科学技術創成研究院
Institute of Innovative Research

東京工業大学
Tokyo Institute of Technology

Institute of Innovative Research

Director-General's Message

It is a great honor for me, as well as a big responsibility, to have been appointed as the director-general of the Institute of Innovative Research (IIR) on April 1, 2018.

It has been two years since the Institute of Innovative Research (IIR) launched. Tokyo Institute of Technology reorganized its research structure on April 1, 2016 and launched IIR involving about 180 faculty members to create innovative research in emerging and interdisciplinary research fields. The IIR consists of four research laboratories for new missions, two research centers, and research units, which will conduct cutting-edge research in small teams.

Since its inception in 2016, IIR has conducted various activities to advance its mission of creating new research fields, promoting interdisciplinary research, formulating solutions for pressing societal problems, strengthening collaboration with industry, and developing industrial infrastructures. Expectations are high regarding IIR's contributions to societal and industrial innovation through the creation of new value from scientific and technological knowledge and the development of young scientists and engineers who will lead academia and industry in the future. The roughly 180 faculty members who make up the research laboratories, centers, and units on both Suzukakedai and Ookayama Campus carry out pioneering research in a wide range of fields including life science, materials, energy, information technology, machinery, and disaster prevention. While these talents enjoy the intellectual space to engage in creative, divergent thinking, all components of IIR collaborate organically to create new knowledge and maximize their collective impact on society.

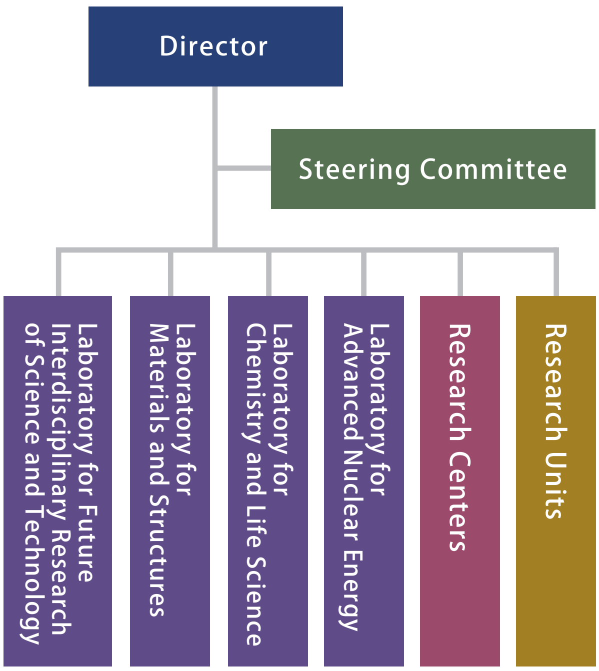
Tokyo Institute of Technology was selected as a Designated National University by Japanese Minister of Education, Culture, Sports, Science and Technology (MEXT) on March 20, 2018 in recognition of its abilities to develop world-leading education and research activities. We will do our best to create innovative research and to contribute to the education of innovative young researchers and engineers. On behalf of all the members of IIR, I would like to appreciate your supports to our activities.

Tokyo Institute of Technology
Director-General,
Institute of Innovative Research

Professor
Fumio Koyama

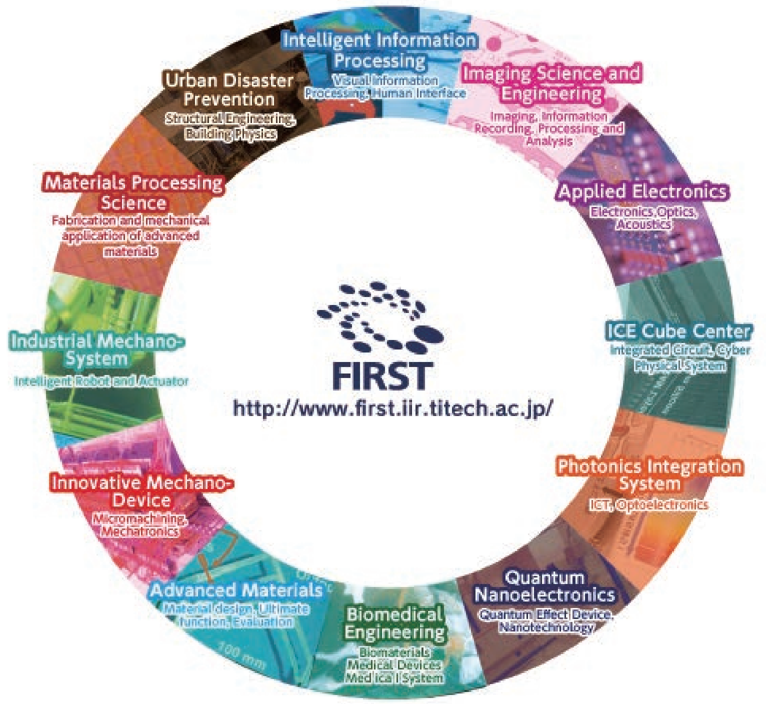
Outline

The mission of the Institute of Innovative Research (IIR) is twofold — to promote active cooperation within and beyond the organization by providing an open research environment, and to continuously improve this environment so that researchers can focus fully on their work and make the most of their abilities. By accomplishing this mission, IIR can create new research areas and new technologies that solve existing problems in society and lay the foundations of future industry. In the long run, IIR aims to become a world-leading innovation center.



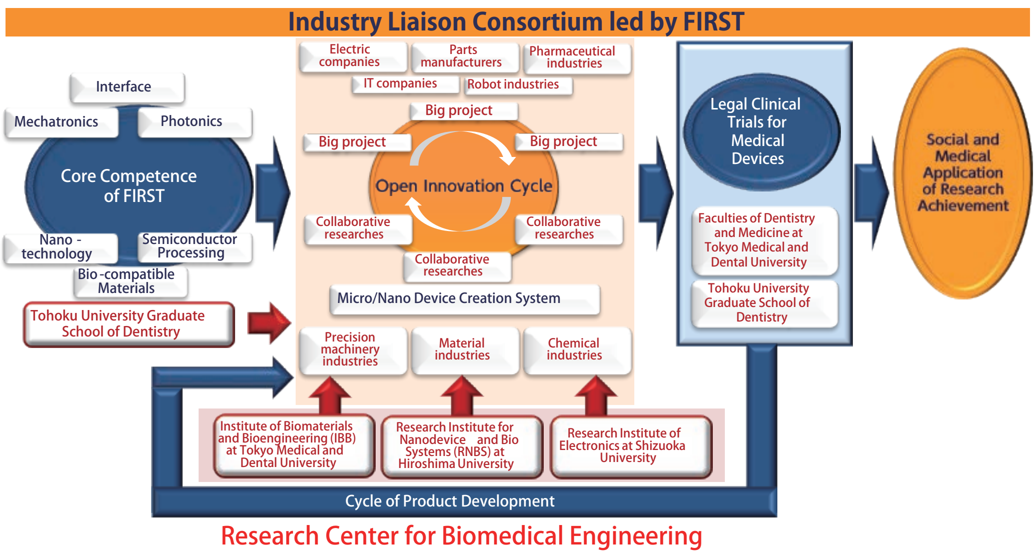
Laboratory for Future Interdisciplinary Research of Science and Technology

Through the integration of different fields, such as mechanical engineering, electrical and electronics engineering, metallurgy, information engineering, environmental engineering, disaster prevention engineering, social science, chemical engineering, and physical engineering, among others, we create new industrial technologies that are suitable for the present era and aim to contribute toward a more prosperous future for our society. By integrating multidisciplinary research fields, such as industrial sociology, economics, law, and humanities and sociology with a central core of science and engineering, we establish scientific technology aimed at creating new industrial technologies for the realization of a prosperous society.



Research Center for Biomedical Engineering

The Biomedical Engineering Research Center places its primary focus on providing an interdisciplinary network for researchers in the field of biomedical engineering, as authorized by Ministry of Education, Culture, Sports, Science and Technology. Being made up of four institutes, namely Laboratory for Future Interdisciplinary Research of Science and Technology (FIRST) at Tokyo Institute of Technology, Institute of Biomaterials and Bioengineering (IBB) at Tokyo Medical and Dental University, Research Institute for Nanodevice and Bio Systems (RNBS) at Hiroshima University, and Research Institute of Electronics at Shizuoka University, this research center utilizes the specialties of each research institute to enhance the functions of each university, promotes interdisciplinary collaboration with researchers of other national and international institutes, and contributes to the future improvement of medical service, health care system, and bioengineering fields, by widely applying interdisciplinary research achievements in society.



Laboratory for Future Interdisciplinary Research of Science and Technology

Intelligent Information Processing Research Core

Mathematical science and engineering of brain information processing, Human interface and virtual reality, Human olfactory interface, Natural language processing and computational linguistics, Artificial intelligence

Applied Electronics Research Core

Electron devices, Integrated system, Optical measurements, Ultrasonics, Plasma technology

Photonics Integration System Research Center

Ultrafast photonic network, New generation photonic sensing system, Optical wireless power transmission system, High speed, low power consumption, highly efficient photonic integrated devices and systems

Innovative Mechano-Device Research Core

Establishment of nano-fabricating technology, Creation of innovative actuators and sensors, Observation of comprehensive dynamic behavior for complex mechano-devices/systems

Industrial Mechano-System Research Core

Micro / Nano Mechatronics, Biomedical Engineering

Materials Processing Science Research Core

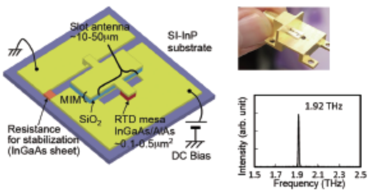
Fabrication of DLC films and functional carbon thin films, Classification and surface-designing of adamant thin films, Surface coatings to correspond to environmental preservation, Application of carbon materials to photovoltaic cells and microbial fuel cells, Precision and micro plastic forming

Advanced Materials Research Core

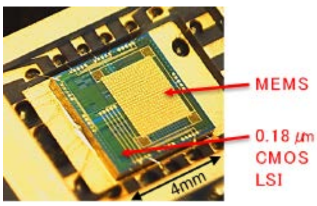
Metallurgy for industrial applications, Design, development and applications of innovative functional materials, Mechanics of Adhesive Joints, Mechanics of Composite Material, Solid Mechanics, Development, processing, evaluation and applications of nano-micro materials

Imaging Science and Engineering Research Center

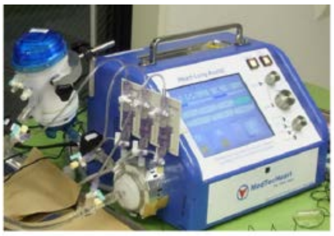
Spintronics, Integrated devices·Integrated circuits, Organic electronics, User Interface and Man-Machine Interaction, Image processing, Information Security, Artificial Intelligence



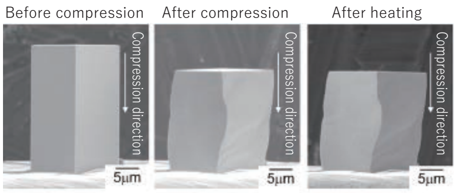
Terahertz Oscillatorarray



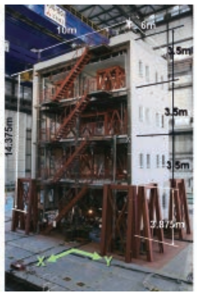
One-Chip Accelerometer



The figure above: Joint development of extracorporeal blood pump system with Tokyo Tech -TMDU originated venture "MedTech Heart"
The figure on the right: Joint development of a surgical robot system with Tokyo Tech originated venture RIVERFILED Inc.



Deformation behavior of novel biocompatible AuCuAl shape memory alloy evaluated by micro-material mechanical testing.
The micro-material testing machine and the materials were developed in this laboratory.



Full Scale Shaking Table Test of Steel Moment Resisting Frame

Quantum Nanoelectronics Research Center

Quantum effect devices, Nanotechnology

Urban Disaster Prevention Research Core

Earthquake Engineering, Passive Control Structures, Isolated Structures, Seismic Retrofit, Wind Engineering, Tsunami Resilient Structures, Optimization and Variational Methods

Advanced Loading and Real-scale Experimental Mechanics Laboratory

Real-scale loading experiment, Super-tall buildings & Civil mega-structures, Large base isolators & Large structural members

NuFlare Future Technology Laboratory

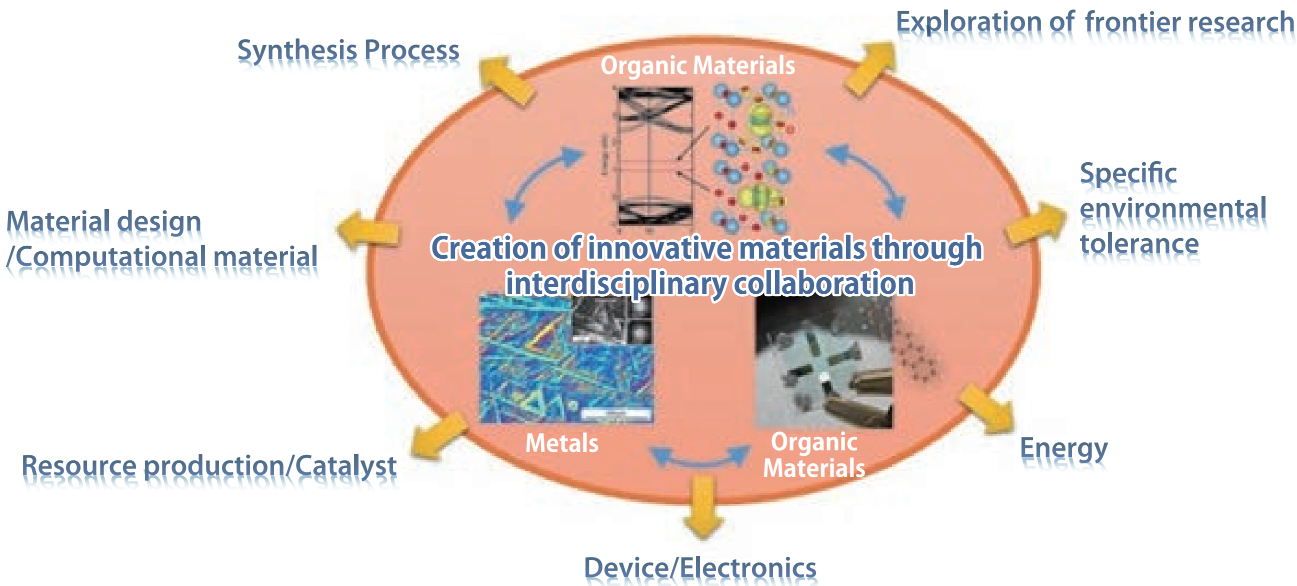
Advanced electron beam writer, Improvement of writing speed, Development of high-speed data transfer module, Advanced thin film deposition, Device physics and characterization, New materials for power devices

ICE Cube Center

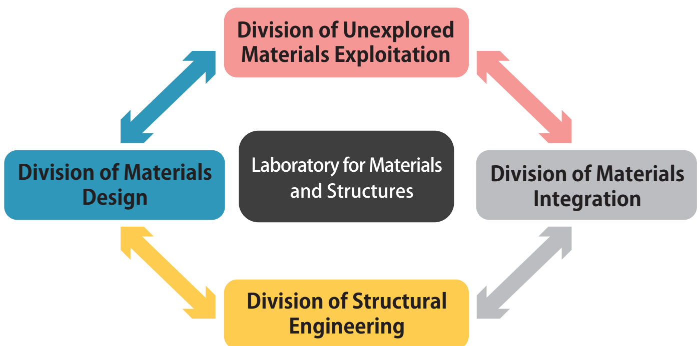
Integrated Circuit・RF CMOS Circuit, Wireless Sensor Network System, Platform for Integration with Diverse Functionalities, Integrated CMOS-MEMS Technology, Swarm Electronics, Cyber Physical System, Tera-Byte 3D Large Scale Integration, Bio-Platelets Generation Device, Ultra-Small Cooling Device, Delightful Agriculture

Laboratory for Materials and Structures

MSL aims to create innovative materials with conspicuous properties and functions via interdisciplinary materials science techniques and inorganic materials, metals, and organic materials.
The ultimate goals of our lab include the following:
a) development of innovative materials based on novel concepts, b) design of innovative materials in pursuit of original guiding principles based on underlying theories in materials science and different scientific fields, and c) contributions to the solution of social problems, including safety and environmental problems, through the application of innovative structures and materials.



MSL is developing interdisciplinary researches based on four divisions: Division of Unexplored Materials Exploitation, Division of Materials Design, Division of Materials Integration, and Division of Structural Engineering.



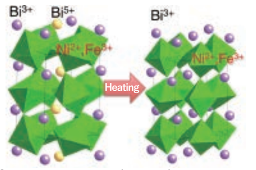
Joint Usage/Research Center

Laboratory for Materials and Structures (MSL) has been designated as the Joint Usage / Research Center for Advanced Inorganic Materials by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) since 2010. The Collaborative Research Projects (hereafter, "CRP") of MSL include the five different types of research and workshop.

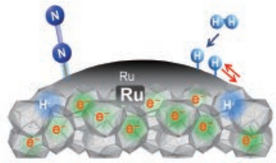
- International CRP: Research projects conducted by a team consisting of MSL faculties and researchers of foreign organizations using facilities, equipment, data, etc., available at MSL.
- General CRP : Research projects conducted by a team of MSL faculties and researchers of other organizaitons.
- Topic-Specified CRP: Research projects on specified topics coordinated by MSL faculties.
- International Workshop
- Workshop

Laboratory for Materials and Structures

Division of Unexplored Materials Exploitation



Giant Negative Thermal Expansion

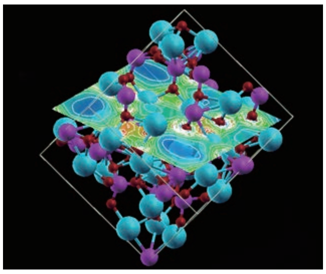


Highly active catalysis for ammonia production

The Division of Unexplored Materials Exploitation aims to create a series of materials with unexplored functions/phenomena and their novel guiding principles based on underlying theories in materials science and different scientific fields.

- Truly novel materials are created, such as electrical conductors, ion conductors, ferroelectric materials, magnetic materials, fluorescent materials, and catalysts for elucidation of mechanisms.
- Elucidation of mechanisms for novel physical phenomena is based on nano-structured magnetic materials and the exploitation of novel functions via their atomic-scale junctions.
- The realization of new functionalities occurs not by using noble elements but by using ubiquitous elements—i.e., “ubiquitous element strategy.”
- The exploitation of materials with novel photonic, electrical, magnetic, and chemical functions is caused by unique crystal structures.

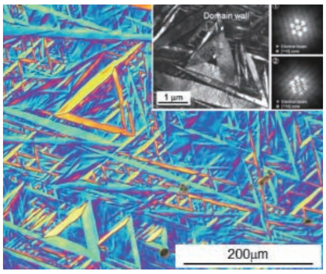
Division of Materials Design

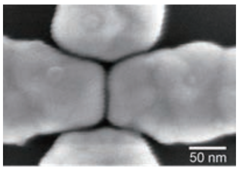


The Division of Materials Design aims to predict, design, and develop materials with novel functions through non-traditional approaches and elucidate mechanisms using high-level calculations, analyses, and syntheses.

- Materials design based on a combination of materials theory, calculations, and informatics, which is known as “Materials Informatics.”
- Design and development of novel functional materials based on advanced structure analyses including ultra high-speed time-resolved measurements, high-precision thermal measurements, and spectroscopic measurements.

Division of Materials Integration





The Division of Materials Integration aims to develop novel materials with superior functions via interdisciplinary materials science methods based on versatile inorganic, metal, and organic materials.

- Devics are developed based on novel materials and processes, including oxide electronics, nanoelectronics, and liquid crystal devices.
- Superior structural materials that are resistant to harsh environments are developed. These include shape memory, superelastic, thermal resistant, corrosion resistant, and abrasion resistant materials. Their basis includes inorganic, metal, organic, and polymer materials, and/or combinations of these.
- Novel energy materials that are developed are based on solar cells, rechargeable batteries, low-power semiconductors, and electrodes with low overpotential.
- Novel spintronic devices have their basis in solid-state physics; applications include electronic, optical, and medicinal system technologies.
- Ultimate design systems are established and crucial material functions are investigated for advanced mechanical motion systems.
- Innovative resource production is based on highly functional catalyst materials.

Division of Structural Engineering

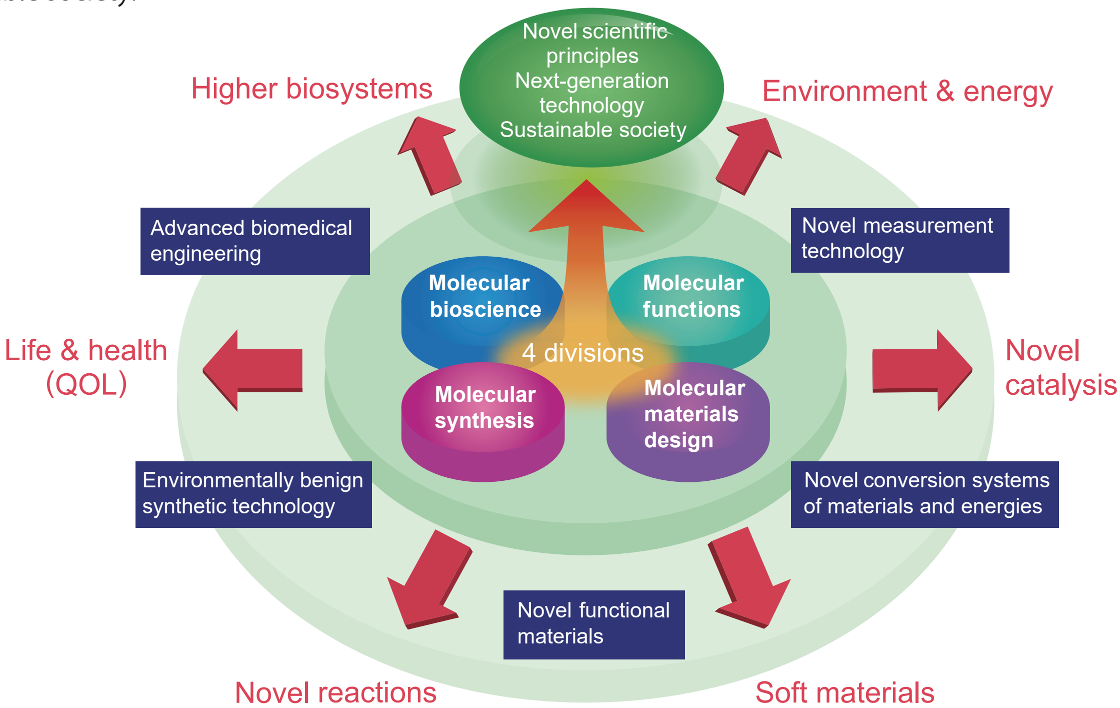

High-rise Isolated Building where Earthquake and Wind Observation are Carried out in Suzukakedai Campus

This division is specialized in earthquake, wind, and fire resistant engineering for structures of buildings and other constructions. The researchers perform extensive experimental and analytical studies addressing a wide range of subjects including material properties, members’ behavior, and structural performance. The topics of main interest are as follows:

- Mechanical characteristics of steel, concrete, and all other materials used in structures and protective systems to resist earthquakes, winds, and fire.
- Behavior of structural members such as beams, columns, walls, and braces, as well as protective devices including dampers and isolators.
- Performance of structures against strong and/or long duration vibrations caused by earthquakes and winds, as well as strength loss caused by fire.

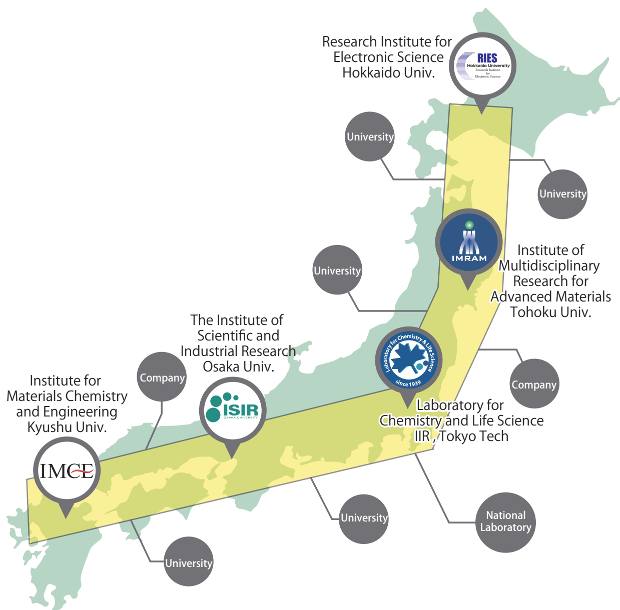
Laboratory for Chemistry and Life Science Institute of Innovative Research

At the Laboratory for Chemistry and Life Science, we conduct studies toward the formation of new perspectives on materials proposing new theories by gathering knowledge from both domestic and international networks. This is achieved through a research system consisting of various disciplines in chemistry based on molecular science, as well as four disciplines in life science: molecular bioscience, molecular functions, molecular synthesis, and molecular materials design. Through the creation of the next-generation scientific technology, we aim to contribute toward the evolution of advanced human civilization and the realization of a more prosperous and sustainable society.



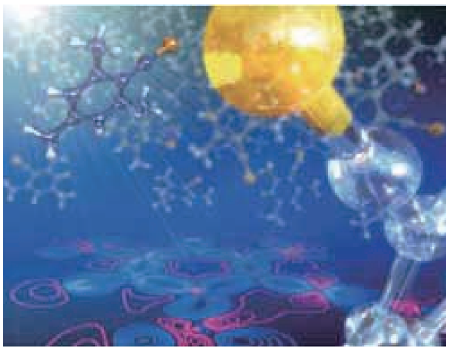
Network Joint Research Center for Materials and Devices

The Laboratory for Chemistry and Life Science, Tokyo Institute of Technology forms a joint research network with the Research Institute for Electronic Science, Hokkaido University, the Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, The Institute of Scientific and Industrial Research, Osaka University, and the Institute for Materials Chemistry and Engineering, Kyushu University. We conduct a wide range of joint research activities such as the synthesis of chemical substances, the fabrications of devices or the development of analytical instruments. Utilizing the characteristics of the network consisting of external researchers and researchers affiliated with the five research institutions, many collaborative studies are conducted every year, achieving excellent results. To strengthen this network, we have introduced a “CORE lab,” which is run by young researchers from other organizations, where they perform joint research with their host supervisors. Principal investigators selected through public recruitment carry out long-term integrated collaborative research.



Discipline of molecular materials design

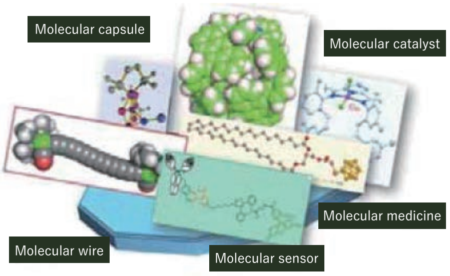
The properties and functions of materials are determined by the spatial arrangement of atoms and molecules that form these substances. In this discipline, with organic molecules and macromolecules as the target, we pioneer the methodology that aptly organizes such molecules to work toward the creation of novel materials that have better and new functions. The materials that can be easily deformed by thermal stresses or thermal fluctuations at about room temperature due to their softness and suppleness of the molecules are called soft materials. Depending on the design, it is possible to create substances that move like creatures. In this discipline, we capture the behavior of the molecules from both static and dynamic aspects; thus, we readily develop a new soft material by precisely regulating the molecular organization process and morphology in various levels from nano-scale to macroscopic scale. We aim to contribute toward the diverse scientific fields, such as information, transmission, energy, medicine, and environment, among others.



Creation of functional materials through the precise regulation of the molecular organization

Discipline of molecular synthesis

Molecules are fundamental components of a substance, and based on the diverse structures and sizes (e.g., molecular weight), they could express unlimited functions. In this discipline, we use our unique principle and methods to create novel molecules and cement the foundation required for the development of the expression of molecular functions. We target all the organic, inorganic, metallic complex, macro, and supramolecules to ultimately build a new molecular world by combining elements, bonds, and secondary structures.



Constructing molecular structures based on new concepts

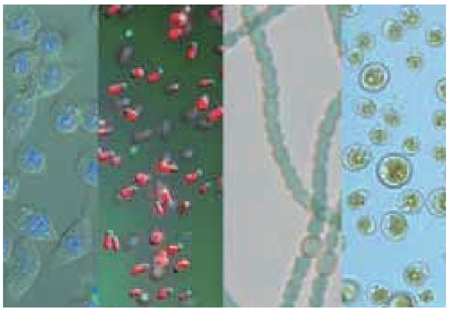
Discipline of molecular functions

The smallest unit of a substance is its molecules, and the macroscopic properties that we observe are regulated through the structures and reactions of the molecules. In this discipline, we study molecular functions using the latest analytical methods and advanced theoretical calculations to understand the properties of the molecules and molecular aggregates. Based on the understanding of molecular functions, we develop advanced materials, devices, fuel cells, and catalysts, among others to contribute toward the actualization of a prosperous and sustainable society.

Elucidation of molecular functions through a real-time tracking of chemical reactions

Discipline of molecular bioscience

The human body works as a combination of diverse chemical reactions involving molecules with elaborate structures that humans, after all, could scarcely fathom their complexity and how they regulate the body. In this discipline, we aim to understand the molecular mechanisms and regulatory mechanisms involved in various reactions occurring in living bodies, such as production and storage of energy, molecular recognition, and molecular motion, using chemical terminology. By integrating the obtained findings, we develop new technologies, such as clean energy and new disease diagnostic tools, to contribute to humanity.



Chemical understanding and application of diverse biological phenomena

Laboratory for Advanced Nuclear Energy

In addition to pursuing theories associated with nuclear power, we are leading the applied research in this field and aim to contribute toward its sustainable development globally. Along with conducting fundamental research to overcome energy problems, solving global environmental issues due to carbon dioxide emissions, and enabling the peaceful use of nuclear energy, we also promote mission-driven research in innovative nuclear systems, actinide management, global nuclear security, and advanced radiology. Furthermore, we will conduct studies on measures toward the recovery from the Fukushima nuclear accident, which is a major issue in Japan, including the decommissioning of nuclear reactors and environmental decontamination.

Our Objectives

We have been conducting research and education activities with a comprehensive mission of promoting " nuclear research for the protection of peaceful, safe, and secure lives and for the establishment of a prosperous society." Prior to this research institute, the nuclear engineering institute was set up in April 1956 with an objective of studying the theory and application of nuclear reactor engineering. It was promoted to the status of a university research institute in April 1964 and it has over 60 years of history. Despite its small scale, it has achieved many outstanding results in the field of nuclear power and applied radiation. During the second phase midterm target period (2010–2015), the research institute has promoted mission-driven research in the following areas: innovative nuclear power system research, actinide management research, global nuclear power security research, and advanced radiology, as well as basic and fundamental research in these four areas (Figure 1). The Laboratory for Advanced Nuclear Energy succeeded this. In addition, we began environmental decontamination efforts in response to the TEPCO Fukushima Daiichi Nuclear Power Plant accident that occurred due to the Great East Japan Earthquake on March 11, 2011, and we are working toward the rebuilding of Fukushima. This laboratory focuses on the fundamental research of nuclear power to solve energy and global environmental problems. We are a central research institution that explores the frontier of nuclear energy and aims to become a global collaboration base for nuclear power and radiation application in cooperation with the USA, Europe, post-Soviet states, and Southeast Asian nations, such as Indonesia, Vietnam, and Thailand. As a university research laboratory, educating the students is also an important mission for us.
The Graduate Course in Nuclear Engineering is an interdisciplinary course that spans across three schools (Engineering, Materials and Chemical Technology, and Environment and Society) and five departments (Mechanical Engineering, Electrical and Electronic Engineering, Materials Science and Engineering, Chemical

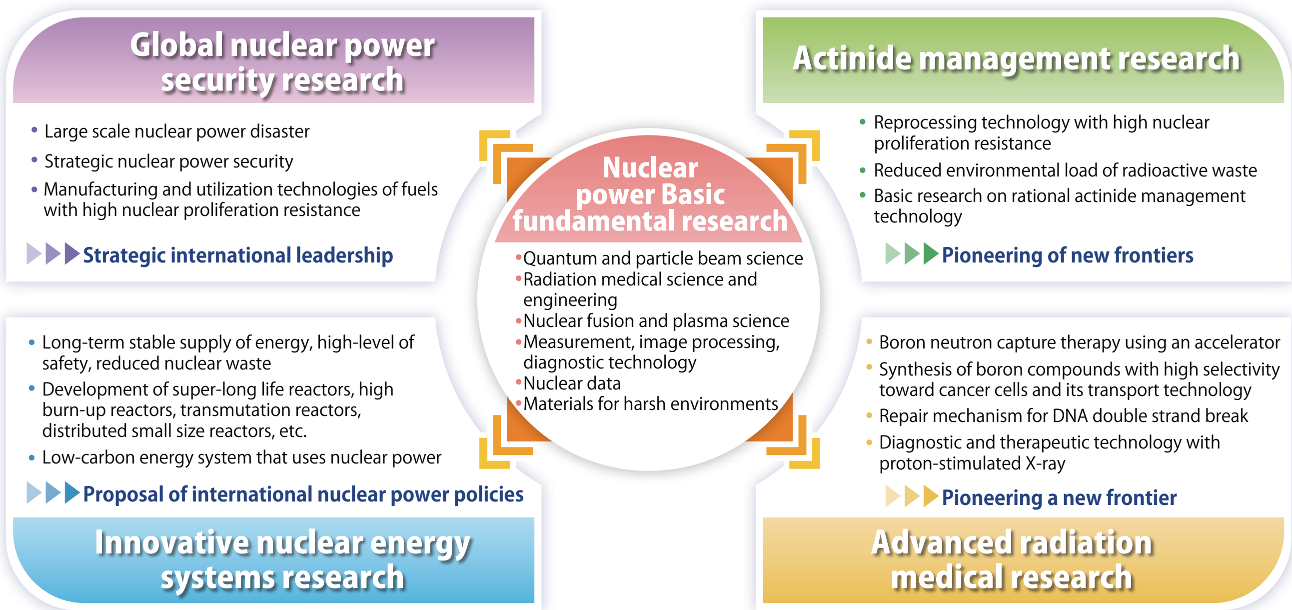


Figure 1. Structure of the research activities in our laboratory.

Science and Engineering, and Transdisciplinary Science and Engineering), and is managed by the teaching staff of this laboratory. We believe that this program provides the advanced education to nurture excellent students to continue building the next-generation society. The teaching staff conducts mission-driven and fundamental studies, as mentioned above, in the following five research areas:

Research on the Fukushima Nuclear Power Plant Accident

The Fukushima Daiichi Nuclear Power Plant Accident in March 2011 polluted the surrounding environment by releasing radioactive materials, leading to a significant loss of trust in the nuclear safety among the citizens. The Laboratory for Advanced Nuclear Energy is conducting various studies for an early recovery from the Fukushima Nuclear Power Plant accident.

① Recovery of radioactive cesium from contaminated soil and high volume reduction of waste

We are developing a recovery and solidification system, where the radioactive cesium is recovered from a large amount of contaminated soil around the Fukushima Prefecture using high-speed ion-exchange phenomenon in subcritical water and put through high volume reduction solidification to form a stable inorganic matter.

② Critical accident analysis of core meltdown

In the Fukushima Daiichi Nuclear Power Plant Units 1–3, the cores melted and a large portion of those cores are thought to have become fuel debris. By analyzing the phenomenon in which fuel debris has reached a critical level, and then quantitatively predicting emitted energy and radiation, we are elucidating measures that guarantee safety for the workers in the case of a criticality accident (Figure 2).

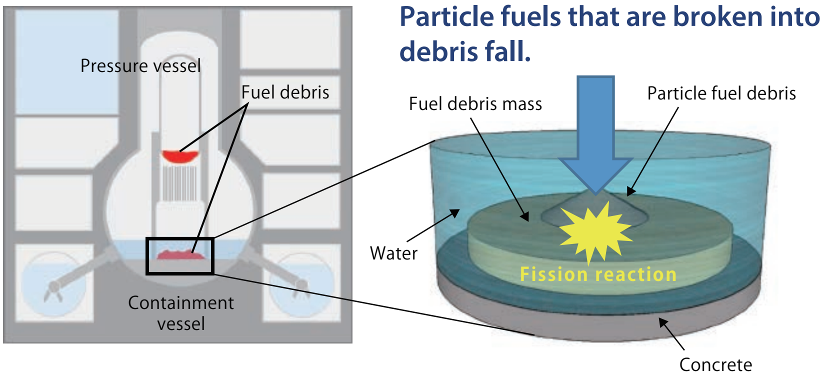


Figure 2. An example of a potential criticality accident.

③ Integration of robot transport and ultrasound sensor to understand the properties of debris

We are developing a fluid measurement technology that determines the leak locations in the containment and the pressure vessels by transporting an ultrasound sensor into the vessel using a robot. While the robot is acquiring the positional information, the properties of the debris are also obtained (Figure 3).

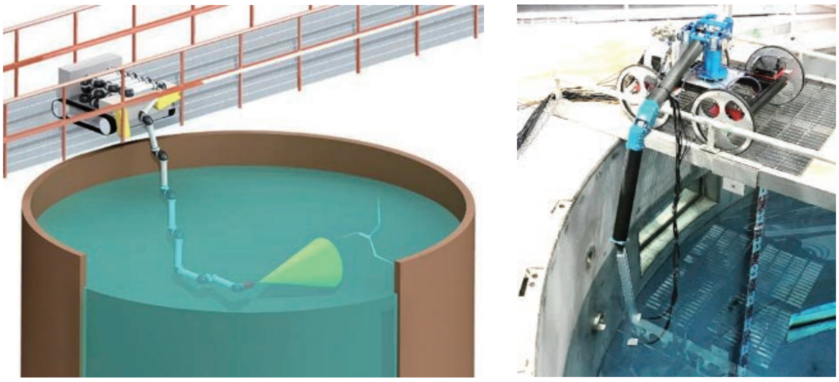


Figure 3. The ultrasound measurement system using a sensor-transporting robot.

International Research Center of Advanced Energy Systems for Sustainability

We aim to establish an advanced energy system that realizes the stable and environmentally-friendly use of energy while making use of existing social infrastructures associated with energy. Going beyond the framework of conventional university research, we establish an open innovation center for businesses, government, and municipalities to participate and create/promote research projects to find solutions for problems that the society and industries are facing. We aim to present solutions that will undoubtedly change the society and industries.

Center Director
Takao Kashiwagi

https://aes.ssr.titech.ac.jp/english/

To actualize open innovation, there are six joint research courses (please see the table) and a research promotion committee consisting of about 50 private businesses and 15 municipalities at the AES center. With these entities at the center, we advance research projects through collaborations with the teaching staff from both inside and outside the university, receiving support from the federal government and municipalities. In addition, to provide smooth progress and a sound foundation for these projects, we conduct platform activities promoting our work, such as organizing routine symposiums outside the university and seminars and training workshops for the AES members, among others.

Joint research courses

Courses	Joint research topics
ENEOS low-carbon energy system	Research and development of an integrated energy system to create a low-carbon society
N T T facilities smart energy network	A study on the next-generation energy network (smart energy network) in the community
Tokyo Gas smart energy network	A study on the smart energy network
Toshiba smart urban infrastructure system	Research and development of a complex solution to build a smart urban infrastructure
Mitsubishi Corporation Renewable energy	A study on the advanced use of renewable energy
Hitachi energy integrated control system	A study on integrated control of multiple energy sources including renewable energy

Advanced Research Center for Social Information Science and Technology

For all citizens to receive efficient and convenient government services and high-quality medical services, citizens must be able to obtain, confirm, and utilize information stored and managed by the government and medical organizations. Therefore, we conduct our studies with an objective of organizing a safe and secure system, where one can acquire, confirm, and use ones' own information (social information sharing platform). We aim to use this platform to actualize one-stop government services and life-long individual health management.

Center Director

Nagaaki Ohyama

asist.ssr.titech.ac.jp

Research topics at the Advanced Research Center for Social Information Science and Technology

Advanced Research Center for Social Information Science and Technology

① Research on the information sharing platform system

A study of a safe and secure social information sharing platform, where individual information managed by the government and medical institutions is acquired, confirmed, and utilized by the individual as needed.

② Research on the electronic administration

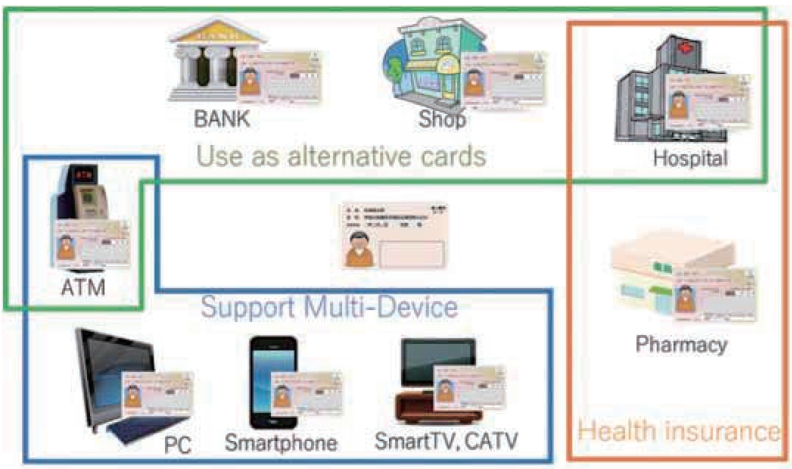
A study of the procurement manner of various government information systems that support electronic administration to eliminate some persistent problems such as poor cost-effectiveness and delayed updates

③ Research on the social security services

A study of the system that proposes utilization of life-long health and medical information with the prevention of lifestyle-related diseases, and allows for individuals to view, obtain, and use their health information through the Internet.

In addition, to introduce a highly public social information sharing platform, it is essential to promote, alongside research activities, system considerations and extensive collaborations among industries, government, and academia. In addition to academic research, this center works closely with the federal government and related ministries to advise on the policy planning to develop a system essential for such an end. The figure below shows the usage of the public identification service (Japanese Public Key infrastructure: JPKI), which we have been studying, as reflected in various current systems and policies. To promote the collaboration with industries, we conduct collaborative research projects with associated companies, as well as implementing international standardization activities through the International Organization for Standardization(ISO) with consideration for future international development.

A usage case of JPKI* implemented with My Number cards.



Tokyo Tech
Institute of Innovative Research

Cell Biology Center

Outline and the mission statement

Life is supported by the behavior of proteins stipulated by genetic information. The image of the cell, the basic unit of life, has significantly changed in recent years, and its dynamic existence is being shown in various aspects.

The Cell Biology Center has gathered associated researchers both from inside and outside the university with Prof. Dr. Yoshinori Osumi, a global leader of cell biology as the center director. Our research center forges the actualization of an unprecedented “cell” research consortium. At this center, we advance the understanding of cells by establishing the fundamental technology to visualize, analyze, and create/heal/manipulate the molecular functions from the expression and recombination of genes to the synthesis, modification, and decomposition of proteins and their cellular function dynamics. While conducting international advanced research in the elucidation of life phenomenon at the cellular level, we aim to significantly contribute toward the discovery of drugs and medical care based on cell research.

Center Director

Yoshinori Osumi

www.rcb.iir.titech.ac.jp

Research areas

While building a research system consisting of various principles of biological sciences, such as cell biology, molecular biology, biochemistry, and biophysics, we developed the next-generation cell research that integrates other fields, such as material science and information science, both within and outside the institution.

Specific efforts

(1) Visualization of cells: Visualization and analysis of the internal structure of cells and molecular behavior in cells using next-generation imaging.

(2) Analysis of cells: Molecular functional analysis of major life phenomena in cells.

(3) Creation, healing, and manipulation of cells: Completion of cell editing technology; Reconstruction of higher-order life phenomena.

Chaperone — Taguchi Lab

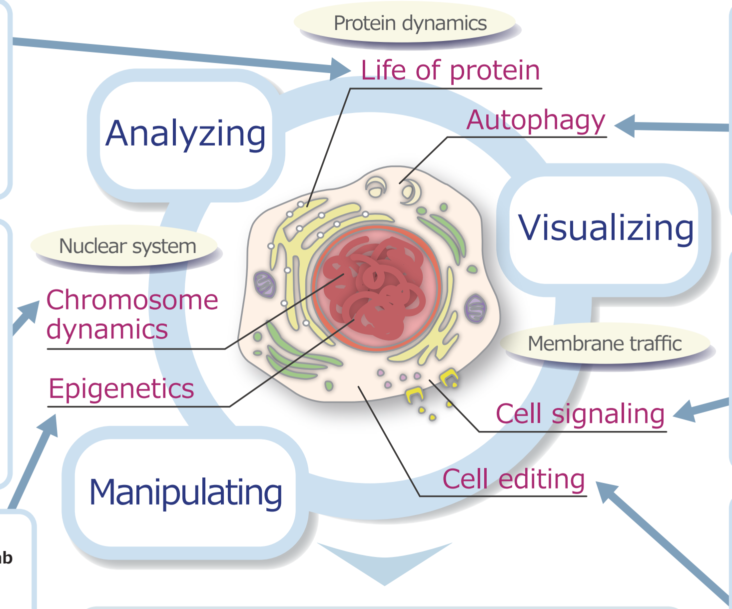
Elucidate how a newly synthesized protein (newborn chain) in the cells acquires its functions in the molecular mechanism through translation rate adjustment and chaperone research.

Chromosome dynamics — Iwasaki Lab

Chromosomes that store genes, the blueprint of cell functions, move dynamically within the nucleus depending on cell replication and DNA repair. The mechanism of temporal and spatial regulation of this chromosome dynamics is elucidated.

Epigenetics — Kimura Lab

After the transcription and translation of histones, imaging of the modified live cells and epigenome analysis are utilized to elucidate the dynamics of gene expression regulation associated with onset, differentiation, regeneration, and pathology.



- Elucidation of life phenomena at the cellular level
- Contribution of drug discovery and medical care based on cell research

Autophagy — Osumi Lab

Systematic and quantitative analyses of physiological functions of autophagy, selectivity of degradation substrate, decomposition process, and transport of the decomposed products to form a viewpoint of metabolic change using a yeast system.

Cell signaling — Komada Lab

Negative control of expression by decomposition of cell membrane protein and molecular mechanism of diseases onset due to the disorder is elucidated thus, contributing toward the understanding of cell functions and drug recovery/medical care.

Cell editing — Kano Lab

Combining cell editing technology by introducing molecules into cells and next-generation image analysis technology will elucidate the regulatory mechanism of cellular function of human iPS cells and establish a development platform for the production of new cells.

Global Hydrogen Energy Unit

Tokyo Tech Research Units

Overview

Hydrogen is important for global warming countermeasures and energy security. To introduce large-scale renewable energy with high fluctuation, it is necessary to use hydrogen, which is suitable for transportation and storage. In Japan and overseas, many projects are rapidly underway, focusing on topics such as the transportation of renewable energy through conversion to hydrogen (P2G), the building of an international hydrogen supply chain, the development of highly efficient hydrogen power generation, and designing systems for the development of a hydrogen society. Toward a hydrogen society, we are promoting research to solve various problems in a multifaceted, objective, and scientific way, based on collaboration between industries, government, and academia centered around this university, as well as collaborative research with the international community.

Research Unit Leader **Ken Okazaki**

Profile

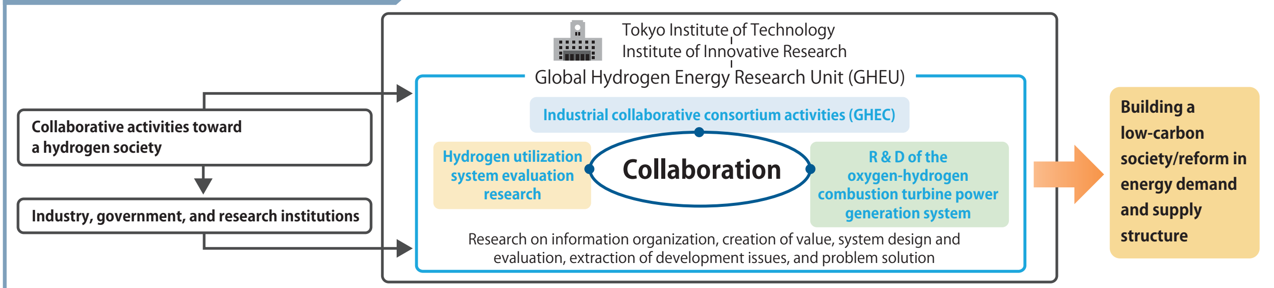
2015 Institute Professor (Professor Emeritus), Tokyo Institute of Technology
2007-2011 Dean, Graduate School of Engineering, Tokyo Institute of Technology
2000 Professor, Department of Mechanical and Control Engineering, Graduate School of Science and Engineering, Tokyo Institute of Technology
1998 Professor, Department of Mechanical Engineering and Science, School of Engineering, Tokyo Institute of Technology
1992 Professor, Tokyo Institute of Technology
1984 Associate Professor, Toyohashi University of Technology
1980 Lecturer, Toyohashi University of Technology
1978 Assistant Professor, Toyohashi University of Technology
1978 Doctor of Engineering, Department of Mechanical Engineering, Graduate School of Science and Engineering, Tokyo Institute of Technology
1973 Bachelor of Engineering, Department of Mechanical Engineering, School of Engineering, Tokyo Institute of Technology

WEB http://www.ghe.iir.titech.ac.jp/index-e.html

Research goals

Hydrogen society is defined as “a society that uses hydrogen and hydrogen utilization technology is distributed and expanded, and as an energy to support industrial foundation, where about 20% or more of all energy consumption uses hydrogen as a secondary energy, with sufficiently quantitative contribution toward energy security and global environmental conservation” (Okazaki, 2016). The following three projects are the focus of our research activities to achieve this goal. 1) “Global Hydrogen Energy Consortium (GHEC)” aims to nurture the collaborations among industries, government, and academia to solve problems toward the hydrogen society, such as related technologies and systems centered on the global hydrogen energy. 2) “Research and development of oxygen-hydrogen combustion turbine power generation system” focuses on the study of hydrogen power generation as a commissioned project of NEDO to lead the research and development projects such as hydrogen utilization (since 2018). We are engaged in the research and development of a closed-cycle gas turbine system that is expected as an ultrahigh-efficiency power generation system beyond the existing open-cycle gas turbine. 3) “Hydrogen utilization system evaluation research” conducts analysis and evaluation including the overall supply chain by the full-scale introduction of hydrogen, and predicts the future social and industrial trends based on theory as “total system introduction scenario survey” (2016–2017+, a NEDO commissioned project). By integrating these results, we presented a technology development scenario. To further develop this technological development scenario, we continue to extend the scope of this study.
We aim to contribute to society by promoting these projects through collaboration between research institutions and industries in Japan and overseas.

Toward a hydrogen society



Advanced Data Analysis and Modeling Unit

Tokyo Tech Research Units

Overview

The accelerated increase in the level of information this century has seen the generation of a greater amount of big data on human behavior than ever before. The Advanced Data Analysis and Modeling Unit utilizes big data owned by public and private entities in an integrated manner to clarify phenomena in human society from a scientific viewpoint. The unit attempts to express changes in society through equations applying both mathematics and physics. Expansion in this field of research will make possible the prediction of future conditions in economic and social systems in much the same way we now forecast weather utilizing airflow equations.

Research Unit Leader **Misako Takayasu**

Profile

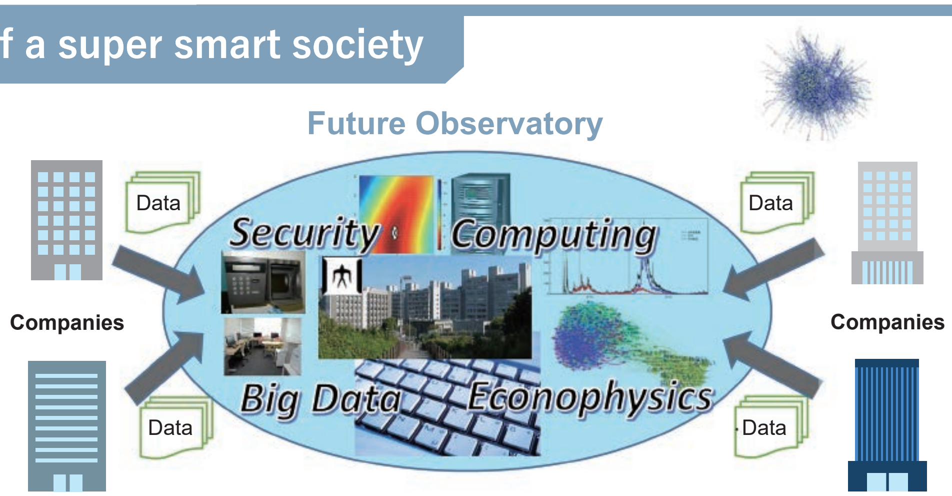
- 2017 Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2016 Associate Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2015 Associate member, Science Council of Japan (Committee on Physics and Informatics)
- 2007 Associate Professor, Department of Computational Intelligence and Systems Science, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology
- 2000 Assistant Professor, Department of Complex and Intelligent Systems, Future University Hakodate
- 1997 Assistant Professor, Faculty of Science and Technology, Keio University
- 1993 JSPS Research Fellow, Tohoku University
- 1993 Doctor of Science, Department of Material Science, Graduate School of Science and Technology, Kobe University
- 1987 Bachelor of Science, Department of Physics, School of Science, Nagoya University

WEB www.adam.iir.titech.ac.jp

Research goals

Transactions in financial markets are made in milliseconds, and the amount of data collected in real time is now one million times greater than it was 20 years ago. It is now also possible to scientifically formularize how violent fluctuations in prices occur and how these affect other markets, which we do in much the same way as we write molecular formulas based on detailed observation. The Advanced Data Analysis and Modeling Unit attempts to analyze big data in a wide range of fields, including financial markets, to create descriptive mathematical models. This makes it possible to understand individual research conducted in different fields in an integrated manner. Through the Future Observatory, which will be established to store big data and serve as a base for scientific research, the unit attempts to precisely simulate future conditions to solve a wide range of problems encountered in society to gain a multilateral understanding of phenomena in economics and human society.

Needs of a super smart society



Creating added value in society through cutting-edge integration of big data

Advanced Computational Drug Discovery Unit

Overview

Molecular simulation is a method of calculating molecular activity to analyze the physical and chemical properties of compounds used in innovative drug discovery. Bioinformatics and systems biology are applied to analyze biological data using information-science methodologies such as artificial intelligence, bigdata analysis and machine learning. Integrating these methods, the Advanced Computational Drug Discovery Unit (ACDD) develops in silico technology for innovative drug discovery from an academic point of view through large-scale GPU computation using the TSUBAME supercomputer. Utilizing and complementing biochemical research conducted by pharmaceutical companies, the unit aims to establish methods of innovative drug discovery through open innovation with industries.

Research goals

It is essential for future innovative drug discovery to develop ideas and methods that facilitate beneficial collaboration between universities and corporations. ACDD sets the goal of realizing open innovation and aims to realize the establishment of an open drug discovery environment within five years. The unit will establish an advanced computational drug discovery model while focusing on the following three themes:

- Open utilization of the drug discovery environment by Tokyo Tech and pharmaceutical companies
- Establishment of an open-participation type in silico drug discovery contest
- Provision of education for industry professionals through the *in silico* drug discovery training program

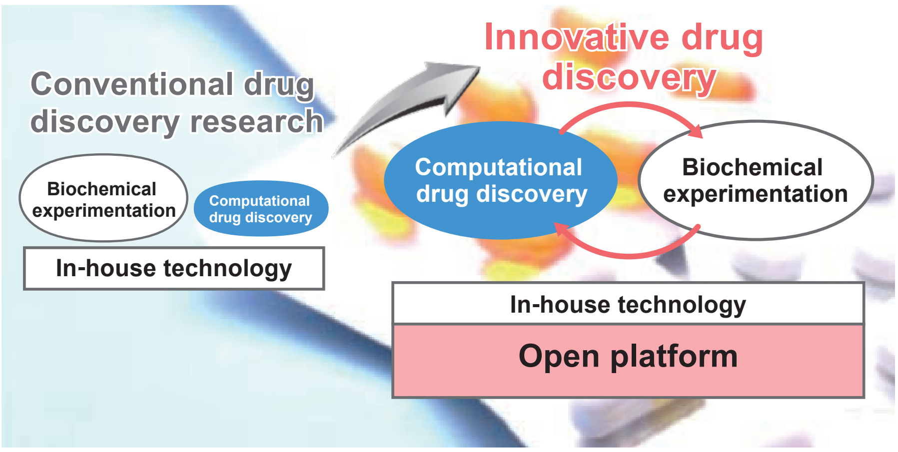
Research Unit Leader **Masakazu Sekijima**

Profile

2016 Associate Professor, Institute of Innovative Research, Tokyo Institute of Technology
2009 Associate Professor, Global Scientific Information and Computing Center, Tokyo Institute of Technology
2008 Planning Officer, Planning Headquarters, National Institute of Advanced Industrial Science and Technology
2003 Research Scientist, Computational Biology Research Center, National Institute of Advanced Industrial Science and Technology
2002 Research Staff, Computational Biology Research Center, National Institute of Advanced Industrial Science and Technology
2002 Ph.D., Department of Biotechnology, Graduate School of Agricultural and Life Sciences, University of Tokyo

WEB www.bio.gsic.titech.ac.jp/acdd/

Advanced Computational Drug Discovery Unit



A new Tokyo Tech research unit aiming to form an open platform for experimental studies on innovative drug discovery through integration of computational technology and experimental biochemistry

Hybrid Materials Unit

Tokyo Tech Research Units

Overview

Nanoparticles, measured in units of one billionth of a meter, are extensively applied in engineering. However, we have yet to fully clarify the properties of sub-nanoparticles, particles that are even smaller than nanoparticles. This has hindered the development of synthesis methods. It is expected that if we can freely structure sub-nanoparticles by programming the number of atoms in them and the compounding ratio of constituent elements, then we can create substances with properties that are completely different from what we have now. Specifically, there is no known method for integration and combination of atoms of different metallic elements. Considering the more than 90 metallic elements in the periodic table of elements, the potential combinations are infinite. The Hybrid Materials Unit aims to create new materials using a highly precise hybrid method of blending metallic elements utilizing uniquely developed dendritic polymers (dendrimers) with the goal of opening the door to a new field that will serve as the base for next-generation functional materials.

Research Unit Leader

Kimihisa Yamamoto

Profile

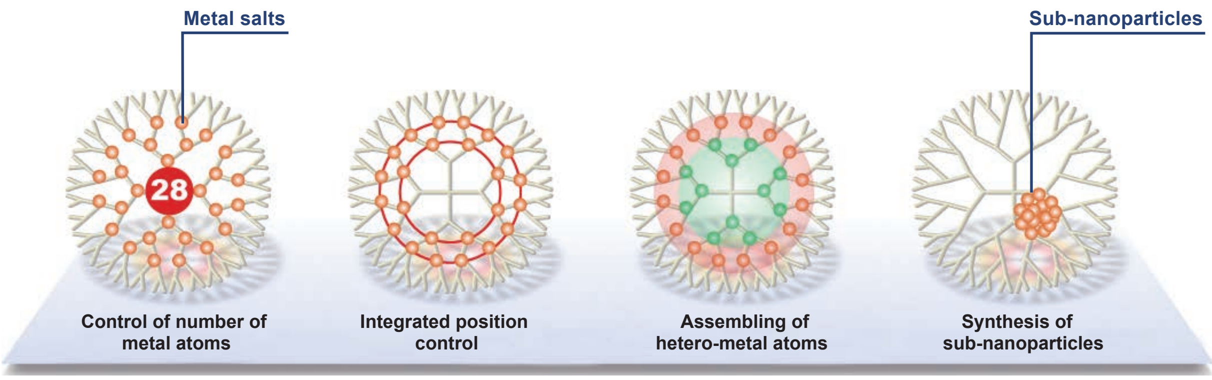
- 2016 Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2010 Professor, Chemical Resources Laboratory, Tokyo Institute of Technology
- 2002 Professor, Faculty of Science and Technology, Keio University
- 1997 Associate Professor, Faculty of Science and Technology, Keio University
- 1990 Doctor of Engineering, Graduate School of Science and Engineering, Waseda University
- 1989 Research Associate, School of Science and Engineering, Waseda University
- 1985 Bachelor of Engineering, Department of Applied Chemistry, School of Science and Engineering, Waseda University

WEB www.res.titech.ac.jp/~inorg/yamamoto/member/yamamoto/

Research goals

Dendrimers have a three-dimensional structure with internal voids like the spaces between the branches of a tree. They are high-molecule structures with regular geometrical shapes and potential gradient. In the past, metallic sub-nanoparticles were thought to have been randomly arranged. However, the Hybrid Materials Unit was the first to discover that dendrimers have a stepwise complexation that extends from their inner to outer layers. The unit also established a method of synthesis that allows flexible and accurate control of the number, arrangement, ratio, and order of similar and dissimilar elements. The unit calls this the atom hybrid method. By applying this method, the Hybrid Materials Unit aims to produce new materials that are beyond our imagination, clarify their properties, and discover the number of atoms and correlations with different types of elements. The unit also aims to systematize new materials and create a next-generation material library leading to the future design of materials.

Atom hybrid method

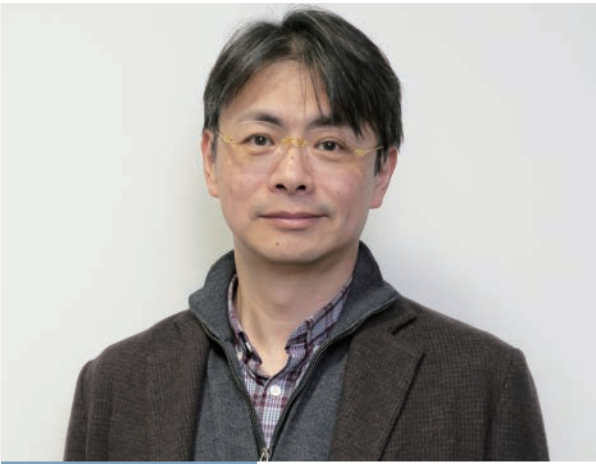


Tokyo Tech Research Units

Biointerfaces Unit

Overview

The Biointerfaces Unit focuses on mechanisms by which information sent from our brain moves our body, and develops technology that enables brainwaves to control machines and devices. The unit also develops technology capable of assessing the condition of organs such as the liver, kidneys, and brain to promote health and enable the early detection of disease. Utilizing sensors that noninvasively assess the condition of the brain and other organs, the unit develops biointerfaces that control devices using collected biological signals. The goal of the unit is to utilize biointerfaces not only for the benefit of the elderly and disabled, but also for a wide range of purposes including the development of equipment designed to maintain health in daily life.



Research Unit Leader **Yasuharu Koike**

Profile

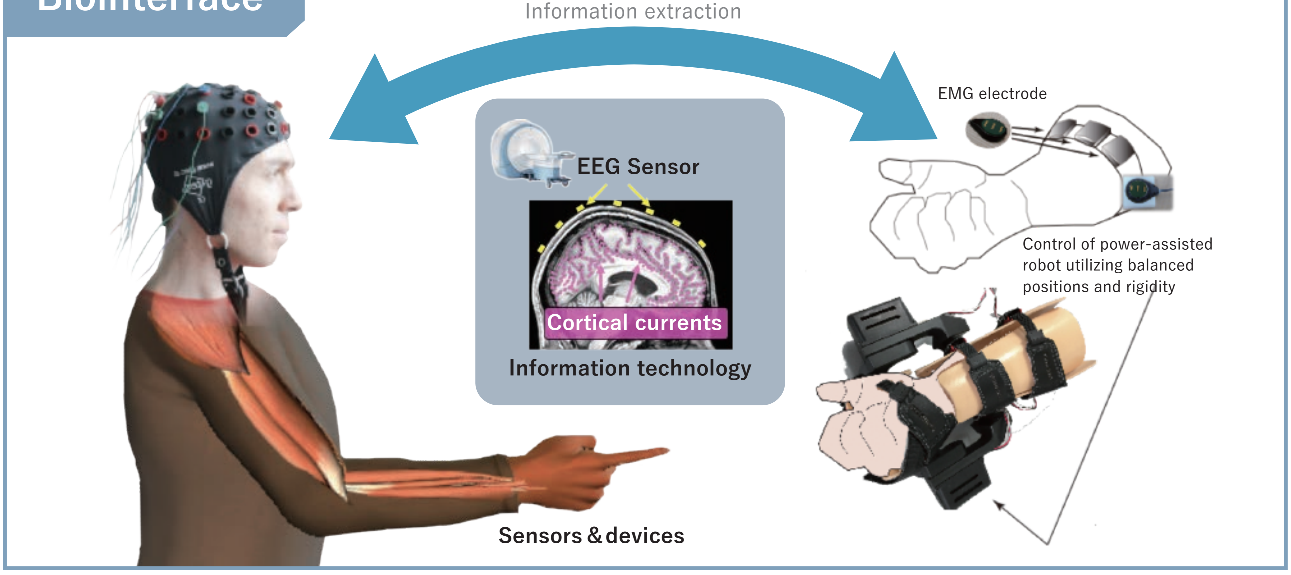
2016 Professor, Institute of Innovative Research, Tokyo Institute of Technology
2009 Professor, Precision and Intelligence Laboratory, Tokyo Institute of Technology
1998 Associate Professor, Tokyo Institute of Technology
1995 Toyota Motor Corporation
1992 Researcher, Advanced Telecommunications Research Institute International
1989 Toyota Motor Corporation
1989 Master of Engineering, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology
1987 Bachelor of Engineering, School of Engineering, Tokyo Institute of Technology

WEB www.cns.pi.titech.ac.jp/kylab/

Research goals

The Biointerfaces Unit aims to clarify the mechanisms of hand and foot movements via signals from the brain utilizing brain waves and electromyograms, develop prosthetic arms and hands that can be moved by brain activity alone, and apply this technology to rehabilitation of individuals suffering from limb paralysis due to strokes and other diseases. The unit also plans to develop mobile devices that can noninvasively detect internal conditions from outside of the body. These include the condition of the liver and bladder, and other biological information such as blood and breathing to be used in the prevention of disease. By bringing together such technologies, the unit conducts research and development for wearable devices capable of monitoring health.

Biointerface



Innovative Heterogeneous Catalysis Unit

Tokyo Tech Research Units

Overview

The Innovative Heterogeneous Catalysis Unit aims to develop and commercialize innovative catalysts that surpass existing concepts. Catalysts are used to accelerate chemical reactions when synthesizing compounds from ingredients, and have supported industrialization in the form of food and petrochemical production. Still, new catalysts must be developed and improved to preserve natural and other scarce resources, and to prevent environmental pollution. The unit sets the goal of developing and realizing mass production of environmentally friendly solid catalysts.

Research Unit Leader **Michikazu Hara**

Profile

2016 Professor, Institute of Innovative Research, Tokyo Institute of Technology
2006 Professor, Materials and Structures Laboratory, Tokyo Institute of Technology
2000 Associate Professor, Chemical Resources Laboratory, Tokyo Institute of Technology
1999 Postdoctoral fellow, Pennsylvania State University
1995 Assistant Professor, Chemical Resources Laboratory, Tokyo Institute of Technology
1992 Corporate Research and Development Center, Toshiba
1992 Doctor of Science, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology

WEB www.msl.titech.ac.jp/~hara/

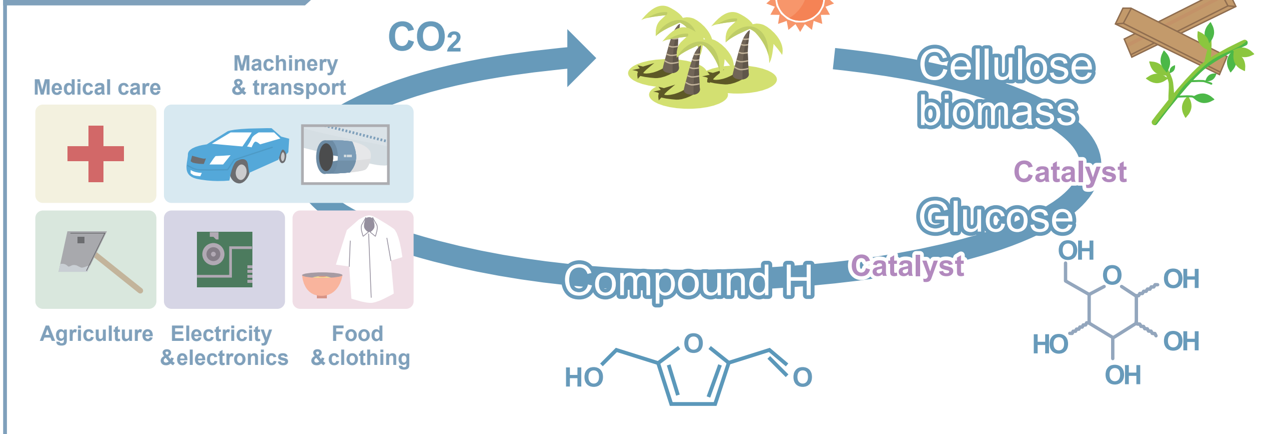
Research goals

To replace petroleum as an ingredient in a broad range of products, the Innovative Heterogeneous Catalysis Unit aims to develop catalyst technology capable of producing glucose from organic resources made from biomass such as weeds, waste wood, and inedible parts of plants, and converting the glucose to a wide range of chemical resources. The unit aims to secure resources that serve as alternatives to petroleum while reducing CO_2 emissions.

In addition, the Innovative Heterogeneous Catalysis Unit also works on improving the efficiency and commercialization of new electride catalysts produced from ammonia, catalysts discovered in joint research with Professor Hideo Hosono at the Materials Research Center for Element Strategy. These new catalysts can be produced at atmospheric pressures and temperatures lower than those required for the Haber-Bosch process. Requiring only half the energy compared to conventional methods, the unit is looking to implement downsized plants for electride catalysts in ammonia synthesis that can be operated in developing countries and countries without adequate infrastructure.

The Innovative Heterogeneous Catalysis Unit is also promoting the development of new solid catalysts and research to clarify their mechanisms.

New biomass



Advanced Nuclear Fuel Cycle Unit

Overview

In order to realize sustainable nuclear power generation, we develop advanced technologies to process and dispose high-level radioactive waste (HLW) and aim to establish a highly safe and low-emission ; environmental preservation-type nuclear fuel cycle that dramatically reduces the environmental load and radiation risk due to radioactive waste. Additionally, to overcome the aftermath of the Fukushima Nuclear Power Plant Accident, we develop technologies to remove radioactive substances from the contaminated soil and water. Furthermore, we propose options for methods of processing contaminated water and prepare scenarios for consensus to solve the problems of the disposal of radioactive wastes through discussions with the stakeholders include citizens (Fig.1-1).

Research Unit Leader **Kenji Takeshita**

Profile

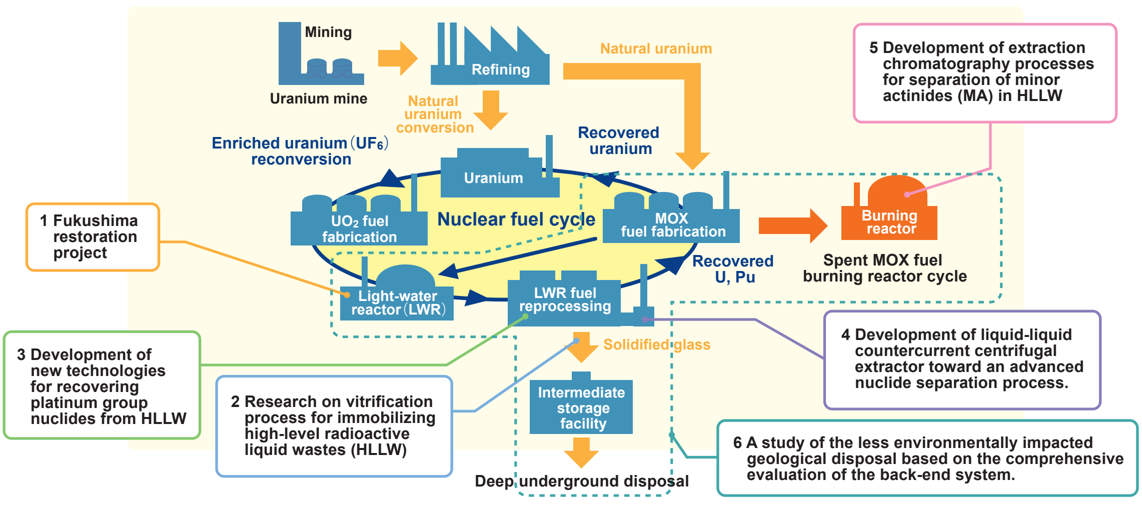
- 2018 Director and Professor, Laboratory for Advanced Nuclear Energy, Tokyo Institute of Technology
- 2016 Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2010 Professor, Research Laboratory for Nuclear Reactors, Tokyo Institute of Technology
- 1996 Associate Professor, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology
- 1992 Chief Researcher, Institute of Research and Innovation
- 1987 Researcher, Institute of Research and Innovation
- 1987 Doctor of Engineering, Department of Nuclear Engineering, Graduate School of Science and Engineering, Tokyo Institute of Technology

WEB www.anfc.iir.titech.ac.jp

Research goals

We are researching and developing the advanced glass body solidified HLW of spent nuclear fuel, stored in an intermediate storage facility for lowering the waste heat amount and buried underground as final disposal (Fig.1-2). At the same time, we are developing the pretreatment technology of vitrification process to recover and separate platinum group nuclides from HLW that generate a large number of solidified glasses (Fig.1-3). We are also designing a centrifugal extractor for separating cesium (Cs) and strontium (Sr) that lower the storage efficiency of solidified glasses (Fig.1-4). We set a goal to develop, scale up and demonstrate these technologies in 5 years, and then put into practical use.
In addition, by separating minor actinides (MA: trans-uranium elements other than plutonium) from HLW, and mixing them with nuclear fuel, the radio toxicity of the waste can be significantly reduced. We develop such MA separation technology, and it is possible in the future that the wastes except MA could be managed on the ground instead of being buried underground. From the viewpoint of future energy policy, we also conduct a study on the fast-breeder reactor cycle that aims to reduce the amount of wastes and improve the utilization rate of uranium and plutonium drastically (Fig.1-5). Furthermore, instead of focusing on the approach from upstream of nuclear fuel cycle to geological disposal of the spent nuclear fuel waste, we are conducting a study of the less environmentally impacted geological disposal based on a comprehensive evaluation of the back-end system (Fig.1-6).

Fig.1 Environmental preservation-type nuclear fuel cycle



Tokyo Tech Research Units

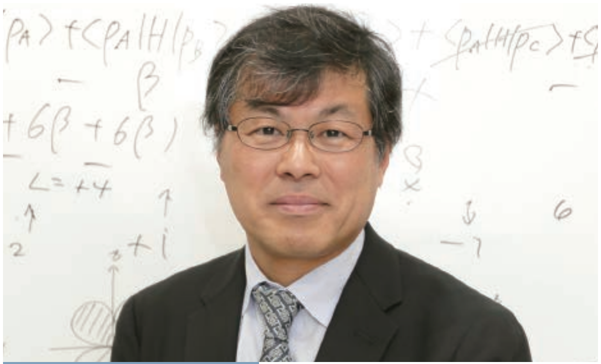
Clean Environment Unit

Overview

The Clean Environment Unit works on the real-time detection of airborne substances which cause environmental pollution. By understanding the distribution and severity of pollution, and by clarifying its causes, the unit aims to realize a clean environment. Specifically, it promotes research utilizing resonance-enhanced multiphoton ionization (REMPI), detecting and analyzing a wide range of hazardous substances such as PM 2.5 and automobile exhaust in the atmosphere. The unit also applies the technology to analysis of materials and promotes its use in material sciences. Based on its fundamental research findings, the Clean Environment Unit also develops and improves apparatus in which REMPI is employed.

Research goals

Identification of substances in the atmosphere requires complicated pretreatment such as separation by chromatography and concentration by solvent evaporation. However, REMPI makes it possible to ionize the substances to be identified by adjusting the wavelength of the laser light, enabling detection in real time. This is called resonance enhancement, which the unit can apply to the analysis of constituents of solid materials by vaporizing them with focused ion beams. The Clean Environment Unit further promotes fundamental research aiming to improve the sensitivity and resolution of REMPI. The unit also works on the commercialization of supersensitive solid material analysis apparatus utilizing REMPI for application in the analysis of radioactive elements in Fukushima, and material analysis of semiconductors and steel.



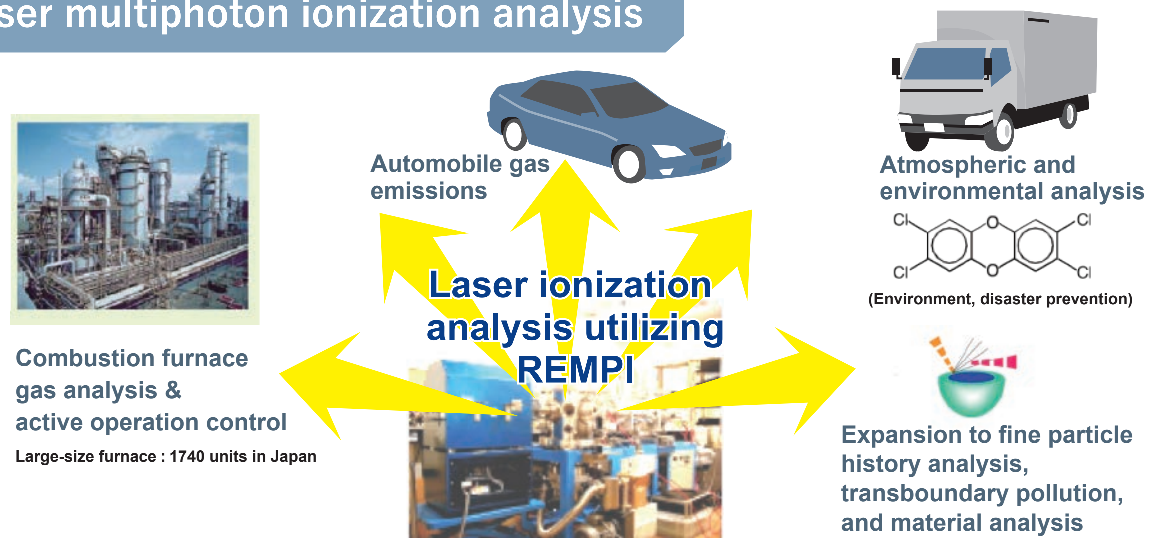
Research Unit Leader **Masaaki Fujii**

Profile

2016 Professor, Institute of Innovative Research, Tokyo Institute of Technology
2014 President of Japan Society for Molecular Science
2014 Trustee of the Spectroscopical Society of Japan (until present)
2003 Professor, Chemical Resources Laboratory, Tokyo Institute of Technology
1999 Director, Laser Research Center for Molecular Science, Institute for Molecular Science, Okazaki National Research Institutes
1997 Professor, Institute for Molecular Science, Okazaki National Research Institutes
1993 Associate Professor, Department of Chemistry, School of Science and Engineering, Waseda University
1993 Researcher, Precursory Research for Embryonic Science and Technology 21 (Light and Material area), Japan Science and Technology Agency
1988 Visiting scientist under US-Japan Collaboration on Solar Energy, Cornell University
1987 Doctor of Science, Tohoku University
1985 Research Associate, Department of Chemistry, Faculty of Science, Tohoku University
1985 Withdrew from doctoral degree program with full credits, Department of Chemistry, Graduate School of Science, Tohoku University
1982 Bachelor of Science, Department of Chemistry, Faculty of Science, Tohoku University

WEB www.csd.res.titech.ac.jp/indexj.html

Laser multiphoton ionization analysis



Nanospace Catalysis Unit

Tokyo Tech Research Units

Overview

In order to realize a low-carbon society, it is essential to reduce dependency on fossil fuels, utilize fossil resources more effectively, and reduce CO_2 emissions. The Nanospace Catalysis Unit aims to establish innovative production processes for nanospace catalysts and chemical substances utilizing diverse carbon resources. Nanospace catalysts have a number of super-fine pores (nanospaces) at the nanometer level in crystals. This unit focuses on the catalytic properties of zeolite,* one of the porous crystalline materials that controls the catalytic active site at the atomic level, and works to develop breakthrough catalysts that contribute to the realization of a low-carbon society.

*Zeolites are aluminosilicates with molecular-size pores in their crystal structures

Research Unit Leader **Toshiyuki Yokoi**

Profile

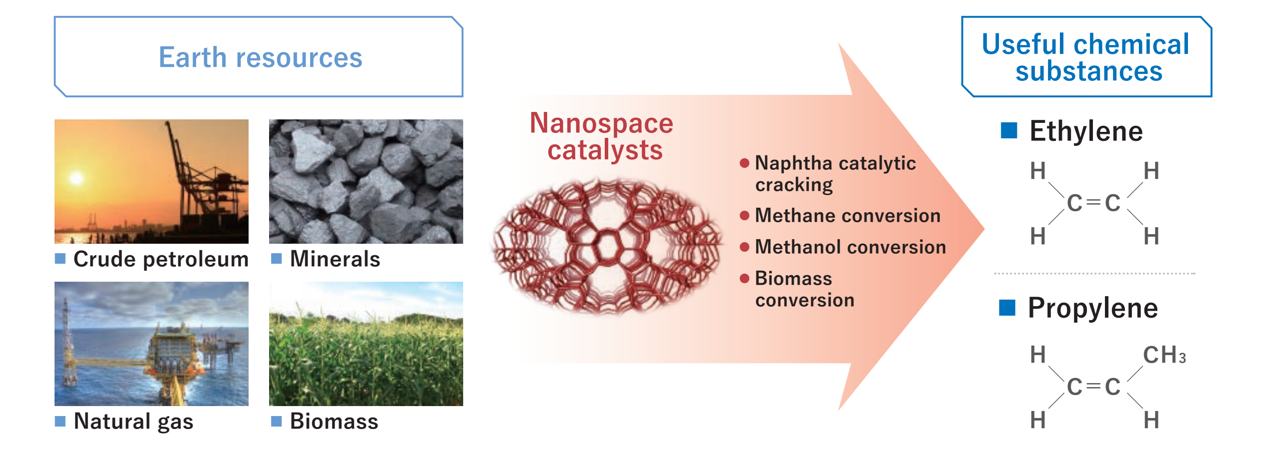
- 2018 Associate Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2016 Assistant Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2006 Assistant Professor, Chemical Resources Laboratory, Tokyo Institute of Technology
- 2004 Assistant Professor, Department of Chemical System Engineering, School of Engineering, University of Tokyo
- 2004 Doctor of Engineering, Department of Materials Science and Engineering, Yokohama National University

WEB www.nc.iir.titech.ac.jp

Research goals

The diameter of zeolite pores is one nanometer or less. Larger molecules cannot pass into these pores. Therefore, zeolite can select smaller molecules such as methane and methanol, and promote their chemical reactions. Utilizing the characteristics of zeolite, this unit places catalytic active sites in optimal positions in pores at the atomic level with the goal of establishing catalytic reaction processes designed to synthesize useful chemical substances such as methanol and ethylene from methane, which until now has only been used as a fuel, and to synthesize basic chemical substances such as ethylene and propylene from methanol obtained from CO_2 and water.

Innovative nanospace catalysts that produce useful chemical substances utilizing diverse carbon resources



All-Solid-State Battery Unit

Overview

Smart phones, tablets and other mobile devices have become essential to our daily lives, and the paradigm shift to electric vehicles is expanding globally. The traditional power source employed in these devices has been the lithium-ion battery, which contains a liquid electrolyte. However, safer, more compact, and higher-performing batteries are greatly sought after. The superionic conductor (solid electrolyte) developed by Professor Ryoji Kanno functions over a broad range of temperatures, and its material allows ions to move within the structure selectively at high speed. It delivers outstanding safety and stability, does not leak, and has a high energy density, making it a key technology for all-solid-state batteries. The All-Solid-State Battery Unit leverages its lead in the development of superionic conductors to promote the commercialization of all-solid-state batteries.

Research goals

Development of solid electrolyte materials as a key technology for all-solid-state batteries

(1) Development of methods for synthesizing superionic conductors in large amounts for commercialization

(2) Development of fundamental process technology for commercialization of composite electrode materials

(3) All-solid-state battery prototyping and practical use evaluations (environmental impact assessments)

(4) Demonstration of high performance and functionality through verification of principles and advanced analyses

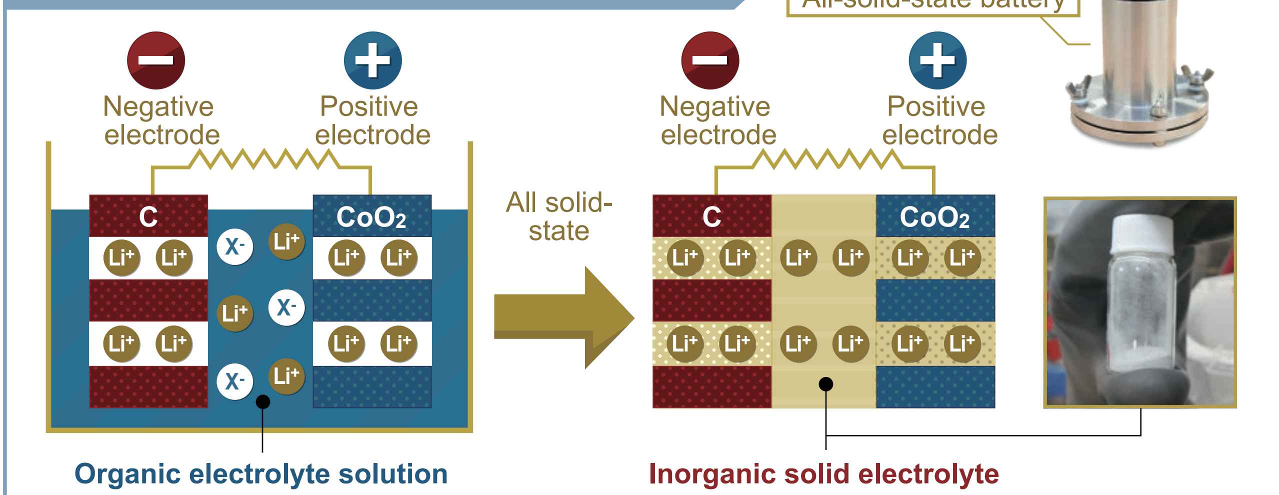
Research Unit Leader **Ryoji Kanno**

Profile

- 2018 Unit leader, All-Solid-State Battery Unit and Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2016 Professor, School of Materials and Chemical Technology, Tokyo Institute of Technology
- 2001 Professor, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology
- 1989 Associate Professor, Faculty of Science, Kobe University
- 1985 Doctor of Science, Osaka University
- 1980 Research Associate, Faculty of Engineering, Mie University
- 1980 Master of Science, Inorganic & Physical Chemistry Division, Graduate School of Science, Osaka University
- 1978 Bachelor of Science, Department of Chemistry, School of Science, Osaka University

WEB www.kanno.echem.titech.ac.jp

All-solid-state lithium battery system



Quantum Computing Unit

Tokyo Tech Research Units

Overview

After decades of continued efforts in basic research, a prototype quantum computer was announced and commercialized in 2011 under the protocol of quantum annealing proposed by the group led by Professor Hidetoshi Nishimori in 1998. The machine has since been upgraded to its current fourth generation, and has spurred a flurry of R&D activities in industry as well as in academia toward real-life applications. Quantum computers are expected to process some of the very complicated tasks that are out of reach of supercomputers. The list of such tasks considered within reach of near-future hardware includes traffic optimization, portfolio optimization, large-scale code debugging, solutions to fluid equations, air traffic control, and medical diagnosis. Research activities of the Unit will cover a broad range of areas of quantum annealing from basic theory to software and applications.

Research Unit Leader **Hidetoshi Nishimori**

Profile

- 2018 Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2016 Dean, School of Science, Tokyo Institute of Technology
- 2011 Dean, Graduate School of Science, Tokyo Institute of Technology
- 1996 Professor, School of Science, Tokyo Institute of Technology
- 1990 Associate Professor, School of Science, Tokyo Institute of Technology
- 1984 Assistant Professor, School of Science, Tokyo Institute of Technology
- 1982 Doctor of Science, Department of Physics, School of Science, The University of Tokyo
- 1982 Research Associate, Department of Physics, Rutgers University
- 1981 Research Associate, Department of Physics, Carnegie-Mellon University
- 1977 Bachelor of Science, Department of Physics, Faculty of Science, The University of Tokyo

WEB www.stat.phys.titech.ac.jp/nishimori/

Research goals

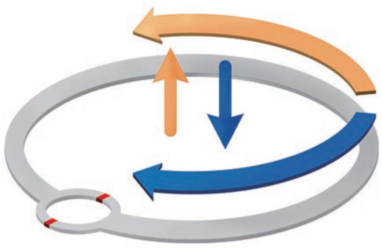
Quantum annealing, a term taken from the metallurgy technique “annealing” , is a metaheuristic (generic approximate algorithm) for optimization problems. Basic theories are still to be established on the mechanisms of enhancement of its performance. The Unit thus focuses on the following topics:

(1) Possible enhancement of the performance by the introduction of new mechanisms.

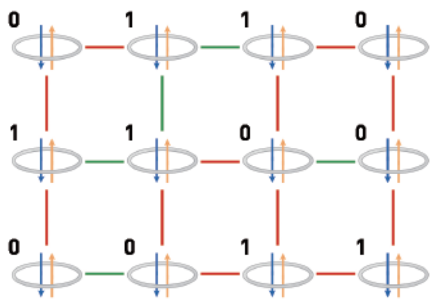
(2) Error correction in quantum annealing.

(3) General methodologies to express optimization problems with the Ising model.

Quantum Bits and Annealing



In the quantum world, very small metal circuits at ultra-low temperature accommodate electric currents circling clockwise and anti-clockwise simultaneously, which are used to represent “0” and “1” simultaneously in a quantum bit (qubit). This is in marked contrast to the conventional computer, which uses bits that can only be set to a single state of "0" or "1".



As we turn on the interactions between qubits, the possibility of superposition of two states “0” and “1” is reduced at each qubit, and the system eventually settles to a single state.

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すずかけ台キャンパス
東急田園都市線(すずかけ台駅下車 徒歩5分)