groups.

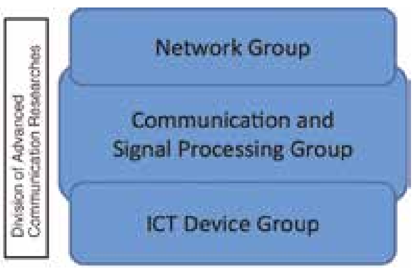


Fig.1. Group Structure

The research topic in each group is as indicated below.

1. Communication and Signal Processing Group

In the Communication and Signal Processing Group, researches on physical layer communication scheme and signal processing technology that are appropriate to short range communication. In short range communication, fast communication speed, simultaneous operation of large number of devices, guarantee of real time transmission, low power consumption and so on are required. In addition, the available frequency band is limited and development of the communication scheme that efficiently utilizes the limited frequency band is necessary. In this division, a high-speed and highly-reliable short range wireless communication scheme that utilizes the limited frequency band efficiently is researched and developed in cooperation with the experts in communication systems and signal processing. The use of basic communication schemes such as UWB(Ultra Wide Band) and OFDM(Orthogonal Frequency Division Multiplexing) are assumed and the technologies such as signal processing, coding, etc. to sophisticate them are researched. Moreover, it is assumed that the short range wireless communication is operated as the underlay of existing wireless communication systems or operated in the white spaces. Therefore, the communication scheme that can achieve optimal performance considering the interference against the other communication systems is researched. Exploiting newly available frequency bands is also a research topic in this group.

2. Network Group

In the Network Group, the network technology that connects the large numbers of short range wireless communication devices efficiently is researched. In the applications of short range wireless communication such as sensor network, RFID, etc., it is assumed that large number of devices are being operated simultaneously in a small area. Under such situation, construction of an efficient network is necessary in order to administrate these communication devices efficiently and optimize the frequency utilization in time and space. The Network Group develops the network technology that is appropriate to the short range communication in cooperation with the Communication and Signal Processing Group. In addition, the technology to use the network seamlessly in the various applications, the technology to optimize communication resources, cross layer optimization to achieve optimal frequency utilization and power consumption are researched.

3. ICT Device Group

In the ICT Device Group, the device technology that is required to realize a short range wireless communication system is researched. In the short range communication systems, it is assumed that large numbers of devices are used under mobile environments. Therefore, reduction of the device size and development of low power consumption device are important research topics in addition to development to high speed devices. In order to develop a practical device, the cooperation between the ICT Device Group and the Communication and Signal Processing Group mutually confirming the needs and seeds in device development is necessary. An optimal device development is performed in close cooperation with the Communication and Signal Processing Group.

As mentioned above, in this division, research and development of the next generation short range wireless communication technology are performed in cooperation of three research groups. In addition, the research that contribution to the Japanese and international standardization is taken into consideration is also expected.

Information and Societal

Division of Advanced Urbanism and Architecture

Established: April 2014

muno@rs.kagu.tus.ac.jp

Director
Professor,
Department of Architecture,
Faculty of Engineering
Motomu Uno

Objectives	The construction of the city environment plan theory that is sustainable and resilient by updating of modern architecture and urban infrastructure.
Future Development Goals	We will develop regional researches, contributions to local communities, and regional exchanges to the subject area, aiming a modeling of city revitalization plan. And we will generalize to a regional planning, evaluation of a plan, and agreement of a plan.

This research division is composed of experts of architecture, city planning and civil engineering. Stuffs belong to Division One and Division Two of 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.

City Culture, City Planning, City Performances
Researches on urban and architectural Design, which are composed of three research fields above. We will contribute to urban re-development and re-design for the existing study area, proposing sustainable urban environment by research results and design studies as scientific knowledge.

Characteristics of the Research Division

As for the problems about today's urban environment and urban life, which become highly modernized and industrialized, almost of them are caused by complex and correlative matters. Only results of individual research areas that have been finely specialized and divided, can not solve the problems of necessity of sustainability and resilience for creating, maintaining and managing good human urban environment. Therefore, our research division aims to the construction of practical integration system of city forming, and it will be reduced to the region as a specific scientific knowledge, helping to build up urban planning policy. From the points of reduction to society of results of academic research and social contribution of the university, and administrative organizations, private companies, NPO, etc. expect to our field of research. And our division has the characteristics that it belongs to social engineering, like civil engineering.

Academic and Social Features

Experts and researchers who belong to this division have lots of excellent research achievement in each field. Therefore, they are recognized as leaders of each fields of major academic societies, Architectural Institute of Japan, Japan Society of Urban Planning, and Japanese Architecture History Society and others. Comprehensive research by collaboration utilizing the expertise of each researcher and its reduction to society are demands from society and era, and the framework of this study department that specializes in advanced research of urban environment makes it possible to implement elastically and quickly. It is the advantages of the researchers of this division and our team can make full use of the network of each academic society, and it also becomes the social characteristic. As for originality of this research division, one is that we will cooperate and perform the advanced study of each field that primarily affects a building and city planning, and another is that we will analyze the overall issues of modern city in the context of a chronological Edo-Tokyo 400 years to study on designing and planning methodology. Especially, researches of the Outer Moat(Sotobori) surrounding area and Kagurazaka area, where is the home town of TUS, are region with unique characteristics in the points of world city history and of world urban structure. So, it can be said that this study will gather attention internationally.

Research Area

Research area is, firstly Sotobori with its outskirts area and Kagurazaka campus area. Secondly same type area of modernized castle towns (Nagoya, Osaka etc.) inside Japan, thirdly same type area of Asian cities (Seoul, Beijing, Bangkok etc.) that is going to be modernized. We will model urban structure of process of each city and apply graded results of research sequentially and develop to general urban research.

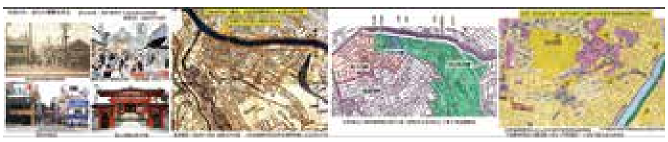
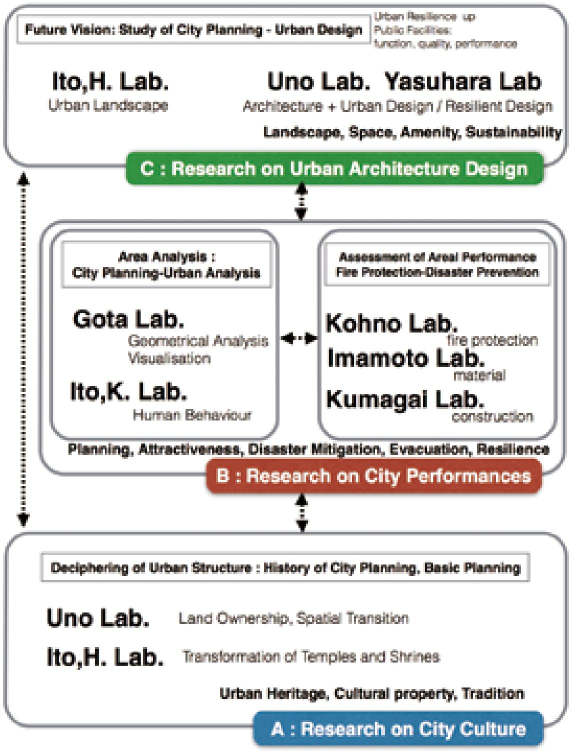


Fig. 1 Historical Changes of Kagurazaka "Outside of Sotobori", Lecture of Professor Akihisa ITO, April 2014

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



Tbl. 1 Research field and partners

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 2015 ✉ ytanaka@tus-mono-koto.org

Information and Societal

Division of Things and Systems

Director
Professor,
Department of Innovation Studies,
Graduate School of Innovation Studies
Yoshio Tanaka

Objectives	To research and develop Future Style Industry structure and business design by high technology and advanced research.
Future Development Goals	In parallel researching with Industry. This research division intended to find out research seeds and to make seed technology base on advanced Business design.

There are many Japanese good companies who are providing good products and good components with high quality these thirty to forty years. However, We Japanese Industry is losing position these several years. We need to understand current situation. Consider current positioning, we defined our objective is to revitalize Japanese industry by 'Things and Systems' at IoT world (Outcome Economy) with NEW Business Design.

Industry Reformation from Things oriented (QCD) to System with New Business Design.

Introduction and Background to the establishment

In this Division, we have already built up two entities with Industry, National research and universities. The first one is named at 'Things and System' consortium which is composed of Industry companies. The Second one is "Things and Systems Society' which aimed at to research innovation mechanism for Production/process oriented to total system with products by Faculties, Researchers and students. Our goal is revitalize Japanese industry by 'Things and Systems' .

The consortium is formed by not only Japanese Industry companies but US. Chairperson of the consortium is Mr. T. Nagashima, former CEO of Teijin Corp and chaired the council of the Japanese Association of Corporate Executives of Things and System. Prof. Tanaka named as Vice Chairman. The Society is formed by Faculties, National Institute Researchers, Business School students, Industry researcher's. The Chairperson is Mr. K. Motoyama, who is the CEO of Tokyo University of Science and have experienced several management position, such as CEO of Asahi Soft Drinks. These two entity and Things and System research division is collaborative discussion meeting every month. The scheme is as follows.

Research on Service IT

From the viewpoint of Servicization, this group research about efficiency, computerization and value proposition regardless of production and service as a total system.

Research on Advanced THINGS and SYSTEMS

From a management of technology of view, this group research process of the transformation from products oriented to integrate service, technical management, HR and organization for the management systems of transforming to service or the global expansion that integrated business administration.

Research on DATA Science

This team makes research, data analysis, security system, privacy system and system interoperability on BIG data, which I collect from the real world, based on computer science and data mining technology.

Research on Practice Study

This team research and study on practice case which THINGS industry has experienced to change or reform. Cases are mainly sort out from Things and System consortium member companies and global companies.

Research on Design Thinking (New)

Research on Intelligent System (New)

Research on Fintech Research (New)

Table 1. Research members of Things and Systems Division

Job title	Name	Main research field
Director, Professor	Yoshio TANAKA	ICT, Computer software, Business system
Professor	Masanori SAKAMOTO	Industrial strategy, Electronic materials
Associate professor	Aya ISHIGAKI	Industrial administration
Visiting Professor	Masayuki NUMAO	Computer science
Visiting Professor	Makoto YOKOZAWA	Information science
Visiting Professor	Takanori SEKI	Application Software
Visiting Professor	Kazuo KAJIMOTO	Information science
Visiting Researcher	Hisashi HAZEKAWA	Service engineering

To be Added New Members for New Group

Collaboration between industry, academia and government

As a related organization of this research department, we cooperate with the "Things and Systems Association". They are building the opportunity to discuss with experts (National Institute members, corporate managers, R&D engineers and planning department). This Division has operated a workshop of monthly in cooperation with them.

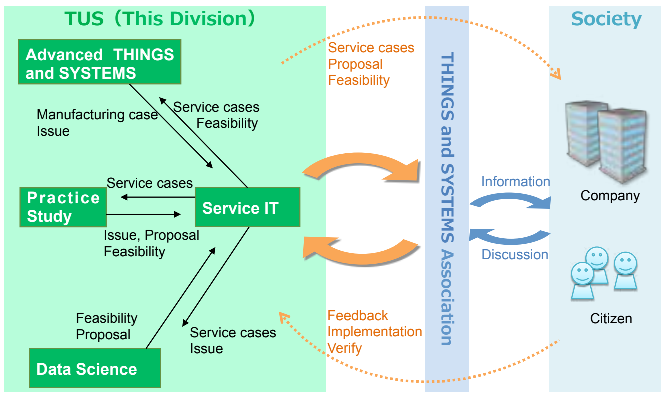


Fig 1. Organization of Division of Things and Systems, and collaboration framework

Research Objective

To research and develop Future Style Industry structure and business design by high technology and advanced research.

Established: April 2016
miura@rs.kagu.tus.ac.jp

Atmospheric Science Research Division (ASRD)

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

Objectives	To clarify the effect of aerosols on air pollution and climate change, the ASRD will observe atmospheric pollutants in the urban, mountain, and maritime atmospheres.
Future Development Goals	The ASRD will activate the collaborated research and make the network of Japanese atmosphere observatory.

ASRD is the division to carry out research on air pollution and climate change by observation in the urban air, the ocean air, and the mountain air. We study the processes of new particle formation, particle growth, and cloud formation at the Tokyo Skytree and at the summit of Mt. Fuji. We will study the mixture effects of maritime and urban aerosols by sea and land breeze.

Long range transport of atmospheric pollutants and aerosol-cloud interaction.

ASRD is the division to carry out research on air pollution and climate change by observation in the urban air, the maritime air, the mountain air, and trans-boundary air (Fig. 1). ASRD has twenty members. Their roles and observation sites are shown in Fig. 2.

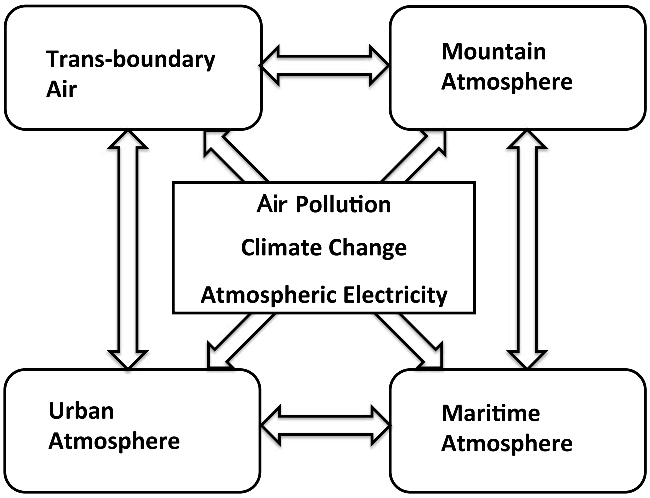


Fig.1. Mutual relationship of the research field.

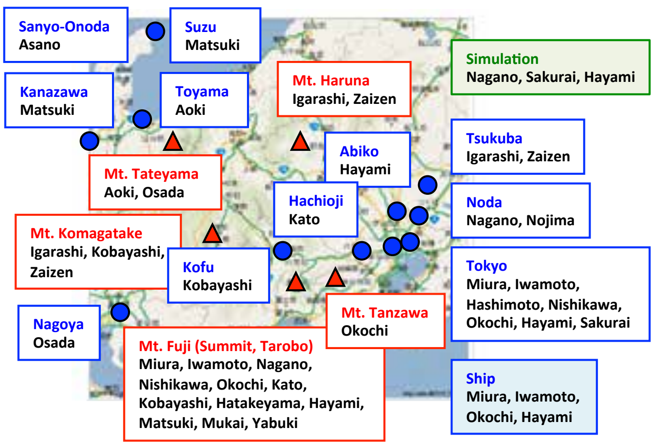


Fig.2. Roles of ASRD members and their observation sites, mountain (red) and surface (blue) sites.

1. High concentration cause of PM2.5 in the Kanto district

Concentration of PM2.5 has decreased by diesel car emission controls considerably in South Kanto, but an achievement of environmental standard rate of PM2.5 is still low. The possibility of the transported pollution is considered as this cause, but PM2.5 occurs not a thing growing only in China anywhere. Because the particles are removed from all over the atmosphere if there is rainfall during transportation, it is thought that the long-range transportation from the continent is performed in the free troposphere. Therefore we get cooperation of the authorized nonprofit organization 'Valid Utilization of Mt. Fuji Weather Station' (http://npo.fuji3776.net/) and observe it at the old Mt. Fuji Weather Station at the summit of Mt. Fuji and study the condition that PM2.5 becomes high concentration. In addition, the hygroscopic aerosol particle can cause the high density of PM2.5. Therefore, by observation using Tokyo Bay or a ship, I investigate the influence of the marine atmosphere aerosol particle.

2. Effects of atmospheric aerosols on climate change

Changes in the atmospheric abundance of greenhouse gases and aerosols, in solar radiation and in land surface properties alter the energy balance on the climate system (IPCC2013). Aerosols affect the climate both directly (by scattering and absorbing radiation) and indirectly (by serving as nuclei for cloud formation). These effects remain the dominant uncertainty in radiative forcing.

Sulphur and organic species originated from ocean make new particles to increase the number of cloud condensation nuclei and change properties of cloud. However, in the planetary boundary layer (PBL), there are many sea-salt particles that provide surfaces for heterogeneous chemical reactions with sulphur or organic gases. There are a few papers of new particle production observed in the PBL under a highpressure system. It suggests that particles are produced in the free troposphere (FT).

Because of the altitude, mountain sites are well suited to studying aerosol-cloud interactions. Our station on Mt. Fuji is particularly important, as Fuji is an isolated peak normally situated in the FT. Furthermore, by using the Tokyo Skytree and the research vessel, we investigate the characteristic of aerosol particles in the urban and maritime atmosphere (Fig. 3).

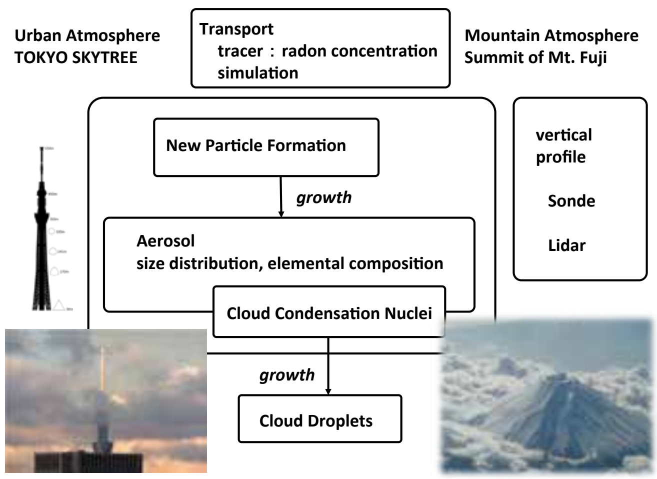


Fig.3. Study on the process of new particle formation and cloud formation in the urban and maritime atmosphere.

Established: April 2016
mune@is.noda.tus.ac.jp

Information and Societal

Division of Super Distributed Intelligent Systems

Director
Professor,
Department of Information Sciences, Faculty of Science & Technology
Munehiro Takimoto

Objectives	Development of new parallelizing or distributing techniques in several level, and application of them to several areas including AI.
Future Development Goals	Development of highly parallelized/distributed AI systems that can handle manually processed huge data, and multiple robots for practical missions.

This research division aims to give effective domain specific parallelization/distribution solutions for each system in various levels. The solutions include the design of parallel models inspired from cell signal processing or social insects. We believe that the challenges of this division will open new horizons for parallel or distributed systems.

R&D on highly parallelized/distributed systems and algorithms, and high performance computing tools.

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 data mining and result in innovative science technologies, we have to enhance parallelization and distribution in algorithms and execution styles.

Division of Next Generation Data Mining Technology, which is the previous division, especially focuses attention to medical and bio-systems, and has developed next generation data mining software together with researchers in artificial intelligence and statistics areas. In the process of that, we have found that we have to enhance parallelization/distribution to achieve new innovative technologies. In Division of Super Distributed Intelligent Systems, we will improve the results of the division of next generation data mining technology, and develop new parallelizing/distributing techniques based on performance issues that the results have exposed. For example, we will 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 parallel/distributed models based on knowledges given by cell signal processing or social insects. 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

As shown in Fig.1, we address the issues of parallelization and distribution in three hierarchical levels, “applications” , “models, and “infrastructures” as follows:

1. Parallel/Distributed Applications

In the application level, considering three applications, “data mining & machine learning” , “image processing” and “distributed robot controls” , their special researchers improve system performance using application-level techniques such as a cloud computing.

2. Parallel/Distributed Infrastructures

In the Infrastructure level, considering “programming languages” , “language processors” and “network protocols” , their special researchers directly improve the parallelization and distribution techniques on various infrastructures.

3. Parallel/Distributed Models

In the model level, considering “evolutionary computation” , “cell communications” and “biological systems” , their special researchers develop models for making infrastructures work more efficiently. Also, they develop new models through which the improvements of infrastructures directly lead to the speedup of applications.

Expected Effectiveness

Productions developed and knowledges found in each level can quickly be shared by all the levels. Because of that, we can give domain specific effective solutions, as shown in Fig.2. For example, we have developed a system for detecting distraction of drivers based on movement of eyes in the previous division. The system can expose cognitive distraction of drivers through AI’ s integrating environment information and eye movement data. In the system, since AI has to process huge various sensor data, it requires parallel learning and inference algorithms, and their parallel or distributed execution. Thus, truly parallel execution is given by improvement of the system in multiple levels, which is achieved by cooperation between specialists in several areas.

We believe that the challenges of this division will give breakthroughs in many traditional techniques, and open new horizons for parallel or distributed systems.

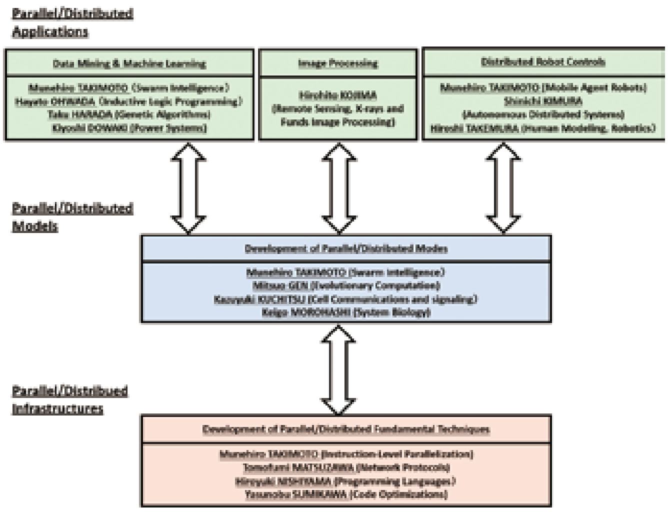


Fig. 1 Members of the division and their relations

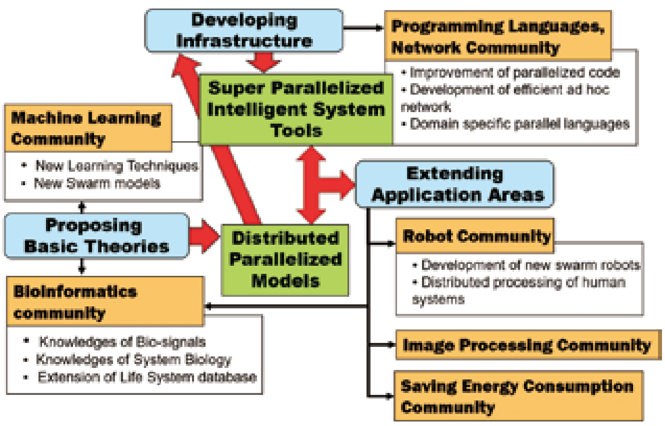


Fig. 2 Expected effectiveness

Information and Societal

Division of Intelligent System Engineering

Established: April 2016 hyogo@ee.noda.tus.ac.jp

Director
Professor,
Department of Electrical Engineering, Faculty of Science & Technology
Akira Hyogo

Objectives	To research and develop human-like, human-friendly intelligent systems with autonomy for medical and space applications by amalgamating different engineering technologies and sciences, thereby making a contribution to society and mankind.
Future Development Goals	To research and develop even more intelligent, more human-like, safer and more advanced intelligent systems with autonomy for medical and space applications.

This division reorganized in April 2016, and has been starting to aim at the medical and space applications. In this Division, we will tackle research and development of humanlike and human-friendly intelligent systems with autonomy for medical and space applications using a lot of valuable research results which are improved and united further more by our talented group of research personnel and excellent equipment..

R&D on human-like, human-friendly intelligent systems with autonomy for medical and space applications

Intelligent systems draw on a number of disciplines, including information engineering, image engineering, discrete mathematics, computer science, artificial intelligence, IT engineering, radio wave systems, medical bio-electronics, analog electronic circuits, integrated circuit engineering and semiconductor circuit engineering. Our task is to research and develop human-like intelligent systems.

Basic research on intelligent systems for medical applications

Here, we are mainly engaged in research in the following five areas.

○Bio-information sensing and healthcare

Research on sensing for bio-interfaces, and so on, and extracting various bio-information for healthcare.

○Radio wave communication systems for wearable IT devices

We are researching and developing PAN (Personal Area Network) wireless communication systems using UWB (Ultra Wideband) for wearable (body-attached) IT devices. We are also clarifying the electro-magnetic wave transmission properties of body surfaces and conducting R&D on UWB compatible antennas. Beyond these, we will produce various bio-information via networks using these systems for provision to healthcare.

○Energy supply systems for embedded systems and data transmission systems

Research on energy supply techniques for embedded systems e.g. embedded artificial hearts or capsule endoscopes and also data transmission systems and circuits.

○Cancer diagnosis and therapy using a microwave

○Wireless energy supply system for embedded systems and wearable IT devices

Research on space crafts with autonomy

Higher level intelligence and making to autonomy are requested from control systems of space crafts as the mission that they should accomplish variously becomes complex. Since there are strong requirements in weight and capacity in the equipment in the space unlike one on the earth, higher performance devices are strongly required for space crafts. Therefore, main purpose of this research is how to reduce the size and weight of the control computers and sensor systems in space crafts keeping their performance.

Research on downsizing of systems, and high-frequency and low power circuits

For medical and space applications of an intelligent system, downsizing and the low power consumption of the system are strongly required. And also the higher frequency operation is required of the circuits for high-volume data transmission and high-speed operation. Here, we are mainly engaged in research in the following three areas.

○Research on high-frequency analog circuits

In the intelligent systems of the future, it will be essential for systems to communicate and exchange vast amounts of information with each other. To this end, we are conducting R&D on GHz-band high-frequency front ends, including high frequency circuits, low noise amplifiers and mixers for wireless LANs, and so on.

○Low-voltage, low-power circuits

As the scale of intelligent systems increases in future, so the range of applications is expected to broaden. Since battery operation and power-saving operation will be essential, we are also researching and developing circuits that operate at 1.5V or less.

○Integrated circuits

All the circuits necessary for the system are integrated for making of the system micro, and the techniques to achieve it with one integrated circuit are researched.

By pursuing the research efforts outlined above, we will be able to construct systems with enhanced performance and turn all terminals into advanced information terminals. Moreover, by integrating all of these circuits, we will also be able to achieve ultra-compactness. (see Fig. 1)

○Analog to Digital Converters (ADCs) and Digital to Analog Converters (DACs).

For our intelligent systems novel high performance ADCs and DACs hav been studied and developed.

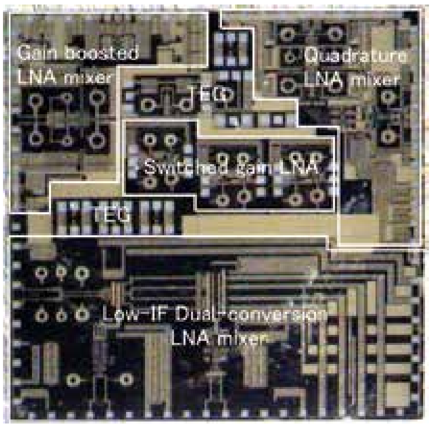


Fig. 1 Microphotograph of the proposed Integrated circuits (5mm×5mm)

Research on communication method and network where an intelligent system is supported

Due to send and receive data efficiently, we are studying antennas, transmission lines, signal processing circuits and also communication protocols.

Research on energy systems where an intelligent system is supported

The focus is addressed to life and the energy system in the region, and the evaluation model of the decentralized energy system and the ideal way of a regional traffic system as Global warming measures are researched.

We think these techniques can adjust to the system from which energy-saving is demanded when medical applications such as the embedded devices are applied.

Research of software and theory to make hardware systems work more flexibly and autonomous

Due to make hardware of intelligent systems work more efficiently, the software, the programming language, and the information theory, and so on, are researched to support theoretically for the systems.

Fundamentals

IR FEL Research Center

Established: April 1999 fel-tus@rs.noda.tus.ac.jp

Director
Professor,
Department of Chemistry,
Faculty of Science Division I
Koichi Tsukiyama

Objectives	Contribution to the basic and applied research in the various field of science and technology. The research fields contain chemical reaction dynamics, spectroscopy of molecules and clusters, diagnostics of surface, material processing, etc.
Future Development Goals	Development of a Laser Center involving infrared free electron laser, ultra short pulse laser, and frequency tunable dye laser, etc.

FEL-TUS occupies an extremely specific position in global terms as a variable frequency pulsed light source in the mid-infrared region. We are currently promoting basic research in molecular science and spectroscopy as a priority research task, with a view to making maximum use of its characteristics. We will continue our efforts for the further development of our Center as a research base for molecular science.

- Basic and applied research relating to photo science using mid-infrared free electron laser - Development of far-infrared free electron laser

In April 1999, the IR FEL Research Center (FEL-TUS) was established at the TUS Noda Campus as a base for enhancement of IR FEL and development of new photo-science using IR FEL, a research project under Grant-in-Aid for Creative Scientific Research. While development research on the Free Electron Laser (FEL) itself is underway in a number of research institutions, FEL-TUS is one of the few facilities that prioritize research on the use of light by harnessing the characteristics of FEL as a mid-infrared light source.

Figs. 1 and 2 show a schematic outline of the FEL device and the structure of the undulator. An electron beam generated by the high-frequency electron gun has its energy spread regulated by the α-magnet, and is forced toward the linear accelerator. The electron beam, now accelerated to a maximum 40 MeV, passes through a deflecting magnet and is led toward an undulator. This is a radiation-producing device in which thin permanent magnetic plates (using SmCo for the poles) are aligned periodically in vertical bipolar alternation, generating a magnetic field that is modulated in the fashion of a sinusoidal wave. When accelerated electrons are passed through the undulator, the electrons oscillate and generate synchrotron radiation in the tangential direction. This synchrotron radiation is accumulated inside a pair of the gold-coated concave mirrors (called optical resonators) set at both outer ends of the undulator, and is amplified by a strong reciprocal effect with the electron beam. FEL light is output through a 1 mm-diameter pinhole in the upstream mirror. In this respect, FEL has no laser medium and its principle of oscillation differs essentially from the original laser (Light Amplification of Stimulated Emission of Radiation). The main body of the FEL is surrounded by a 2 m thick concrete wall to prevent neutrons and γ rays from leaking out. The FEL light emitted from the resonator is first converted to parallel rays, then propagated in free space mode in a vacuum to ensure that it is guided with its properties being retained inside the laboratory. Although small in scale, FEL-TUS is a facility that includes an accelerator. As such, the advice and guidance of experts are vital to its operation and management. In fiscal 2009, our Center was selected as an Accelerator Science Support Project of the High-Energy Accelerator Research Organization, and currently maintains a stable operational status under a system of full support.

A marked characteristic of FEL is that it involves no limit on oscillation wavelength due to absorption of the medium; in principle, oscillation is possible in any wavelength region. Of course, generating ultraviolet light with FEL requires an electron beam of correspondingly high energy, along with a commensurate increase in facility scale. FEL-TUS is designed specifically for the mid-infrared region (MIR). Its practical oscillation wavelength is 5～10 μm, which corresponds to the absorption frequencies for vibrational modes of molecules. Another major characteristic lies in the time structure of oscillation. The repetition frequency of FEL-TUS is 5 Hz, and pulses made every 200 ms are called macropulses. Each macropulse consists of a string of micropulses at 350 ps intervals. The peak power of micropulses is several MW, corresponding to a high photon density of 1026 photons per second.

By drawing on these characteristics of FEL light, we are able to conduct different types of new experiments that would not have been possible with conventional light sources. Our Research Center is promoting the following, in particular, as priority tasks:

(1)Tracing the physical and chemical processes such as photodissociation and isomerization induced of molecules by multiple photon process.

(2)Tracing the chemical reactions of vibrationally excited molecules using a pump-and-probe method.

When molecules are irradiated with light, they normally absorb single photons. But cases such as FEL, in which the output power is high, they induce the phenomenon of multi-photon absorption, in which several photons are absorbed at a time. If the sum total of all the photon energy absorbed exceeds the energy of chemical bonds, these bonds may be broken (dissociated). FEL is capable of exciting specific vibrational modes in molecules, and is therefore expected to be able to induce selective dissociation of bonds and reactive processes. Understanding the details of this in macroscopic terms is the target of (1) above. Protein aggregates such as the amyloid fibrils are in many instances associated with serious diseases including amyloidosis. Those aggregates contain many β-sheet structures which are formed by intermolecular hydrogen bonds of peptide backbones. Although the fibril structure is so robust in a physiological solution, FEL tuned to the amide I band (6.0 μm) can dissociate the amyloid fibrils which are formed by lysozyme, insulin, and calcitonin peptide fragment into each native monomeric form. The effect of FEL on the refolding of amyloid fibrils can be analyzed by using electron microscopy, MALDI-TOFMS, and FTIR following the FEL irradiation. As a mechanism, it can be suggested that non-covalent bonds between β-sheet structures can be affected by the FEL irradiation tuned to the amide band. As for (2), vibrationally excited molecules are known to cause specific reactions, and the aim is to elucidate microscopically, i.e. via molecular science, what properties of molecules cause this specificity. "Pump-and-probe" is a technique of first generating vibrationally excited molecules via FEL (pumping), then tracing the behavior of these molecules using a separate laser light (probing). By introducing a second laser light, not only are we able to identify reaction products, but also to completely define the direction and speed of their movement as well as their quantum state distribution, etc.

This research center has been financially supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) from 2007, which promoted active use of IR FEL for basic and applied research by external users. At present, ~10 research groups including companies and national institutions are carrying out their original experiments. Because FEL is simply a light source in the mid-infrared region, it is absolutely necessary to combine FEL radiation with suitable detection techniques in order to perform highly sophisticated spectroscopic measurements. We hope that researchers with a variety of scientific background and unique experimental skills make use of FEL radiation and that our center develops as a research base for a variety of fundamental research fields.

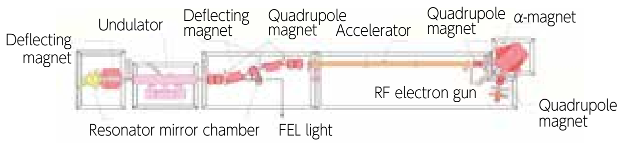


Fig. 1 Schematic outline of FEL-TUS

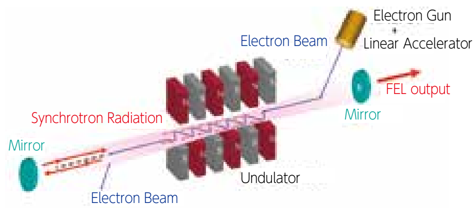


Fig. 2 Structure of undulator

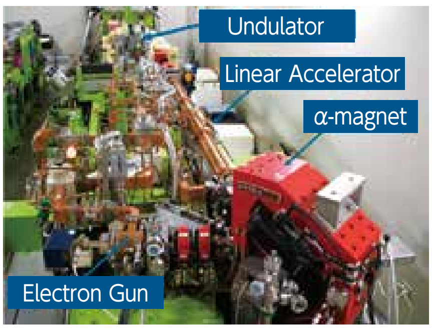


Photo Main body of the infrared free electron laser

Fundamentals

Imaging Frontier Center

Established: April 2015

asuda@rs.tus.ac.jp

Director
Professor,
Department of Physics,
Faculty of Science & Technology
Akira Suda

Objectives	To develop advanced non-invasive live imaging technologies beneficial for research in various fields of life science
Future Development Goals	To develop novel live imaging technologies and demonstrate their useful applications to observe living cells and biomolecules

Live imaging is a key technology for making progress in various fields of life science research. TUS has a good research system where a wide range of specialists can collaborate in this interdisciplinary field. In this Center we will develop innovative live imaging technologies towards the next-generation of life sciences.

Research and development on leading-edge imaging technologies

Establishment of the Center

Imaging is a key technology of the 21st century in the field of basic science and medical/industrial applications. TUS has a large variety of research specialists; this is a great advantage for producing innovative imaging devices, materials, and techniques by interdisciplinary collaborations. Thus, in 2011, we set up the Imaging Frontier Research Division for the purposes of (i) the promotion of collaborative research by exchange of information about mutual studies and (ii) the enlightenment of young scientists and students. Based on the activities of this Division, now we have launched the Imaging Frontier Center (IFC) to build a base for creating cutting-edge core technologies for imaging. In this Center, we will execute a close feedback between the technical development by researchers in physics, chemistry, and engineering and the verification studies by life scientists in order to develop novel imaging technologies which have a large spillover effect on basic and applied sciences.

Research Content

To realize fluorescence imaging at deep observation depths we propose to develop imaging technology using infrared light in the wavelength range over 1000 nm (OTN), which would exclude any obstacles in the observation pathway (Fig. 1). We also plan to clarify the mechanism by which an aqueous reagent makes biological samples optically transparent and develop a transparency technique to remove the autofluorescent material in subcellular organelles in plant cells, which can obstruct the image. The members will share such background removal technologies and undertake application research in the fluorescence imaging of animals and plant cells.

Fig 1. Blood vessel imaging of a mouse

In addition, we are planning to develop an imaging system that will present *in vivo* visualization of the reaction, the temperature, and the hardness as multidimensional information, which is not possible to do using current techniques. For elemental technology, we will develop a laser-induced surface deformation method enabling the measurement of the dynamic properties of the cell and its organization, and a fluorescence nano-thermometry for temperature imaging of the cell. Furthermore, we will make a fluorescent probe for visualizing the multidimensional information including enzymatic reactions using complex chemistry and biotechnological techniques (Fig. 2).

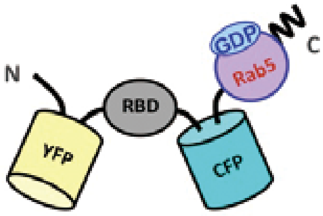


Fig 2. FRET sensor for visualizing the ON/OFF reaction of the G protein

Based on these technologies, we will develop an imaging system that can display information about a living body, showing entities such as blood vessels, living tissue, and organs in real time, which can be used to diagnose and clarify types of cancer, cranial nerve disease, and immunological diseases. We will also develop imaging systems for visualizing reactions, and the temperature and hardness of micro-fine structures in a living body, and for visualizing farm products without autofluorescence of the plant. An outcome of the Center will be the creation of innovative diagnostic systems that will contribute to the promotion of life innovation and green innovation, increasing the health and reinforcing the competitiveness of agriculture in Japan.

Research Organization

The Center aims to create a responsible imaging technology to meet demands of specialists of various fields of life sciences as imaging users. For achieving the aims, we are attempting close communications among specialists from various scientific and engineering research fields and those from life sciences. Accordingly, the Center consists of both of the users and designers of bioimaging technologies. The Center expects close interdisciplinary collaboration for the enhancement of the development of the key technologies. Collaboration among the members of other divisions or centers in the RIST, as potential users or designers, is also encouraged. The members will also collaborate with researchers in other universities or institutes not only for cutting-edge research but also to organize workshops or training courses on bioimaging, which will promote the development of a center of excellence of the bioimaging in TUS.

Expected Outcome and Spreading Effect

Now that the whole genome information for various species of organisms has been analyzed, live imaging technology, with which dynamics of biomolecules and their interactions inside living cells can be studied, is essential to a broad range of research and development in life sciences. In this Center, fully integrated interdisciplinary research, including laser technology, innovative fluorescence probe technology and live-imaging of various organisms including animals and plants, will be undertaken to develop innovative imaging technologies for use worldwide. We expect breakthroughs to be made in the life sciences using innovative live imaging technologies. TUS offers this potential methodology to the world community, and will contribute to the training of forward-looking young scientists and students to gain a broad knowledge in both material and life sciences and technology.

Imaging Frontier Center
IFC
Tokyo University of Science

Fundamentals

Division of Mathematical Modeling and its Mathematical Analysis

Established: April 2015

kato@ma.kagu.tus.ac.jp

Director
Professor,
Department of Mathematics,
Faculty of Science
Keiichi Kato

Objectives	We, those who study mathematical analysis, numerical analysis, physics or technology, all together study for interdisciplinary researches
Future Development Goals	In this year, we discuss each other on the researches of each member and determine how to make our interdisciplinary researches possible.

This division has been established on the April of 2015. 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 or numerical analysis.

Interdisciplinary researches between mathematical analysis, numerical analysis, physics and technology

This division is established on the April of 2015. We introduce our plans and our seeds of future researches in the following.

Application of the representation of solutions to Schrödinger equations via wave packet transform:

Using our representation of solutions to Schrödinger equations via wave packet transform, we will establish a method to compute the energy levels and its eigenstates for given potentials. We will apply this method to physical situations via numerical analysis. (Keiichi Kato)

Time-dependent density functional theory (TDDFT) simulations of ultrafast electron-ion correlated dynamics under high external fields:

We recently applied the TDDFT to laser-assisted field evaporation of nanostructures to elucidate the microscopic mechanism of electronic excitations and ion detachment. We also develop the TDDFT program code to enable the long- time simulations of multi-component quantum dynamics.

Stochastic analysis associated with tree structures and hierarchical phenomena:

Eligible probabilists are also taking membership of this division. From the fields of p-adic numbers to tree models in various practical studies, crucial importance of hierarchical structures are observed and related mathematical models are applied in cognitive science and DNA analysis, etc. We will work out analytic methods and statistical methods to reveal probabilistic significance in such theoretical frameworks. Potential impacts to mathematical finance and data analysis will be focused on. (Hiroshi Kaneko)

Asymptotic behavior of solutions to generalized Keller-Segel systems:

As a model describing chemotaxis, the Keller-Segel system is well known and studied. From both mathematical and biological point of view it is an important problem whether a solution to the Keller-Segel system exists and is uniformly-in-time bounded or not. Recently Ishida-Yokota found a method to solve the boundedness problem in a slightly generalized model, which is open still now. We will solve the boundedness problem in more generalized model and study the asymptotic behavior of the solution. (Tomomi Yokota, Sachiko Ishida)

Variational problems for p(x)-growth functionals and its application:

A functional with p(x)-growth first appeared in the mathematical model of thermistor, and more generally partial differential equations having terms with variable exponents appear in several models including, for example, rheology. Continuing mathematical analysis on variational problems for p(x)-growth functionals, I would like to try to find a new approach for some applications. (Atsushi Tachikawa)

Blind separation of multi-reflected signals in a convex polygonal room:

The purpose of this study is to present and apply a mathematical formula to a numerical experiment for blind separation of multi-reflected signals in an unknown convex polygonal room. In recent studies, formula for a one-reflection model based on Blind Source Separation (BSS) have been proposed in which the main purpose is to identify a source signal and a one-wall location from observed signals. In practical applications, however, it is often essential to consider multi-reflected signals, and then a one-reflection model requires review to take these into account. In this study, we propose a new iterative method for the multi-reflection issue and apply the method to typical cases in which a one-source signal is multi-reflected by the walls of a room. The basic assumption in our method is that the locations of the observation points are known, while the one-source signal, the locations of the source point and the walls of the room are unknown.(Fumio Sasaki)

Mathematical analysis on nonlinear elasticity with application to fracture phenomena in mind:

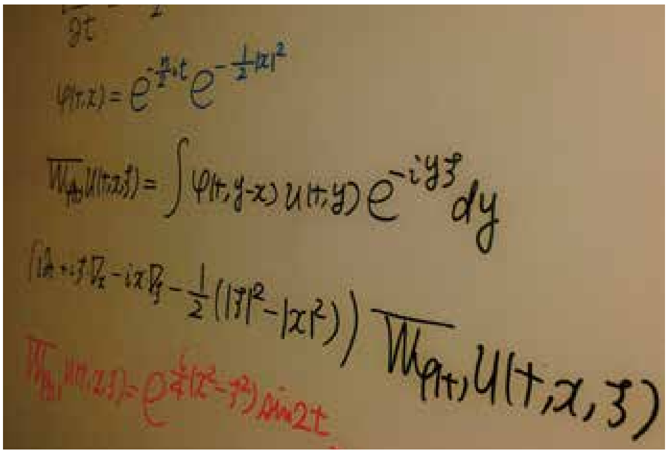
Brittle fracture under an assumption of linear elasticity has been systemized as linear fracture mechanics and its simulation software has also been developed. However there are a lot of engineering hypothesis, so it's difficult to construct mathematical model covered general fracture phenomena. In order to treat wide variety of fracture phenomena it is important to analyze nonlinear elastic model which is physically meaningful. Then, in this research we deal with mathematical analysis on nonlinear elastic model suitable on real fracture phenomena. (Hiromichi Itou)

Mathematical analysis on inverse problems for nondestructive testing:

Nondestructive testing is a technique for evaluating specimens embedded defects without destruction. This has a lot of application not only in material mechanics, but also in medical imaging such as computed tomography(CT) and Magnetic resonance imaging(MRI) and geophysics (determination of inner structure of the earth). In the mathematical model, the problems are often described as inverse boundary value problems and we have considered reconstruction problems for cracks, polygonal cavities in linear (visco)elasticity and for welding area in electric conductive body. In the future we will study inverse crack problems in (visco) elasticity for nondestructive testing and inverse problem for evaluation of material constants.(Hiromichi Itou)

Singularity and large time behavior of solutions to nonlinear partial differential equations:

The purpose of this study is to give a sufficient condition for the occurrence of the vacuum state for the generalized barotropic model which describes the motion of gas. Especially, we are going to show that the vacuum state can occure , if initial gas pressure is high. In parallel with this study, I progress in studies of the solvability and the large time behavior for the drift diffusion equation which describes the motion of electron in semiconductor, together with Masakazu Yamamoto in Niigata university.



Division of Modern Algebra and Cooperation with Engineering

Established: October 2016 ito_hiroyuki@ma.noda.tus.ac.jp

Director
Professor,
Department of mathematics,
Faculty of Science & Technology
Hiroyuki ITO

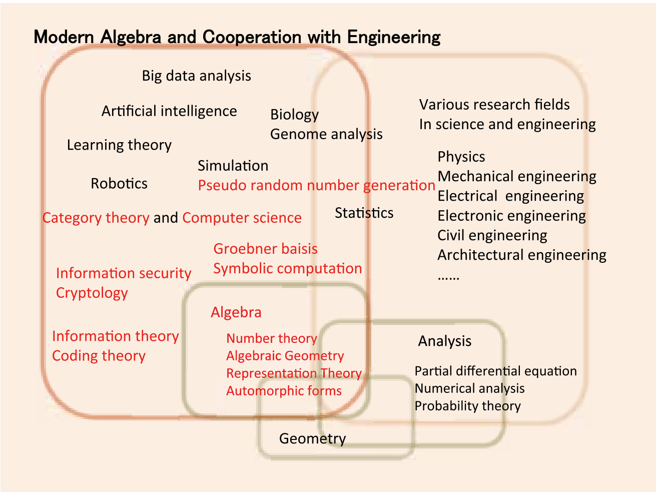
Objectives	To research and develop algebra itself and algebra based engineering, also to find new engineering fields cooperation with algebra, thereby making a contribution to mathematics and engineering.
Future Development Goals	To make contribution to mathematics and engineering, and to make the center of research on algebra and its applications to engineering.

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 find new cooperative research fields between algebra and engineering which make mathematical innovation.

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 science, information technology, electrical and mechanical engineering, etc., after 20th century, and produce many useful results and effects which are indispensable for modern human life. Our division based on algebra are going to cooperate with another division "Mathematical modeling and its 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, and applied algebra. 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 three 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.

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

The first step is to make relationship between person and person in various research fields, which has already done. The second step is expanding the relationship between person and person to person and group. Final step is expanding the relationship to group and group, and developing a new cooperative research fields based on algebra.

Affiliation	Job title	Name	Academic degree	Main research field
Department of Mathematics Faculty of Science and Technology	Professor	Hiroyuki Ito	Doctor(Science)	Algebraic geometry Applied algebra
Department of Mathematics Faculty of Science Division I	Professor	Katsunori Sanada	Doctor of Science	Ring theory
Department of Mathematics Faculty of Science Division I	Professor	Masanari Kida	Ph.D	Number theory
Department of Mathematical Information Science Faculty of Science Division I	Professor	Yosuke Sato	Ph.D	Computer algebra
Department of Mathematical Information Science Faculty of Science Division I	Professor	Hiroshi Sekigawa	Doctor (Mathematical Science)	Computational Mathematics
Department of Mathematics Faculty of Science and Technology	Associate professor	Hiroki Aoki	Doctor(Science)	Automorphic forms
Department of Mathematics Faculty of Science and Technology	Associate professor	Yoshitaka Hachimori	Doctor (Mathematical Science)	Algebra Number theory
Department of Information Sciences Faculty of Science and Technology	Associate professor	Nobuko Miyamoto	Ph.D (Management Science and Engineering Course)	Discrete mathematics Combinatorial designs and their applications
Department of Mathematics Faculty of Science Division I	Associate professor	Naoko Kunugi	Doctor(Science)	Representation theory
Department of Mathematics Faculty of Science Division II	Associate professor	Takaoh Sato	Doctor (Mathematical Science)	Algebra, Geometry
College of general education Faculty of Science and Technology	Junior associate professor	Takashi Nakamura	Doctor (MathematicalScience)	Analytic number theory
Department of Mathematics Faculty of Science and Technology	Junior associate professor	Toru Komatsu	Doctor(Science)	Number theory
Department of Mathematics Faculty of Science and Technology	Junior associate professor	Tomokazu Kashio	Doctor(Science)	Number theory
Department of Mathematics Faculty of Science and Technology	Junior associate professor	Hisanori Ohashi	Doctor(Science)	Algebraic geometry
Department of Electrical Engineering Faculty of Science and Technology	Junior associate professor	Yasutaka Igarashi	Doctor(Philosophy)	Information security Cryptanalysis
Department of Mathematics Faculty of Science Division I	Assistant professor	Tomohiro Itagaki	Doctor(Science)	Algebra
Department of Information Sciences Faculty of Science and Technology	Assistant professor	Shoko Chisaki	Doctor(Science)	Combinatorial designs and their applications

Joint Usage/Research Center

Photocatalysis International Research Center (PIRC)

Established: April 2015 pirc@rs.tus.ac.jp

Director
President,
Tokyo University of Science
Akira Fujishima

Objectives The purpose of this research institute is becoming core institution of photocatalysis by allowing visitors to use facilities which enable to evaluate photocatalytic performance in this research institute, and by promoting collaborate research among researchers.

Future Development Goals Our research institute aim for providing 1) energy saving and environment-friendliness society, 2) safety society with sense of security and 3) comfortable space.

We, living in 21 century, have many problems regarding global warming, depletion of resources, air and water pollution. Photocatalysis is environmental technology which has many potentials. This research institute devotes problem solving in the world by development of photocatalysis, by becoming core institution for photocatalysis and by promoting collaborate research among researchers.

By using unique facilities in this research institute, photocatalysis research and technology are further developed to apply for society.

Background of photocatalysis

The development of photocatalysis has been the focus of considerable attention in recent years with photocatalysis being used in a variety of products across a broad range of research areas, including especially environmental and energy-related fields. Following on from the water splitting breakthrough reported by Fujishima and Honda in 1972, the photocatalytic properties of certain materials have been used to convert solar energy into chemical energy to oxidize or reduce materials to obtain useful materials including hydrogen and hydrocarbons, and to remove pollutants and bacteria on wall surfaces and in air and water. Of the many different photocatalysts, TiO_2 has been the most widely studied and used in many applications because of its strong oxidizing abilities for the decomposition of organic pollutants, superhydrophilicity, chemical stability, long durability, nontoxicity, low cost, and transparency to visible light. The photocatalytic properties of TiO_2 are derived from the formation of photogenerated charge carriers (hole and electron) which occurs upon the absorption of ultraviolet (UV) light corresponding to the band gap. The photogenerated holes in the valence band diffuse to the TiO_2 surface and react with adsorbed water molecules, forming hydroxyl radicals (•OH). The photogenerated holes and the hydroxyl radicals oxidize nearby organic molecules on the TiO_2 surface. Meanwhile, electrons in the conduction band typically participate in reduction processes, which are typically react with molecular oxygen in the air to produce superoxide radical anions ($O2^{•-}$). In addition, TiO_2 surfaces become superhydrophilic with a contact angle of less than 5° under UV-light irradiation. The superhydrophilicity is originated from chemical conformation changes of a surface. The majority of the holes are subsequently consumed by reacting directly with adsorbed organic species or adsorbed water, producing •OH radicals as described above. However, a small proportion of the holes is trapped at lattice oxygen sites and may react with TiO_2 itself, which weakens the bonds between the lattice titanium and oxygen ions. Water molecules can then interrupt these bonds, forming new hydroxyl groups. The singly coordinated OH groups produced by UV-light irradiation are thermodynamically less stable and have high surface energy, which leads to the formation of a superhydrophilic surface. TiO_2 is the most widely studied photocatalyst and it is used in numerous applications because of its compatibility with modern technology. New materials and applications involving TiO_2 can improve our lives in areas such as energy production and environmental protection.

Background of establishment of PIRC

TiO_2 photocatalysis is widely used in a variety of applications and products in the environmental and energy fields, including self-cleaning surfaces, air and water purification systems, sterilization, hydrogen evolution, and photoelectrochemical conversion. The development of new materials, however, is strongly required to provide enhanced performances with respect to the photocatalytic properties and to find new uses for TiO_2 photocatalysis. This research institute opens facilities regarding photocatalysis and collaborates with researchers to develop photocatalysis, which starts from April, adopted by a program of Ministry of Education, Culture, Sports, Science and Technology.

Purpose of PIRC

Photocatalysis was started from the foundation of Honda-Fujishima effect, which is a technology originated in Japan, and was mainly developed by Japanese researchers. This research institute opens facilities related to research on photocatalysis and is aimed to promote collaborate research among outstanding researchers. By promoting this mission, this research institute play a role of core institution of photocatalysis to apply photocatalysis to society.

Characteristic of PIRC

Industry of photocatalysis develops to 100 billion JPY and society requests many kind of applications. This research institute creates air and water purification system using self-cleaning effect and strong oxidation ability, and clean energy such as hydrogen from artificial photosynthesis. To realize it, we promotes to construct JIS and ISO and to use facilities to evaluate photocatalytic performance. Furthermore, we support state of the art of new synthetic methodology of photocatalysts using plasma process etc. We open our facilities to public and collaborate researches with researchers to develop photocatalysis which can apply society. Our research institute is aimed for providing 1) energy saving and environment-friendliness society, 2) safety society with sense of security and 3) comfortable space. We accept some challenges for general research topics and ten challenges for specific one.

Figure 1 Board of research institute of photocatalysis

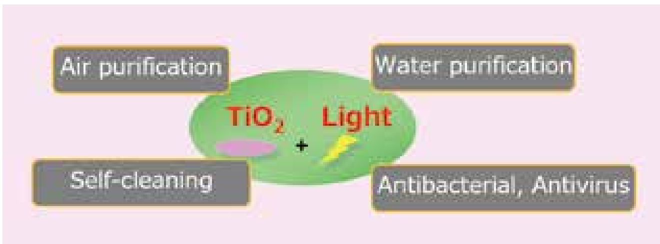


Figure 2 Application of photocatalysis

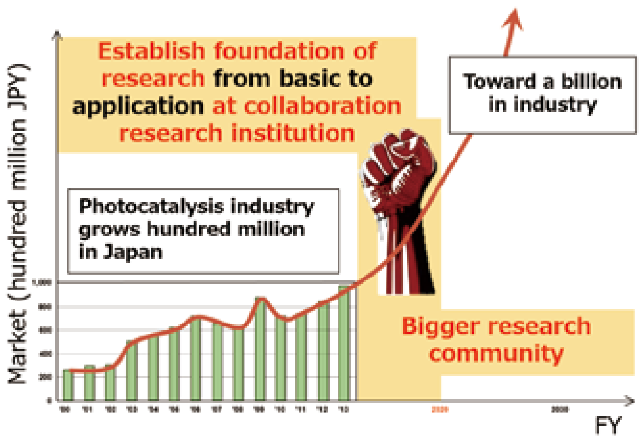


Figure 3 Goal of research institute of photocatalysis

Joint Usage/Research Center

Research Center for Fire Safety Science

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

Director
Professor,
Department of Architecture,
Faculty of Engineering Division Ⅱ
Makoto Tsujimoto

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.

Recruitment 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~E]

A. Fundamental research on building fire safety

(Examples from the past)

- Relative comparison of the combustion behavior of different types of electric cables involved in a fire
- Evaluation of environmental health and safety at firefighting activity in building with Class A Form
- Experimental examination concerning visual accident perception of smoke
- Study on hot current flow behavior along an inclined corridor

B. Fundamental research on material combustion science

- Study on evaluating heat release properties of panel products using model box

C. Research on technology and measures pertaining to fire safety

- Research of the safety measures about fire protection of institution
- Terahertz hazardous gas detection through fire and smoke

D. Fundamental research on fire safety and disaster prevention

E. Fundamental research on large-scale fire

[Emphasis Category, F] (※)

F. 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 11 members (5 from inside and 6 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)

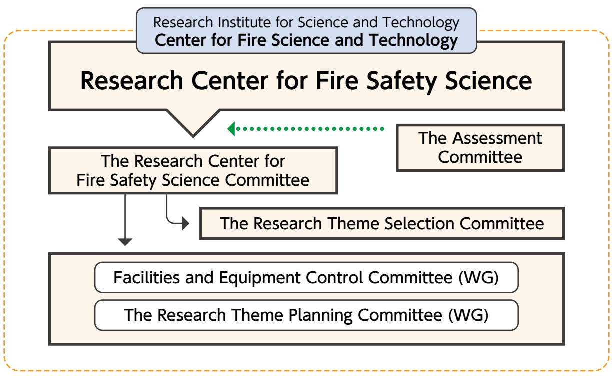
This committee (WG) is primarily involved in the operation planning of the full-scale experimental facilities. It is also responsible for the maintenance of facilities and equipment installed in the institution. In addition, it gives users instruction on how to use these facilities and equipment and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

Structural Fire Testing Furnace (Medium scale)

This unit is used to evaluate the fireproof 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)×1.5m (D)×1.5m (H), can also provide immediate heating.

Multiple Full-scale Furnace

This device is used to measure the fireproof duration of horizontal materials of buildings including beams, floors and roofs by using the standard heating test (ISO834). Fireproof 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.

Structural Fire Testing Furnace (Large scale, for Walls)

This unit is used to evaluate the fireproof 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.

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-tatami-mat 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.

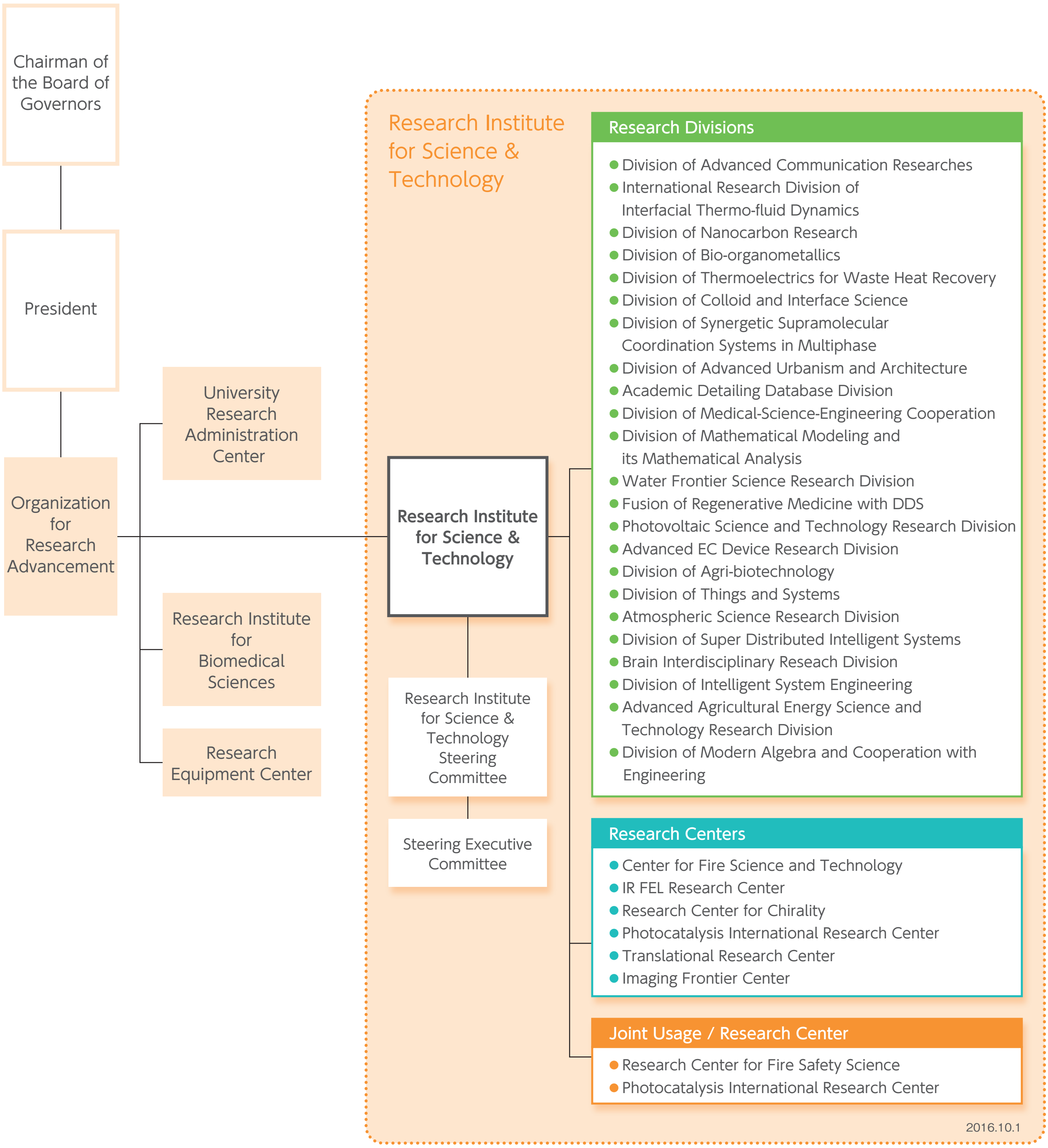
FTIR Gas Analyzer

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/m^2.

Rist Organization Chart

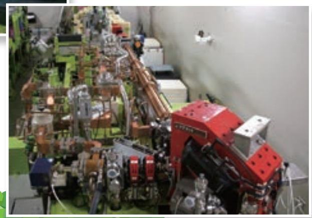


Noda Campus

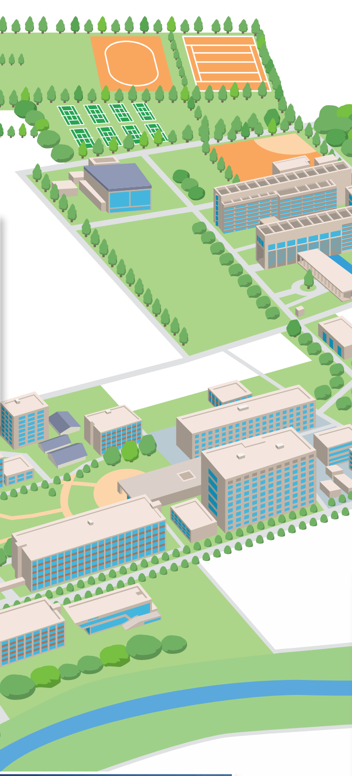
The Convergence

Research Equipment Center

Genome and Drug Research Center



IR FEL Research Center



Research Center for DDS

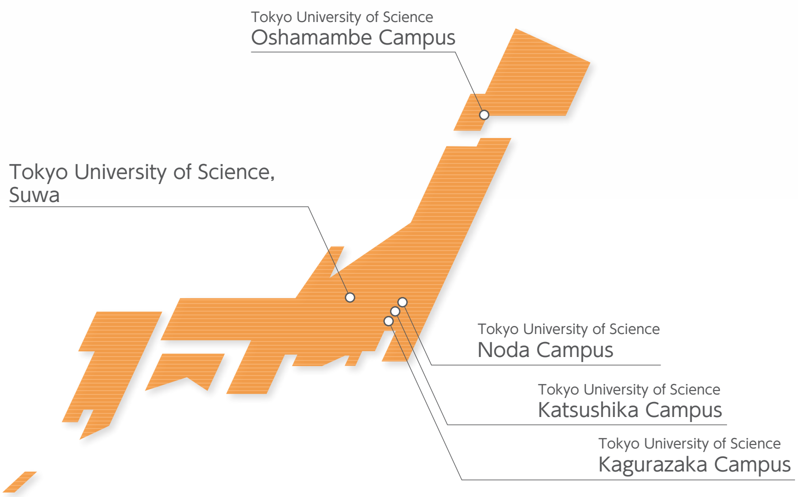
Research Institute for Biological Sciences

Information Media Center

Center for Fire Science
and Technology

Photocatalysis International
Research Center(PIRC)

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] http://www.tus.ac.jp/rist/

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

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Tokyo University of Science
2016/2017

RIST creates new directions in science and technology achievable“only at TUS”.