RIST TUS

Research Institute for Science & Technology

2019/2020

Information and Societal

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

Bio and Pharmacy

- Center for Animal Disease Models
- Fusion of Regenerative Medicine with DDS
- Division of Agri-biotechnology
- Brain Interdisciplinary Research Division
- Chemical Biology Division Supported by Practical Organic Synthesis
- Academic Detailing Database Division
- Division of Nucleic Acid Drug Development
- Division of Synthetic Biology

RIST TUS
Research Institute for Science & Technology

Structural Materials

- Research Division of Multiscale Interfacial Thermofluid Dynamics
- CAE Advanced Composite Materials and Structures Research Division

Fundamentals

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

Functional Materials

- Photocatalysis International Research Center
- Water Frontier Science & Technology Research Center
- Photovoltaic Science and Technology Research Division
- Advanced EC Device Research Division
- Advanced Agricultural Energy Science and Technology Research Division
- Division of Nanocarbon Research
- Division of Colloid and Interface Science

Center

Funded jointly by TUS and MEXT-Supported Program. Expected to form a strategic research organization after termination.

Division

Funded exclusively by a core of a Center.

Building a better future with

Message from the Director

In a university, education and research are inseparably linked to one another and have a synergistic relationship which contributes to significant growth and development.
Education, in various academic fields, lays the foundation of knowledge in these areas while research transcends the boundaries of these academic areas and contributes to development of applied knowledge and techniques useful for our human society. If education is the longitudinal axis, then research is the horizontal axis.
The Research Institute for Science and Technology plays the role of that horizontal axis within the Tokyo University of Science and is an organization which exists to support outstanding and original research.
On April 1, 2015, a newly reorganized Research Institute for Science and Technology was established. Research within the Institute is carried out by different research divisions, research centers and joint usage research centers which are organized within a full-scale, comprehensive research promotion framework.
The longer term aims of the Research Institute for Science and Technology are to educate highly competent graduate students, equipped with the innovative and creative skills needed for the betterment of the future human societies and economies. The Institute has been striving to transcend the various academic fields and eliminate barriers between academia and industry and society as well as promote international collaboration.
In 2015, Sustainable Development Goals (SDGs) were announced by the United Nations.
The Research Institute of Science and Technology has consistently focused on research in environmental preservation and energy conservation.
Carbon recycling, under the initiative called for by the Japanese Prime Minister' s Office and recently being focused on by the international industrial community, will be one of the main areas of research at the Photocatalysis International Research Center.
The Research Center for Space Colony is conducting research on development of sustainable technologies, that would be essential for long-term survival of humans in extra-terrestrial environments. The reuse and recycling of heat energy, water, air and food production in such closed environments would be technologies that would have varied uses on earth as well.
It is important to develop innovative and integrated technologies that can be used to tackle the unprecedented global issues facing our society.
It is towards this end that we seek to do away with the barriers between research centers and divisions, foster mutual cooperation, create new research clusters and produce new academic trends and results.

Dr.Hideaki Takayanagi
Director
Research Institute for Science and Technology
Tokyo University of Science

Systems

Architecture

Modeling and its Mathematical Analysis
and Cooperation with Engineering

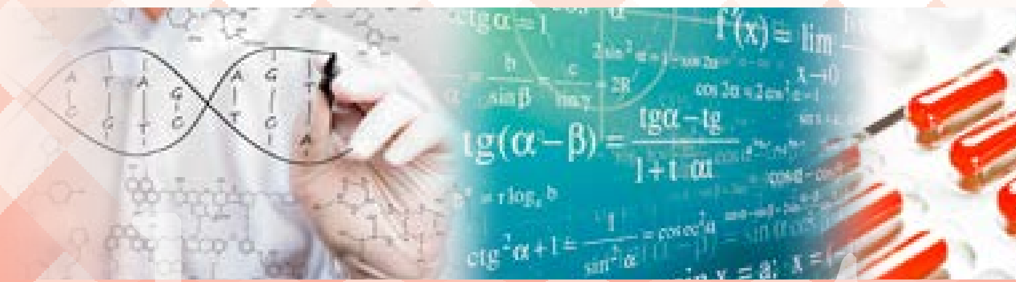
TUS and expected to be

Joint Usage / Research Center

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

Science

INDEX

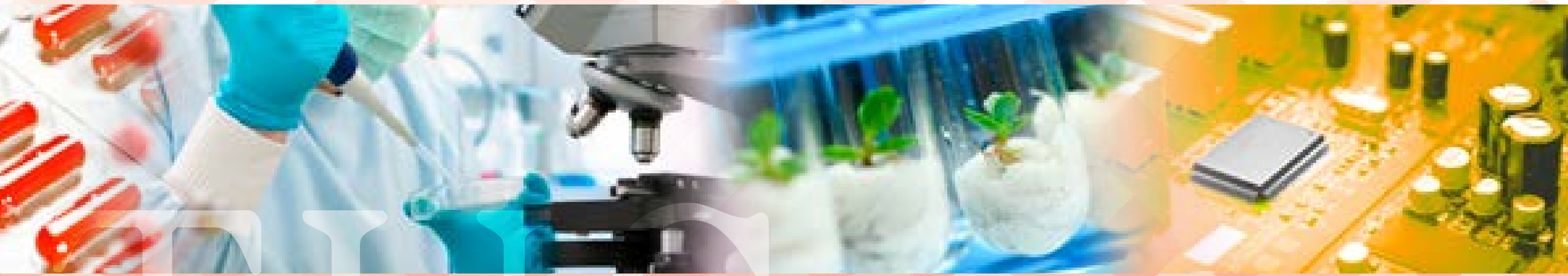


Only at

Analysis
Engineering

The Edge of Cross Disciplines

Research Centers / Research Divisions
2019/2020

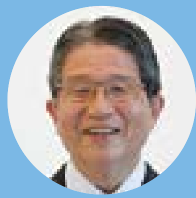


TUS

Photocatalysis International Research Center (PIRC)

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

Director
Distinguished Professor,
Tokyo University of Science
Akira Fujishima
Ph.D.



Objectives	PIRC conducts photocatalytic researches on self-cleaning, environmental cleanup, and artificial photosynthesis and considers novel applications. PIRC aims R&Ds promoting the photocatalytic technology to the next-stage.
Future Development Goals	PIRC produces original and cutting-edge research results for the photocatalyst market expansion and aims to be the worldwide hub of this field.

There are still various possibilities and chances on photocatalysts and challenging toward these is important. PIRC leads the spread/development of photocatalysts by public relations as well as training for and excellent global people who will take the green innovation.

Establishment of the practical integrated system for environmental cleanup and energy production by deepening photocatalytic technologies

History of PIRC

As a center for strategic R&Ds of an integrated photocatalytic system indispensable for enhancing competitiveness of photocatalysts and related industries, and nurturing excellent global people who will take the green innovation by photocatalysts, the Ministry of Economy, Trade and Industry (METI) selected PIRC for the Innovation Center Establishment Assistant Program. The former division (The Division of Energy and Environment Photocatalyst) was dissolved in favor of PIRC in April 2013.

Application of Photocatalysts and Remaining Problems

Photocatalyst is a Japan-origin technology and Japan has been a leader in this research field. Photocatalyst has been attractive as a promising technology to solve energy/environmental problems. Titanium dioxide (TiO_2) is a representative example of photocatalysts. When ultraviolet (UV) light, which is included in the sunlight, is irradiated, TiO_2 shows "oxidation power" and "superhidrophilicity". Oxidation power is useful for deodorization, sterilization, and antifouling, while superhidrophilicity is useful for antifogging and antifouling (self-cleaning). From a perspective of artificial photosynthesis, complete water splitting producing hydrogen and oxygen in stoichiometric ratio by the Honda-Fujishima effect has been studied aggressively for many years, although its practical use has not been achieved.

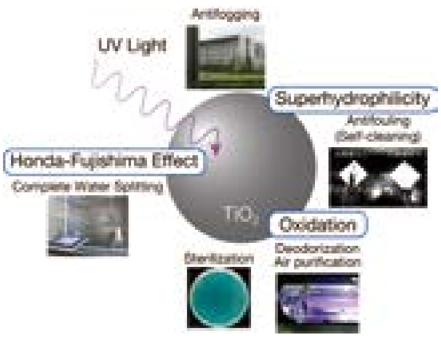


Figure. 1 Photocatalysis and its application

Recently, photocatalysts and its related technologies are applied for housing, purifier, and life/medical filed. An international cooperative project on standardization of photocatalytic evaluation (ISO) is in progress. However, several problems are still remaining. The development of a highly-efficient visible light-active photocatalyst enables to purify the inside of a room under a fluorescent light and the establishment of the sterilization/medical treatment system integrating cell biology/microbiology and photodynamic therapy are examples. Constricting photocatalytic water splitting system producing practical amount of hydrogen has been a big issue since the first discovery of photocatalysis. Furthermore, several tasks such as the establishment of artificial photosynthesis regarding to the reduction of carbon dioxide (CO_2) and its recycling are undertaken at national level.

Aims of PIRC

PIRC aims to overcome the remaining problems on photocatalysts based on our achievements. PIRC also develop an integrated photocatalytic system on practical environmental cleanup/energy production through empirical researches between industry-academia-government collaboration.

Research Organization of PIRC

PIRC not only conducts the latest researches but also aims to create a hub where researchers both inside and outside TUS can join. The feature of PIRC is nurturing human resources and promoting international exchange through the participation of young scientists from both Japan and foreign countries. PIRC also invites research collaborator from other research institutes and industries and widely conducts from basic studies to product/market developments. By utilizing these, PIRC conducts photocatalytic studies.

Although PIRC conveniently divides elemental technologies on photocatalyst in three units, each unit cooperates. By integrating elemental technologies developed at each unit, PIRC creates a high-performance photocatalyst and a novel functionalization. PIRC prepares the system with public institutes and private companies for activation of photocatalytic industries.

Activities at PIRC will launch a new scientific/technological field for energy/environmental problem solution. In addition, obtained results on material development and its fabrication process would bring a ripple effect on a peripheral research field.

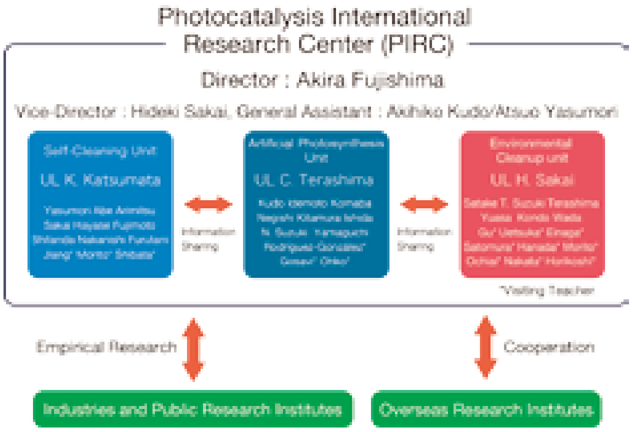


Figure. 2 Organization chart of PIRC

Research theme

Self-Cleaning Unit

Self-cleaning effect of photocatalyst (especially TiO_2) is achieved by using "oxidation power" and "superhydrophilicity" under UV light and widely used in various applications. However, there are several important issues such as a highly durable coating on organic glass/vehicle body and a measure against the change of interior light source (from fluorescent lamp to white LED lamp). This unit studies on self-cleaning materials for interior/exterior and coating technique of photocatalysts. We work on morphological control of photocatalyst particles, coating materials (such as shape processing, survey for inorganic/organic base material), combination with functional materials (such as organic polymer/glass), and survey for visible light-active photocatalysts.

Artificial Photosynthesis Unit

As clean energy-production system, hydrogen-producing technology in which water is split and energy-conversion technology in which hydrocarbons are formed by CO_2 reduction with photocatalyst and solar light are known as an artificial photosynthesis and aggressively studied research fields. Studies on artificial photosynthesis started from the Honda-Fujishima effect reported in Nature in 1972. However, artificial photosynthesis has not practically used because the solar to hydrogen efficiency is still low even now. This unit works on the development of highly efficient novel (electro) photocatalysts for water splitting and CO_2 reduction. We also study an integrated system of electric power generation and its storage for the effective use of solar light.

Environmental Cleanup Unit

It is well known that strong oxidation of photocatalyst shows antibacterial and antivirus effect and photocatalyst-coated tiles are introduced as interior of an operation room in a hospital. This unit conducts basic studies such as an analysis of sterilization mechanism and spore inactivation by photocatalysts. In addition, as biological applications of photocatalysts, we work on the improvement of seed germination and rare sugar production.

Water Frontier Science & Technology Research Center

Established: November 2016

waterfst@rs.tus.ac.jp

Director
Professor,
Department of Chemistry,
Faculty of Science DivisionI

Hiroharu YUI
Ph.D.

Objectives	Development of basic researches and control technologies of water structures, wetting, and flow at the surfaces of various materials that promote regenerative medicine, low-frictional machinery, and so on.
Future Development Goals	As a worldwide research center, we promote the research and education of water on various materials' surfaces by the collaboration with companies, medical center and research institutions in the world.

This center is founded by the research branding program organized by The Ministry of Education, Culture, Sports, Science and Technology (MEXT) Japan. We will push the sciences and technologies of water on materials forward to realize a prosperous longevity and low-energy consumption society by integrating intelligence and powers of the researches and students through worldwide collaborative researches.

Developing sciences of water structures, wetting, and flow on the surfaces of various materials and their application.

Water is ubiquitous and an essential substance that flexibly hydrates various molecules. It plays crucial roles to assist structuring and fulfilling our organs and also brings oxygen molecules and nutrition to every cell in our living bodies. Further, water also exists on the surfaces of materials that surround and assist our ordinal life under ambient conditions with adequate humidity. Although these water molecules are not visible, they crucially affect the maintenances of our living bodies, industrial manufacturing processes utilizing catalysts and machines, and the functions of materials utilized in transport machinery such as cars, ships, and aircrafts and in medical ones such as artificial heart and blood vessels.

However, surfaces of the materials are generally very complicated. For example, they have physical surface roughness beyond the atomic-scale and various chemical functional groups that change according to the environments, and take three dimensional matrix structures in living bodies. It has been difficult issue to selectively measure water molecules on these materials' surfaces and to study them by conventional theoretical approaches and simulations.

To develop novel technologies, it is crucial to understand water structures and dynamics on these complicated surfaces. For the deepening of the basic science of these water molecules, collaborative and interdisciplinary researches are crucial by combining (1) Materials formation with controlled surfaces with nanoscale precision and with chemical functional groups, (2) Selective in-situ measurement techniques with high spatial and temporal resolutions, and (3) Multiscale theoretical approaches and calculations.

Our research center was established on Nov. 2016 by the aid of the research promotion program organized by the MEXT Japan for the purpose of the foundation of an international research center for the water on materials' surfaces. The center address the local structures of water molecules in the vicinities of the materials' surfaces in nanometer scale, and their wetting and flow dynamics ranging from the nanometer to micrometer scales. Our main purpose is to deepen the fundamental science that provides us an integrated view of correlating water structure, wetting and flow dynamics in multiscale on materials surfaces. These basic researches contribute to enhance the functions of the materials' surfaces by controlling water structures and wetting and flow dynamics on them. Based on these science and technologies, we pursue the contribution to the development of healthy, low energy-consuming sustainable future societies through the productions of biocompatible materials for regenerative medicine and low-frictional materials for various machineries.

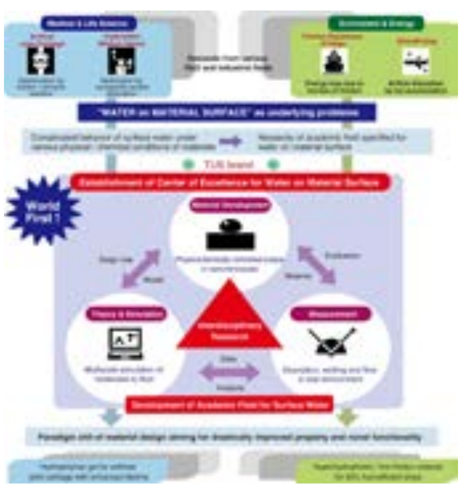


Figure. 1 Background for the establishment, the aim and our collaborative activities, and the future scope of our research center.

W-FST center is composed of 6 groups (G1-G6) as follows, where the member efficiently research and discuss on focused topics.

G1 Materials' Surfaces
G2 Bio-Interfaces
G3 Basic Researches on Wetting and Flow Dynamics
G4 Basic Researches on Theories and Simulations
G5 Measurements and Controls on Flow Dynamics
G6 Analyses and Applications of Aqueous Environments

In each group, researchers collaborate for the productions of materials with nanometer-scale precisions, for the development of specific measurements instruments, and for theoretical and simulative approaches to solve challenging problems. Further, through the inter-group collaborations, we will promote science and technologies of the water on materials surfaces as a world-wide characteristic research center.

G1 and G2 are the groups for the production of materials surfaces finely controlled with nanometer-scale precision. G1 mainly studies materials for energy-saving, such as for low-frictional surfaces and for stable energy storage. G2 develops biocompatible hydropolymers for artificial joint cartridges in regenerative medicine. These groups study on the correlations between the local structures and dynamics of water on materials' surfaces and their various functions. These groups also develop new instruments that enable us to measure local structures and dynamics of water molecules with in-situ conditions.

G3 and G4 are the groups for basic researches of water structures and dynamics on materials' surfaces, which crucially affect their functions. G3 focuses on the wetting and flow dynamics of water on materials surfaces whose hydrophilic and hydrophobic natures are finely controlled. G4 aims to develop integrated theoretical and simulation methods that can address local water structures, and wetting and flow dynamics that correlate with each other in multiscale manner.

G5 develops novel diagnostic and analytical devices that are based on a finely controlled wetting and flow dynamics. G6 develops new analytical methods and reaction schemes based on a characteristic nature of water that hydrates almost every natural molecule. These newly produced devices and analytical methods will contribute to the development of prosperous longevity, low-consumption, and sustainable future societies.

New materials with controlled surfaces produced by G1 & G2 and new devices and analytical methods developed by G5 & G6 provide ideal research targets for G3 & G4. In turn, newly developed fundamental theories and simulations by G3 & G4 will be helpful for advancing the functions of materials (G1 & G2) and for designing novel devices and analytical methods (G5 & G6).

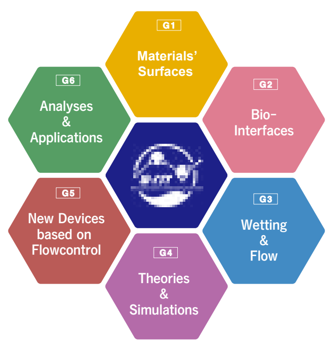


Figure. 2 The roles of 6 research groups in our center and their interdisciplinary collaborative researches.

Functional Materials

Photovoltaic Science and Technology Research Division

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

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

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 the end of 2018, approximately 500 GW of installed photovoltaic systems were in operation worldwide. 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 renewed 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 14 researcher listed in Table 1. These members are 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.
- The development of solar sharing and matching modules that will make possible for 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. It 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.

Table 1 Members of Photovoltaic Science and Technology Research Division

Affiliation of key role	Job title	Name	Academic degree	Main research field
Faculty of Science and Engineering Department of Electrical Engineering	Professor	Mutsumi Sugiyama	Doctor (Engineering)	Semiconductor material engineering / Thin film photovoltaic cell
Faculty of Science Division II Department of Physics	Professor	Zhao Xinwei	Doctor of Engineering	Semiconductor nano-material engineering / Thin film photovoltaic cell
Faculty of Science Division II, Department of Chemistry	Professor	Takashiro Akitsu	Doctor (Science)	Coordination Chemistry / Solar cells of organic/inorganic hybrid materials
Faculty of Engineering Department of Industrial Chemistry	Associate Professor	Morio Nagata	Doctor (Engineering)	Organic photovoltaic cell/ Perovskite solar cell, Artificial photosynthesis
Faculty of Engineering Department of Electrical Engineering	Associate Professor	Yuzuru Ueda	Doctor (Engineering)	Electricity and energy engineering / Photovoltaic system
Faculty of Science and Engineering Department of Electrical Engineering	Associate professor	Junji Kondoh	Doctor (Engineering)	Photovoltaic power system / Power conditioning system
Faculty of Industrial Science and Technology, Department of Applied Electronics	Associate Professor	Takashi Ikuno	Doctor (Engineering)	Nano energy conversion materials / Photovoltaic devices
Faculty of Science Division II, Department of Chemistry	Assistant Professor	Tomoyuki Haraguchi	Doctor (Science)	Coordination Chemistry / Dye Sensitized Solar Cell
Faculty of Science and Engineering Department of Electrical Engineering	Assistant Professor	Kim Joonam	Ph.D (Materials Science)	Compound semiconductor solar cells
Faculty of Engineering Division II Department of Electrical Engineering	Professor (part-time)	Toshiaki Yachi	Doctor of Engineering	Energy conversion engineering / Photovoltaic power generation system
Research Institute of Science and Technology	Visiting Professor	Tokio Nakada	Doctor of Engineering	Semiconductor material engineering / Thin film photovoltaic cell, CIGS solar cell
Suwa University of Science, Faculty of Engineering	Visiting Professor	Yoichi Hirata	Doctor (Engineering)	Energy conversion engineering / Photovoltaic power generation system
Suwa University of Science, Faculty of Engineering	Visiting Professor	Yasuyuki Watanabe	Doctor (Engineering)	Organic photovoltaic cell / Organic Electronics
Ehime University, Graduate School of Science and Engineering	Visiting Professor	Sho Shirakata	Doctor of Engineering	Semiconductor material engineering / Thin film photovoltaic cell, CIGS solar cell

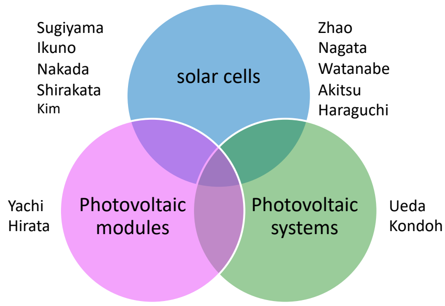
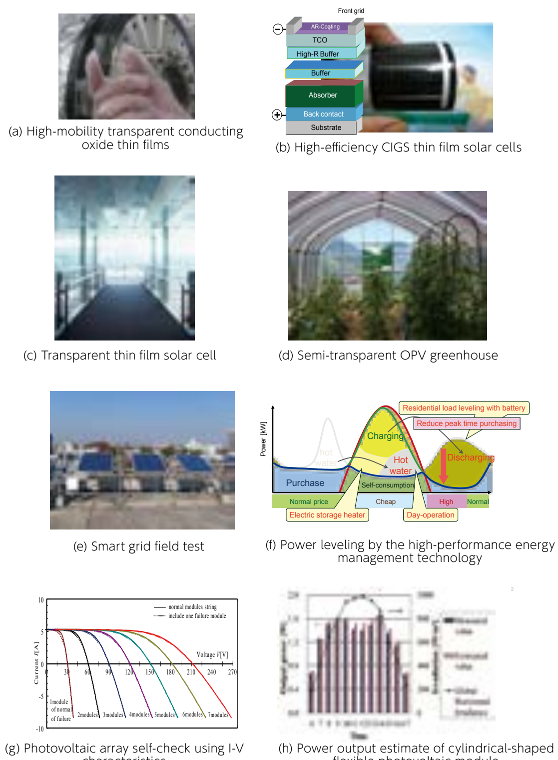


Fig. 1 Formation of Photovoltaic Science and Technology Research Division.



(a) High-mobility transparent conducting oxide thin films
(b) High-efficiency CIGS thin film solar cells
(c) Transparent thin film solar cell
(d) Semi-transparent OPV greenhouse
(e) Smart grid field test
(f) Power leveling by the high-performance energy management technology
(g) Photovoltaic array self-check using I-V characteristics
(h) Power output estimate of cylindrical-shaped flexible photovoltaic module

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

Functional Materials

Advanced EC Device Research Division

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

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

Masayuki Itagaki
Ph.D.

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

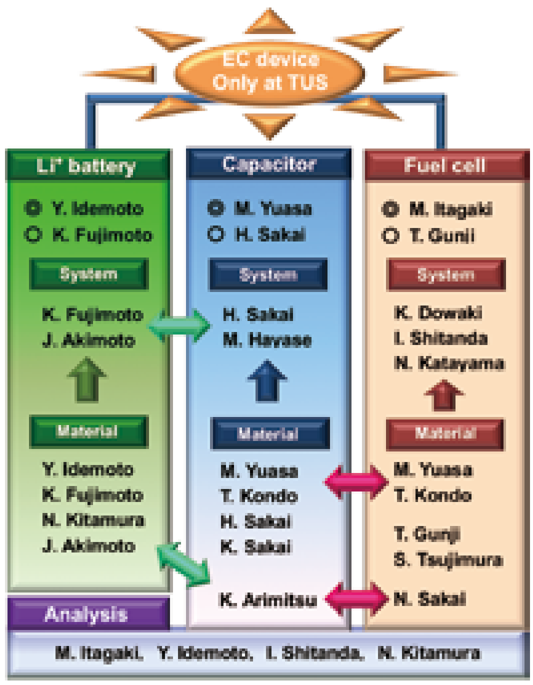
We aim to perform high-throughput material screening, and device-oriented electrochemical and structural analyses in addition to preparation of high-capacity electrodes whose structures are well-controlled at atomic-to-micro levels.

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.



Functional Materials

Advanced Agricultural Energy Science and Technology Research Division

Established: April 2016

watanbey@rs.sus.ac.jp

Director
Professor,
Department of Mechanical and Electrical Engineering, Faculty of Engineering, Suwa University of Science

Yasuyuki Watanabe
Ph.D.

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

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

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

The idea behind the establishment of this division

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

Innovative agricultural engineering based on solar matching

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

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

Members and research fields

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

■Suwa University of Science
- Professor Yasuyuki Watanabe (agricultural solar cells, photosynthesis measurement)
- Professor Hideaki Matsue (communication and network engineering, agricultural IoT)
- Professor Takashi Matsuoka (quantum information theory)
- Assistant professor Kazuhiro Yamaguchi (image and signal processing)

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

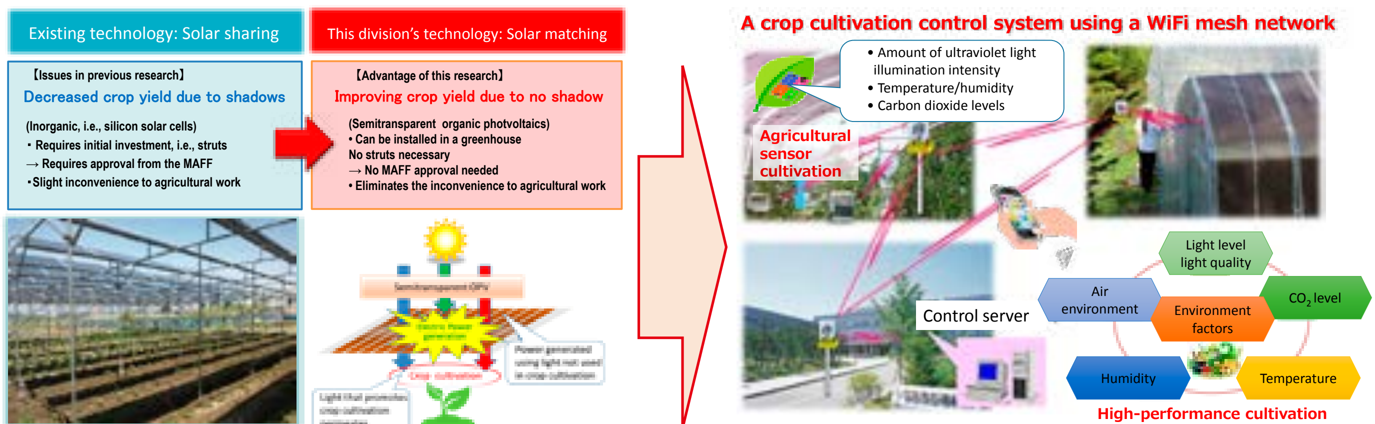
■ Kyushu University, Chihaya Adachi Laboratory
- Assistant professor Hajime Nakanotani (agricultural organic LED)

■ Ideal star inc.
- Visiting professor Kenji Omote (organic photovoltaic solar cells)

■ Japan Advanced Institute of Science and Technology
- Visiting professor Tatsuya Shimoda (printed electronics)

Future ideas to pursue

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



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

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

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

Functional Materials

Division of Nanocarbon Research

Established: October 2012

takahiro@rs.tus.ac.jp

Director
Professor,
Liberal Arts,
Faculty of Engineering

Takahiro Yamamoto
Ph.D.

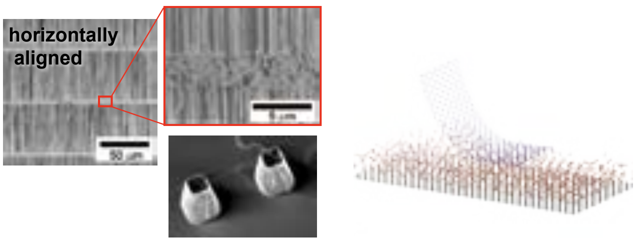
Objectives	To investigate novel properties relating to carbon nanotubes and graphene, and to develop material sciences utilizing the nanospace of nanotubes and the interaction between nanotubes and various molecules.
Future Development Goals	To promote advanced researches on nanocarbons based on tight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

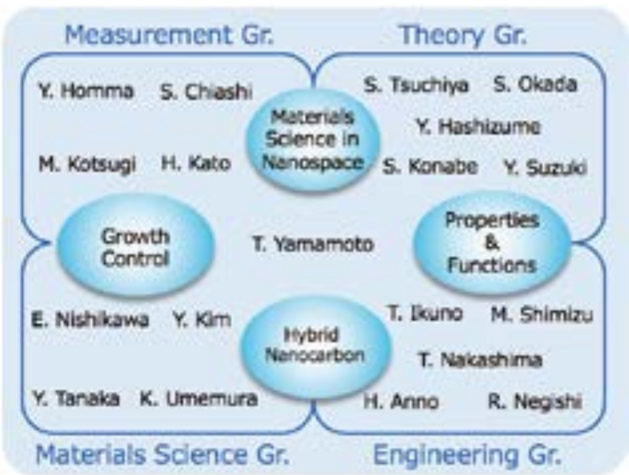
Nanocarbon is an active research field with increasing publications. Our research division is unique in that advanced researchers of nanocarbons are getting together and perform researches with wide scopes. In particular, tight collaborations between theorists and experimentalists are our strength. We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

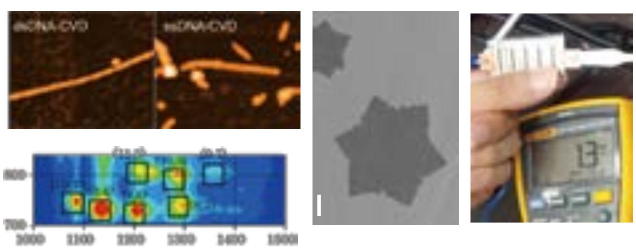
Research and development on carbon nanotubes and graphene.

Carbon nanotubes and graphene are low dimensional materials (with linear and flat shapes, respectively) composed of networks of 6-members rings (honeycomb structure). Owing to strong covalent bonds of carbon atoms, they have excellent mechanical strength and chemical stability enough to sustain the monolayered structure in a free space. Furthermore, they exhibit properties peculiar to the geometrical configuration and low dimensionality, which cannot be expected for three-dimensional crystals. As you can see from the fact that the Nobel Prize in Physics 2010 relates to graphene, nanocarbons such as carbon nanotubes and graphene are extensively studied in basic science. In the future, nanocarbons are expected to play a main role in an industrial revolution as iron and silicon did in the Industrial Revolution and the information technology revolution, respectively.

The Division of Nanocarbon Research covers topics of nanocarbons from fundamental to applied researches by collaboration of experts in theoretical and experimental condensed matter physics, electrical engineering, thermal engineering, and biophysics. We expect synergy effects by enhancing mutual discussion and exchange of ideas in the division.







Research topics

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-Hybrid Materials

- We study structural properties of composites composed of nanotubes and biomolecules (DNA, protein). Specifically, we fabricate biodevices with nanotubes functionalized by DNA, and examine whether the structural properties of the biomolecules are retained, and whether the molecular recognition function is retained.
- We theoretically investigate the host-guest interactions of the nanotube/ biomolecule composites, and clarify the effect on the properties of the composites.

Growth Control of Nanocarbons

- We develop techniques for precise structural control of nanocarbons based on the various nanotube synthesis techniques such as vertically-aligned growth on silicon and silica substrates and horizontally-aligned growth on quartz substarte.
- We study novel synthesis methods of nanocarbons utilizing arc discharge by changing the discharge ambience, electrode materials, etc. We also study novel methods for graphene synthesis.

Properties and Functions

- We develop the physics of energy conversion based on nanocarbons and its application.
- We establish the basic science for nanocarbon-based paper electronics.

Division of Colloid and Interface Science

Established: January 1981 hisakai@rs.noda.tus.ac.jp

Director
Professor,
Department of Pure and Applied Chemistry, Faculty of Science and Engineering

Hideki Sakai
Ph.D.

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

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

Basic and applied researches on phenomena at various interfaces

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

Let us take, for example, a coarse spherical particle with a radius of 1cm. By crushing this particle, we can create a cluster of microparticles with a radius of 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. The surface area of the coarse particle, however, is 12cm^2, about the same size as the palm of your hand. But when the coarse particle is crushed, the total surface area increases 10,000 times to 12m^3. 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 .

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), Professor Takeshi Kawai (Department of Industrial Chemistry, Faculty of Engineering), and Professor Hideki Sakai (Department of Pure and Applied Chemistry, Faculty of Science and Technology, 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 2018. 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 interface where molecules and atoms are continually going in and out through the interface, whereas "hard interface" means a static interface where no exchange of molecules and atoms take place at the interface. The representative materials of the former are spherical and worm-like micelles, emulsions, vesicles and Gibbs monolayers, while the latter are metal nanoparticles and nanowires, nanoporous materials 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 dimensions, namely, zero and three dimensions, one dimension and two dimensions. We aggressively pursue the fully understanding of the fundamental phenomena and the functions at the both interfaces, and hope to achieve the development of novel functional materials(Figure 1).

Figure 1

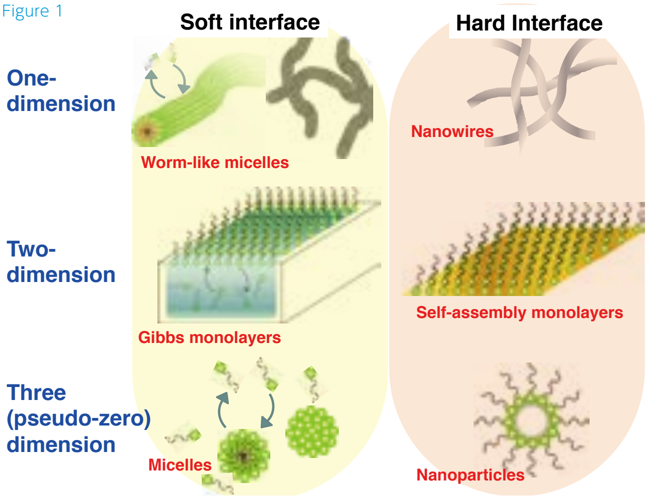
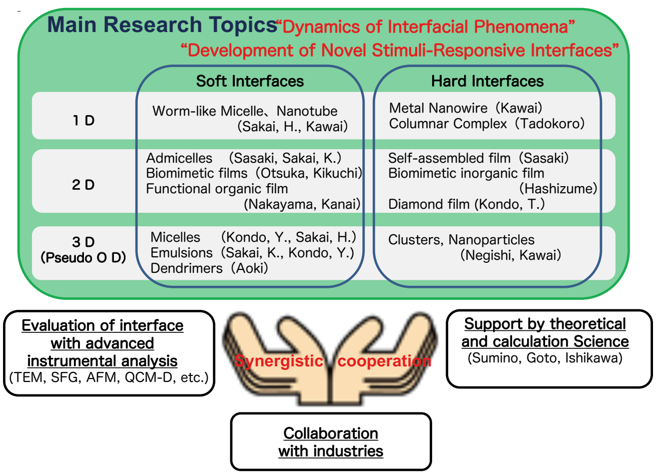


Figure 2



In this division, we are going to investigate research intensively, especially focusing on "Advanced analysis of phenomena observed at various interfaces", and "Development of novel stimuli-responsive interfaces". Both basic and applied research are conducted effectively and synergistically by collaboration of researchers who specialize in chemistry, physics, life science, mechanical engineering, and theoretical science. Collaboration projects with industries are also promoted intensively with the aid of URA (University Research Administration Center)(Figure 2).

Established: April 2017 i2plus@rs.tus.ac.jp

Research division of multiscale interfacial thermofluid dynamics

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

Objectives	Our research group focuses on thermofluid dynamics which involves transport phenomena around interfaces in multiscale and on development of interdisciplinary and interactive research activities.
Future Development Goals	Final goal of our research division is to establish a leading-edge research group which deals with various interfacial thermofluid dynamics by creating mutual researcher network.

This research division has been started in April 2017 as a subsequent organization of “International Research Division of Interfacial Thermo-Fluid Dynamics”. The aim of the group is to expand the spatial scale of concern from micro/nanoscale to multiple scale and the associate application fields through the international activities on research and education.

Interfacial thermofluid dynamics from microscopic to macroscopic point of view from fundamental to its application.

This research division (nicknamed as ‘I^{2}plus’) was established in the Research Institution for Science and Technology (RIST), Tokyo University of Science, in April 2017, as a subsequent organization of “International Research Division of Interfacial Thermo-Fluid Dynamics (2012-2016)”. The aim of I^{2}plus is to expand our knowledge of thermofluid dynamics involving interfacial transport phenomena toward realizing highly efficient heat and mass transfer technologies with low energy consumption and low contamination of environments. Our research division consists of young researchers from Europe, the United States and our university, Tokyo University of Science (Fig. 1).

Research

Our division focuses its activities on interfacial thermofluid dynamics in which multiscale physical and chemical processes are involved. In the previous division, we investigated microscopic dynamics of the fluid in the vicinity of the solid-liquid-gas three-phase boundary and to apply it to engineering technologies. This division has been launched as a successive division of the previous one to expand our understanding and technologies to more complicated systems in multiscale and to various application fields, especially following topics.

(A) Elucidation of “dynamics wetting” with three-phase contact line interacting with small objects

Establish a novel heat and mass transfer theory associated with three-phase contact line and its dynamics from nano/micro/meso/macroscopic description including interaction with small objects

(B) Advanced handling technologies of droplets and particles with the use of fluid flow induced by physicochemical properties distribution or gradient

Develop sophisticated droplet/particle manipulation technologies by means of gradient of gas-liquid or liquid-liquid interfacial tension that is externally induced

(C) Dynamics of association and dissociation of cell and protein with flow

Elucidate detailed mechanisms of specific association and dissociation between endothelial cells and blood cells with the aid of some proteins on the surface of cells including dynamics from molecules to cells

The macroscopic pictures of above topics are basically governed by multiple scales from nanometer to meter scales as in Fig. 1. Therefore, this division is tackling these problems by interdisciplinary, intersectional and interactive collaboration with the members without any border.

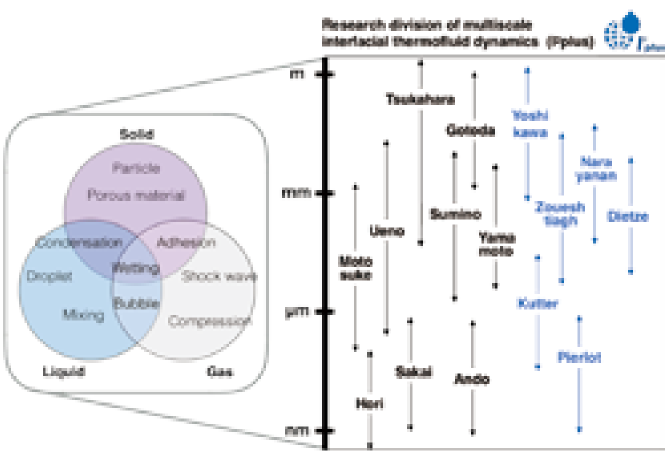


Fig. 1 Important thermofluidic phenomena associating interface within a phase or between/among phases and its scale and relevant research members of this research division (I^{2}plus). Black and blue color indicates TUS and overseas member, respectively.

International collaboration

Networking is always significantly important especially when we study challenging issues. This research division, I^{2}plus, promotes international collaborations not only within the division but also all over the world to have fruitful discussion and inspiration for achieving our goals. About 40% of division members belong to overseas universities or institutes, and there are other research collaborators in foreign countries who are not so far I^{2}plus members. Mutual collaborations in their researches among the members and researchers with all the relevant disciplines are highly encouraged. Our international collaboration network now ranges over more than 10 countries; US, UK, Canada, France, Denmark, Germany, Austria, Belgium, Spain, India, Taiwan, China and so on.

Events

In parallel with the research activities, this division organizes several workshops (I^{2}plus Workshop) and seminars (I^{2}plus Seminar) that are open to the public in a year. In the I^{2}plus Workshop, students and faculty members make active discussion through presentations of their latest research results and insights. In order to accelerate cross-disciplinary interaction, students are actively encouraged to join the poster sessions. In the I^{2}plus Seminar, we invite researchers from all over the world who are experts of various relevant fields. Also, the international symposiums are held. In 2017, we hosted a kick-off symposium, five I^{2}plus seminar, one I^{2}plus Workshop and two I^{2}plus International Symposium on Interfacial Thermofluid Dynamics. In 2018, one International Symposium and five I^{2}plus Seminars were organized. In these events, we had fruitful discussion and exchanged ideas with speakers and participants. We intend to have these events frequently to promote our collaborative researches and to encourage mutual discussion between researchers.

Education

We also make strong efforts to realize mutual exchange of students between overseas 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. In 2017 and 2018, several faculty members stayed at Université Lille 1 (France) to promote the launch of new collaborative research project. We frequently sent faculty members students to foreign universities or research institutes for different collaboration studies. Also, we are very keen to accept researchers and students from all over the world to enforce our researches and promote mutual exchanges. During their stays, we have opportunities to meet and discuss with the other division members who is not involved the collaborative research to seek for new collaboration.

Fig. 2 Snapshot at 6th I^{2}plus Workshop (9th May 2019, Katsushika campus, Tokyo University of Science, Japan)

CAE Advanced Composite Materials and Structures Research Division

Established: April 2018 ogihara@rs.noda.tus.ac.jp

Objectives

The main objective of our research division is to create deeper relations between academia and industry and to boost the number of industry-ready CAE engineers significantly through engineering research using CAE technology with a focus on advanced composite materials, including carbon-fiber-reinforced plastic (CFRP) and their structures.

Future Development Goals

The aim is to further the academia–industry partnership through collaborative research on the subject of advanced composite materials and structures conducted individually by our faculty members, while also cultivating more CAE engineers. We also intend to expand this development greatly from the second year onward.

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

Shinji Ogihara
Ph.D.

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

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

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

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

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

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

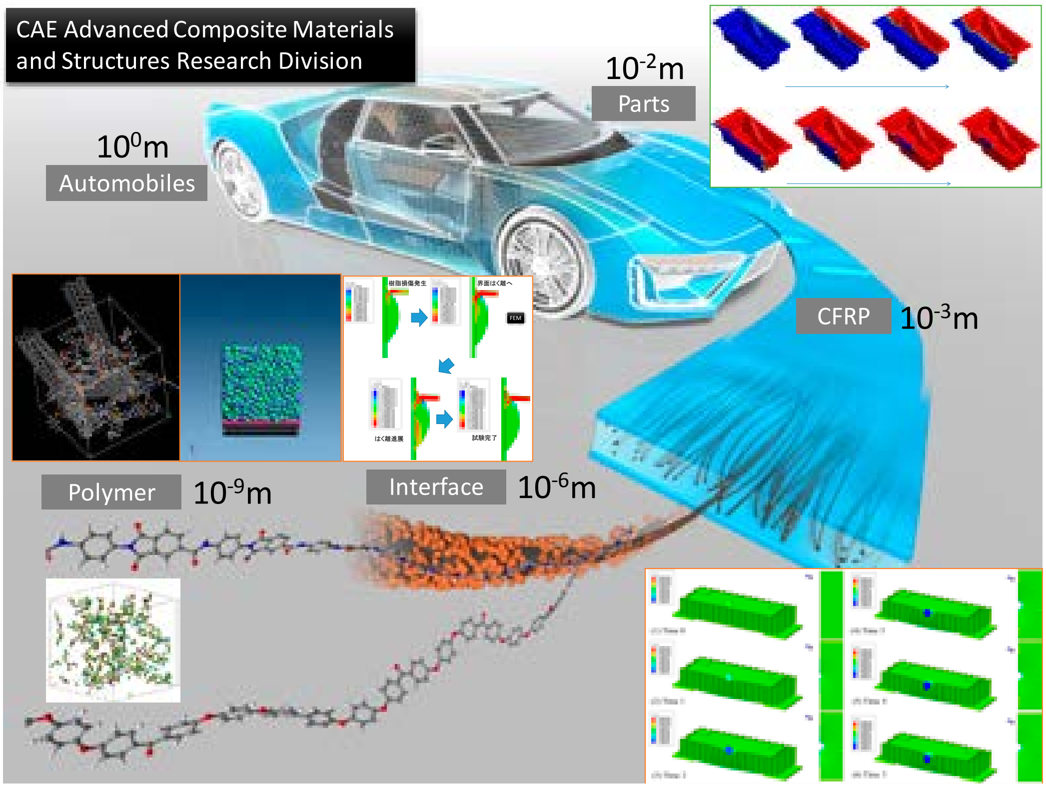


Fig. 1 Overview of research range covered by our group

Bio and Pharmacy

Center for Animal Disease Models (CADM)

Established: April, 2013

iwakura@rs.tus.ac.jp

Director
Professor,
Research Institute for Biomedical Sciences

Yoichiro Iwakura
D. Sc.

Objectives	To elucidate pathogenic mechanisms of diseases such as autoimmune, allergic and neurological diseases and tumors, and develop novel therapeutics against these diseases
Future Development Goals	To get more insight into disease pathogenesis and to develop new therapeutics through cross-research field collaboration in Noda area.

The homeostasis of our body is maintained through concerted actions of many genes. Therefore, it is critically important to elucidate gene functions in order to develop new therapeutics. I believe that we will be able to develop novel drugs and therapeutics through the collaborations of our research groups.

Elucidation of diseases mechanisms and development of new therapeutics through generation of gene-modified mice.

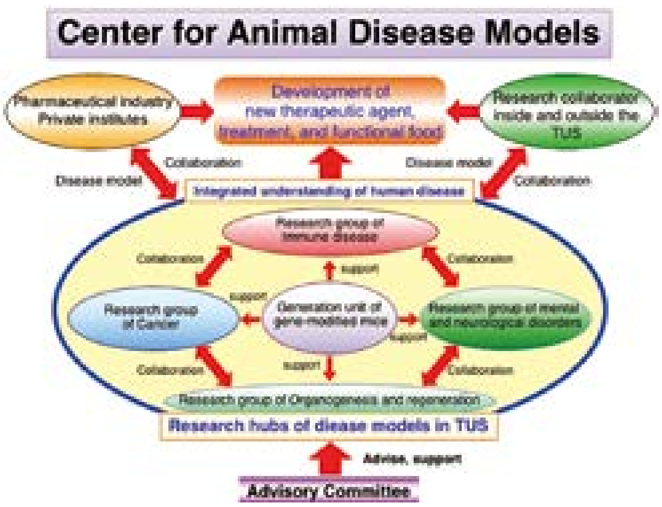
The Aim

Center for Animal Disease Models (CADM), Tokyo University of Science (TUS), was established in 2013, supported by the MEXT Strategic Research Foundation at Private Universities. In April 2018, as a subsequent organization, this center was reorganized for further promotion of research activity. Animal disease models are indispensable for investigation of causes of human diseases and development of therapeutic agent, treatment, and functional food. Animal experiments have made great contribution to the progress of human health and life-science research. Many of them were achieved by using gene-modified mice, and as the researchers who developed the method of generating gene-modified mice have won the 2007 Nobel Prize, gene-modified mice are greatly useful for the analysis of the function of disease related genes.

CADM try to clarify the mutual relationship between gene function and cause of onset for diseases that are a social problem such as autoimmune diseases, allergy, lifestyle diseases, cancer, neurological diseases, and aging by using gene-modified mice of disease related genes. We try to address these big challenges by collaborating with the researchers of biological- and life-science field in TUS. Furthermore, we are aiming to form research hubs of animal model diseases in TUS to develop new therapeutic agent, treatment, and functional food. We are expecting that new therapeutic drugs and therapies will be developed through the activities of this research center.

Research Groups

CADM set up a developmental engineering team to support the generation of gene-modified mice in the center and we will promote the generation and supply of genetically modified mice. Each group in the center promotes cross-sectoral collaborative research by sharing gene-modified mice and analytical methods such as animal disease models.



1. Immune Disease Research Group (Yoichiro Iwakura, Masato Kubo, Daisuke Kitamura, Haruo Kozono, Tomokatsu Ikawa, Shuhei Ogawa, Ce Tang, Soo-Hyun Chung, Sachiko Kubo, Yosuke Harada, Yoichiro Isohama, Chiharu Nishiyama)
   Based on the generation and functional analysis of gene-modified mice of the genes such as inflammatory cytokines, innate immunity receptors and signaling factors, we aim to develop novel therapeutic agents and functional foods for autoimmune diseases and allergies.
2. Organogenesis/Regeneration Research Group (Ryo, Goitsuka, Shunsuke Kon, Tomoko Masaike)
   This research group analyzes the molecular mechanisms of organogenesis, organ maintenance, and movement of cell organelles by generating gene-modified mice, which have genetic mutation involved in these events. This group also investigates the association between abnormality of these events and carcinogenesis. Finally, we aim at application to cancer therapy.
3. Mental/Neurological Disorder Research Group (Teiichi Furuichi, Takeshi Nakamura)
   This group analyzes the mechanism of the onset of mental and neurological disorders by using animal disease models caused by dysfunction of neural circuit formation related gene. This group aims at application to therapy of mental and neurological disorders.
4. Cancer Research Group (Kouji Matsusima, Tatsunobu Mizuta, Naoko Nakano, Satoshi Ueha, Masayuki Sakurai, Yuya Terashima, Masahito Sadaie, Mitsutoshi Tsukimoto, Kazunori Akimoto)
   This group investigates the mechanism of cancer development at the molecular, cellular, organ, and individual levels by generation of gene-modified mice involved in the onset of cancer. This group aim to develop anticancer therapy by elucidating the functions of responsible gene.
5. Advisory Committee (Makoto Asashima, Kazuhiko Yamamoto, Ken-ichi Yamanura, Naoko Otani, Kensuke Miyake, Gaichi Higami, Shin Aoki)
   The member of Advisory Committee "Consisting of experts inside and outside TUS" instructs and advises on the operation of the center, research policy, individual research contents, etc.

Research Supporting Activities (2013-2018)

Embryo Manipulation

Year	2013	2014	2015	2016	2017	2018
Generation of gene-modified mice	1	9	10	9	14	2 lines
Cryopreserved embryo	25	25	48	28	27	50
Recovered litters from cryopreserved embryo	14	7	9	3	13	4
Microbiological cleaning	16	9	4	10	11	23

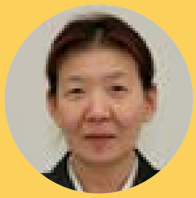
Distribution of Gene-modified Mice

Year	2013	2014	2015	2016	2017	2018
Japanese institutions	36	19	13	23	27	24 cases
Foreign institutions	65	29	37	29	16	21

Fusion of Regenerative Medicine with DDS

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

Director
Professor,
Department of Pharmacy,
Faculty of Pharmaceutical Sciences
Kimiko Makino
Ph.D.



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

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

R&D on regenerative medicine with DDS.

DDS

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

Nanomedicine

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

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

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

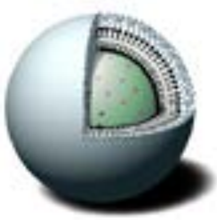


Fig 1. Pegylated liposomal doxorubicin

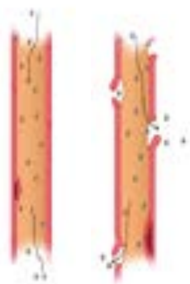


Fig 2. Pegylated liposomal doxorubicin in normal (left) and tumor vessels.

Regenerative medicine

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

Pulmonary drug delivery system

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

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

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

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.

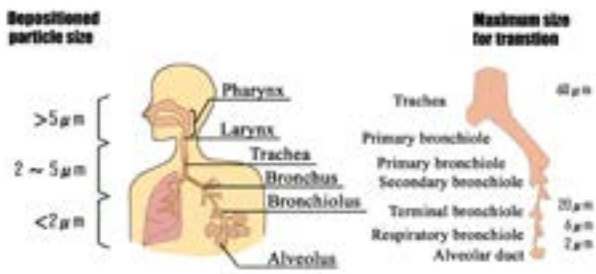


Fig 3. Deposittioned particle size in respiratory tract.

Division of Agri-biotechnology

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

Director
Professor,
Department of Biological Science and Technology, Faculty of Industrial Science and Technology
Hiroaki Shimada
Ph.D.

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.

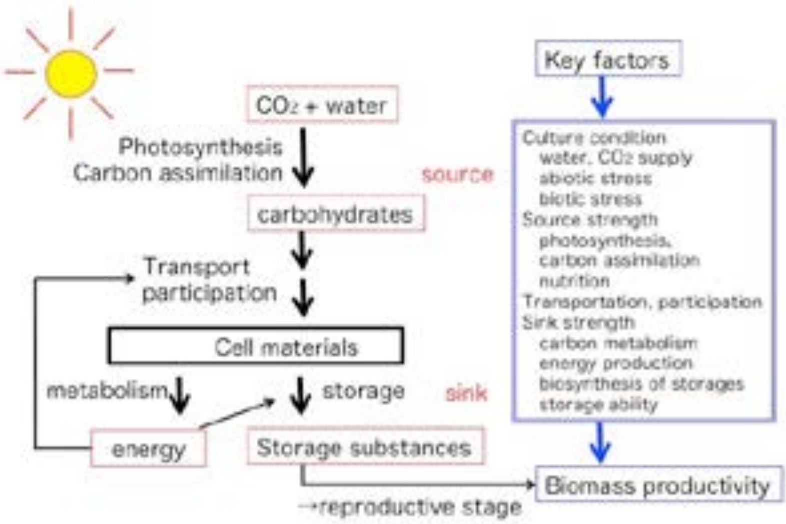
In this research section, we study on the basic research for the following three items, which we focused on the improvement of biomass productivity on the above-mentioned points of view: They include the inspection for the improvement of the plant function on a cell level, individual level, and group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



Bio and Pharmacy

Established: April 2016
tfuruichi@rs.tus.ac.jp

Brain Interdisciplinary Research Division (BIRD)

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

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

Teiichi Furuichi
Ph.D.

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

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

The Scope of the Brain and Neuroscience Field

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

Healthy Brain, Healthy Mind

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

Information Processing in the Brain

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

Goals of the Brain Interdisciplinary Research Division

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

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

(1) Brain Health and Disorders Group

With a focus on cognition, this group aims to elucidate the mechanisms of brain health and disorders (e.g. depression with pessimistic cognitive characteristics; senile dementia that reduces cognitive and memory function; social cognition and communication difficulties caused by autism) and develop therapeutic and diagnostic drug seeds. This will be achieved through multidimensional research studies all aspects from the molecular and neural circuitry to model animals.

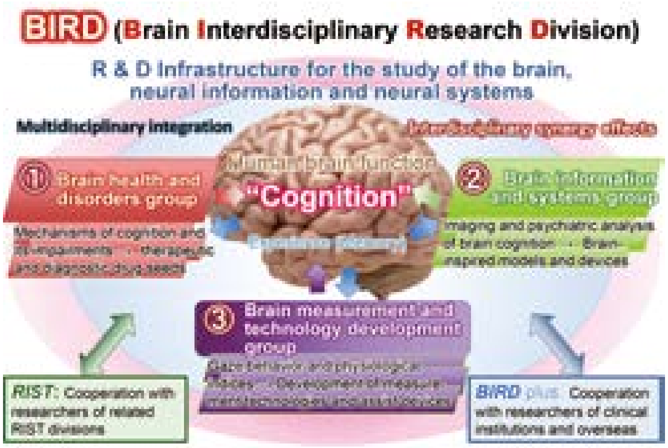
(2) Brain Information and Systems Group

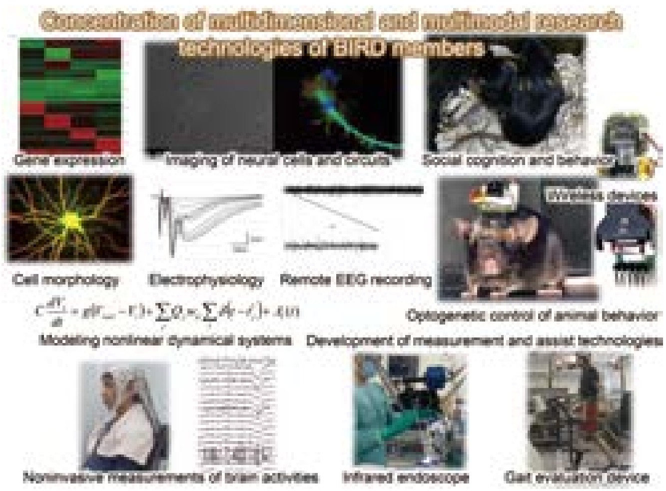
This group aims to elucidate, model and theorize the brain information processing systems with a focus on human visual perception. The group aims to achieve these goals through multidisciplinary studies including brain function imaging, cognitive psychological experiments and brain algorithms.

(3) Brain Measurement and Related Technology Development Group

This group aims to develop measurement and evaluation technologies of brain function and impairment and their assist devices through multidisciplinary study of movement such as gaze behavior and locomotion as well as personality traits and physiological indices which reflect the internal state of the brain.

Researchers (14 members): [Sci. Tech.] T. Furuichi, Y. Sano, Y. Nishiyama, H. Takemura, H. Ichikawa, [Pharm. Sci.] A. Saitoh, D. Yamada, [Sci. I] O. Araki, T. Urakawa, [Ind. Sci. Tech.] N. Aikawa, H. Natori, E. Segi-Nishida, [Eng.] T. Ikeguchi, [Res. Inst. Biomed. Sci.] T. Nakamura
Guest Researchers (2 members): T. Kimura (Kanazawa Univ.), M. Hashimoto (Fukushima Med. Univ.)





Established: April 2018
shiina@rs.kagu.tus.ac.jp

Chemical Biology Division Supported by Practical Organic Synthesis

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

Isamu Shiina
Ph.D.

Objectives

Our goals include the efficient production of pharmaceutical products from natural and/or artificial compounds. In our research department, our team will collaborate with researchers within the campus, as well as outside, who have made considerable achievements in the field of molecular biology, thereby completely exploiting synthetic organic technologies from which the representative research can derive its strength.

Future Development Goals

Recently, the discovery of new medicines originating from academia via industry–university collaboration from an industrial viewpoint has attracted a significant amount of attention. Results obtained from such researches provide a methodology for solving various issues associated with the development of drugs derived from natural sources.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

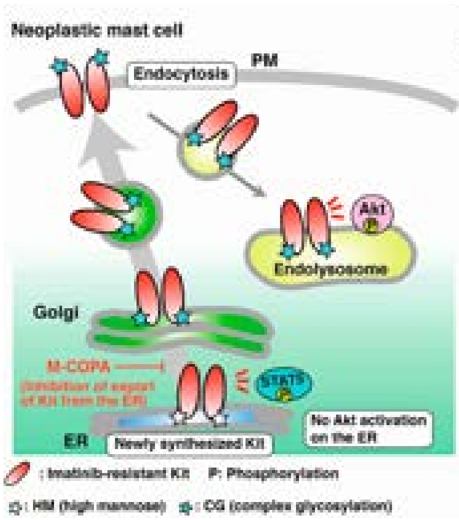


Fig. 2 Proliferation Suppression Mechanism of Cancer Cells Using M-COPA (Fig. 2 was created by Dr. Yuuki Obata who collaborates with Prof. Shiina: *PLOS ONE*, 12(4), e0175514 (2017))

Bio and Pharmacy

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

Academic Detailing Database Division

Director
Professor,
Department of Pharmacy,
Faculty of Pharmaceutical Sciences
Masayo Komoda
Ph.D.

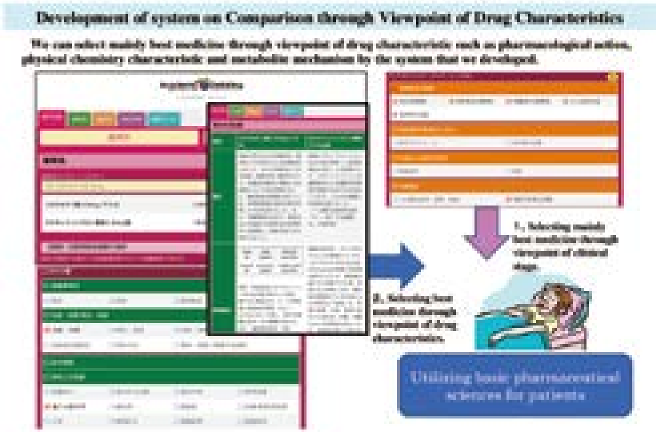
Objectives	Academic detailing is personalized support for improving both knowledge and clinical decision-making by the latest non-commercial evidence-based data.
Future Development Goals	Due to the spread of academic detailing, We will lead to better prescription and contribute to the improvement of medicine treatment quality 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. We will do research about the effectiveness of Academic detailing.

Extension of Academic Detailing and Development of Database

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.



Development of Academic · Detailer Training Program

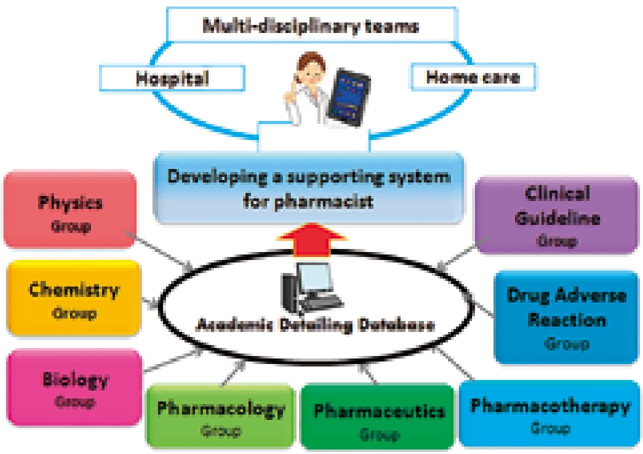
We will utilize basic pharmacology clinically to train Academic Detailers that can provide fair neutral drug comparison information based on evidence and disseminate Academic Detailing.

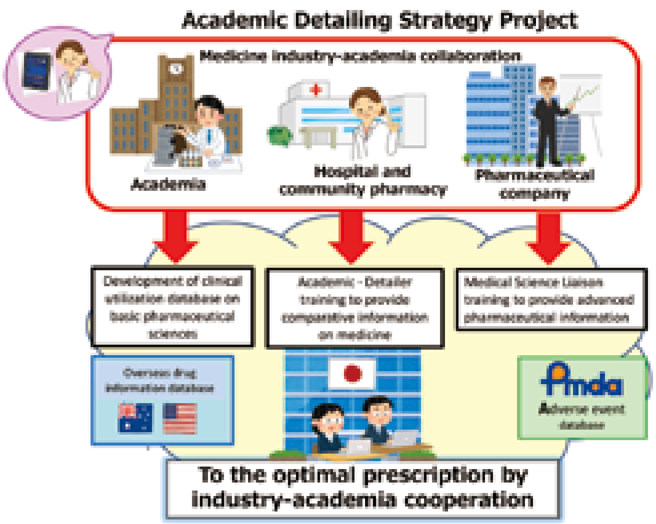
Research on Academic Detailing Effect

We will study the influence of academic · detailing to doctor on prescription.

Industry-academia cooperation

We will create academic / detailing support data base with industry-university collaboration and build collaboration with medical science · liaison training.





Division of Nucleic Acid Drug Development

Established: April 2019

twada@rs.tus.ac.jp

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

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

Takeshi Wada
Ph.D.

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

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

History of This Division

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

Research Objectives

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

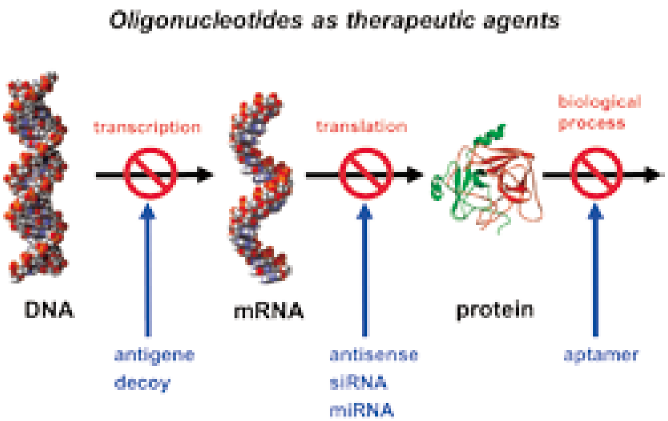


Figure 1.

Members

In-house Members

Faculty of Pharmaceutical Sciences
Takeshi Wada, Kazuki Sato (Organic chemistry)
Makiya Nishikawa, Kosuke Kusamori (Drug delivery system)
Takehisa Hanawa, Yayoi Kawano (Medicinal formulation)
Yoshikazu Higami, Masaki Kobayashi, Ryoma Tagawa (Molecular pathology and metabolic disease)
Kazunori Akimoto (Molecular Pathology)
Satoru Miyazaki, Yosuke Kondo (Bioinformatics)

Faculty of Science
Hidetaka Torigoe (Biophysical chemistry)

Faculty of Industrial Science and Technology
Chiharu Nishiyama, Takuya Yashiro (Immunology, allergy and molecular biology)

Research Institute of Biomedical Sciences
Masayuki Sakurai (Biomolecular Chemistry)

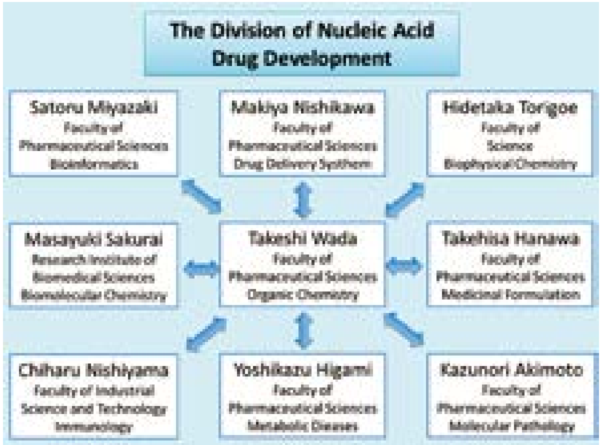


Figure 2.

Current Situation of Nucleic Acid Drugs and Our Research Topics

Nucleic acid-based drugs are anticipated to be an epoch-making remedy for the treatment of intractable hereditary diseases. The global market size of nucleic acid-based drugs is predicted to expand to 19 billion dollars in 2030 from 2 billion dollars in 2018, according to the estimation of Seed Planning Inc., a marketing research and consulting enterprise. Although much efforts have been devoted to the research of nucleic acid-based drugs, only 8 drugs have been approved so far. There are a lot of challenges to overcome for the development of potent nucleic acid drugs, and a break-through is required for the further progress of this area. To address this issue, we are dealing with following topics;

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

Division of Synthetic Biology

Established: April 2019 sachi@rs.tus.ac.jp

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

Sachihiro Matsunaga
Ph.D.

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

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

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

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

Strategy 1: Plant genome transplantation

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

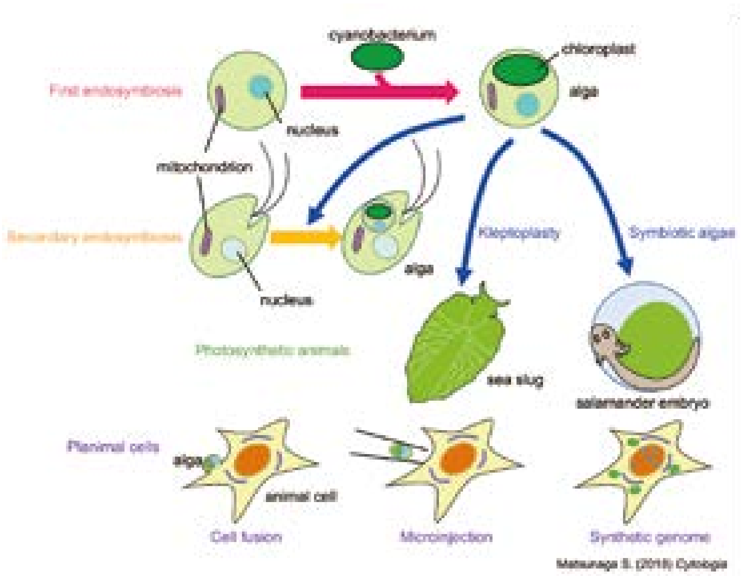
Strategy 2: Genome transfer beyond the species barrier

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

Strategy 3: Cell creation leading to regenerative medicine

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

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



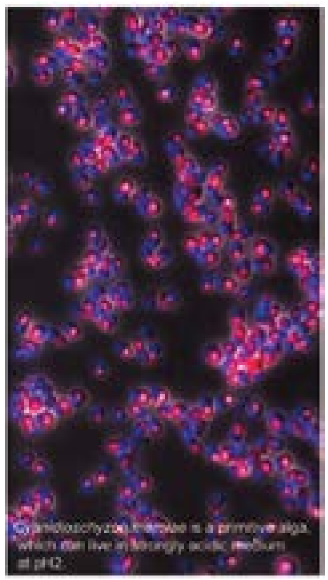


Figure 1 Creation of artificially photosynthetic animal cells “planimal cells”

Center for Fire Science and Technology

Established: April 2004

ihagiwara@rs.tus.ac.jp

Director
Professor,
Research Institute for Science and Technology

Ichiro Hagiwara
Ph.D.

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.

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.

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

Fire science at TUS

In 1981, Tokyo University of Science established Department of Fire Science and Technology in its Institute for Science and Technology. The aim was to set up a research center that would promote research on the safety technology to protect human life and property from fires, and research on the fire science that supports the technology. This development was initially started by the inauguration of a course on Architectural Fire Safety Engineering when the Department of Architecture, TUS was founded some 50 years ago. In this way, TUS laid the foundations of research and education on fire science ahead of the times, when such developments were unknown in other universities. These foundations have yielded a strong 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 track 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. "Fire Safety Information Center in Asia based on Sharing Expertise-New Fire Safety in Information Society" was started. Fire Safety Information in Asia as a research base that focuses on building a network of networks, and works together to reduce fire risk in Asian cities, we have realized the global development of science, which is an issue for the 21st century.

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

Fire Research and Test Laboratory

Taking the opportunity of being adopted as the 21st Century COE Program, this laboratory was built in March 2005. It is one of the largest and most functional laboratories in the world meant solely for fire science. Built at Noda campus, it has abuilding area of 1,500 m2, and gross floor area of 1,900 m2, and a height of 20 m (Photo1). Members of the Center constructed a basic plan and did the designing utilizing their wealth of experiences, so that the laboratory would enable us to promote world-leading researches on fire sciences.

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

Graduate School of Global Fire Science and Technology

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

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

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

Designated Performance Evaluation

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

Performance evaluation is conducted by an evaluator who has expert knowledge of the field of performance evaluation based on the business method approved by the MLIT.

※ 2019 business start schedule (during approval application)

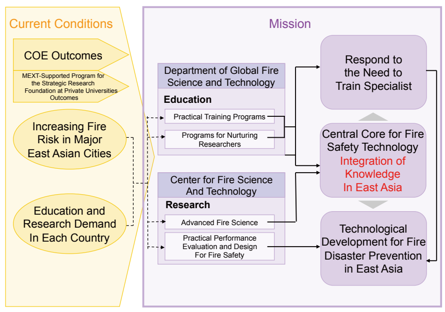


Fig. 1 Perspective of the Center for Fire Science and Technology

Photo 1 Fire Research and Test Laboratory

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

Information and Societal

Research Center for Space Colony (RCSC)

Established: November 2017 rcsc@rs.tus.ac.jp

Director
Vice President,
Astronaut,
Tokyo University of Science

Chiaki Mukai
M.D., Ph.D.

Objectives	RCSC aims for R&D of technologies necessary for long term stay of human in an extreme closed environment, which is indispensable for frontier expansion of mankind. And to realize that, we (RCSC) gather technologies related to space.
Future Development Goals	RCSC transfers technologies created in the process of R&D to private companies. We collaborate not only for the space exploration but also for upgrading lifestyle of human being on the earth.

RCSC possesses technologies such as component development of the satellite, functional materials, energy creation, construction, IoT, sensor etc. TUS has strength to develop technologies through R&D processes for long term stay of human in an extreme environment. The university that does not have the Department of Aeronautics and Aerospace Engineering aiming to revitalize Japan's space industry through industry-academia collaboration by the idea not caught by the stereotype of conventional space development.

Research Center for Space Colony ~Advancement and Social Implementation of the Space Stay Technology~

History of RCSC

TUS is private university of science and engineering in Japan and has cultivated know-how of heterogeneity comprehensive researches.

RCSC gathers TUS's technologies such as component development, functional materials, energy creation, construction, IoT, sensor etc. All of these fields are related to satellite science for spaces exploration. These technologies are extremely important for understanding and development of the universe, which is the frontiers of mankind. RCSC was established for the development of technologies that are necessary for human to stay in a closed environment for a long term in space.

RCSC was established with the aim to develop technologies through industry-academia-government collaboration. Our goal is to contribute human society through innovative R&D, promote social implementation of the technologies, and human resource development. RCSC was adopted as a branding project by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Japan. The former division (the space research conference) was dissolved in favor of RCSC in November 2017.

Present Problems

There are several problems while staying in the closed environment in space. Space colony is indispensable for frontier expansion of human. There are many issues to be solved, such as supplying necessary energy for living, recycling water / air, and producing foods necessary for self-sufficient. In order to deal with these problems, we need to gather the TUS's knowledge, respond with integration powers, and promote cooperation with private companies.

Aims of RCSC

RCSC aims to realize the use of sophisticated space-stay technologies on earth and contributes to the social implementation of these technologies by promptly transferring to private companies through collaboration. In addition, RCSC aims to contribute to national resilience by building disaster-resistant houses, solving food crisis, and revitalizing the very small space industry. We also focus to develop systems that deal with QOL, agriculture, energy and recycles of waste products in space through industry-academia collaboration.

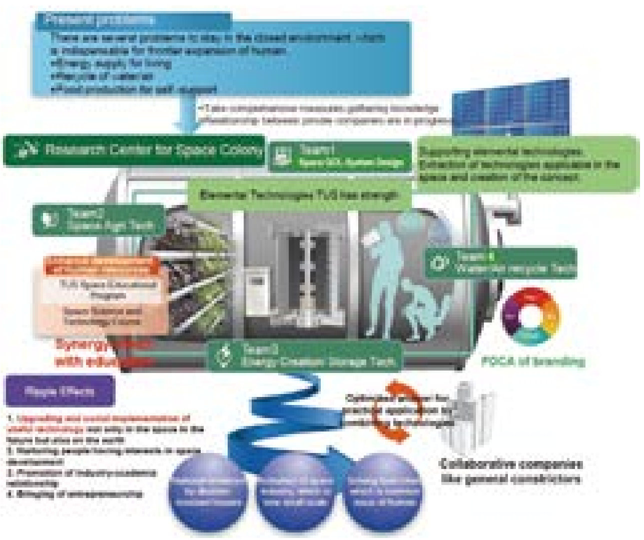


Fig. 1. Outline of the RCSC

Research Organization of RCSC

RCSC is composed of four teams. R&D of these four teams work together in cooperation and transfer the technologies created by R&D processes promptly to private companies with an aim to use them for space exploration as well as upgrading lifestyle of human being on the earth.

Team-1 : Space QOL•System Designing Team

Team-1 supervise the overall project. It designs system necessary to improve the QOL (Quality of Life). It extracts the necessary technologies, assuming that human being stay for a long period of time on the moon, exposed to special environmental conditions such as microgravity and low pressure.

Fig. 2. Mission of Team-1 (Space QOL・System Designing)

Team-2 : Space Agri Tech. Team

Team-2 will develop element technologies of space agriculture by using the in-liquid plasma technology and the photocatalysis technology in combination. It investigates the development of self-sufficient agricultural products using limited resources in a closed space condition considering sanitation.

Fig. 3. Mission of Team-2 (Space Agri Tech.)

Team-3 : Energy Creation / Strage Tech. Team

Team-3 will develop high efficiency and high power solar cells made of materials with excellent cosmic radiation durability, thermal-to-electric power generation system with indoor and outdoor temperature difference that can generate electricity even at night, and flywheel type high energy density power storage system cooperating with solar cell / thermal battery.

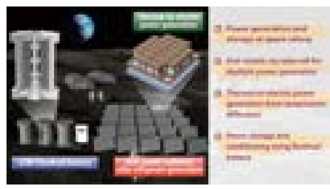


Fig. 4. Mission of Team-3 (Energy Creation / Storage Tech.)

Team-4 : Water / Air Recycle Tech. Team

Team-4 will develop a system that fully recycles various kinds of water and gases discharged from the human body and equipment using functional materials such as highly active photocatalyst.

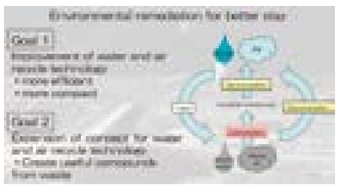


Fig. 5. Mission of Team-4 (Water / Air Recycle Tech.)

Division of Things and Systems

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

Director
Professor,
Department of Management,
School of Management

Masanori Sakamoto
D. Eng.

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 them into the technology based on advanced Business design.

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

Industry Scheme Reformation from Things oriented (QCD) to Value oriented one by ICT based SYSTEMs

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 founding Chairperson was Mr. T. Nagashima, former CEO of Teijin Corp and chaired the council of the Japanese Association of Corporate Executives of Things and System. The current Chairperson is Mr. Yoshiyuki Miyabe,CTO and Senior Managing Executive Officer of Panasonic Corporation. Prof. Yoshio Tanaka has been named as Vice Chairperson.

The Society has been formed by Faculties, National Institute Researchers, Business School Students, Research Engineers in Industry. The Chairperson is Mr. K. Motoyama, who is the Chairperson of the board of directors of Tokyo University of Science and have experienced several management positions, such as CEO of Asahi Soft Drinks Co., Ltd. These two entity and our "Things and Systems" research division hold collaborative discussion meeting every month. The scheme is as follows.

Research on Service IT

From the Servitization point of view, this group will research about the efficiency, computerization and value proposition regardless of production and service as a total system.

Research on Advanced THINGS and SYSTEMS

From a management of technology of view, this group will research the process of the transformation from "the just products oriented business" to "the integrated service business" including the technical management, HR and organization for the management systems leading the servitization and the global expansion, that is to say the integrated business administration.

Research on DATA Science

This team will make research on the data analysis, security system, privacy system and system interoperability on the BIG data, which would be collected from the real world, based on computer science and data mining technology.

Research on Practice Study

This team will make research and study on the practical case which "THINGS industries" have experienced to change or reform it to the THINGS and SYSTEMS ones. Cases are mainly sort out from the both Things and System consortium member companies and the global companies.

Research on Design Thinking (New)

Focusing on the Experiences realized by the Systems instead of the Things brought by the hardware making, this division is discussing on the emotional satisfaction, comfort and happiness put into the practice by setting the timing, physical circumstances, and things in accordance with the human mindset at the moment adequately set by the Systems which may realize a fully enjoyable dinner party without the alcoholic drinks or even the expensive meats in the near future.

Research on Intelligent System (New)

Pursuing for the general formalism to design the Systems denoted by f(x), where y = f(x) would be the output of the experience useful and helpful for the people having problems to eliminate. We have to collect the voices of the people to find the adequate output y, and construct the function finding the crucial parameter of x. This group discuss on the above process setting some real business problems for the exemplifying cases.

Research on FinTec Research (New)

In the fiscal year of 2018, this group made the collaboration with a major foreign finance company, to verify the effectiveness of the ESD investment for the companies which received the funding. The SDGs issued by UN based on the belief that the ESD investment would make the companies profitable compared with the ones having no consideration for the sustainable society. This research would open the first pages of the qualitative research on the assumptions of SDGs.

Table 1. Research members of Things and Systems Division

Job title	Name	Main research field
Director, Professor	Masanori SAKAMOTO	Industrial strategy, Electronic materials
Professor	Yoshio TANAKA	ICT, Computer software, Business system
Professor	Aya ISHIGAKI	Industrial administration
Visiting Professor	Masayuki NUMAO	Computer science
Visiting Professor	Takashi YAMASHITA	Actuarial analysis
Visiting Professor	Yohichi MOTOMURA	Information science
Visiting Professor	Tomoaki MINOWA	Information science
Visiting Associate Prof.	Hisashi HAZEKAWA	Service engineering
Visiting Associate Prof.	Yuichi KATAYORI	Fund management, Fintech
Visiting Researcher	Hisanori TAKADA	Fund management, Fintech
Visiting Researcher	Tomofumi SATO	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 including the National Institute members, the company corporate managers, R&D engineers and managers in the planning department. This Division has operated a workshop of monthly basis in cooperation with them.

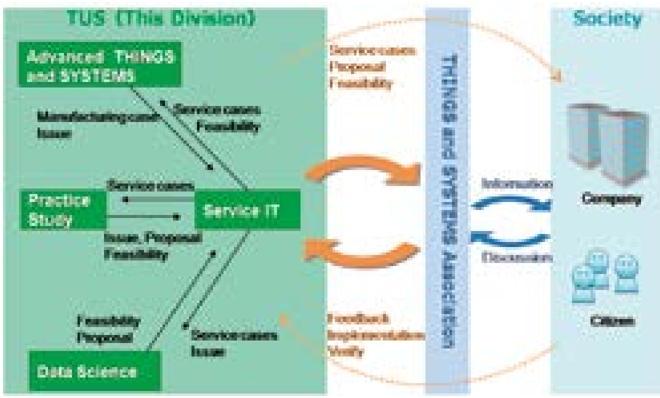


Fig 1. Organization of Things and Systems Division, and collaboration framework

Information and Societal

Atmospheric Science Research Division (ASRD)

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

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

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

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

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

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

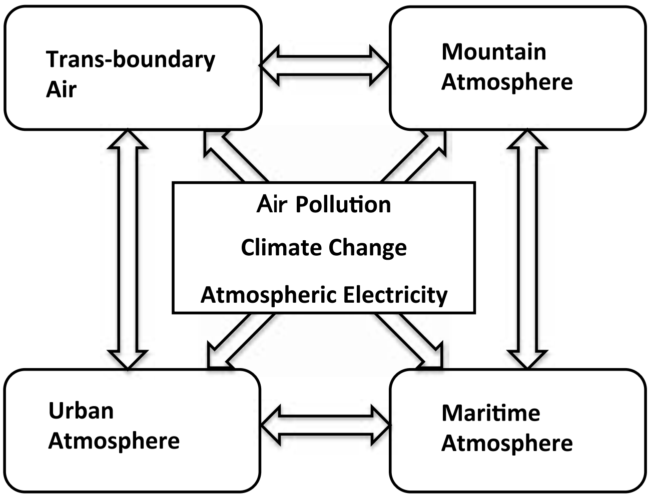


Fig.1. Mutual relationship of the research field.

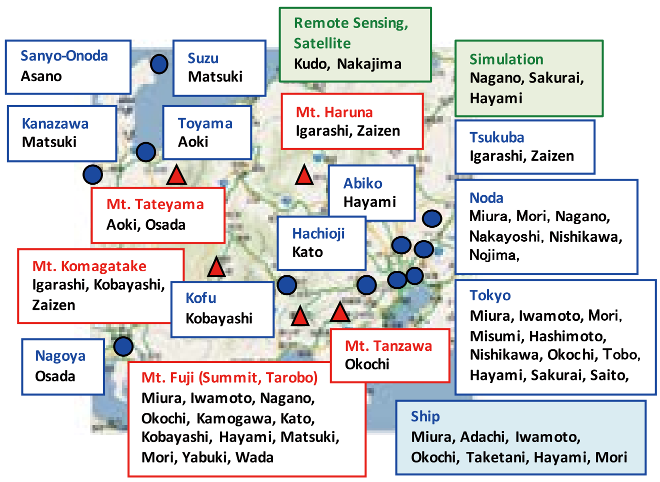


Fig.2. Roles of ASRD members and their observation sites, mountain (red) and surface (blue) sites.

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

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

2. Effects of atmospheric aerosols on climate change

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

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

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

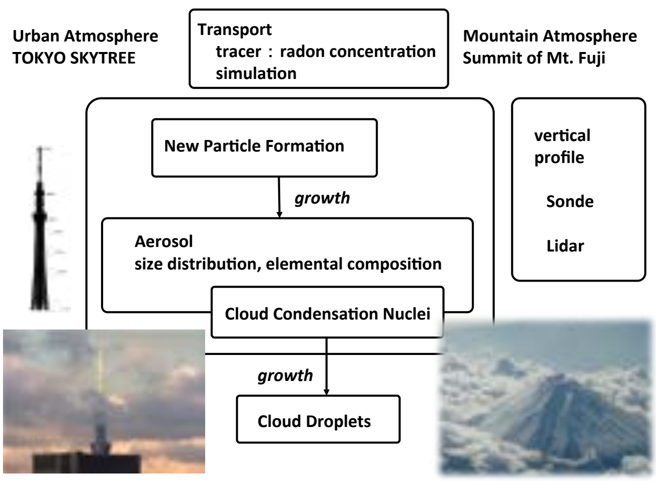


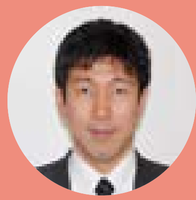
Fig.3. Study on the process of new particle formation and cloud formation in the urban and maritime atmosphere.

Established: April 2016

mune@rs.tus.ac.jp

Division of Super Distributed Intelligent Systems

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



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

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

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

Introduction and Background

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

Division of Next Generation Data Mining Technology, which is the previous division, especially focuses attention to medical and bio-systems, and has developed next generation data mining software together with researchers in artificial intelligence and statistics areas. In the process of that, we have found that we have to enhance parallelization/distribution to achieve new innovative technologies. In Division of Super Distributed Intelligent Systems, we will improve the results of the division of next generation data mining technology, and develop new parallelizing/distributing techniques based on performance issues that the results have exposed. For example, we will enhance execution efficiency in the low level that is related with programming languages, parallel/distributed algorithms, and network protocols. In addition, we will design new parallel/distributed models based on knowledges given by cell signal processing or social insects. Eventually, we will apply these techniques and models to several areas such as image processing, power systems, machine learning, robot systems, software engineering tools and so on, including data mining.

Research Hierarchy

We address the issues of parallelization and distribution in three hierarchical levels, "applications", "models, and "infrastructures" (Fig. 1.) as follows:

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

2. Parallel/Distributed Infrastructures
In the Infrastructure level, considering "programming languages", "language processors" and "network protocols", their special researchers directly improve the parallelization and distribution techniques on various infrastructures.

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

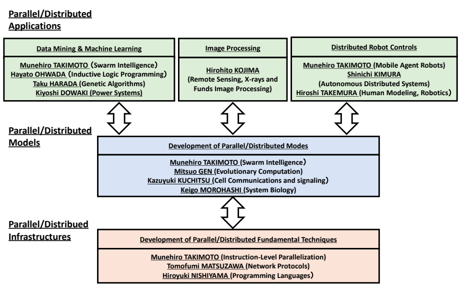


Fig. 1. Structure of the division

Research topics

Currently, the following three projects are running:

1.Enhancement of milking using a milking robot

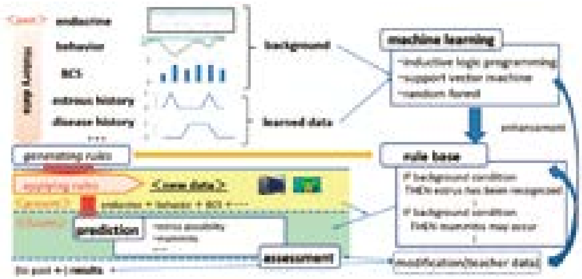


Fig. 2. Relation between a milking robot and A.I.

As shown in Fig. 2, the purpose of this project is to generate an endocrine model based on the transition of the ratio of pheromones to milk components automatically given by a milking robot. Precise prediction of the endocrine enables cows to always be enceinte, so that the amount of milk generated by the cows can be kept constant. To generate the endocrine model, we use inductive logic programming, which is one of A.I. methods.

2.Enhancement of raising using a suckling robot

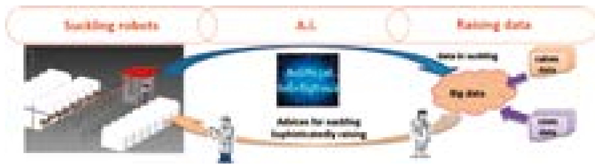


Fig. 3. Relation between a suckling robot and A.I.

In this project, as shown in Fig. 3, A.I. generates a manual for operating a suckling robot, which can automatically give the suitable amount of milk to each calf at suitable time. However, it is difficult to decide several parameters depending on the condition of each calf. A.I. generates a suckling model through assessing the conditions of calves suckled by the robots. The suckling model results in a manual for operating the robots.

3.Enhancement of grass and gazing managements

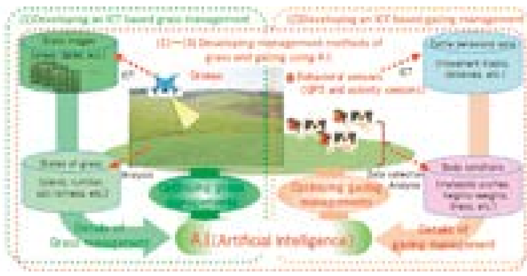


Fig. 4. Relation among grass managements, gazing managements and A.I.

In this project, A.I. optimizes grass and gazing managements using information from several sensors and images that drones give, as shown in Fig. 4. The grass that cattle have may include some kinds of plants not good to them. Such plants become found by A.I. through feedbacks from the sensors and drones, so that grass and gazing managements can be developed semi-automatically.

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

Division of Intelligent System Engineering

Director
Professor,
Department of Electrical Engineering, Faculty of Science and Technology
Akira Hyogo
Ph.D.

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

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

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

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

Basic research on intelligent systems for medical applications

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

○Bio-information sensing and healthcare

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

○Radio wave communication systems for wearable IT devices

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

○Energy supply systems for embedded systems and data transmission systems

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

○Cancer diagnosis and therapy using a microwave

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

Research on space crafts with autonomy

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

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

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

○Research on high-frequency analog circuits

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

○Low-voltage, low-power circuits

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

○Integrated circuits

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

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

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

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

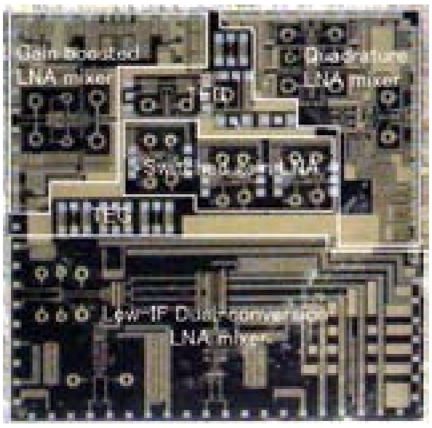


Fig. 1 Microphotograph of the proposed Integrated circuits (5mm×5mm)

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

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

Research on energy systems where an intelligent system is supported

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

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

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

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

Established: April 2014

Division of Advanced Urbanism and Architecture

o.taka@rs.tus.ac.jp

Director
Professor,
Department of Architecture,
Faculty of Engineering
Osamu Takahashi
Dr. Eng.

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. We will also enhance construction and fire safety.

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 Department of Global Fire Science and Technology. 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

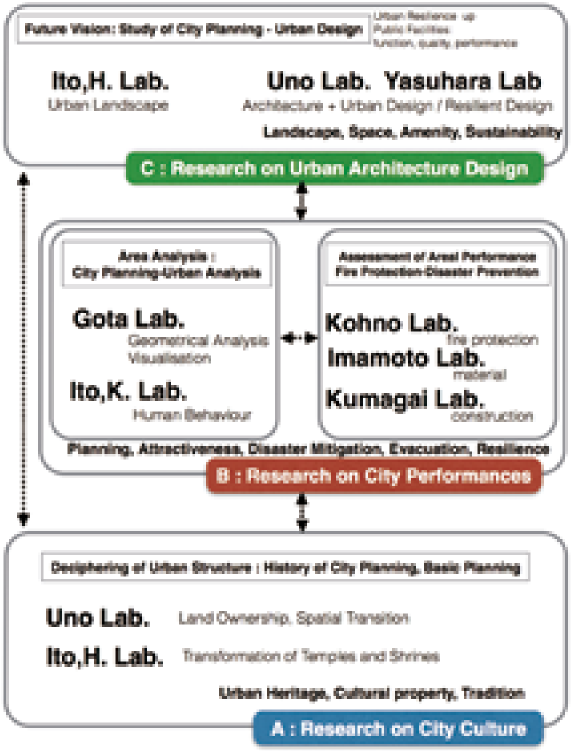
As for the problems about today's urban environment and urban life, which become highly modernized and industrialized, almost of them are caused by complex and correlative matters. Only results of individual research areas that have been finely specialized and divided, can not solve the problems of necessity 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.



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

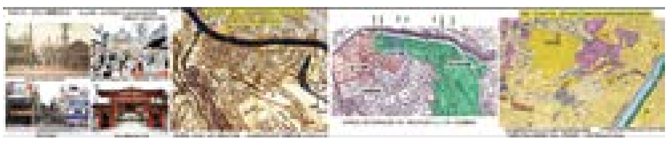


Fig. 1 Historical Changes of Kagurazaka "Outside of Sotobori", Lecture of Professor Akihisa ITO, April 2014

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

IR FEL Research Center

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

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

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	Future Development Goals: Development as a laser center equipped with mid-infrared and THz 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

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

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

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

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

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

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

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

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

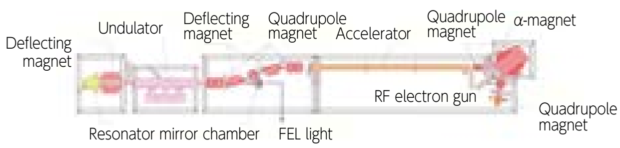


Fig. 1 Schematic outline of FEL-TUS

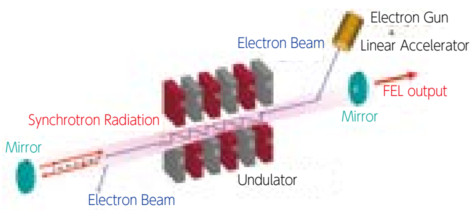


Fig. 2 Structure of undulator

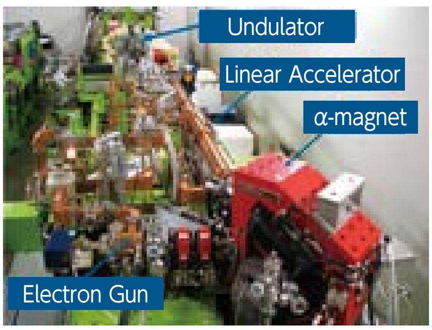


Photo Main body of the infrared free electron laser

Imaging Frontier Center

Established: April 2015

asuda@rs.tus.ac.jp

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

Akira Suda
Ph.D.

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

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

Research and development on leading-edge imaging technologies

Establishment of the Center

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

Research Content

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

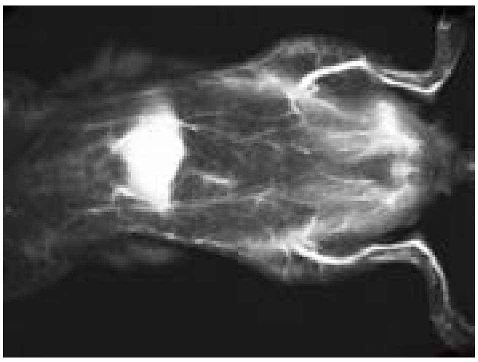


Fig 1. Blood vessel imaging of a mouse

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

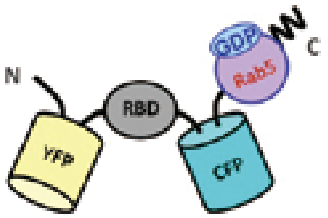


Fig 2. FRET sensor for visualizing the ON/OFF reaction of the G protein

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

Research Organization

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

Expected Outcome and Spreading Effect

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

Imaging Frontier Center
IFC
Tokyo University of Science

Fundamentals

Division of Mathematical Modeling and its Mathematical Analysis

Established: April 2015

kato@rs.tus.ac.jp

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

Keiichi Kato
Ph.D.(Mathematical Sciences)

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

This division has been established on the April of 2015. Our aim is to make interdisciplinary researches between mathematical analysis, numerical analysis, physics, chemistry, biology and technology. The members of our division are willing to cooperate to those who need to techniques of mathematical analysis or numerical analysis.

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

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

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

Using our representation of solutions to Schrödinger equations via wave packet transform, we will establish a method to compute the energy levels and its eigenstates for given potentials. We will apply this method to physical situations via numerical analysis. Recently we have succeeded to make numerical calculus by this method and estimate the efficiency of this method now. (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. (Kazuyuki Watanabe)

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)

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)

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

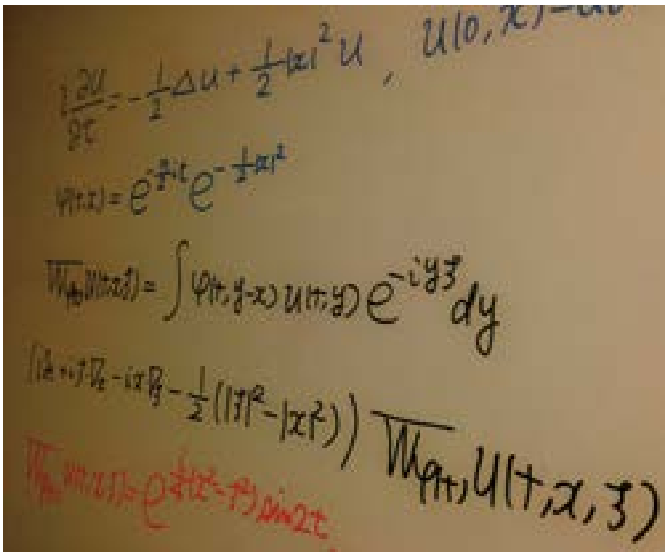
Brittle fracture under an assumption of linear elasticity has been systemized as linear fracture mechanics and its simulation software has also been developed. However there are a lot of engineering hypothesis, so it's difficult to construct mathematical model covered general fracture phenomena. In order 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 Yuusuke Sugiyama(University of Shiga Prefecture) and Masakazu Yamamoto(Niigata University).(Keiichi Kato)



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

Division of Modern Algebra and Cooperation with Engineering

Director
Professor,
Department of mathematics,
Faculty of Science and Technology
Hiroyuki Ito
Doctor of Science

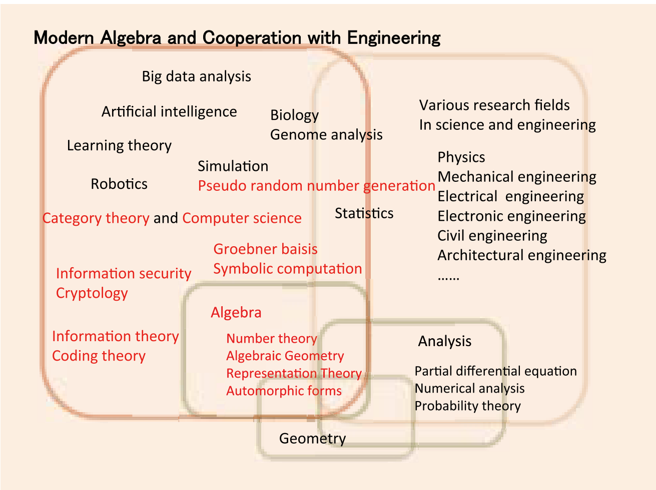
Objectives	To research and develop algebra itself and algebra based engineering, also to find new engineering fields cooperation with algebra, thereby making a contribution to mathematics and engineering.
Future Development Goals	To make contribution to mathematics and engineering, and to make the center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

This division do research from purely theoretical mathematics to experimental engineering, and make cooperative environment between mathematicians and researchers in algebra based engineering. Furthermore, the division will contribute to find new cooperative research fields between algebra and engineering which make mathematical innovation.

Theoretical research on algebra and its applications on engineering

Background and purpose of the division

It is important for mathematics, which has more than 2000 years history for research, to interact with other research fields outside mathematics. Research area of pure mathematics is roughly divided into three parts, algebra, geometry and analysis. One can think that algebra and analysis are two wheels of a cart, via geometry and geometric objects. In its long history, analysis, which treat mainly continuous objects, has been developed in interaction with various engineering technology. On the other hand, algebra, which treat mainly discrete objects, has been started to make interaction with information science, information technology, electrical and mechanical engineering, etc., after 20th century, and produce many useful results and effects which are indispensable for modern human life. Our division based on algebra are going to cooperate with another division "Mathematical modeling and its Mathematical analysis", and are going to be a basis of science and technology to cooperate with various research areas. And finally, to be a center of research on algebra and algebra based engineering.



Research on Modern Algebra and Cooperation with Engineering

The division consists of various researchers inside Tokyo University of Science, whose research fields are number theory, arithmetic geometry, algebraic geometry, commutative algebra, representation theory, automorphic forms, algebraic topology, discrete mathematics, combinatorial design, computational mathematics, computer algebra, cryptology, information security, coding theory, and applied algebra. In the past, these researchers have cooperated with each other in the occasion of seminars, workshops and international meetings. As an activity of this division, we pursue further cooperative relationship not only inside the division, but also outside the division, and we are going to produce many cooperative research between pure mathematics and engineering.

More precisely, the division consists of three groups for purely mathematical research and three groups for applied research. Pure mathematics groups are managed by holding seminars, workshops and symposiums on algebra, algebraic geometry, number theory, and so on. Engineering groups are also managed by making a place for engagement of researchers of pure mathematics and engineering, and by proposing and developing many research plans for both sides, mathematics and engineering.

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

About the Future of Modern Algebra and Cooperation with Engineering

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

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

Joint Usage/Research Center

Research Center for Fire Safety Science

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

Director
Professor,
Research Institute for Science and Technology
Ichiro Hagiwara
Ph.D.

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

Open Call Schedule

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

The rough schedule of the application is as follows:

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

Reference Research Theme (Examples from the past)

[General Category, A～E]

A. Fundamental research on building fire safety
- An experimental study on measurement method and estimation algorithm of radiant heat flux from large scale facade fire

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

C. Fundamental research on fire safety and disaster prevention
- An Experimental Study on Fire Prevention Effect with High Viscosity Liquid on A Wood Board

D. Fundamental research on large-scale fire

E. Research on technology and measures pertaining to fire safety

[Emphasis Category, F] (※)

F. Experimental Research on Building Structural Fire Resistance

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

[Innovation Category, G] (#)

G. R & D issues that can be expected for technological innovation to reduce fire risk (#)

(#) Among the various technologies contributing to the reduction of fire risk, such as fire-resistive technology, fire safety material development, fire-fighting technology, firefighting activity support, those that can be expected to be commercialized in recent years are targeted

Management Structure and Assessment Procedure

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

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

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

The Research Theme Selection Committee

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

Facilities and Equipment Control Committee (WG)

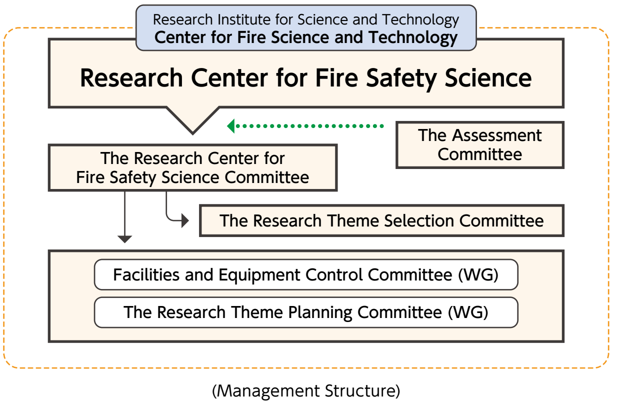
This committee (WG) is primarily involved in the operation planning of the experimental facilities. It is also responsible for the maintenance of facilities and equipment installed in the institution. In addition, it gives users instruction on how to use these facilities and equipment and on safety control.

The Research Theme Planning Committee (WG)

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

The Assessment Committee

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



(Management Structure)

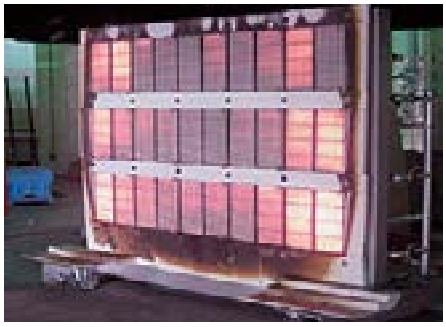
Example of Available Facilities/Equipment

Cone Calorimeter Testing Device (ISO 5660)

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

FTIR Gas Analyzer

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



ICAL Testing Unit (Heat Radiation Panel)

This unit is designed to elucidate the burning behavior of combustible materials under the condition where a certain heat flux was given through radiative heat transfer. The unit can also be used to investigate the behavior of members exposed to radiative heat. The panel heater has a heating area of 1.75 m (W) × 1.38 m (H). Members can be exposed experimentally to surface temperatures up to 950 and a heat flux of 50 kW/m^2.

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)

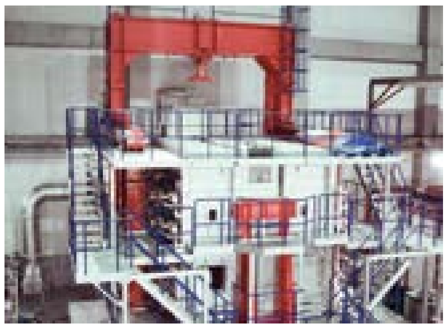
This unit is comprised of a space of 2.4 m (W) × 3.6 m (D) × 2.4 m (H) (approximately, the size of a 6-tatami-mat room) and an opening 0.8 m (W) × 2 m (H). It can be used to recreate a fire in a room with furniture and dry walls, which can be developed into a fully developed fire. In addition, flashover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

Structural Fire Testing Furnace (Medium scale)

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

Structural Fire Testing Furnace (Large scale, for Walls)

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



Multiple Full-scale Furnace

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

Joint Usage/Research Center

Photocatalysis International Research Center (PIRC)

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

Director
Distinguished Professor,
Tokyo University of Science

Akira Fujishima
Ph.D.

Objectives PIRC aims to be a core institute of photocatalytic researches by opening our facilities enable to evaluate photocatalytic performance, and promoting to create a community of researchers via collaborate research.

Future Development Goals PIRC aims to realize 1) energy-saving and eco-friendly society, 2) safe, secure, and healthy society, and 3) comfortable space through the implementation of photocatalysts.

The 21st century is called the “environmental century”. We are now facing several problems such as global warming, depletion of resources, and air/water pollution. Photocatalyst is an “environmental technology” having various potentials. We would like to make PIRC a hub for photocatalytic researches, develop a photocatalytic research field by promoting worldwide collaborative researches, and then contribute to solve various problems.

By utilizing unique facilities in PIRC, we deepen a photocatalytic science for social implementation.

Background of photocatalysts

The development of photocatalysts has been attractive in these years. Photocatalysts have been not only studied in various research fields including especially environmental and energy-related fields but also used in a variety of products.

Followed by the epoch-making report on water splitting by Fujishima and Honda in 1972, the photocatalytic properties have been used to convert solar energy into chemical energy to obtain useful materials including hydrogen and hydrocarbons by oxidizing or reducing materials and to remove pollutants and bacteria on the wall surfaces and in air/water.

Among various photocatalysts, TiO_2 has been the most widely studied and used in many applications because of its superior properties such as strong oxidizing abilities to decompose 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 (i.e., holes and electrons) induced by absorbing ultraviolet (UV) light of which energy is equal or greater than the band gap energy of TiO_2. The photogenerated holes/electrons in the valence/conduction band diffuse to the TiO_2 surface and oxidation/reduction is occurred and active species such as radicals are frequently formed. To give an example, electrons in the conduction band typically react with molecular oxygen in the air to produce superoxide radical anions ($O_2{\bullet}^-$). Formed active species attract organic pollutants/bacteria and decompose/sterilize them.

In addition, TiO_2 surfaces become superhydrophilic with a contact angle less than 5° under UV-light irradiation. The superhydrophilicity is originated from the change of chemical conformation on the surface. The majority of the holes are subsequently consumed by reacting directly with adsorbed organic species/water. 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. Then, water molecules can 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. Superhydrophilicity is used for anti-fogging and self-cleaning of the surface.

By utilizing above features, materials and applications involving TiO_2 have a potential to improve our lives from a perspective of energy production and environmental cleanup.

History of PIRC

To be a hub of the photocatalytic research network for an accelerative research progress and the development/spread of the technology, PIRC opens facilities for photocatalytic studies and collaborates with various researchers. PIRC was selected as a “Program for Promotion of Joint Research Centers” by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and started from April 2015. In 2018, MEXT decided to enforce PIRC as Joint Usage/Research Center.

Purpose of PIRC

Tokyo University of Science (TUS) holds up “Building a Better Future with Science” as our slogan and aims to be a global university with the international competitiveness, envisioning ourselves not only as TUS of Japan but also TUS of the world. PIRC aims to be a hub for photocatalytic researches by opening our unique apparatus and promoting collaborations with outstanding researchers.

Photocatalyst is a Japan-origin technology, starting from the Honda-Fujishima effect, and Japan has been a leader since its discovery. PIRC advertises this fact and guides the further development of photocatalytic study through inevitable collaborative researches.

Features of PIRC

Although photocatalysis industry is developed to 100 billion JPY, society still demands many kind of highly-developed applications. PIRC promotes GENUINE researches creating clean environment and energy through air/water purification by self-cleaning effect and strong oxidation ability and solar-driven material conversion (artificial photosynthesis), respectively.

PIRC promotes the use of JIS and ISO-based facilities for photocatalytic performance evaluation. Furthermore, PIRC support the development of photocatalyst based on a novel synthesis technique such as state-of-the-art plasma process. PIRC also promotes academic researches toward social implementation by opening our facilities to public and collaborative researches. As examples of the social implementation of photocatalyst, PIRC aims to realize 1) energy-saving and eco-friendly society, 2) safe, secure and healthy society, and 3) comfortable space.

Figure 1 Board of PIRC as Joint Usage/Research Center

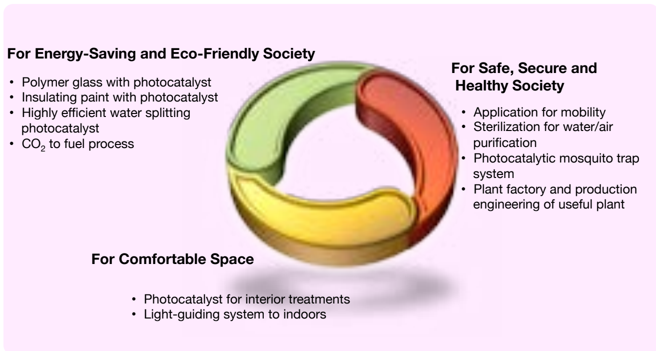


Figure 2 Researches at PIRC

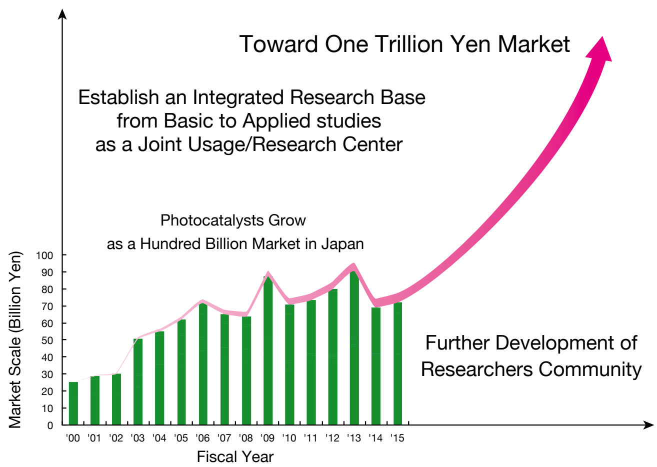


Figure 3 Goal of PIRC

Rist Organization Chart

Chairman of the Board of Governors

President

Organization for Research Advancement

Research Institute for Science & Technology

Research Institute for Science & Technology

Research Institute for Science & Technology Steering Committee

Research Divisions

- Division of Mathematical Modeling and its Mathematical Analysis
- 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
- Atmospheric Science Research Division
- Division of Super Distributed Intelligent Systems
- Brain Interdisciplinary Research Division
- Division of Intelligent System Engineering
- Advanced Agricultural Energy Science and Technology Research Division
- Division of Modern Algebra and Cooperation with Engineering
- Research Division of Multiscale Interfacial Thermofluid Dynamics
- Division of Nanocarbon Research
- Division of Colloid and Interface Science
- Chemical Biology Division Supported by Practical Organic Synthesis
- CAE Advanced Composite Materials and Structures Research Division
- Academic Detailing Database Division
- Division of Nucleic Acid Drug Development
- Division of Advanced Urbanism and Architecture
- Division of Synthetic Biology

Research Centers

- Center for Fire Science and Technology
- IR FEL Research Center
- Photocatalysis International Research Center
- Imaging Frontier Center
- Water Frontier Science & Technology Research Center
- Research Center for Space Colony
- Center for Animal Disease Models

Joint Usage / Research Center

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

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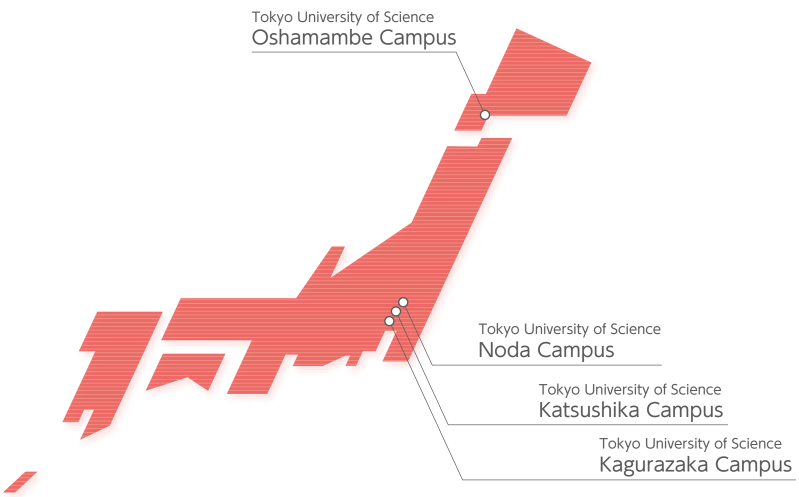
Campus Map



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