RIST TUS

Research Institute for Science & Technology

2015/2016

RIST TUS
Research Institute for Science & Technology

Bio and Pharmacy

Center for Environmental Health Science for the Next Generation
Research Center for Chirality
Translational Research Center
Division of Pharmaco-creation Frontier
Division of Bio-organometallics
Academic Detailing Database Division
Division of Medical-Science-Engineering Cooperation
Fusion of Regenerative Medicine with DDS
Division of Agri-biotechnology

Information and Societal

Center for Fire Science and Technology
Division of Next Generation Data
Mountain Atmosphere Research Division
Division of Intelligent System Engineering
Division of Integrated Science of
Division of Advanced Communication
Division of Advanced Urbanism and
Division of Things and Systems

Structural Materials

International Research Division of Interfacial Thermo-fluid Dynamics

Fundamentals

IR FEL Research Center
Leading -Edge Holography
Imaging Frontier Center
Quantum Bio-Informatics
Division of Mathematical

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

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 core of a Center.

Building a better future with

Mining Technology

Oshamambe town

Researches

Architecture

Technologies Research and Development Center

Research Division

Modeling and its Mathematical Analysis

TUS and expected to be a

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 General

The Research Institute for Science and Technology (RIST) was established in November 2005 to coordinate collaborative research activities throughout the whole university.
After several organizational changes to promote activities within RIST since then, a new research organizational structure of the University has been introduced in April 2015. RIST is now a member of "Organization for Research Advancement" while keeping the same internal structure as before.
RIST consists of Research Centers, Research Divisions and Joint Usage / Research Center.
Centers and Divisions are limited-term research groups on specific scientific targets with members selected throughout whole university, and sometimes even from outside. The Centers are funded jointly by Ministry of Education and the university, while Divisions are financially supported solely by the university and expected to be cores of new Centers. Research Center for Fire Safety Science and Photocatalysis International Research Center are the nationally selected organizations for joint usage / joint research open to public and they are extending their activities internationally.
All the members of RIST, which have different organization structure, explore their activities for their own but at the same time collaborations between members are strongly encouraged to open new horizon in science and technology. To substantiate this, they are grouped into 5 categories, Functional Materials (FM), Structural Materials(SM), Bio and Pharmacy (BP), Information and Societal (IS), and Fundamentals (F). Groups in each category have meetings frequently, while RIST as a whole has an annual meeting, RIST-Forum.
Research activities of RIST are supported by the University Research Administration (URA) Center established in April 2014, a member of "Organization for Research Advancement". RIST, "The Edge of Cross Disciplines", and URA Center, "TUS Global URA Center" share the building, "The Convergence", which had been inaugurated in May 2014 in Noda campus.

I hope and believe that new directions in science which are achievable "only at TUS" will be created based on the very unique research organization, RIST.

Director General,
Research Institute for Science and Technology
Dr. Hidetoshi Fukuyama

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Only at

The Edge of Cross Disciplines

Research Centers / Research Divisions

2015/2016

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

Photocatalysis International Research Center

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

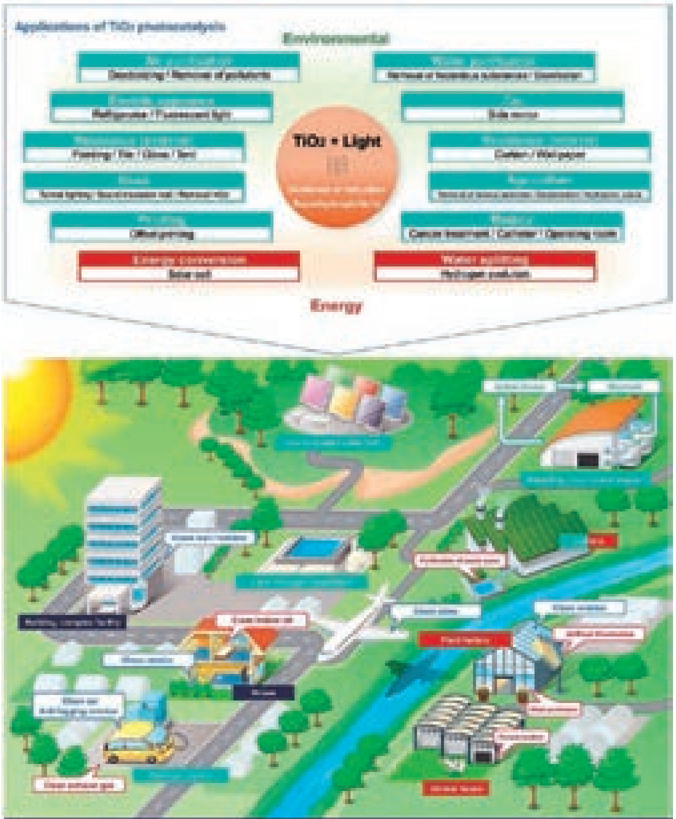
Utilization and conversion of solar energy to fuels and electric energy are an urgent issue in the world. It is indispensable to construct clean energy systems in order to solve the issues.

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.

Functional Materials

Division of Nanocarbon Research

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

Director
Associate Professor,
Department of Liberal Arts,
Faculty of Engineering Division I
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.

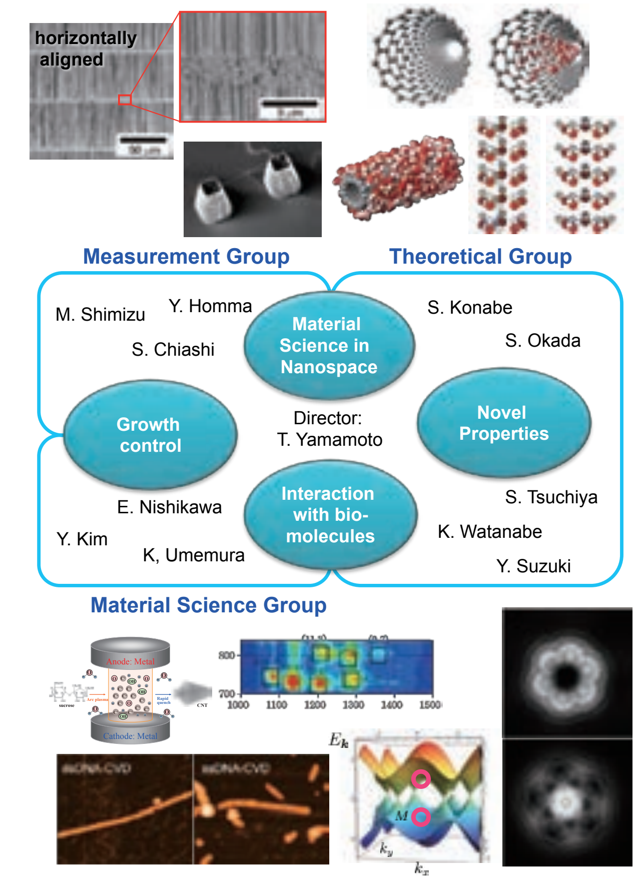
Theoretical Study on Novel Properties

○We 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.



Functional Materials

Division of Thermoelectrics for Waste Heat Recovery

Established: April 2013

k-nishio@rs.noda.tus.ac.jp

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

Functional Materials

Division of Colloid and Interface Science

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

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

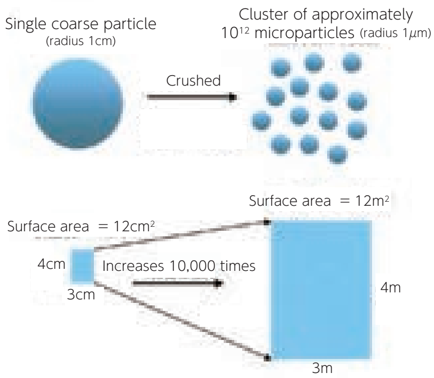
Objectives	To play a leading role in colloid and interface science both in Japan and internationally.
Future Development Goals	We afford a deep understanding of surface phenomena from fundamental aspects and the practical aspects by the assist of exchanges of information and closer collaboration between 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.



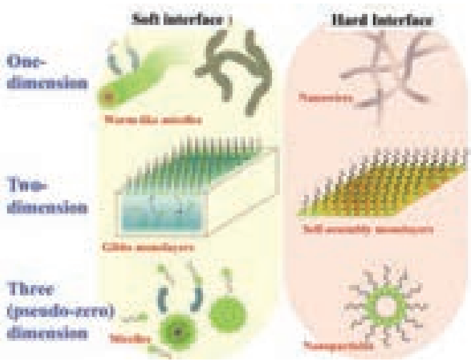
Interface science has a broad range of application, and is related to a variety of fields including surface active agents (surfactants), microparticle (colloid particle and nanoparticle) dispersed systems, microcapsules, gel, solid surfaces, powders, bio-interfaces and environmental colloids.

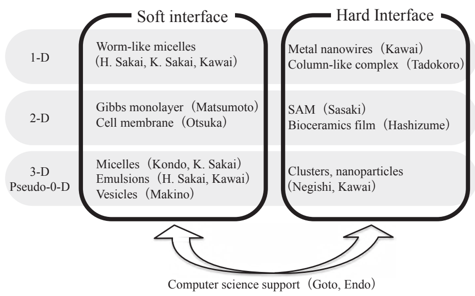
The Division of Colloid and Interface Science was established in January 1981. The first Director, Professor Kenjiro Meguro (Department of Applied Chemistry, Faculty of Science) was succeeded by Professor Tamotsu Kondo (Department of Medicinal and Life Science, Faculty of Pharmaceutical Sciences), Professor 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

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.

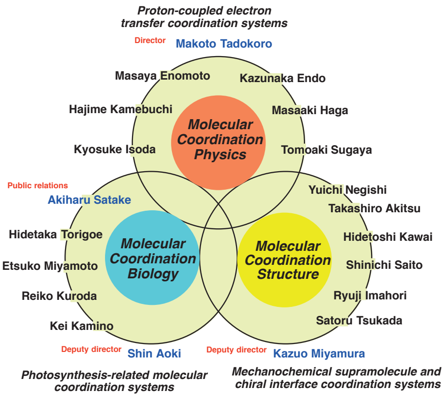
Director
Professor,
Department of Chemistry,
Faculty of Science Division I
Makoto Tadokoro

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.

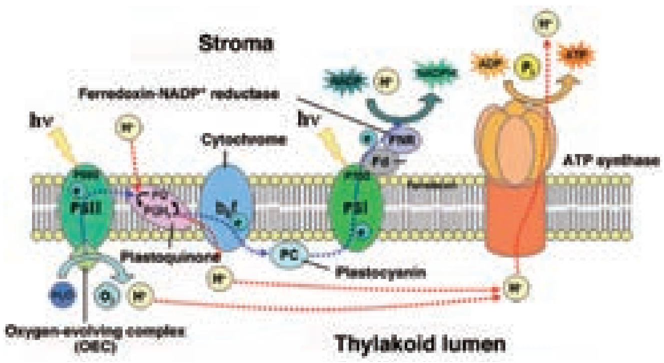


Fig. 1 Biological photosynthesis system (by Wikipedia)

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

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

Objectives	To create novel functional materials through investigating the properties and structures of water on the surface and in the limited space of nano- and bio-materials, and to understand the role of water universally.
Future Development Goals	To promote researches on water with the viewpoints from microscopic to macroscopic scales, and to enhance the collaboration among three research themes.

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 proceed to the researches of water from the new 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 or in nanopores (Fig. 1). 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 step into development of new technologies of water usage in human society through the researches on cleaning, applications to agriculture, water environmental management, cloud formation, etc.

The division consisting of four research groups executes three research themes from understanding on the structures of water in microscopic spaces to innovation of the technologies of water usage (Fig. 2). By the collaboration of members of the three research themes, we are aiming at developing advanced technologies of water utilization based on the understanding of the microscopic structures of water and their functions.

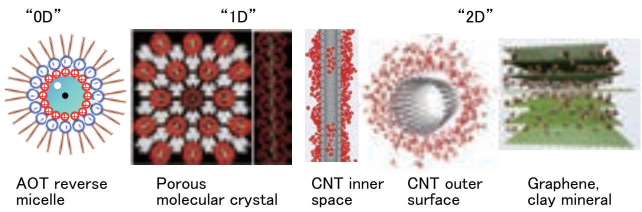


Fig. 1 Water in Low Dimensional Space

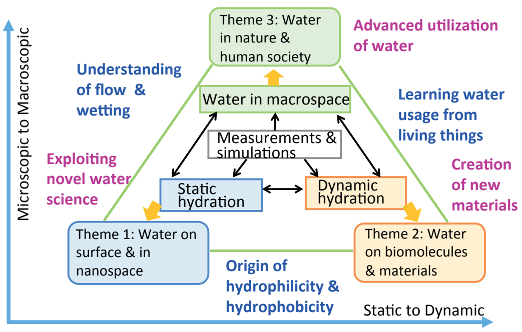


Fig. 2 Organization of Water Frontier Science Research Division

Research groups

○Static hydration: studying static water in microspace
○Dynamic hydration: studying interfacial water under momentum transfer
○Water in macrospace: studying water in nature and human society
○Measurements and simulations: supporting other research groups through measurements and simulations

Research themes

○Water on surface & in nanospace: investigating science of water in microspace
○Water on biomolecules & materials: developing functional biomaterials
○Water in nature & human society: establishing advanced utilization of water in the earth environment and human society

Water on surface & in nanospace

—Understanding and control of structures and properties of water in 1D and 2D spaces—

We exploit novel water science by elucidating properties of water in 1D and 2D spaces from microscopic viewpoints. The function of water, like hydrophobicity or hydrate interaction, varies depending on the structural water formed at the interface. Although the molecular structures are intensively studied in theoretical science, few experimental data have been obtained. We investigate both experimentally and theoretically the water confined in 2D spaces, such as water on graphene and an electrical double layer on the electrode, and in quasi 1D pore, such as carbon nanotubes and nanoporous molecular crystals, and uncover the behaviors of structural water at the interface of materials.

Water on biomolecules & materials

—Development of functional soft-biomaterials based on the understanding and control of interfacial dynamic hydration—

In chemical reactions or material syntheses, interfacial reactions under momentum transfer are important. The control of hydration and dehydration at interfacial reactions is indispensable for efficient reactions and emerging functions of materials. Such the understanding and control of reaction fields rapidly enhance electrochemical reactions, bio-mineralization, and emerging functions of bio-functional polymers. We will develop spectro-imaging systems for tacking the time evolution of hydrate under momentum transfer, and contribute to researches of themes 1 and 3. Furthermore, we will develop simulation methods of fluid-reaction field by merging hydrates in theme 1 and fluidic analyses in theme 3. We are aiming at efficient creation of soft-biomaterials useful in the medical field, and advances in the understanding of functional emerging of those materials.

Water in nature & human society

—Promoting study of science and technology of water utilization based on the understanding and control of water—

Water supports our life and our diet through agriculture which uses water, contributes to industry, and produces various weather. By scientifically approaching macroscopic phenomena of water, we will develop science and technology of water utilization to enrich our lives for our happiness. By complementally combining the knowledge obtained in this theme with those on microscopic behaviors of water obtained in themes 1 and 2, we will promote basic researches on water in the fields close to human society. Experimental and simulation members closely cooperate in various fields such as, in agriculture, improvement of efficiency of hydroponics and production method of fertilizer, in industry, study of cleaning with water, food freezing, environmental management of water, and in nature, cloud formation which closely relates to weather.

Functional Materials

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 2013, approximately 140 GW of installed photovoltaic systems were in operation worldwide, which is an amount that is roughly equivalent to the output of 140 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 11 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 Division I 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 Division I 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

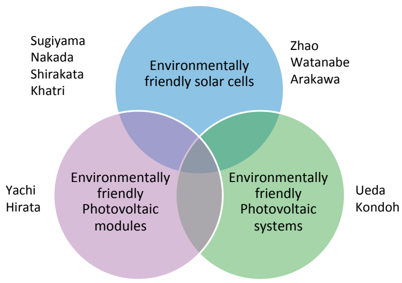


Fig. 1 Formation of Photovoltaic Science and Technology Research Division.

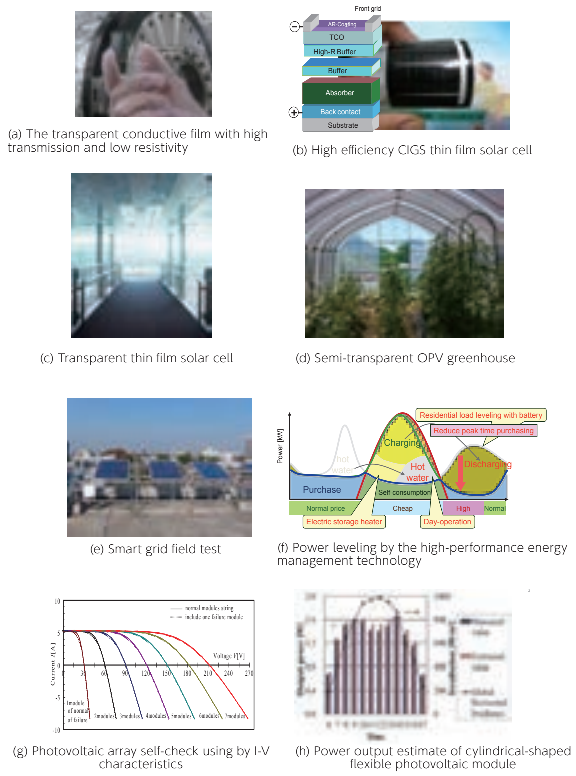


Fig. 2 Research Issues of Photovoltaic Science and Technology Research Division

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 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).

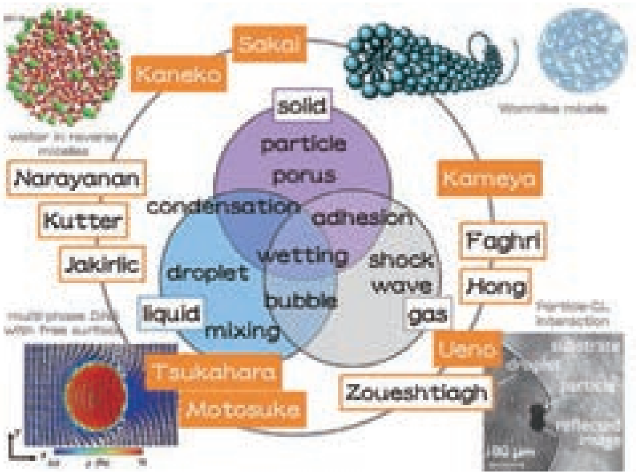


Fig. 1 Prime factors of phenomena within a phase or between/among phases.

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

Established: April 2011

env-health@rs.tus.ac.jp

Center for Environmental Health Science for the Next Generation

Director
Professor,
Research Institute for Science and Technology
Ken Takeda

We hope that the activities of this Center contribute to the creation of an environment that allows the children of the future to live healthy lives.

Objectives	The Center is investigating environmental factors such as airborne nanoparticles that might affect the metabolism or function of the brain, lungs, liver, or kidneys of the next generation, and we are working toward developing a strategic research foundation for creating a society in which the next generation of children can lead healthy lives.
Future Development Goals	We will prevent disease in the next generation of children that might be caused by environmental nanoparticles as a primary or background factor. We hope to preserve an environment that guarantees the healthy growth and development of the next generation.

We perform research on next-generation health and science, in particular cutting-edge research related to the identification and prevention of disease.

The Center started as a five-year project after having been selected as a 2011 recipient of the Private University Strategic Research Formation Assistance Grant from the Japanese Ministry of Education, Culture, Sports, Science and Technology.

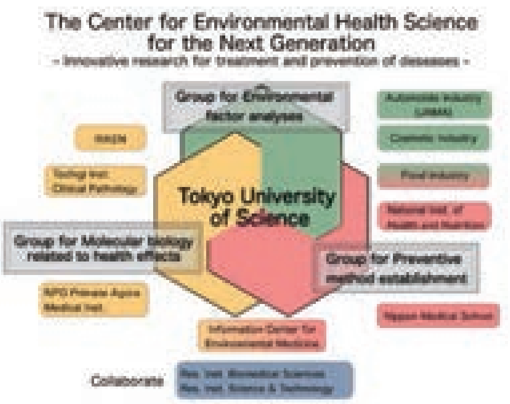
Goals

Our goal at the Center is to form a strategic research foundation for building a society in which the next generation of children can lead healthy lives. To achieve this, we have gathered the combined wisdom of the Research Institute for Science and Technology, and will work in cooperation along with outside research institutes in order to realize an environment that guarantees the healthy growth and development of the next generation. We will also work toward a better understanding of the effects of exercise and nutrition on health, and promote methods of disease prevention and treatment.

Background of the Center

Recent years have brought about great changes in the social and lifestyle environments in which we live, in some cases leading to the emergence of new factors that affect human health. One particular problem both domestically and abroad is environmental factors that affect the growth and development of children.

In 2010, the Japanese Ministry of the environment began a 15-year study, the "Japan Eco & Child Study", a nationwide epidemiological investigation related to child health and the environment. The goal of the study is to investigate the hypothesis that exposure to environmental factors from the fetal period through childhood might play a role in areas such as fertility and pregnancy, congenital abnormalities, psychoneurotic development, immunity and allergies, and the metabolic and endocrine systems.



The director of the Center and the colleague are already establishing the academic frontiers of the Private University Strategic Research Formation Assistance Grant from the Japanese Ministry of Education, Culture, Sports, Science and Technology through health sciences research related to nanoparticles. The Center has already used animal experiments to demonstrate the maternal-to-fetal transfer of nanoparticles and nanomaterials released into the environment, which are produced as the base materials for use in nanotechnology.

In order to further reveal the health effects of nanoparticles and nanomaterials on the next generation and to better understand the effects of exercise and nutrition on the health and development of children, we established the Center for Environmental Health Science for the Next Generation by bringing together researchers from different fields from within the University, starting with the School of Pharmaceutical Science and other research departments. Research is also being performed in coordination with outstanding institutes and researchers from outside the University that have made advances in nanoparticle-related health sciences, for example with Prof. Masao Sugamata, director of the Tochigi Institute of Clinical Pathology.

Desired results of the Center's research

1)At present, there are almost no overseas research institutes that are focusing on the health effects of nanomaterials on the next generation. Nonetheless, we have already obtained promising results. We hope that the new team formed at the Center will lead the world in research related to environmental health science on the next generation.

2)We hope to identify environmental factors, pathologies, and molecular mechanisms related to allergic and autoimmune diseases which have become prevalent in children in recent years, and we hope to establish treatment methods for those diseases.

3)We hope to develop experimental primate model systems in order to identify how microparticles and various nanomaterials in exhaust fumes affect the next generation, and then to extrapolate data related to effects on human health and the establishment of treatment methods.

4)Various nanoparticles are unintentionally created and released into the environment during the course of daily life. We intend to focus in particular on the nanoparticles found in diesel exhaust and cigarette smoke, and to identify their health effects on the next generation. By analyzing the behavior and mechanisms of nanomaterials created from other microparticle sources, we hope to identify health effects on children and the next generation.

5)We will examine the effects of exercise and nutrition in order to help prevent next-generation health effects due to environmental factors. We also aim to find methods of disease prevention through the pharmaceutical management of diseases at the early stages of symptom development.

The significance of research at the Center

The goals set forth by this Center will not be attainable through traditional models of medical and environmental research. What is required is an academic union of the fundamental areas of nanomaterial health science (such as nanoscale physics, chemistry, analysis, toxicology, pathology, and molecular biology) with the new viewpoints of the next generation of health sciences (immunology, nutrition, kinesiology, pharmacology, and medicine). In doing so, we hope that the characteristic aspects of a technical university will lead to the establishment of new frontiers and the development of new integrated academic areas, as well as aid in the training of young researchers. We hope that the Center's research will help to create an environment where the children of the next generation can live healthy lives.


System for exposure to diesel exhaust

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.

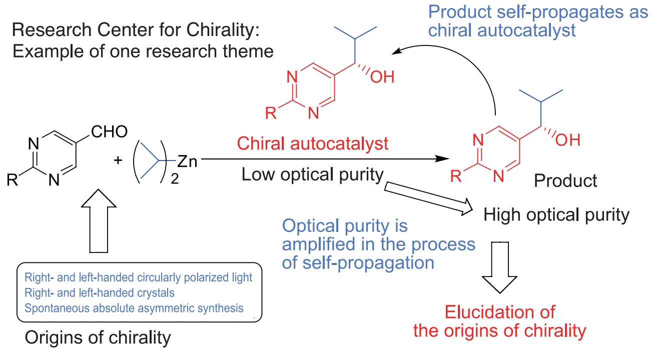
Characteristics

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.

Bio and Pharmacy

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.

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 October 2015, the TR Center houses 25 in-house researchers (19 from the Faculty of Pharmaceutical Science, 2 from the Faculty of Science, 1 each from the Faculty of Engineering, Faculty of Science and Technology, and I from Faculty of Industrial Science and Technology) and 29 visiting research fellows from outside the TUS community.

In-house Researchers (25)

Faculty of Pharmaceutical Science: Yoichiro Isohama (Applied Pharmacology); Junichiro Oka, Yayoi Tsuneoka, Sachie Hamada (Neuropsycho-pharmacology); Masayo Komoda (Medical safety sciences); Tsugumichi Sato (Pharmacoepidemiology, Therapeutic risk management); Takehisa Hanawa, Yayoi Kawano (Clinical design); Tatsuya Higashi, Shojiro Ogawa (Bio-analytical chemistry); Takashi Hirota (Drug metabolism and pharmacokinetics); Kazumi Yoshizawa (Pharmacology and therapeutics); Kazunori Akimoto (Molecular Medical Science); Yoshikazu Higami, Yuka Sudo (Molecular pathology and metabolic disease); Fumio Fukai, Takuya Iyoda (Molecular patho-physiology); Takeshi Wada, Rintaro Iwata (organic synthetic chemistry, Life Molecular science) Faculty of Science: Hidetaka Torigoe (Biochemistry), Hidenori Otsuka (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 (29)

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: Masahiko Tanabe (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 Hospital: Koji Yamamoto (Translational and clinical research), Sasaki Institute: Takao Sekiya (Pharmaceutical science), Takao Sekiya, 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
4. Discovery of calorie restriction mimetics that extend healthy lifespan (University of Tsukuba, Nagasaki University Sasaki Institute)
5. Development of antisense oligodeoxynucleotides that accelerate skin wound healing (Nagasaki University)
6. Clinical trial of bath therapy using the antiscabietic agent ivermectin

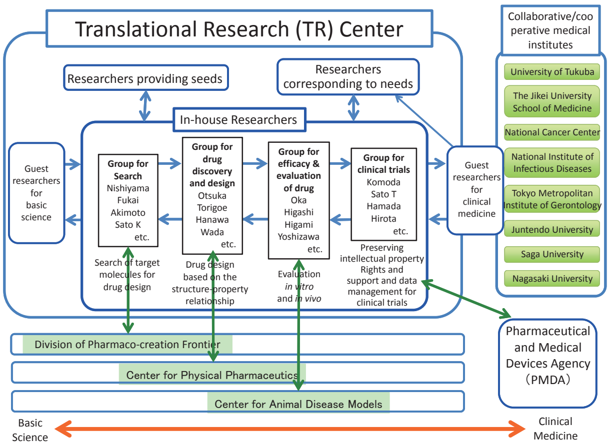


Fig : research organization of TR Center, Cooperation of In-house Researchers and Guest Researchers

Bio and Pharmacy

Established: October 2011 ✉ tanuma@rs.noda.tus.ac.jp

Division of Pharmaco-creation Frontier

Director
Professor,
Department of Biochemistry,
Faculty of Pharmaceutical Sciences
Sei-ichi Tanuma

Objectives	To research and develop a new drug-creation system combining the identification of crinical-target proteins by genomics/proteomics analyses and highly sophisticated structure-based in silico drug-design methodologies and methods, thereby making a contribution to the development of novel pharmaceuticals.
Future Development Goals	To develop a new discipline, theoretical drug-creation biochemistry , based on biological physicochemistry , which is one of the strengths in Tokyo University of Science.

Recently, there are many problems in pharma-companies such as decrease of new approved pharmaceuticals and less strategies for new drug discovery. To find a way out of the difficulties, researching and developing on novel drug-creation systems using *in silico* strategies are very important. We would like to contract a base for theoretical drug-creation, which is able to send it to the world. We invite the participation in our division of researchers who are interested in drug-creation approaches.

Establishment of a new drug-creation system based on *in silico* platforms

Characters of the Division of Pharmaco-creation Frontier

The Division of Pharmaco-creation Frontier(PCF) was established in October 2011. Its predecessor was the Research Institute for Genome and Drug, where analyses of apoptosis regulatory mechanisms and development of *in silico* drug-design methodologies and methods were performed. For example, validation of drug-targeting proteins by new established assay methods using model mouse, preparation of monoclonal anti-bodies against transcriptional factors, and development of *in silico* drug-creation methodology targeting protein-protein introduction(COSMOS and BIOS methods).

While sharing the same basic perception of issues, the Division of PCF is characterized by its forcus on the generation of new drug lead compounds using our established *in silico* drug-creation platforms, and by development of practical drug-creation systems.

Organization of the Division of PCF

The Division of PCF currently consists of 13 experts in such diverse specializations as Molecular Biology Biochemistry, Cell Biology, Genetics, Molecular Oncology, Molecular Neurology, Drug-metabology, Genomic-pharacology Bioinformatics, Organic Chemistry, Pharmaco-kinetics, Enviromental-heath Science, Brain Science, Surgery, and so on. Collaborative relationships among these individuals are illustrated in Figure 1.

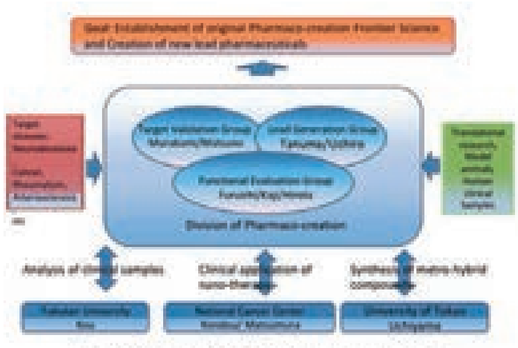


Figure 1. Organization of the Division of Pharmaco-creation Frontier

In-house Researchers(15)

Sei-ichi Tanuma, Toshiyuki Kaji, Jun-Ichiro Oka, Takashi Hirota, Yoshikazu Higami, Fumiaki Uchiumi, Takumi Uchiro, Kazunori Akimoto, Ryoko Takasawa, Akira Sato(Faculty of Pharmaceutical Sciences),Fumio Sugawara, Sadakazu Furuichi, Sachihiro Matsunaga, Kengo Morohashi(Faculty of Science and Technology), Yasufumi Murakami (Faculty of Industrial Science and Technology)

Guest Researchers(4)

Masanobu Uchiyama(University of Tokyo), Tadashi Kondo(National Cancer Center), Daisuke Shiokawa(National Cancer Center), Kou Sei(Fukutan University Hospital)

Research Contents of the Division of PCF

In the Division of PCF, our researchers join hands with in house 3 groups researchers and gust researchers to constrict theoretical drug-creation systems with the objective of generating the new lead compounds. Toward this end, we are proceeding with research from the following approaches.

(1)Target Validation Group

Identification and validation of novel drug-target proteins by *Drosophila* genetic assay system, Western-blotting screening using monoclonal anti-bodies, and microarray system.

(2)Lead Generation Group

Structure-based virtual screening and drug design targeting the proteins discovered by the target Validation Groups using COSMOS and BIOS methods for protein-protein interaction and protein-DNA/RNA interaction, respectively. Especially, new small compounds targeting apoptosis regulation are designed and synthesized.

(3)Functional Evaluation Group

Small lead compounds targeting apoptosis regulation generated by the Second Group are functionally evaluated by cell cultures and model animals(Figure 2). Also, pharmaco-kinetics of metalohybride compounds are analyzed in detail.

(4)Allying with Outside Institutes

Constructing the library of novel small compounds targeting apoptosis regulation and analyzing the clinical specimens provided by medical institutes to contribute to identification of new drug target proteins.

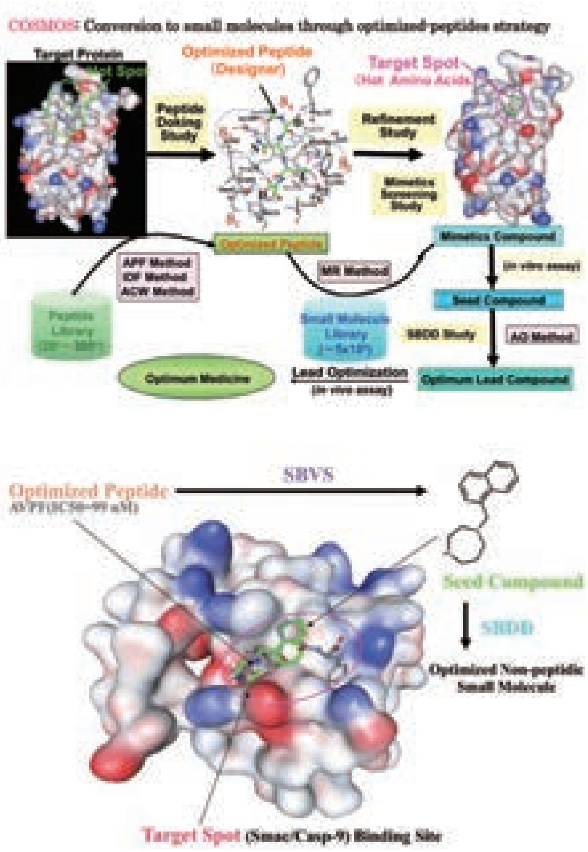


Figure 2. A Novel Methodology for in silico Drug Design, COSMOS

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

Division of Bio-organometallics

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.

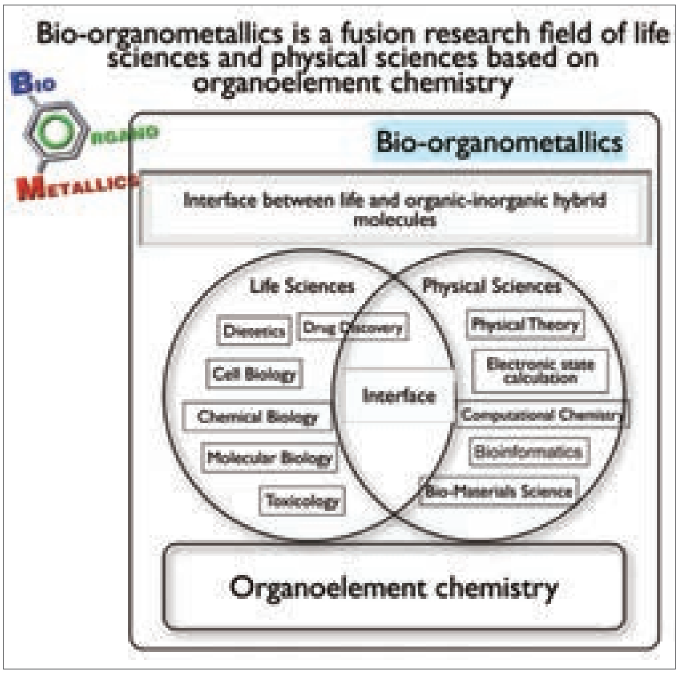
The division of bio-organometallics was founded in October, 2012. It is very significant for bio-organometallics research to obtain a research base in Tokyo University of Science. We will send the research results of bio-organometallics by making full use of organic-inorganic hybrid molecules prior to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

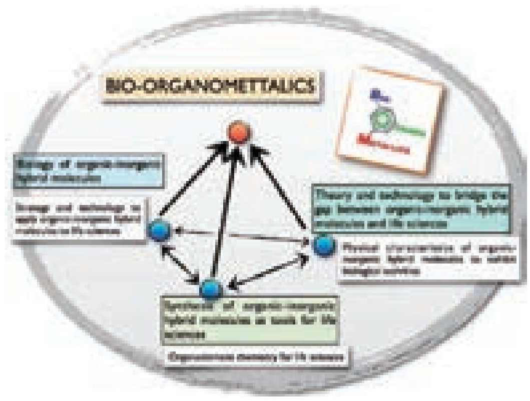
Masanobu Uchiyama (University of Tokyo), Masahiko Satoh (Aichi Gakuin University), Tsuyoshi Miyazaki(National Institute for Materials Science), Chika Yamamoto (Toho University), Shuji Yasuike (Aichi Gakuin University), Yasuyuki Fujiwara (Tokyo University of Pharmacy and Life Sciences), Tomoki Kimura (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 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.

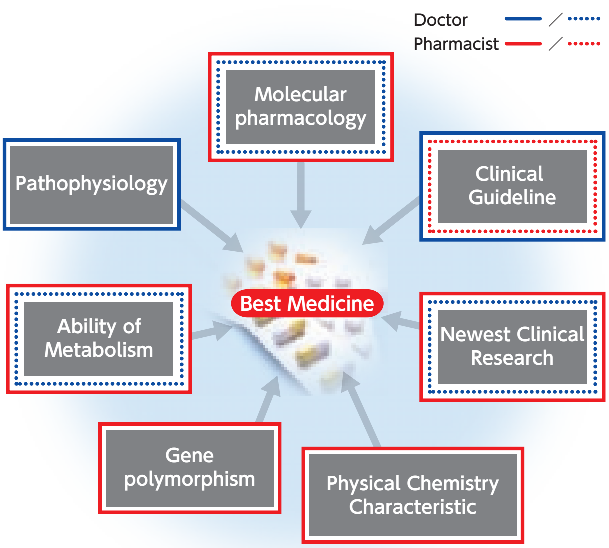


Figure 1. Each point of view to select an appropriate medicine for a patient.

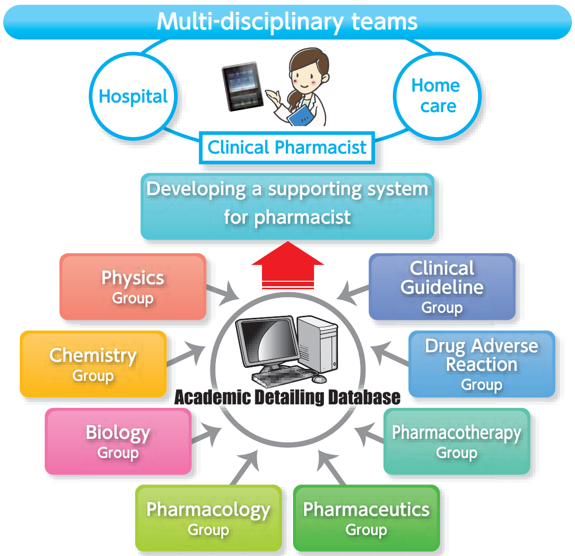


Figure 2. Eight essential fields of the division.

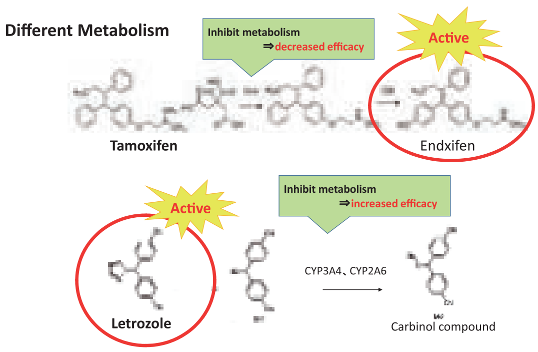


Figure 3. Focused on breast cancer treatment

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

Division of Medical-Science-Engineering Cooperation

Director
Professor, Research Institute for Biomedical Science
Ryo Abe

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.

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

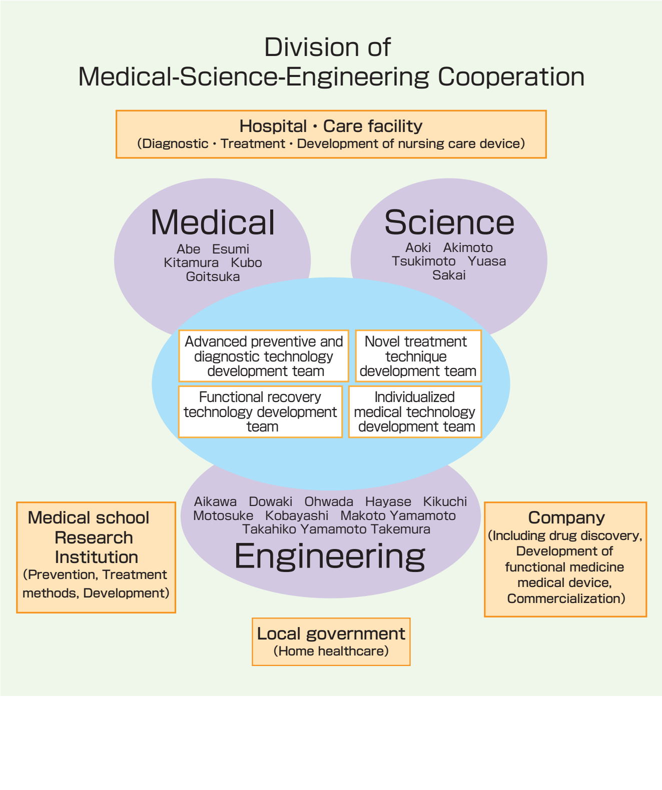
This team aims to 1) discover chemical and biological agents for the treatment of cancer, immune diseases (allergy and rheumatism), and infectious diseases, 2) to develop treatment systems that utilize three-dimensional information from combined diagnostic imaging, and 3) to improve the safety and efficacy 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.



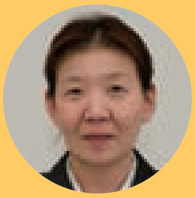
Bio and Pharmacy

Established: April 2015

ddsj@rs.noda.tus.ac.jp

Fusion of Regenerative Medicine with DDS

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.

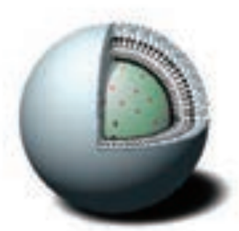


Fig 1. Pegylated liposomal doxorubicin

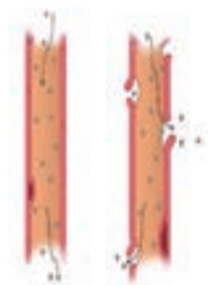


Fig 2. Pegylated liposomal doxorubicin in normal (left) and tumor vessels.

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 endothelial 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,

$$d_{aer} = d_p\sqrt{\frac{\rho_p}{\rho_0}} \qquad (1)$$

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.

Group photo of "5th Indo-Japanese symposium"

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

Division of Agri-biotechnology

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.

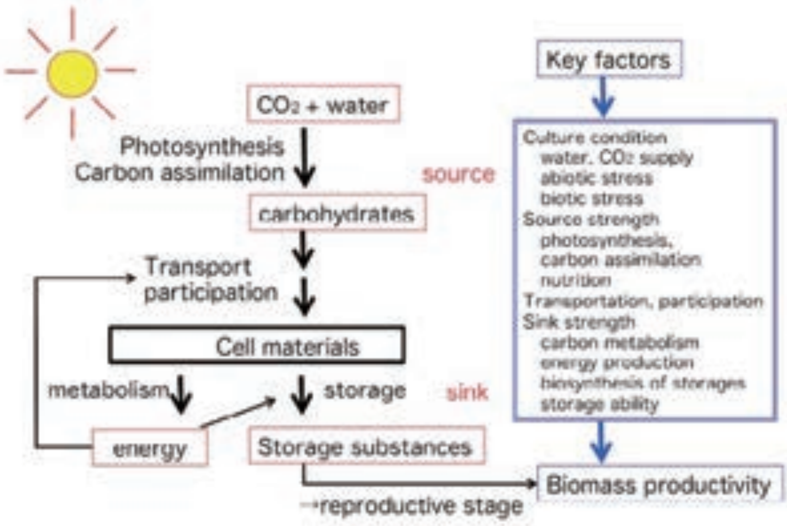
In this research section, we study on the basic research for the following three items, which we focused on the improvement of biomass productivity on the above-mentioned points of view: They include the inspection for the improvement of the plant function on a cell level, individual level, and group 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.



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.

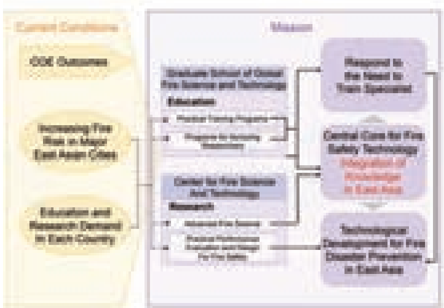


Fig. 1 Perspective of the Center for Fire Science and Technology

Photo 1 Fire Research and Test Laboratory

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

Information and Societal

Division of Next Generation Data Mining Technology

Established: April 2011 ohwada@ia.noda.tus.ac.jp

Director
Professor, Department of Industrial Administration, Faculty of Science & Technology
Hayato Ohwada

Objectives	Creation of new, highly sophisticated methods of information processing by combining traditional statistical methods with AI-based inference engines to develop data mining tools capable of extracting habitual patterns and other knowledge from databases.
Future Development Goals	Attainment of the world's highest level of data mining tool performance as demonstrated through participation in competitive contests, and provision of new tools for supporting various scientific and technological development efforts.

We have brought together experts in various fields, including informatics, statistics, bioinformatics, and life sciences, as we strive to develop the world's most effective data mining tools and to broadly demonstrate their usefulness.

Extraction of habitual patterns and knowledge from lifelog biometric databases

The Division of Next Generation Data Mining Technology was established in April 2011. While new itself, its predecessor was the Research Institute for Science and Technology Knowledge Interface, established in 2005 (and formally concluded in March 2011). The institute to took a broad, multi-disciplinary approach to the development of techniques for the extraction of meaning from vast amounts of data; moreover, as announced at international conferences and presented in scientific journals, among the many accomplishments of the institute are the application of parallel inductive learning and inference engines to data mining systems, the development of multi-domain motif search tools for use in bioinformatics systems, and the use of rotational illusions in medical image analysis systems.

While sharing the same basic perception of the issues, the Division of Next Generation Data Mining Technology is characterized by its focus on the development of next-generation data mining technologies for medical/biometric applications and Web-based data. Toward this end, it contains within its organizational structure a multidisciplinary range of specialties centered on core proficiencies in artificial intelligence and statistics. Here, experts bring together their expertise to create new, highly sophisticated methods of information processing by combining traditional statistical methods with AI-based based inference engines to develop data mining tools capable of extracting habitual patterns and knowledge from the web and from biometric lifelog databases. The division currently consists of 14 experts in such diverse specializations as knowledge engineering, cognitive science, statistical science, bioinformatics, system engineering, and even civil engineering. Collaborative relationships among these individuals are illustrated in Figure 1.

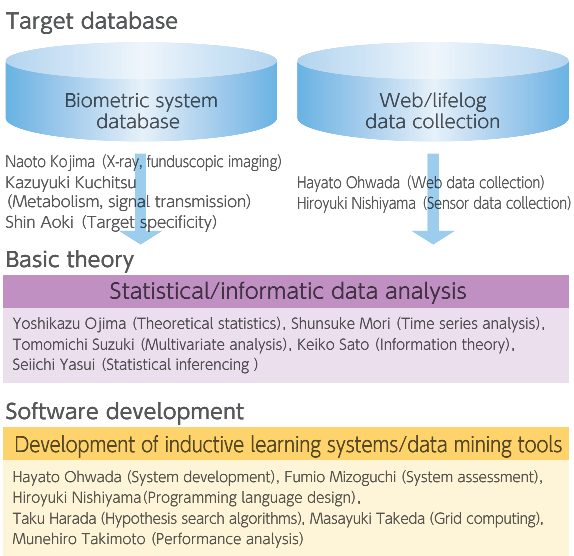


Fig.1 Collaboration among researchers within the Division of Next Generation Data Mining Technology.

The division is already advancing a number of interesting research projects, among them the so-called "Li-Phone (Life-log using Phone)". This project seeks to collect behavioral data for subsequent mining by tracking the usage of an individual's smartphone to create a lifelog—a continuously updated record of what a user does and when and where the user does it. GPS or another such function is used to track location; the smartphone itself, similarly, is used to monitor the person's calling history, Web browsing history, e-mail traffic, and so on.

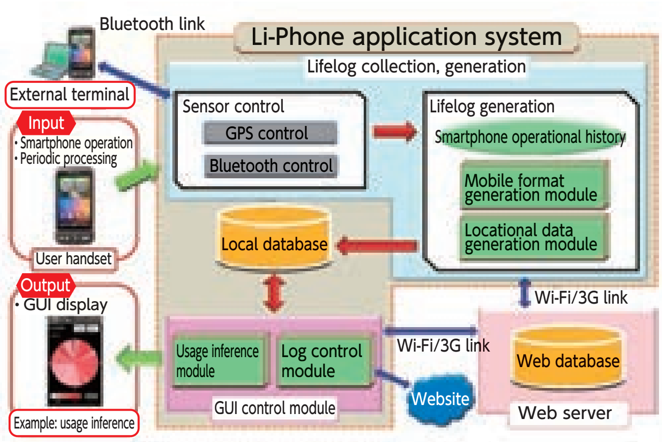


Fig.2 Li-Phone system configuration

Figure 2 shows the configuration of the Li-Phone system. This system utilizes the smartphone's GPS and communications capabilities to continuously maintain a real-time record of the user's position and calling history (ingoing and outgoing calls, Web browsing, etc.). We thus obtain an account of not only where the user was at a certain time, but also how that person was using his or her smartphone.

In our research, we utilized this system to track the smartphone behavior of 10 participants. An examination of the resulting lifelogs revealed that users tended to use their smartphones within certain timeslots and that those slots were relatively unhurried times of day for them. We also found that the patterns evident within the lifelogs could be used to predict the user's busy time periods on the following day. Figure 3 presents an example.

Fig.3 Prediction of user's status by day or date based on location and behavior histories (in this example, 09 February prediction for 10 February)

Established: April 2011

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Mountain Atmosphere Research Division

Director

Professor, Department of Physics, Faculty of Science Division I

Kazuhiko Miura

Objectives	To clarify the effect of aerosols on climate change, the MARD will activate the collaborated research and make the network of Japanese mountain atmosphere observatory.
Future Development Goals	This network of Japanese mountain atmosphere observatory will expand to the international one in future.

It can be said that the free troposphere is the background atmosphere where the influence of the man activity is a little. Mountains located in the free troposphere are likened to the observation towers of nature. We research on the background air pollution, the inetraction of aerosol and cloud and their effects on climate change.

Long range transport of atmospheric pollutants, aerosol-cloud interaction

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 (IPCC2007). 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 (Fig.1).

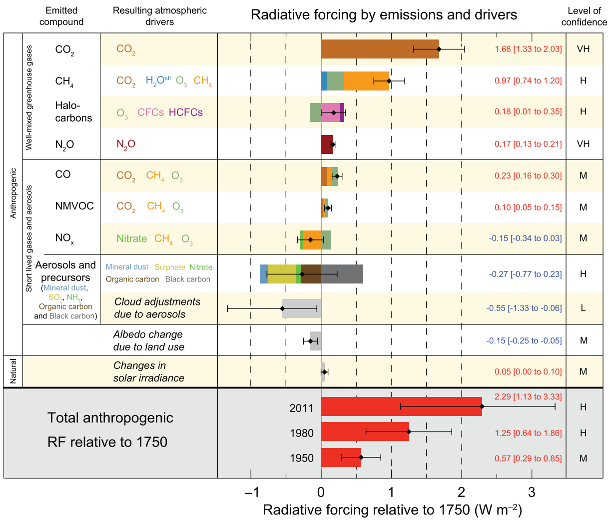


Fig. 1 Radiative forcing estimates in 2011 relative to 1750 and aggregated uncertainties for the main drivers of climate change (IPCC 2013).

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 (Fig.2). There are a few papers of new particle production observed in the PBL under a high-pressure system. It suggests that particles are produced in the free atmosphere (FT).

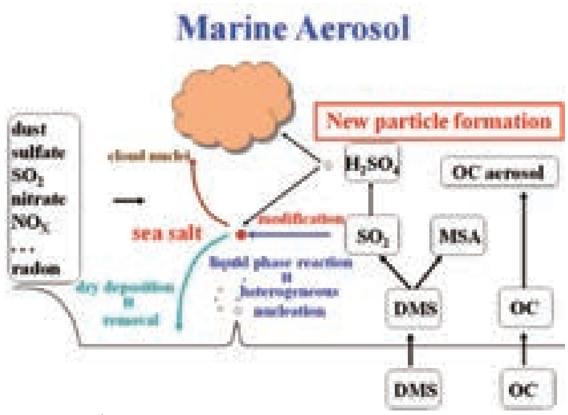


Fig.2 Marine aerosol.

Because of the altitude, mountain sites are well suited to studying aerosol-cloud interactions. We operate a network of mountain observation stations that studies processes of long range transport of atmospheric pollutants across East Asia and Japan, mixing between the PBL and the FT, new particle production and cloud formation. There are a few observatory of mountain site in the GAW (Global Atmosphere Watch) stations, WMO (world meteorological organization). Japanese mountains are important watching observatories, because they located in the east edge of the Eurasia.

Fig. 3 Japanese network of observatory on moutain sites

Our station on Mt. Fuji is particularly important, as Fuji is an isolated peak normally situated in the FT. The purpose of the MARD is not only activating the collaborated research of Mt. Fuji but also making the network of Japanese mountain atmosphere observatory, and in future, to expand it to the international one.

Fig.4 The observatory on Mt. Fuji.

Division of Intelligent System Engineering

Established: April 2011 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 2011, and has been starting newly to aim at the medical and space applications. In this division, we will tackle research and development of human-like 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 with autonomy for medical and space applications.

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.

○Radiowave 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)

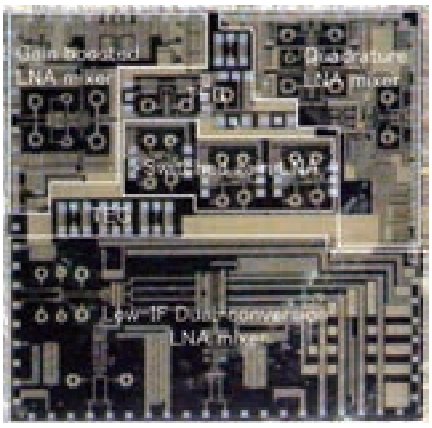


Fig. 1 Microphotograph of the proposed Integrated circuits (5mm×5mm)

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.

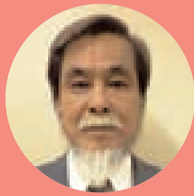
Research of software and theory to make hardware systems work more flexibly and autonomous

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.

Established: October 2011 ✉ tomoylab@rs.noda.tus.ac.jp

Division of Integrated Science of Oshamambe town

Director
Professor, Department of Biological Science and Technology, Faculty of Industrial Science & Technology
Yasuhiro Tomooka



Objectives	To support Oshamambe town by solving problems in scallop culture with biological and engineering technologies, and by participating in its socio-economic activities and education.
Future Development Goals	We have developed collaboration systems among researchers, managers of scallop fishery, leaders of the citizens local government and educational facilities, and began to make progress toward to our goals.

The Oshamambe campus has been supported by the Oshamambe society, and the small town in Hokkaido now has many socio-economical difficulties. This Division is going to study and support the society of the town, using our talented group of research personnel and excellent equipment, in collaboration with the citizen and local government.

We study and support Oshamambe town, in collaboration with the citizens and local government.

Introduction

Soon, thirty years is going to have passed since Faculty of Industiarl Science and Technology was established. Freshmen of the Faculty live in the dormitory and study for one year in Oshamambe campus in Hokkaido, where they can enjoy the nature of the northern island and collaborate with the society of the small town in various activities. Their second year starts in Katsushika campus. More than 5,000 students have graduated from the Faculty and they have been highly evaluated in various Japanese business societies.

During the last 30 years, however, the population of the town has become half in number and gotten aged because of the low rate of birth. This is a general phenomenon occurring in many local governments all over Japan. The citizens and local government of Oshamambe town have taken it seriously and have studied how to cope with the situation. It is critically important for freshmen in Oshamambe campus to live in the town in good socio-economic condition. This Division has been established to collaborate with the citizens and local government and to find better future of the town. To achive the goal, the following stuffs participate in this project ; 2 from Faculty of Science Division 1, 3 from Faculty of Science and Technology, 13 from Faculty of Industrial Science and Technology of Tokyo University of Science, 1 from a private company.

Subdivision: Biology and Scallop Fisheries

Group of Biology of Scallop

Hokkaido area gets more than 90% of catch and culture of scallop, and the main industry of Oshamambe town is scallop culture. The advanced technology in the culture has produced scallop with high quality and quantity, although the industry has biological and environmental difficulties to be solved.

In spite of advanced technology in culture of scallop, developmental biology of scallop has been poorly understood. In this group, we focus our efforts on mollecular analysis of reproduction and larval growth of scallop, especially growth of the adductor muscle. The basic biology of scallop will help to solve problems in culture.

Group of Technology of Scallop Fishery

Cadmium is accumulated in the digestive gland of scallop and the gland is removed during meat-processing. Oshamambe town constructed a plant to extract cadmium and to re-use the glands as fertilizer. However, it was found that the plant did not function as designed. The cadmium-contamination is one of unsolved issues for scallop fishery communities in Northern Japan. This group collects information from these communities and commodities better extracting methods with them. This group also develops original methods to remove the metal by using protein-technology.

In the Funka Bay (Uchiura Bay) scallops are hung into sea water with rope downed from a raft. During culture periods, many animal like ascidians and seaweeds attach the culture equipments, increasing the raft weight. The heavier raft causes extra-labor and extra-cost of fishermen. This group improves the raft system with better materials.

Group of Materials Science of Scallop Shell

As other shell fish fishery does, scallop fishery produces tons of shell. Shell of shell fish mainly contains calcium carbonate. Many methods have been already established to re-use shell, although many of them are expensive and not practical. This group physically and chemically analyzes raw and treated shell materials and aims to find new methods to use scallop shell as functional materials.

Subdivision: Socio-economic Study of Oshamambe Town

This subdivision socio-economically studies Oshamambe town and develops deep relationship between the campus and the town.

Socio-economic activities

The population in the town was 11,164 in 1980 and it decreased to 6,429 in 2010. The local government estimates population of 5,800 in 2020, although the number might be influenced by many factors such as administrative efforts. This subdivision (1) researches the real circumstances of Oshamambe town with methods of sociology and (2) consider reconstructing cultural resources from the point of view of 'the street-view' and environment of the town. (3) According to industry, members of this subdivision using business administration will make some choice based on the socio-economic activities by the new railway (Hokkaido Shinkansen) being opened.

Education

Tokyo University of Science (TUS) provides Oshamambe town with good educational chance. This subdivision will try to organize (4) class of scientific experiments for children throughout the year. TUS provides English classes of native speakers of English and classes of science and scientific experiences. (5) These classes are going to be reformatted in the future in order to improve them.

The freshmen living in the dormitory are also citizens of the town and their roles are getting more significant than ever as the town's population has been getting aged. For instance, they play significant roles in the town, by participating as volunteers in town's festivals, teaching kids science and having a music concert with groups of citizens. This subdivision (6) develops further tight relationship between students living in the campus and the town.

Networking

More than 6,000 freshmen have lived in Oshamambe town and graduated from the University since the Faculty was established. Most of them love the town and people, and some of them re-visit the town. The graduates are latent human source to support the town. They must be happy to be involved in re-building the town. This subdivision (7) establishes an Oshamambe association united with internet among the graduates and ask their suggestion and collaboration.

Bird view of Oshamambe campus and Oshamambe town

Oshamambe campus and Oshamambe town and Uchiura Bay

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

Established: April 2014
muno@rs.kagu.tus.ac.jp

Division of Advanced Urbanism and Architecture

Director
Professor, Department of Architecture,
Faculty of Engineering, Tokyo University of Science
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

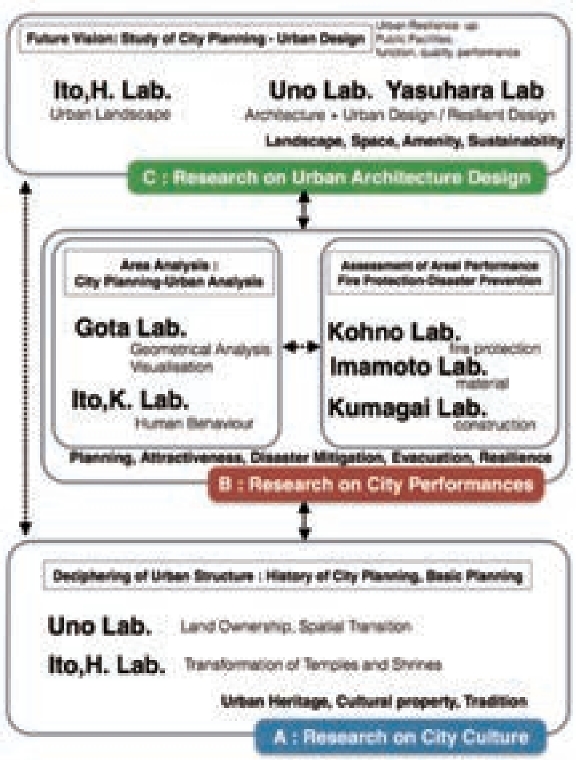
Experts and researchers who belong to this division have lots of excellent research achievement in each field. Therefore, they are recognized as leaders of each fields of major academic societies, Architectural Institute of Japan, Japan Society of Urban Planning, and Japanese Architecture History Society 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

Division of Things and Systems

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

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 of future 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 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. Nakane, who is the CEO of Tokyo University of Science and have experienced several management position, such as CEO of SAP Japan, Senior VP of SAP, COO of I2, CEO of Broadcom. These two entity and Things and System research division is collaborative discussion meeting every month. The scheme is as follows.

Research on Service IT

(Members : Prof. Y. Tanaka, Dr. M. Yokozawa, Mr. T. Seki, Mr. H. Hazekawa)

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

(Members: Prof Y. Tanaka, Dr. M. Sakamoto, Dr. A. Ishigaki, Mr. K. Kajimoto, Mr. H. Hazekawa)

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

(Members: Dr. M. Numao, Dr. M. Yokozawa, Mr. H. Hazekawa)

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

(Members: Dr. M. Sakamoto, Dr. A. Ishigaki, Dr. M. Yokozawa, Mr. K. Kajimoto, Mr. H. Hazekawa)

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.

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

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.

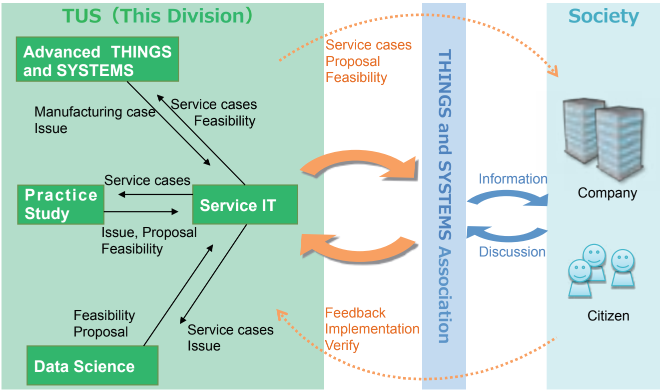


Fig 1. Organization of Division of Things and Systems, and collaboration framework

Research Objective

To establish "Things and System" concept and design New Business Scheme by our research.

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

Fundamentals

IR FEL Research Center

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 a high-frequency electron gun has its energy spread regulated by an α-magnet, and is forced towards the linear accelerator. The electron beam, now accelerated to a maximum 40 MeV, passes through a deflecting magnet and is led towards 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 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 1mm-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 5～11 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 (see Fig. 3). 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 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.

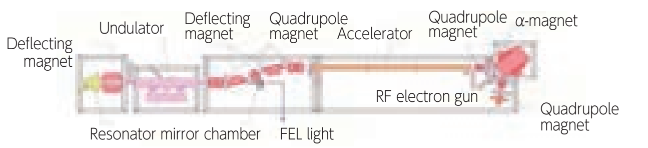


Fig. 1 Schematic outline of FEL-TUS

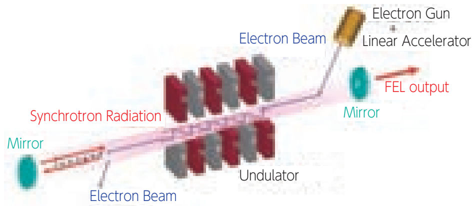


Fig. 2 Structure of undulator

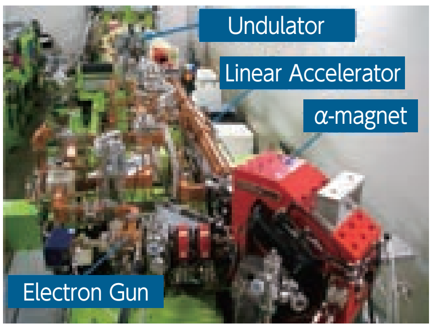


Photo 1 Main body of the infrared free electron laser

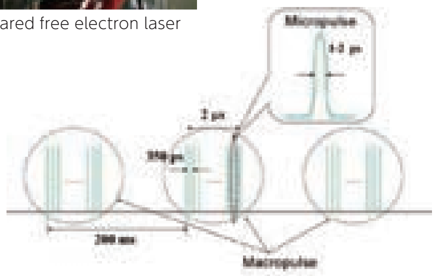


Fig. 3 Pulse time structure of FEL-TUS output

Fundamentals

Established: April 2011 ymanabu@te.noda.tus.ac.jp

Leading-Edge Holography Technologies Research and Development Center

Director
Professor, Department of Applied Electronics,
Faculty of Industrial Science & Technology
Manabu Yamamoto

Objectives	The Center's primary objective is the creation of next-generation high-capacity recordable media (ROM) using holography-based technologies, and the establishment of technologies for 4D measurement of fluid behavior in the vicinity of phase boundaries.
Future Development Goals	To realize our goals of using holography in next-generation high-capacity recordable media and in technologies for 4D measurement of fluid behavior in the vicinity of phase boundaries, a complete redesign of simulations and redevelopment of associated equipment will be required.

Optical technologies have already become an indispensible element in twenty-first century information and measurement devices. Holography technologies incorporating optical phase information are the best-suited techniques for further advancement toward increased functionality and precision. To that end, the Center is pursuing next-generation high-capacity write-once media (ROM) using holography-based technologies, and the establishment of technologies for 4D fluid measurements in the vicinity of phase boundaries.

The Center focuses on the development of next-generation holography-based recordable media manufacturing technologies and 4D fluid measurement techniques.

Overview of the Center and its projects

The name of the project at the Leading-Edge Holography Technologies Research and Development Center is "the development of next-generation holography-based recordable media manufacturing technologies and 4D fluid measurement technologies." This overview focuses on two groups, the Holographic Memory Structuring Group, which is researching the manufacture, duplication, recording, and playback of holographic recordable media, and the Holography Instrumentation Group, which focuses on 4D fluid measurements. The first group aims to create high-precision ROM media by electron beam lithography capable of nanoscale shaping, and to establish mass production methods for duplicating the resulting forms into plastics. The second group aims to establish measurement technologies that utilize waveguide holograms to observe fluid behavior in the vicinity of phase boundaries. Such measurements will use light emitted through a waveguide onto media from a perpendicularly incident laser, making phase boundary observations possible.

Background and goals of the project

Many years have passed since the invention of holography in 1947, yet even today there are few areas where it has been put into practical use, or developed into technologies that are useful in actual applications. The creation of silver holographic decals to prevent forgery of banknotes and credit cards is one of the few examples of current practical applications, but research into holography is being actively conducted to develop as-yet unrealized applications, such as 3D displays, optical elements for head-mounted displays, holographic memory, and holographic measurement instrumentation. A further issue is the relatively small number of researchers worldwide engaged in the study of such applications. One possible reason is the relatively difficulty of such research as compared with research on standard optical disks, owing to the phase information contained in holographs. Although applied holography research is difficult, the potential rewards of new technologies and applications are great if we can persevere in this endeavor.

The goals of this project are as follows.

- *Development of technologies for holographic memory*

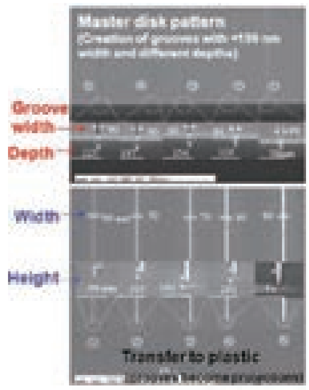
  We aim at raising holographic memory technologies to a level where they can be usefully applied. In particular, this project focuses on the establishment of technologies related to mass production of high-capacity ROM media that can be realized using only optics technology.
- *Development of technologies for the application of holography to fluid measurement*

  The project aims at verifying poorly understood fluid behavior at phase boundaries, in particular, describing resin flow with high precision.

Overview of the Holographic Memory Structuring Group

Examples of high-capacity ROMs currently in use include DVD and Blu-ray discs. Recent applications such as 3D television and film, however, have created demand for storage media with even higher recording densities. Holographic memory is one technology that may make this possible, but increasing the storage density of ROM media will require the development of new microfabrication techniques. Furthermore, pattern formation on ROM discs requires the creation of patterns in the direction of their rotation. Holography involves large amounts of information, with pattern widths and heights that require fabrication with nanoscale precision, but techniques and devices for achieving such high levels of control in a rotation pattern do not yet exist. The theme of this research will therefore be the creation of ROM media through electron beam lithography in vacuum, performed upon a rotating disk.

Nanoscale patterns can be formed using electron beam lithography. The upper part of the figure below shows an image of an actual electron beam lithography pattern, specifically, an example pattern with differing depths of less than 100 nm line width. While technologies required for the creation of holographic masters exist, methods are still lacking for forming these patterns on a disk, as well as for disk duplication and mass production. We therefore plan to pursue the following areas of research.



1. Playback of recorded holographs and calculation of the patterns to be written to disk
2. Fabrication stages related to in-vacuum disk revolution and creation of grooves through electron beam lithography
3. Duplication of created grooves in plastic
4. Hologram playback of the transferred pattern and operation verification

Overview of the Holography Instrumentation Group

Many of the fluid flows seen in the natural world and in industrial applications are accompanied by heat and material transport phenomena, dominated by the formation of vortices that spatially expand. Understanding such flow characteristics is vital to understanding their underlying physical mechanisms, developing numeric prediction models, and constructing artificial control techniques. One method for measuring such flows is particle image velocimetry (PIV), in which fine particles that will not interfere with fluid movement are introduced and tracked, and their behavior imaged. A shortcoming of this method, however, is that it only delivers two-dimensional information. One technique for overcoming this limitation is holography-based PIV—such techniques have already been successfully used to track the three-dimensional movement of fluids at micrometer scales. Research by this group will focus on the development of measurement technologies using holography to measure fluid behavior in the vicinity of phase boundaries.

Conclusion

The Center will continue the work of the Next-Generation Photonics Application Research Division, which developed the world's first technologies for creating write-once holographs. Creation of the Center will allow us to work toward the development of more complex new technologies, as well as to pursue our research with added synergistic effects arising from cooperation between our two groups.

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.

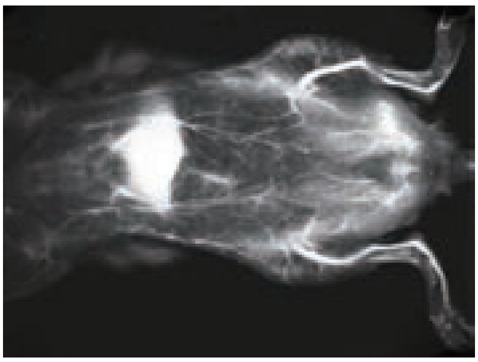


Fig 1. Blood vessel imaging of a mouse

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).

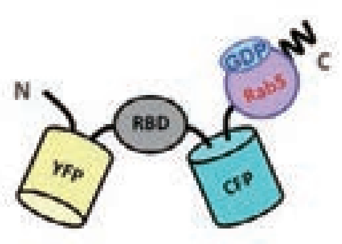


Fig 2. FRET sensor for visualizing the ON/OFF reaction of the G protein

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

Quantum Bio-Informatics Research Division

Established: April 2011 watanabe@is.noda.tus.ac.jp

Director
Professor,
Department of Information Sciences,
Faculty of Science & Technology
Noboru Watanabe

Objectives	To return to the basics of bio-information and quantum information and to focus on the relation between the two for new development.
Future Development Goals	To seriously attempt mutual interaction between bio-information and quantum information, thereby creating a new field that could be called "quantum bio-informatics" .

Our primary goal is to solve fundamental problems by causing a mutual interaction between bio-informatics and quantum information, two areas that appear quite different at first sight. While this in itself is by no means easy, we firmly believe that this kind of basic understanding will be extremely useful in making the new fields of bio-informatics and quantum information truly "fundamental and practical".

Research for new paradigm on information science and life science on the bases of quantum theory

The purpose of this Research Division is to return to the starting point of bio-informatics and quantum information, fields that are growing rapidly at present, and to seriously attempt mutual interaction between the two, with a view to enumerating and solving the many fundamental problems they entail. In our view, there is no other research effort in the world that has such attempts.

The immensely long DNA sequence consisting of four bases in the genome contains information on life, and decoding or changing this sequence is involved in the expression and control of life. In quantum information, meanwhile, we produce various "information" by sequences of two quantum states, and think of ways of processing, communicating and controlling them. It is expected that the problems we can process in time "T" using a conventional computer can be processed in time nearly "log T" using a quantum computer. However, the transmission and processing of information in the living body might be much faster than those of quantum information. Seen from this very basic viewpoint, developing the mathematical principles that have been found in quantum information should be useful in constructing mathematical principles for life sciences, which have not been established yet. The mechanism of processing information in life is also expected to be useful for the further growth of quantum information.

To bring this project to fruition, we plan to bring together Japanese and overseas researchers from various fields including quantum information, quantum probability, bio-informatics, structural biology, stochastic analysis, and solid-state physics, and to hold frequent exchanges between them (visits, invitations, conferences).

Here, we will list some of the basic problems that currently concern us in the separate fields of bio-informatics and quantum information, and will explain our efforts to tackle them.

(1) While the genomes of various living organisms have already been determined, how this information of genome should be understood or processed, and how they are related to the emergence of life, are more or less completely unknown at the moment. In some respects, this problem is connected to the question of how the transmission and change of information is involved in the "shape" of life. Meanwhile, the base sequence of the genome is called the primary structure, and in research related to life from the genome we first need to align the sequences in order to compare several different genes or amino acid sequences. But if the number of sequences being compared becomes too large, this alignment takes very long time. Therefore, we have made an attempt to establish this alignment using quantum algorithms. This has been done recently for some cases. Moreover we develop a high quality alignment algorithm by means of the concept of entanglement. In future, we plan to use our findings in research on classification and change in living organisms such as HIV, and to link it to the introduction of markers for observing changes in disease progression (see for trials along this line). In addition, we will elucidate the dynamics of change and control of bio-information, i.e., how information of life can be read from the base sequence of the genome and how the information is expressed through the intervention of amino acids and proteins, based on the theory of information transmission and processing in quantum information. In this vein, we could succeed to classify HIV and influenza virus.

(2) To establish the Heisenberg uncertainty principle (one of fundamental concepts of quantum mechanics) and to make it possible to describe phase transition and the creation and annihilation of elementary particles, and so on, quantum mechanics have to be described by an infinite dimensional Hilbert space. Therefore quantum information should be incorporated with the essential nature of quantum mechanics and it has to be constituted in an infinite-dimensional Hilbert space, too. The only theory in which such attempts have been completely established is that of quantum entropy which expresses the amount of information. Most of other problems are still incompletely established: (a) The state describing phenomena specific to quantum dynamics (such as quantum interference) is called the "quantum-entangled state". In various aspects of research on quantum information we need to judge whether or not a quantum state is "entangled". However, the method of making this judgment has only been established in a few cases such that the Hilbert space is 2- or 3-dimensional, but in other cases it is very incomplete. (b) We need to establish the mathematics of information communication in infinite-dimensional Hilbert spaces (quantum teleportation, quantum coding).

Infinite systems are also necessary for a physically precise discussion of the genome, since the world of the genome has an overwhelmingly large degree of freedom as the world of physics. Therefore, we will study to what extent the mathematical principles of quantum information in an infinite system are used in understanding changes and transmission of information in Life.

(3) In quantum information theory, the two signals "0" and "1" are expressed by two quantum states, and the changes of information are described in quantum dynamics. As an example, in quantum computation, logical calculations are represented by unitary dynamics. However, actual physical processes are dissipative processes, and unitary processes are merely ideal. Therefore, to make unitary computation suffice for quantum computation is merely idealization, and this causes difficulty to make a real quantum computer. In a first stage of our research in this division, we have constructed a theory of quantum computation incorporating dissipative processes, and introduced a generalized quantum Turing machine, by which we solved the outstanding problem "P=NP". Based on this study, we tried to construct new quantum algorithms for "bio-information". For instance, a quantum algorithm for multiple sequence alignment of amino acids is the efficient algorithm which can solve the multiple alignment problems in polynomial time of input length. Recently, we found some incompleteness for the proofs of the complexity in the Shor quantum algorithm for prime factorization which is published in 1994. In our paper, we showed that Shor's reduction is not achieved in some cases, namely the computational complexity is not in polynomial. Moreover, we proposed a new quantum algorithm to solve the factorization problem in a polynomial time.

Associated with our research of quantum information, we found a new cryptography based on non-commutative mathematics as a byproduct. This new cryptography is faster, lighter and secure than all of present cryptographies. We showed that this cryptography passed all statistical tests, U01-TESTS provided by NIST, and its velocity for data encryption is faster than AES.

(4) While a given sequence of the amino acids designates a protein, the three-dimensional structure of the protein has not been clearly understood yet. With current methods (e.g. molecular dynamics), the mechanism (e.g. "folding") whereby this three-dimensional structure is produced cannot be simulated even by super-parallel computers, as the complexity of computation is far too large. Our conceivable approach would be, firstly, to write this mechanism down by quantum algorithm, secondly, to attempt simulation using a parallel computer when the bit-count is small, and then to consider improving the algorithm on this basis.

(5) Genome information expressed by extremely long sequences of four bases is far more complex than that expressed in sequences of two quantum states. Besides, the speed of transmission and processing of information in life must be even faster than that of quantum information processing, which it self is incredibly fast. Therefore, we will attempt to incorporate the mechanism of bio-information, which is far more complex than that of quantum information, into the mathematical structure of quantum information.

(6) Recently, one faces a fundamental problem appearing in many experiments, particularly in biology, psychology and so on. It is the breaking of total probability law. We have studied this problem and we found a mathematical treatment solving this problem in terms of the concepts of liftings and adaptive dynamics. This new mathematics is one of the non-Kolmogorovian probability theory. We have lots of rooms to develop the theory. In particular, we generalized in a natural way the classical Bayesian inference and studied a mathematical formulation of the non-Bayesian inference which can not be described in Kolmogorovian probability theory. We succeeded to explain the irrational inferences that have been discussed in cognitive psychology. Moreover, we pointed out that the experimental data in Escherichia coli's metabolism violate the total probability law in classical probability, and proposed how to compute the non-Kolmogorovian probabilities in such phenomena.

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 a new division which is established on the April of 2015. We introduce 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:

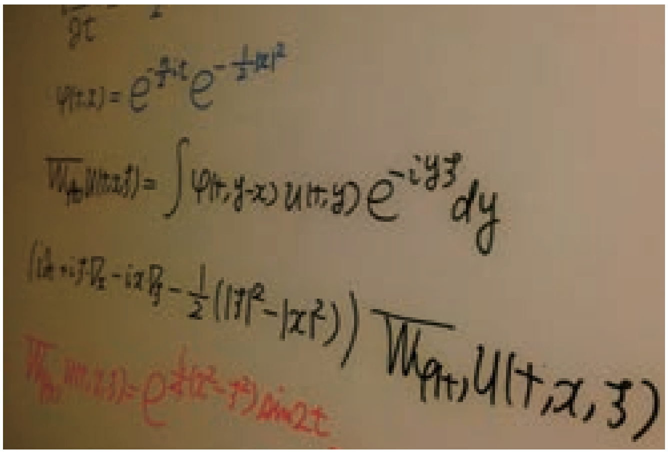
Brittle fracture under an assumption of linear elasticity has been systemized as linear fracture mechanics and its simulation software has also been developed. However there are a lot of engineering hypothesis, so it's difficult to construct mathematical model covered general fracture phenomena. In order 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.



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 ($O_2^{\bullet -}$). 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.

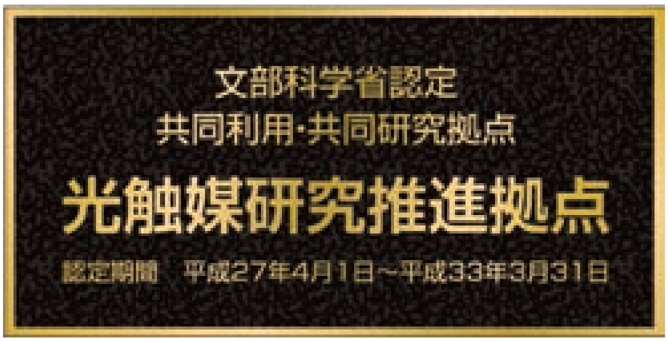


Figure 1 Board of research institute of photocatalysis

Figure 2 Application of photocatalysis

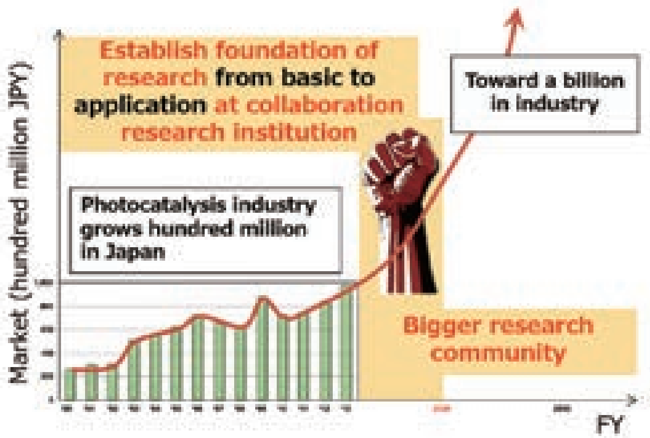


Figure 3 Goal of research institute of photocatalysis

Research Center for Fire Safety Science

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

Director
Professor, Department of Architecture, Faculty of Engineering 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

A. Experimental Study on Fire Prevention/Resistance and Evacuation Countermeasures of Buildings
- Fire Resistance of steel structures damaged by preceding earthquakes
- A study on modeling of burning behavior of combustibles in compartment
- Experimental Study on Behaviors of Fie Spread between Compartment Rooms in a Building
- Study on boundary layer thickness and Gaussian characteristic thickness of ceiling jet

B. Integration of Architecture and Civil Engineering to Study Fires in Particular Space
- Pure research into fire load for the fire safety measures of nuclear plant
- Study on composites of PS / Kenaf / non-halogen flame retardant

C. Other Experiments and Research Activities
- Terahertz imaging and hazardous gas detection through fire and smoke
- Research of the safety measures about fire protection of institution

D. Researches by Younger Researchers with Unique Viewpoints

E. Fundamental Research on Large-scale Fire

F. Experimental Research on Building Structural Fire Resistance

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)

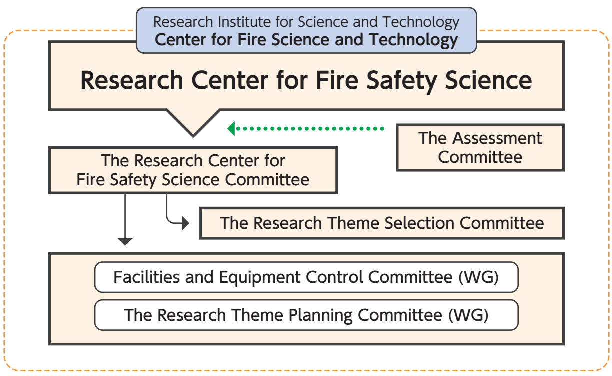
This committee (WG) is primarily involved in the operation planning of the full-scale experimental facilities. It is also responsible for the maintenance of facilities and equipment installed in the institution. In addition, it gives users instruction on how to use these facilities and equipment and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

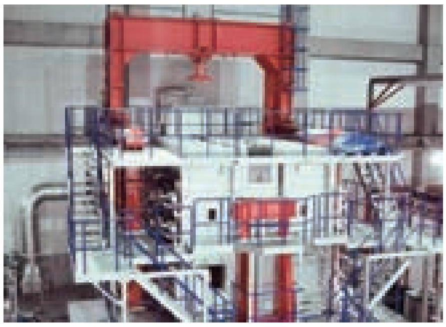
Example of Available Facilities/Equipment

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)

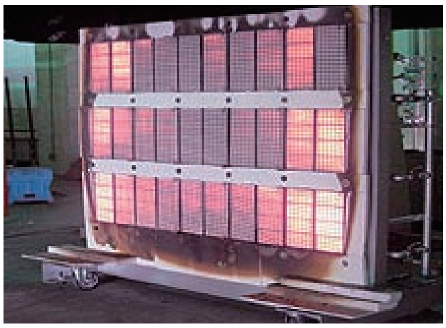
This fire compartment is 6 m (W)× 6 m (D)× 2.7 m (H) in actual size, and the sprinkler system can be attached to the ceiling. The compartment is mainly used to evaluate the fire extinguishing performance of sprinkler systems and also has used for experiments on smoke movement during sprinkler system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

- Chairman of the Board of Governors
  - President
    - Organization for Research Advancement
      - University Research Administration Center
      - Research Institute for Biomedical Sciences
      - Research Equipment Center
      - Research Institute for Science & Technology
        - Research Institute for Science & Technology Steering Committee
          - Steering Executive Committee

Research Institute for Science & Technology

Research Divisions

- Division of Next Generation Data Mining Technology
- Mountain Atmosphere Research Devision
- Division of Intelligent System Engineering
- Quantum Bio-Informatcs Research Division
- Division of Pharmaco-creation Frontier
- Division of Integrated Science of Oshamambe town
- Division of Advanced Communication Researches
- International Research Division of Interfacial Thermo-fluid Dynamics
- Division of Nanocarbon Research
- Division of Bio-organometallics
- Division of Thermoelectrics for Waste Heat Recovery
- Division of Colloid and Interface Science
- Division of Synergetic Supramolecular Coordination Systems in Multiphase
- Division of Advanced Urbanism and Architecture
- Academic Detailing Database Division
- Division of Medical-Science-Engineering Cooperation
- Division of Mathematical Modeling and its Mathematical Analysis
- Water Frontier Science Research Division
- Fusion of Regenerative Medicine with DDS
- Photovoltaic Science and Technology Research Division
- Advanced EC Device Research Division
- Division of Agri-biotechnology
- Division of Things and Systems

Research Centers

- Center for Fire Science and Technology
- IR FEL Research Center
- Center for Environmental Health Science for the Next Generation
- Leading -Edge Holography Technologies Research and Development Center
- Research Center for Chirality
- Photocatalysis International Research Center
- Translational Research Center
- Imaging Frontier Center

Joint Usage / Research Center

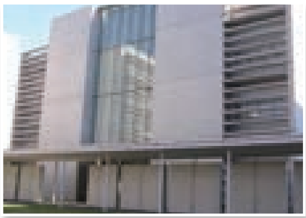
- Research Center for Fire Safety Science
- Photocatalysis International Research Center

2015.10.1

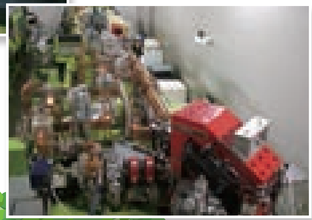
Noda Campus

The Convergence

Research Equipment Center



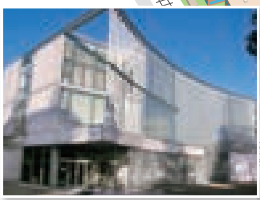
Genome and Drug Research Center



IR FEL Research Center

Research Center for DDS

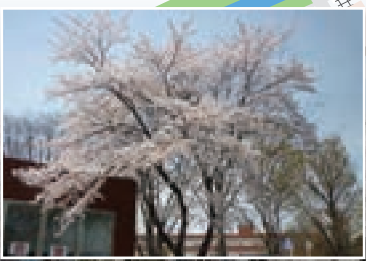
Research Institute for Biological Sciences



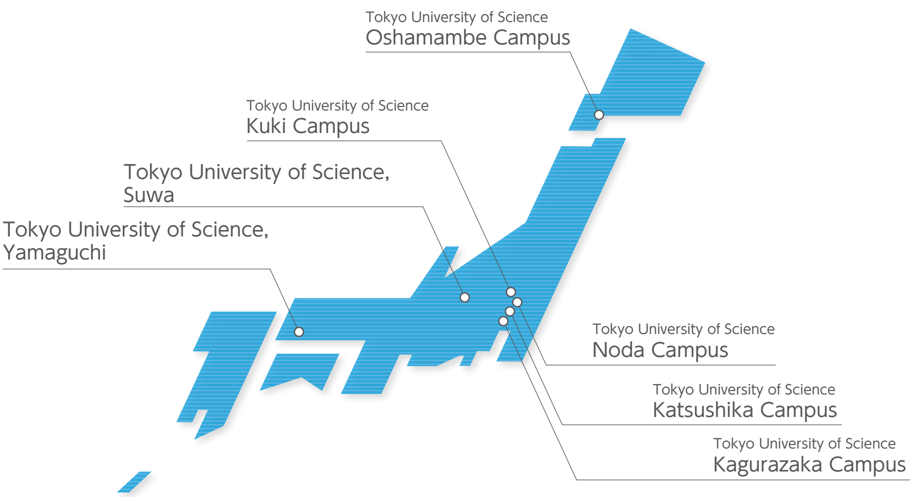
Information Media Center

Center for Fire Science and Technology

Photocatalysis International Research Center(PIRC)



Campus Map



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