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

As part of Tokyo Institute of Technology's restructuring of its research system, the Institute of Innovative Research(IIR) was newly established on April 1, 2016 with approximately 180 faculty members whose mission is to promote the highest level of research.

The IIR is characterized by large-scale research laboratories, medium-sized research centers, and research units that conduct cutting-edge research in small teams. We have expanded our research capabilities under the strong guidance of its first director-general, Kazuya Masu, and his successors Fumio Koyama and Toru Hisabori.

The new financial year has started under the lingering cloud and negative impacts of the global COVID-19 pandemic, amid which the IIR continues to thrive with 179 full-time faculty members, 11 full-time administrative staff (belonging to the administrative departments), 154 part-time faculty members, 185 part-time staff, and 1,155 supervising students (as of April 1, 2021). As a research organization of a designated national university, we continue to champion basic research, applied research, and development research. In addition, we will promote fundamental research as academia and endorse the activities of the Organization for Fundamental Research to nurture young researchers. Moreover, as part of our research on social issues, we will also contribute to the "Initiatives for Overcoming Disasters Caused by COVID-19," which is being independently pursued by researchers aiming to help society break free of COVID-19.

We value three things in managing the IIR. The first core value is freedom. The origin of research lies in the freethinking and intuition of researchers. There are countless examples where the research and interests of a single researcher have yielded results that have shaped history. Even organizations themselves, such as research laboratories, are free to choose the direction in which they go. The second core value is autonomy. In order to conduct research freely and at the same time protect and nurture long-term basic research, it is essential for the organization to be autonomous. In the future, it will be ideal from a strategic point of view to conduct research-related activities as a financially independent research organization. And finally, I hope that our institute will be an organization that delivers smiles continuously — smiles when discovering new facts after a series of experimental failures, smiles when a research project is adopted and when it successfully concludes, smiles when a start-up is launched, smiles when a new horizon emerges from cross-disciplinary discussions, and the smiles when faculty, staff, and students talk with each other (although this may be difficult in the current climate). I do believe that the total sum of these smiles will help in realizing the goal of our institute, which is to bring well-being to society along with the fruits of our research.

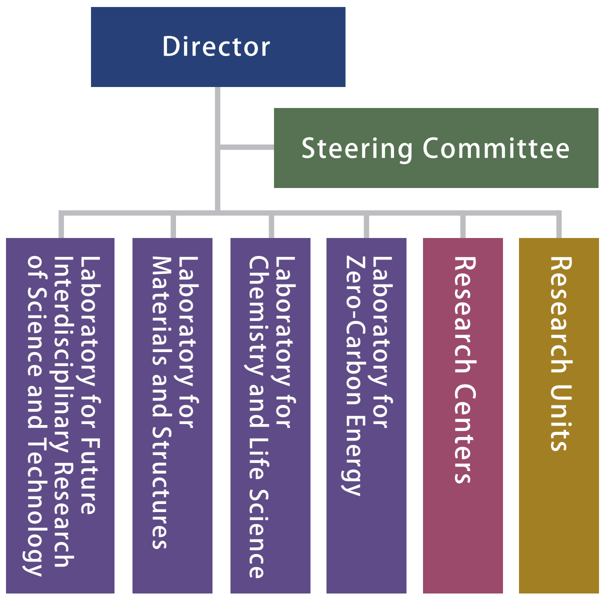
We look forward to your continued guidance and encouragement in the activities of the Institute of Innovative Research.

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

Professor
Naoto Ohtake

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.

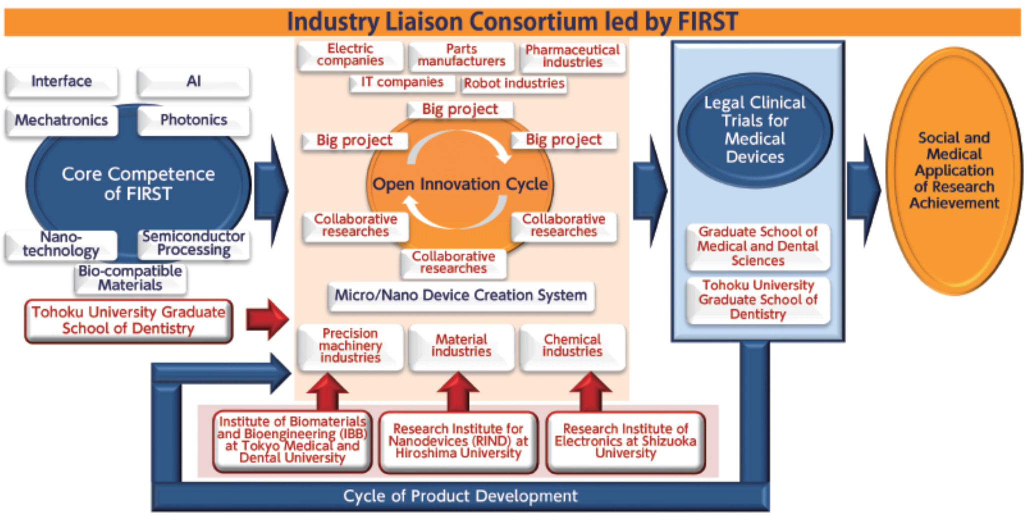


Laboratory for Future Interdisciplinary Research of Science and Technology

We are developing novel industrial technologies to solve the current practical issues, and at the same time, focusing on fundamental researches which are expected to stimulate prosperous paradigm shift in our future society. These challenges will be successful through the integration of diverse fields, such as mechanical engineering, electrical and electronics engineering, material engineering, information engineering, environmental engineering, disaster prevention engineering, social science, and chemical engineering, among others. The complex composition of such multidisciplinary fields is the advantage of our research laboratory. We are establishing scientific technology aimed at creating new industrial technologies for the realization of a prosperous society. We are also integrating industrial sociology, economics, law, and humanities and sociology with a central core of science and engineering.

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 Nanodevices (RIND) at Hiroshima University, and Research Institute of Electronics at Shizuoka University, the 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 care, health care system, and bioengineering fields, by widely applying interdisciplinary research achievements in society.



Research Center for Biomedical Engineering

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 and human-machine interaction

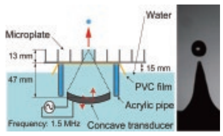
Odor reproduction using odor components and olfactory Display

Imaging Science and Engineering Research Center

Integrated devices, circuits, and systems/ Man-machine interface/ AI algorithm and solution/ Digital-society infrastructure

Applied Electronics Research Core

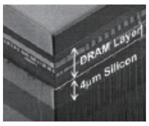
Electron devices, Integrated system/ Optical measurements, Ultrasonics, Plasma technology



Ejection of micro droplet with focused ultrasound

ICE Cube Center

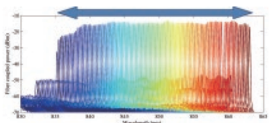
Integrated Circuit・RF CMOS Circuit/ Wireless Sensor Network System/ Platform for Integration with Diverse Functionalities/ Integrated CMOS-MEMS Technology/ Swarm Electronics/ Cyber Physical System/ Tera-Byte 3D Large Scale Integration/ Microfluidics Device/ Ultra-Small Cooling Device/ Delightful Agriculture



Tera-Byte 3D Large Scale Integration

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



Wide wavelength range tunable VCSEL

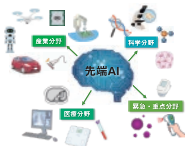
Quantum Nanoelectronics Research Center

Quantum effect devices/ Nanotechnology/ THz devices/ Optoelecronics devices・systems/ Nanophotonics

Electron Beam Lithography Exposure

Applied Artificial Intelligence Research Core

Artificial Intelligence (AI)/ Machine/ Deep Learning/ Data Science/ Medical AI/ Industrial AI/ Science AI



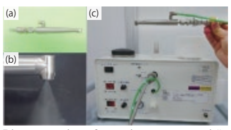
Biomedical Engineering Research Center

Fundamental technologies and applications related to life engineering/ Fundamental researches, development and applications of advanced medical and orthodontic devices and their systems/ Interdisciplinary and collaboration researches for innovative development of biomedical engineering

Disposable maglev centrifugal blood pump in animal test

Innovative Dental-Engineering Alliance Research Core

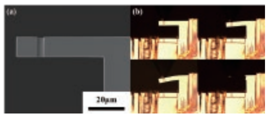
Promotion and grobal expansion of interdisciplinary research based on the Interface Oral Health Science/ Construction of the seamless research system from basic research to clinical application connecting Dentistry and Engineering/ Development of innovative medical devices and establishment of elemental technologies aiming at social implementation



Photographs of our device named " Micro Scale Mist UNIT" (MSM-UNIT) showing the handpiece (a), spraying with the handpiece (b), and the main body of the MSM-UNIT (c) (Reference： BMC Oral Health (2021) 21:286)

Advanced Materials Research Core

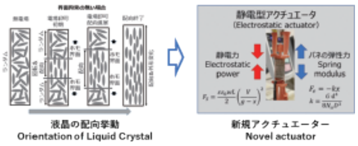
Metallurgy for industrial applications/ Design, development and applications of innovative functional materials



Electroplated gold alloy micro-material with an extremly high strength

Smart Materials & Devices Research Core

Smart actuator (nursing care/ assist robot)/ Smart sensor (gas/ VOC/ chemical/ odor molecule detection)/ Sensing Devise Materials/ High Functional Multilayer integrated materials with 3D printers



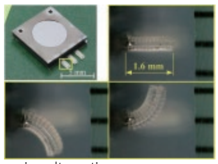
Novel Development concept for smart actuater

LG Material & Life Solution Collaborative Reseach Custers

Materials Informatics/ Development of High Functional Material/ Development of High Dielectric Soft Matter/ High Functional Device System/ Development of New Recycle System

Innovative Mechano-Device Research Core

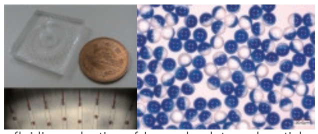
Creation of innovative actuators and sensors/ Establishment of nano-fabrication technology



ER microfinger using alternating pressure source

Industrial Mechano-System Research Core

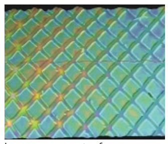
Micro / Nano Mechatronics, Biomedical Engineering



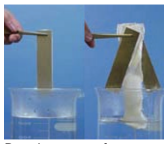
Microfluidic production of Janus droplets and particles

Materials Processing Science Research Core

Fabrication of DLC films and functional carbon thin films/ Surface coatings to correspond to environmental preservation/ Application of hBN nanosheet to proton exchange membrane of fuel cells/ Precision and micro plastic forming/ Adhesion technology for car structures/ Bonding technology for dissimilar materials, such as CFRP and metals/ Development of dismantlable adhesive/ D Property graded adhesive joints



Improvement of wear resistance of Diamond-Like Carbon films by applying surface designing



Development of dismantlable adhesive

Komatsu Collaborative Research Cluster for Innovative Technologies

Increasing power density of bent axis type axial piston motor/ Improving efficiency of swash plate type axial piston pump/ Formation behavior and friction and wear characteristics of ZnDTP derived tribofilm/ Improving pitting fatigue strength of axle gears

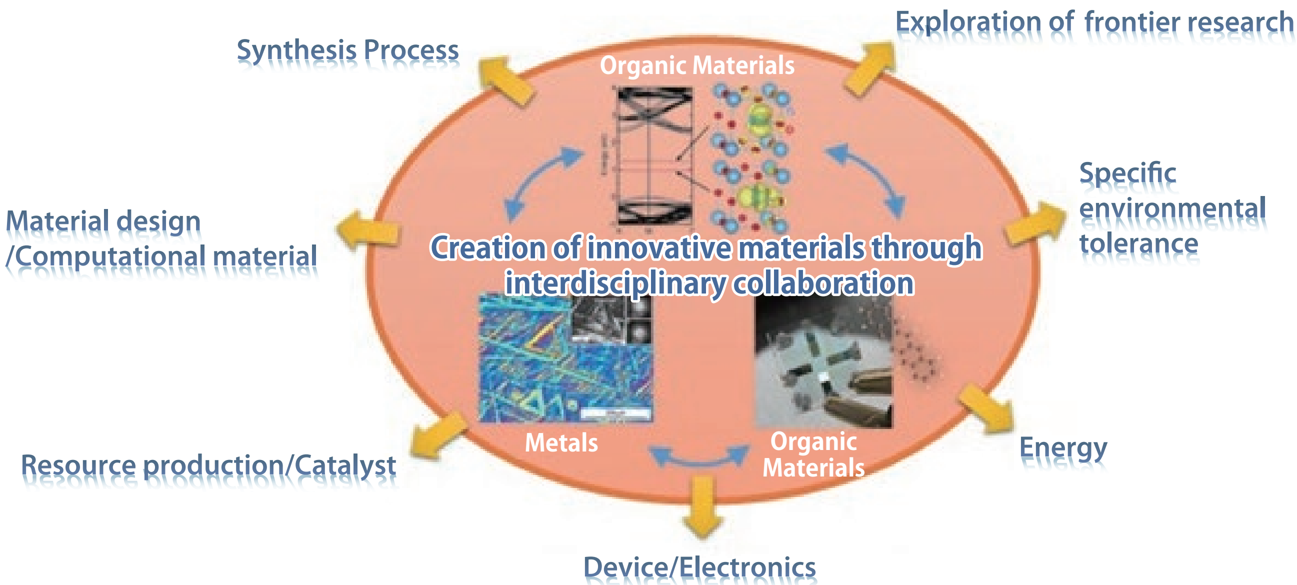
Urban Disaster Prevention Research Core

Earthquake Engineering/ Seismic Retrofit/ Passive Control Structures/ Isolated Structures/ Wind Engineering/ Tsunami Resilient Structures/ Real-scale loading experiment/ Super-tall buildings & Civil mega-structures/ Large base isolators & Large structural members

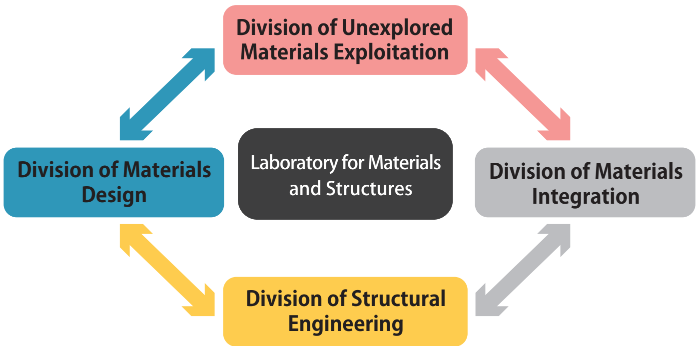
Real scale experiment of steel structure with non-structural components

Laboratory for Materials and Structures

Laboratory for Materials and Structures (MSL) aims to create innovative materials with conspicuous properties and functions via interdisciplinary materials science and inorganic materials, metals, and organic materials.
The ultimate goals of MSL 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

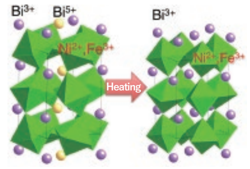
MSL has been designated as the Joint Usage / Research Center for Advanced Inorganic Materials by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) since 2010. The Collaborative Research Projects (hereafter, "CRP") of MSL include the five different types of research and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

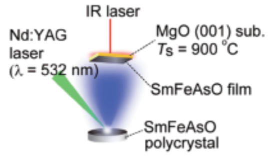
Division of Unexplored Materials Exploitation

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.



Giant Negative Thermal Expansion

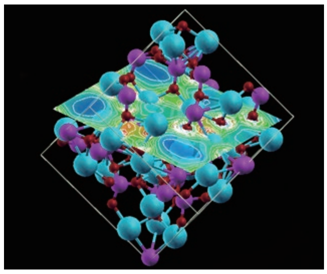


Thin film fabrication by pulsed laser deposition

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.

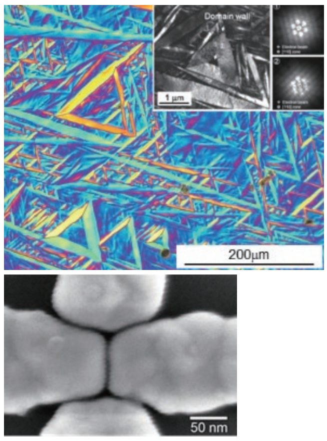
- Materials design based on a combination of materials theory, calculations, and informatics, which is known as "Materials Informatics."
- Design and development of novel functional materials based on advanced structure analyses including ultra high-speed time-resolved measurements, high-precision thermal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

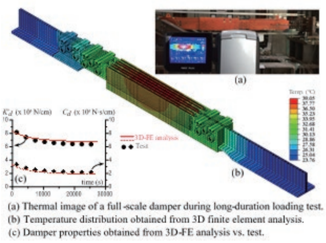
- Devics are developed based on novel materials and processes, including oxide electronics, nanoelectronics, and liquid crystal devices.
- Superior structural materials that are resistant to harsh environments are developed. These include shape memory, superelastic, thermal resistant, corrosion resistant, and abrasion resistant materials. Their basis includes inorganic, metal, organic, and polymer materials, and/or their combinations.
- 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

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:

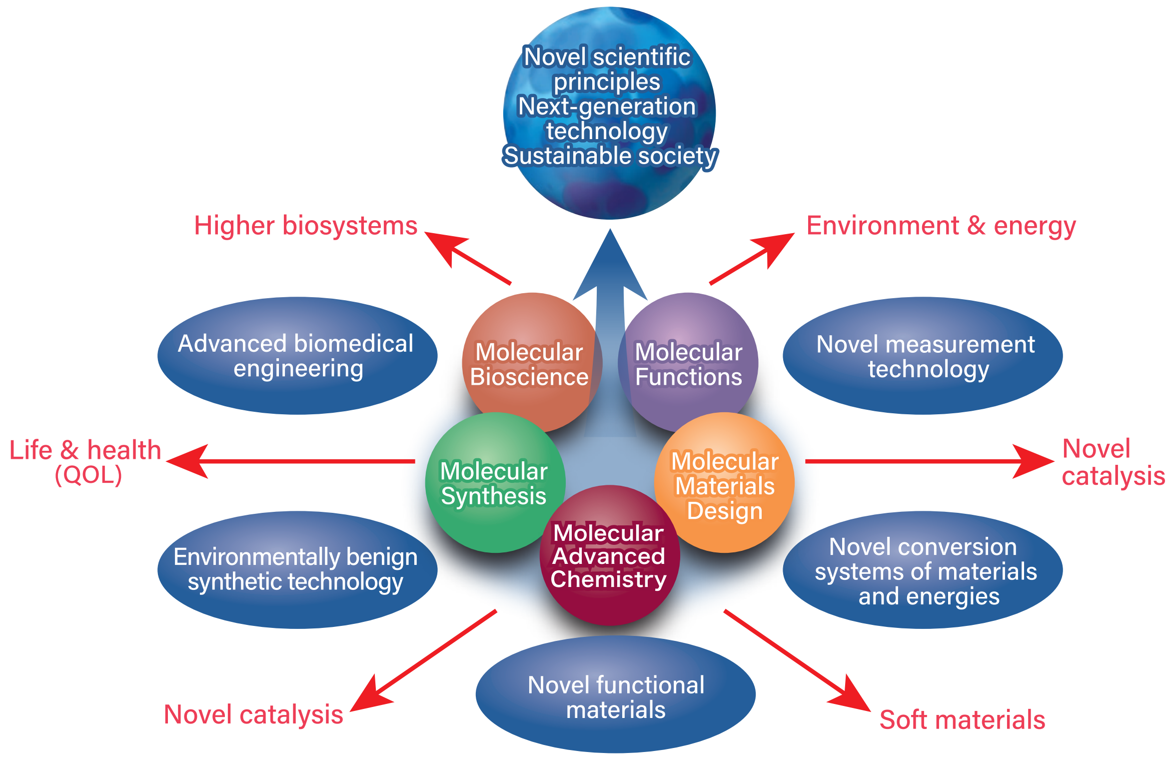
- Mechanical characteristics of steel, concrete, and all other materials used in structures and protective systems to resist earthquakes, winds, and fire.
- Behavior of structural members such as beams, columns, walls, and braces, as well as protective devices including dampers and isolators.
- Performance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



Full-scale viscoelastic damper experiment and simulation
(stiffness, damping, temperature)

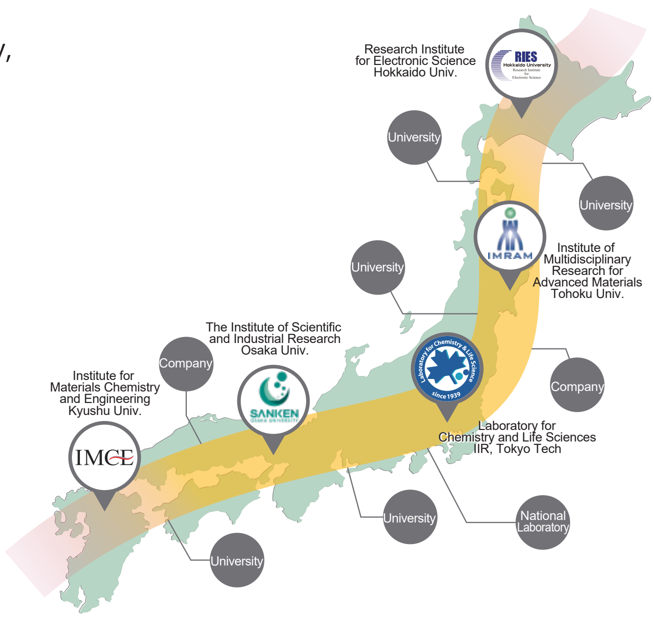
Laboratory for Chemistry and Life Science

The Laboratory for Chemistry and Life Science is dedicated to the advancement of human civilization and the realization of a prosperous and sustainable society with the developments of next-generation scientific technologies. We strive towards these goals through the creation of new theories and new perspectives on materials by gathering worldwide knowledge which is facilitated by our interdisciplinary research divisions in chemistry and life science including Molecular Bioscience, Molecular Functions, Molecular Synthesis, Molecular Materials Design, and Molecular Advanced Chemistry.



Network Joint Research Center for Materials and Devices

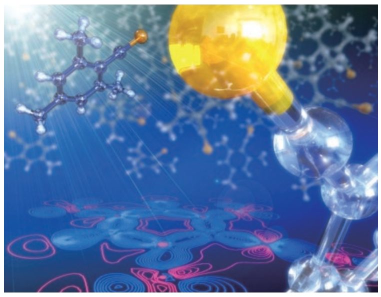
The Laboratory for Chemistry and Life Science, Tokyo Institute of Technology forms a joint research network with the Research Institute for Electronic Science, Hokkaido University, the Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, The Institute of Scientific and Industrial 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.



Laboratory for Chemistry and Life Science

Division of Molecular Material Design

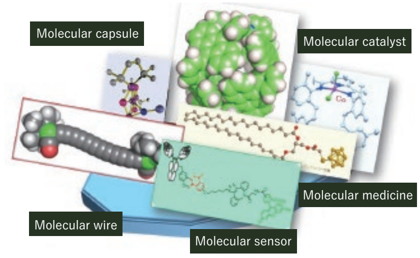
The research interest of this group focuses on the synthesis of functional molecules and polymers and the new methodology that enables controlled assembly of molecular building blocks into a desired structure at various levels from the nanoscale to the macroscopic scale. Deep understanding of the molecular behaviors regarding static and dynamic aspects allows us to design new soft materials that contribute to diverse scientific and technological fields.



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

Division of Molecular Synthesis

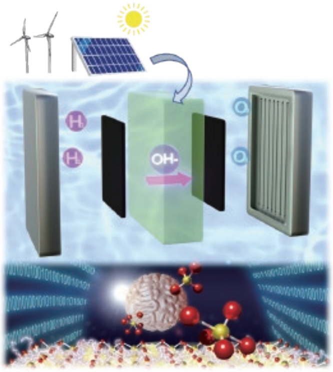
Molecules are fundamental components of a substance, and they could express inf inite functions based on their diverse structures and sizes (e.g., molecular weight). In this discipline, we use our unique principles and methods to synthesize novel molecules and cement the foundation required to develop the expression of molecular functions. We target all organics, inorganics, metal complexes, and macro- and supra-molecules to ultimately build a new molecular world by combining elements, bonds, and secondary structures.



Constructing molecular structures based on new concepts

Division of Molecular Functions

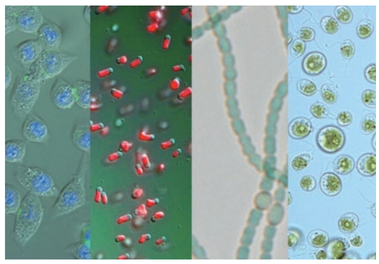
The smallest unit of material is a molecule, and the macroscopic properties that we observe are controlled by molecular functions, i. e. their structures and dynamics. Thus, we have been studying molecular functions by using the advanced experimental and theoretical approach for molecules and molecular aggregates. Based on the understanding of molecular functions, we develop advanced materials, devices, fuel cells, and catalysts, to contribute to achieve a prosperous and sustainable society.



Development of functional devices based on materials informatics

Division of Molecular Bioscience

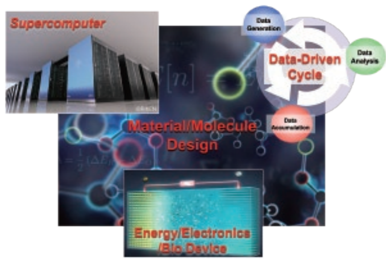
The life involves a variety of chemical reactions and their fine control by molecules with elaborate structures beyond human's imagination.
From this aspect, we aim to investigate and understand the various reactions in living organisms including energy production and storage, molecular recognition, and molecular motion using scientific words.
We'll integrate our obtained findings and then make a futher progress of technologies, e.x., the creation of new clean energy and new diagnostic tool which can contribute to human society.



Chemical understanding and application of diverse biological phenomena

Division of Molecular Advanced Chemistry

Rapid developments in data science, significant improvements in measurement and computational techniques, and the automation of synthetic experiments have given rise to unprecedented new trends in the field of materials and molecular science. In this division, we will develop such pioneering approaches to realize transformations in the development of new materials and new functions, leading to the solution of various social issues.



Advanced Chemical Approaches to Materials and Molecular Design

Laboratory for Zero-Carbon Energy

The laboratory's objective will be to help realize a carbon-neutral society through innovative research and the development of non-fossil (zero-carbon) energy sources, as well as systems for their use. We will help build the foundation of a society capable of sustainable economic growth in harmony with the environment.

The Scope of ZC (Laboratory for Zero-Carbon Energy)

The ZC aims to contribute to the realization of a carbon-neutral (CN) society by constructing a carbon and material circulation system based on zero carbon energy (ZCE), and conducts research and development of technologies necessary for its realization. Figure 1 shows the outlook for Japan's goal of realizing a CN society in 2050. The energy supply side will be converted from fossil fuel dependence to renewable energy and nuclear energy to ZCE.

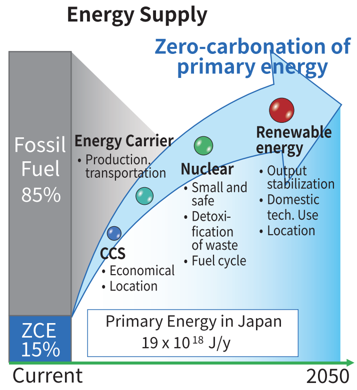


Figure 1. Prospects for zero carbonization of primary energy

Figure 2 shows the energy society that the ZC is aiming for. ZCE is introduced to primary energy. Since the output of renewable energy fluctuates greatly depending on the weather, it is important to stabilize the output. On the other hand, there are also fluctuations on the demand side, and the function of energy storage is indispensable. Therefore, electricity storage (battery) and thermal storage functions are installed. The energy demand side also needs to supply carbon resources in many fields. CO2 emitted there is recovered, converted into carbon resources by ZCE, and recycled for reuse. At the same time, energy carriers are produced, and energy materials will be collected, separated, and regenerated, aiming for establishment of a sustainable energy society.

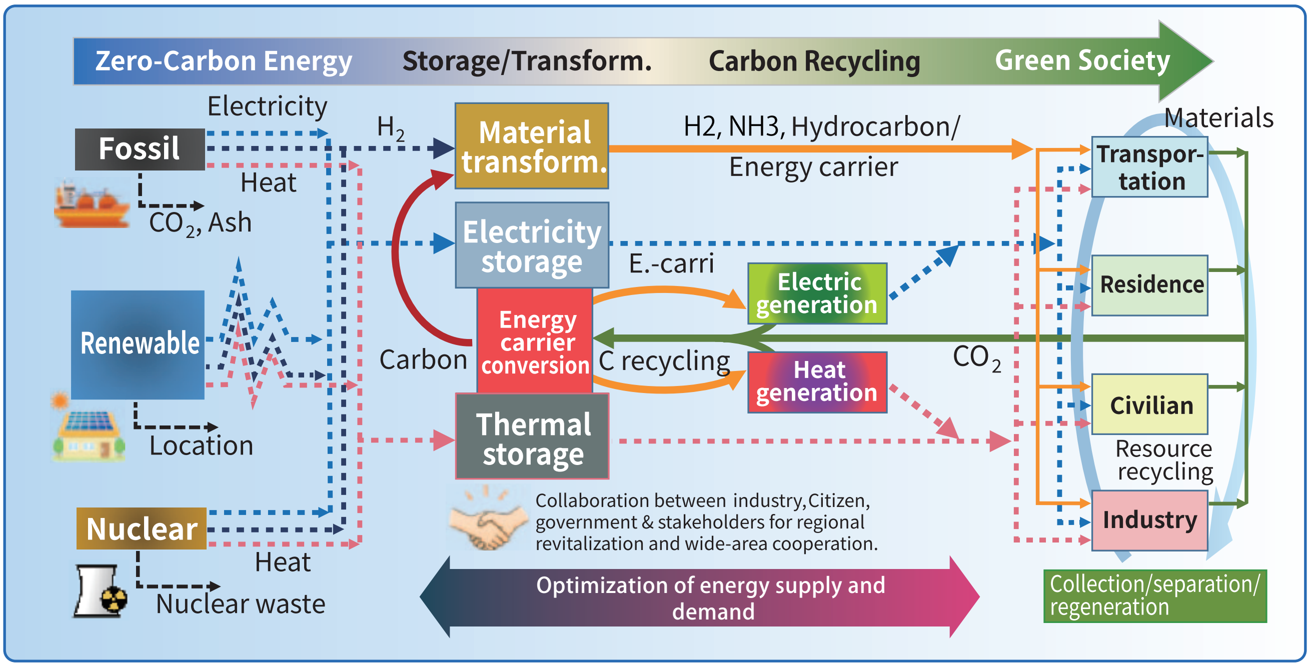


Fig. 2 Energy society vision as the goal of Tokyo Tech GXI

Research organization

The research institute has the Future Energy Division, the Nuclear Energy Division、 and collaborates with the Fukushima Reconstruction and Regeneration Research Unit, and the TEPCO Collaborative Research Cluster. We will establish a collaborative advisory committee to maintain cooperation with society. Green Transformation Imitative (Tokyo Tech GXI) funded by MEXT has started since 2022. Headquarter is set at the laboratory. In order to realize the energy society that the institute aims for, each department and each research field will organically cooperate to promote research and development.

The Future Energy Division

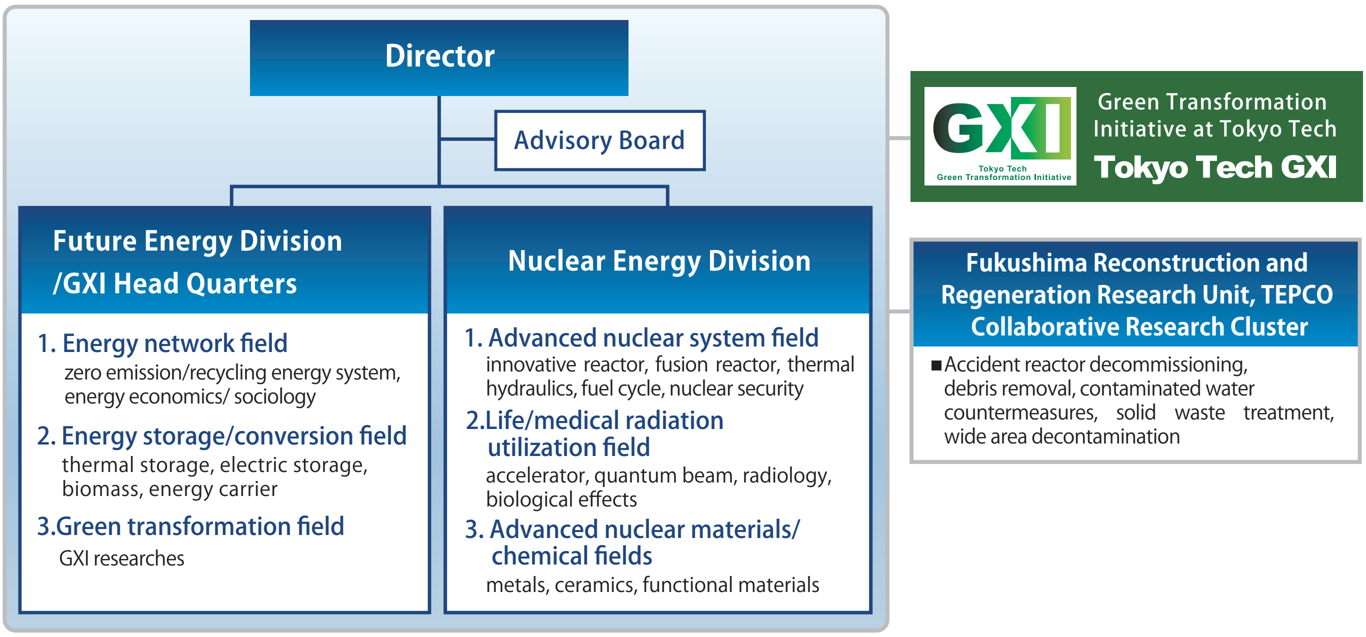
The Future Energy Division will research the net-zero carbon cycle energy systems based on zero-carbon energy needed to build the energy networks of the future. The goal will be to construct economic and stable energy systems based on energy economics and sociology. The division will strive to design stable energy provision systems that compensate for renewable energy sources' instability in generating power. Quantitatively speaking, heat is nearly as essential as electricity in the supply of energy. This division will investigate the storage and conversion of electrical and thermal energy into energy carriers which will play a vital role in future energy networks as well as the material recycling/reuse systems that will support sustainable energy societies. Finally, the division will delve deeper into the public implementation of these systems (energy solutions) in collaboration with residents and the communities they live in, as well as with business, academic and government entities.

The Nuclear Energy Division

The Nuclear Energy Division, meanwhile, will focus on two main tasks. The first is to break free of the closed nature of the Japanese nuclear industry and expand research into advanced nuclear energy systems such as small modular reactors which will offer the safety and mobility / flexibility the zero-carbon energy society requires as well as nuclear fusion reactors, which were expected to become the primary energy source of the new century. The second task is to research the use of radiation in life and medical sciences, which will support cancer treatment and other aspects of the advanced medical care that Japan's aging society will require. To that end, the laboratory will include two organizations specializing in nuclear decommissioning research: the Fukushima Reconstruction and Revitalization Unit and the TEPCO Collaborative Research Cluster for Decontamination and Decommissioning (D&D) Frontier Technology Creation, the latter being a collaboration with the Tokyo Electric Power Company. Through these organizations, the laboratory will help in the decommissioning of the Fukushima Daiichi nuclear power plant.

Tokyo Tech GXI

For realization of the Japanese government policy of 2050 Carbon Neutral (CN), green transformation (GX, change of industrial and social structure according to CN conversion) is indispensable. This project GX Initiative (Tokyo Tech GXI) will be developed to promote research activities that leads the GX society, strengthen startups, and promote the realization of industrial and social collaboration.



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 Ohsumi

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

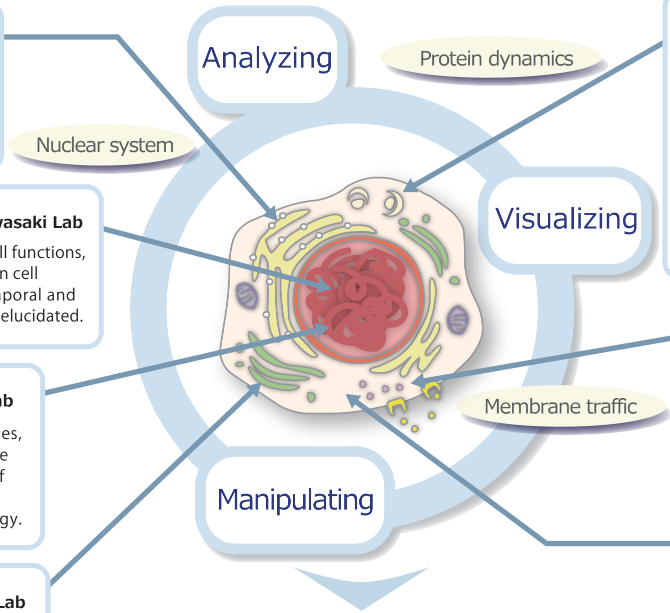
Chromosomes that store genes, the blueprint of cell functions, move dynamically within the nucleus depending on cell replication and DNA repair. The mechanism of temporal and spatial regulation of this chromosome dynamics is elucidated.

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.

Organelle morphology — Fujita Lab

Elucidate the mechanisms shaping organelles and their physiological significance using Drosophila and mammalian cultured cells.



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

Autophagy — Ohsumi Lab, Nakatogawa Lab

Understanding of autophagy using a yeast system. **Nakatogawa Lab:** Elucidation of molecular mechanisms underlying autophagosome biogenesis and selection of degradation targets. **Ohsumi Lab:** Elucidation of physiological functions of autophagy from viewpoints of selectivity of degradation substrate, degradation process, and transport and metabolism of the degradation products.

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.

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

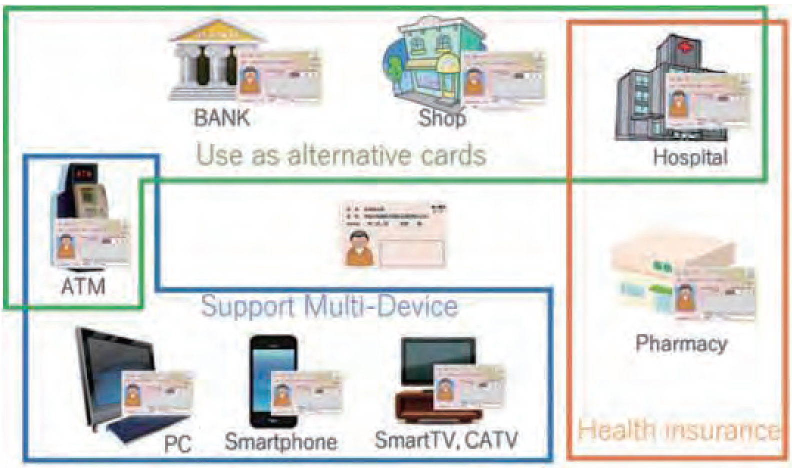
A study of the procurement manner of various government information systems that support electronic administration to eliminate some persistent problems such as poor cost-effectiveness and delayed updates

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.



Future of Humanity Research Center

For the first five years, the Future of Humanity Research Center's activities will be centered on the concept of rita — the Japanese word for altruism.

Exclusivism and accelerating fragmentation are rampant nowadays. Merit-based ideas force people to compete with each other and abandon the weak. This utilitarian view informs decisions on who to socialize with in order to gain the most benefit. The tendency is that if things are quantifiable, they are either valued or cast aside. How can we envision a better society and more fulfilling life in this savage world in which we find ourselves?

The concept of rita and its central idea of acting for someone or something other than oneself might provide us with a clue. At first glance, it may seem absurd. However, this human tendency could help us completely rethink humanity, society, and technology. To illuminate this aspect of our human nature, which stands apart from meritocracy, utilitarianism, and numerical evaluation, we can lead with an altruistic light in our pursuit of "rita-ism."

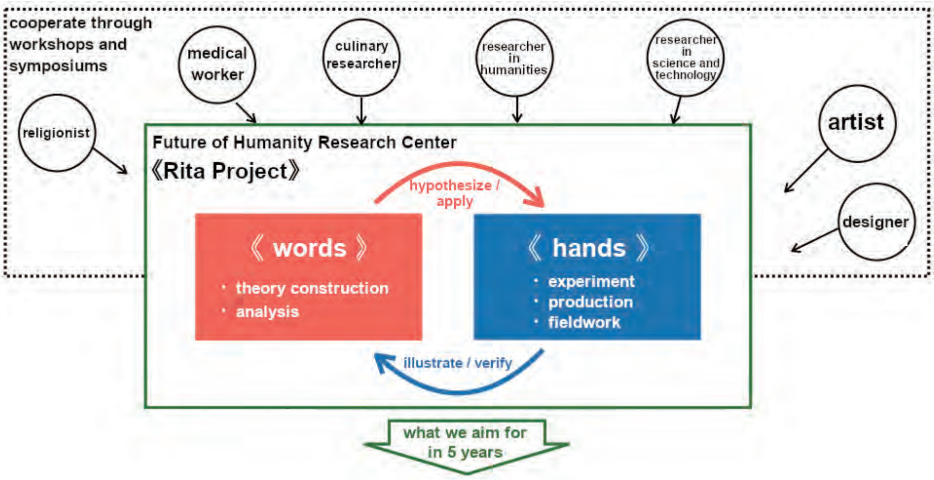
Research areas will range widely from politics, the economy, and religion to AI, the environment, and the universe. Valuing encounters with researchers and experts in various fields, we will avidly extend our reach and open up the field of rita-ism. Our methods involve a flexible approach unique to Tokyo Tech that includes experiments and producing works in addition to methods traditionally employed by the humanities and social sciences such as bibliographic surveys and fieldwork.

The center will disseminate research results in various ways, such as symposiums, books, web articles, and radio. With your help and support, we will plant a variety of seeds in order to achieve the technology that will set humans free in the truest sense and realize a more humane society. Please look forward to the Future of Human Research Center's Rita Project.

Center Director

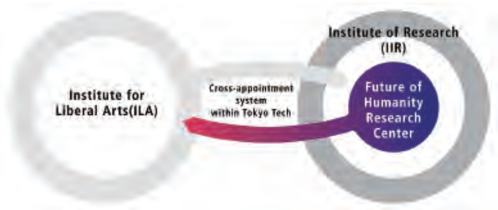
Asa Ito

www.fhrc.ila.titech.ac.jp



★Through establishing an innovative area "rita-ism," we

set questions about humanity which is to be faced now	provide the place to discuss the concept of technology	show a new research model of humanities



In February 2020, the Future of Humanity Research Center was established in the Institute of Innovative Research (IIR) in order to promote liberal arts study. The IIR is an organization that comprises world-class research teams at Tokyo Tech, including the Cell Biology Center led by honorary professor and Nobel laureate Yoshinori Ohsumi. The Future of Humanity Research Center is focused on the humanities but walks hand in hand with leading-edge science and technology research. Under an internal cross-appointment system, ILA faculty belong to the center for two years, in principle.

Tokyo Tech
Institute of Innovative Research

Research Center for All-Solid-State Battery

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 Research Center for All-Solid-State Battery leverages its lead in the development of superionic conductors to promote the commercialization of all-solid-state batteries.

Director
Ryoji Kanno

www.assb.iir.titech.ac.jp/en/

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

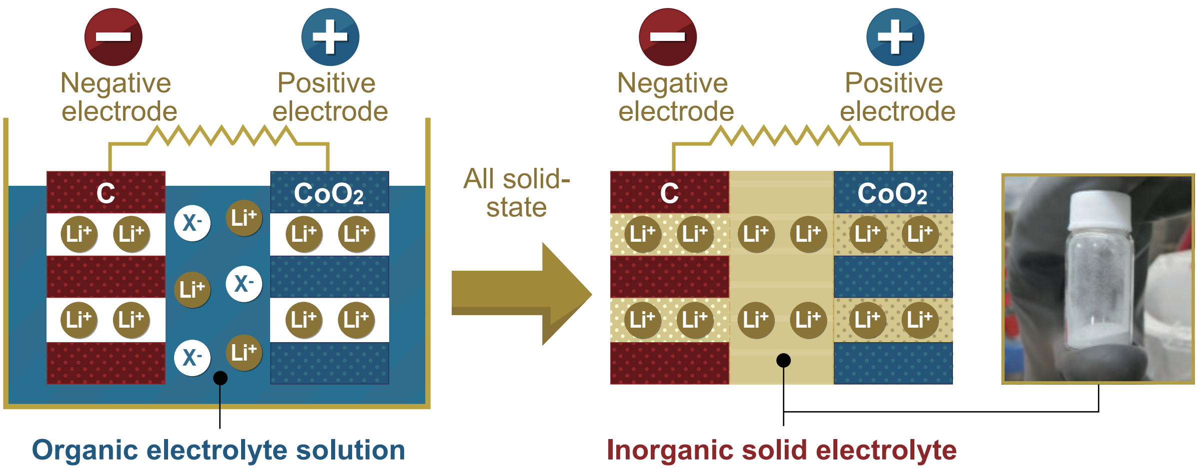
(2) Development of fundamental process technology for commercialization of composite electrode materials

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

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

All-solid-state battery

All-solid-state lithium battery system



Multidisciplinary Resilience Research Center

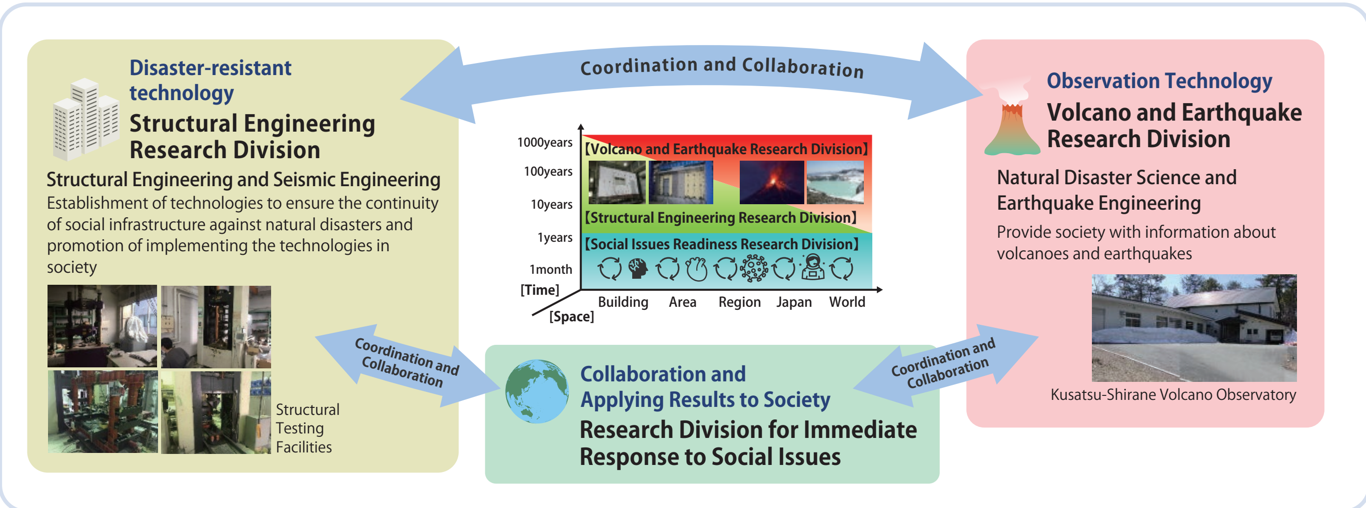
One hundred years have passed since the Great Kanto Earthquake, and it is time for Japan to come together as one to reaffirm its commitment to disaster prevention and mitigation in anticipation of various events, including social issues. We will integrate and strengthen the multidisciplinary resilience research that the Institute has conducted on both tangible and intangible aspects of conventional measures against natural disasters. In addition, based on the experience of COVID-19, we will organize a research center that can flexibly and promptly tackle unknown disasters, with a framework that can bring together the research capabilities of a wide variety of experts across departments and research fields. In other words, we will build a research organization that can continue the research on conventional countermeasures against natural disasters from a medium- to long-term perspective, identify social issues for the short- and medium-term future as well as long-term and beyond, and tackle disaster countermeasures ahead of time. This will allow the Institute to promote activities and disseminate their outcomes, and contribute to the continuous establishment of prevention, mitigation and awareness of disaster.

Director
Shoichi Kishiki

www.mrrc.iir.titech.ac.jp

Research goals

The Research Center will cooperate with the Laboratory for Design of Social Innovation in Global Networks and the Future of Humanity Research Center to identify insufficient countermeasures and future threats (or disasters), and conduct countermeasure research with the "Future Resilience Creation Council," which oversees the Research Division for Immediate Response to Social Issues, Structural Engineering Research Division, and Volcano and Earthquake Research Division. We also will organize research teams that bring together internal and external wisdom to create research areas aimed at future safety and security, using the world-leading safe living spaces and maintenance of functions that the Institute has led the world in, and observation technology and advanced fluid analysis as the scientific and technological basis for the research. As such, the think-tank of the Institute of Innovative Research will be strengthened as a vessel (place of collaboration) for gathering the wisdom of researchers in and outside of the institute to address multidisciplinary social issues. Through research activities in new academic fields, we will promote the development of the next generation who can drive countermeasure research on multidisciplinary social issues across different fields as well as be responsible for future safety and security.



Atomhybrid Materials Unit

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

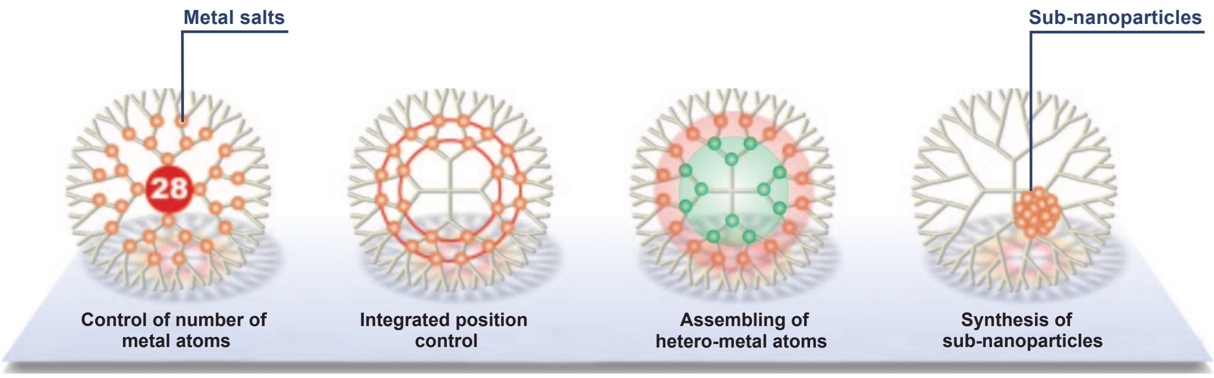
2016 Professor, Institute of Innovative Research, Tokyo Institute of Technology
2010 Professor, Chemical Resources Laboratory, Tokyo Institute of Technology
2002 Professor, Faculty of Science and Technology, Keio University
1997 Associate Professor, Faculty of Science and Technology, Keio University
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

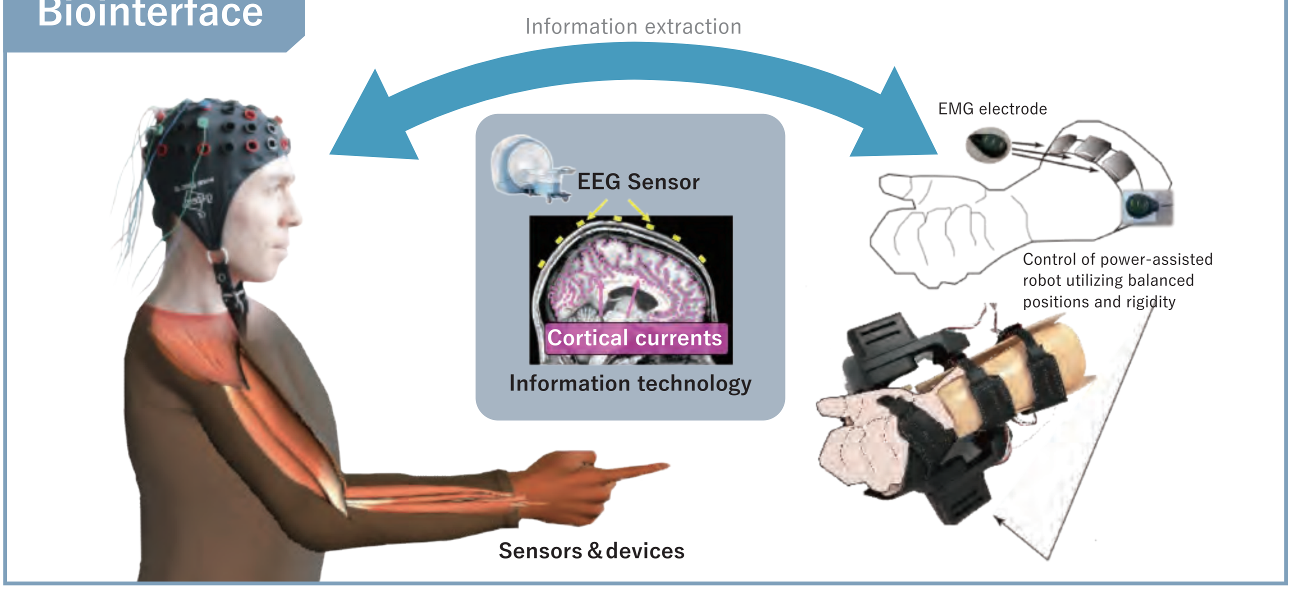
2016 Professor, Institute of Innovative Research, Tokyo Institute of Technology
2009 Professor, Precision and Intelligence Laboratory, Tokyo Institute of Technology
1998 Associate Professor, Tokyo Institute of Technology
1995 Toyota Motor Corporation
1992 Researcher, Advanced Telecommunications Research 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



Tokyo Tech Research Units

Nanospace Catalysis Unit

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

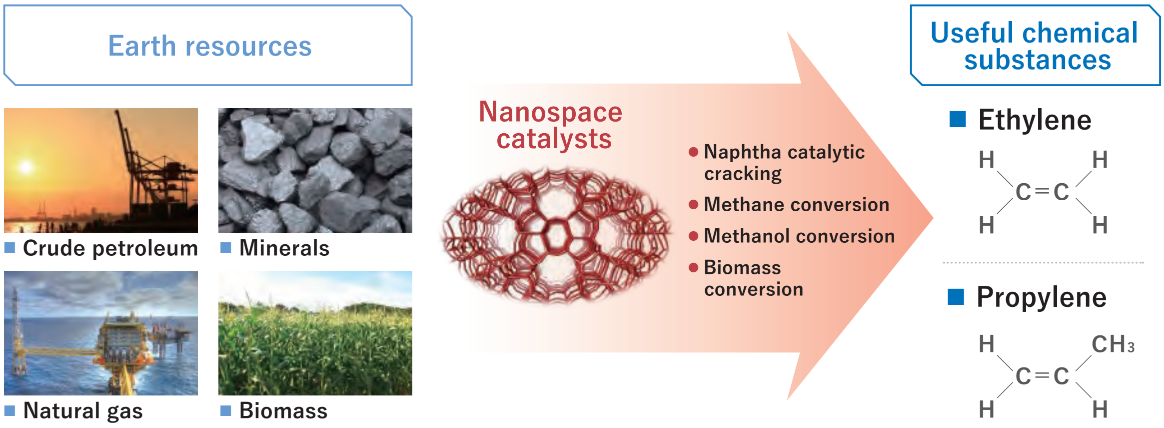
2004 Doctor of Engineering, Department of Materials Science and Engineering, Yokohama National University

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



Tokyo Tech Research Units

WOW Alliance Heterogeneous and Functional Integration Unit

Overview

Semiconductors for CPU and memory indispensable for personal computers and smartphones have improved performance through device shrinkages. However, we are encountering the physical limits of shrinking using conventional technology. The three-dimensional large-scale integration (3D LSI) technology that we developed has special vertical interconnect technology and special ultra-thinning technology for semiconductor die stacks, and improves performance while making the stacks smaller and thinner. Using this technology, we will integrate multiple semiconductor functions into a one-stack module, and our goal is to surpass the limits of shrinking devices two-dimensionally. Further, we will apply matured know-how of the semiconductor manufacturing process to heterogeneous fields and endeavor to create new industries in biotechnology and agricultural engineering.

Research Unit Leader

Takayuki Ohba

Profile

2013 Tokyo Institute of Technology, Professor
2004 The University of Tokyo, Professor
1984 Fujitsu Limited
National Chiao Tung University (NCTU), Visiting Professor
Ph.D received from Tohoku University in 1995

WEB www.wow.pi.titech.ac.jp/

Research goals

To extend the Wafer-on-Wafer (WOW) Alliance, a global platform for industry–academia research started in 2008, we will pursue the following themes.

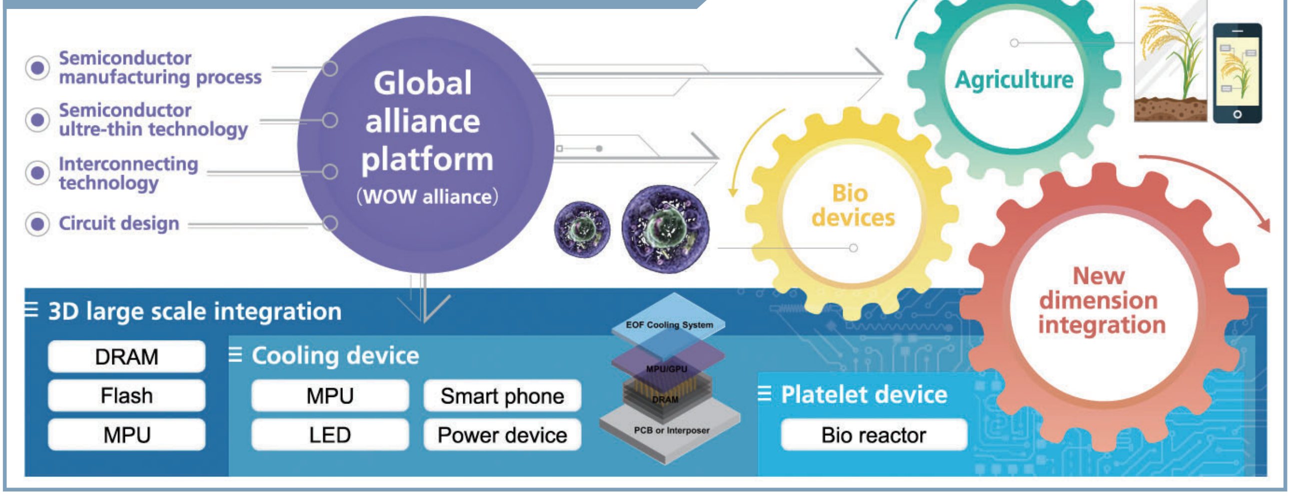
【Three-dimensional integration technology】 We will use the ultra-thinning technology and the vertical interconnect technology possessed by the WOW Alliance to integrate semiconductors three-dimensionally and create a next-generation semiconductor that is higher in performance and lower in power consumption. Furthermore, this work will accelerate the ultra-miniaturization of not only large-scale computing devices such as servers, but various devices equipped with semiconductors to 1/1000th of their current size.

【Cooling technology】 By combining ultra-small cooling devices with three-dimensional stacked semiconductors, our work will allow for simplification of cooling technology and application to the miniaturization of IoT and mobile devices.

【Biotechnology】 We are developing MEMS devices that replicate the vital reactions that take place inside an organism. Specifically, the goal is to apply the semiconductor manufacturing process to prototype a platelet-producing device mimicking the structure and functions of the capillaries inside the spinal cord. We aim to realize stability and improved speed of platelet production at low cost by using fluid mechanics analysis to optimize the structure of the micro-fluid system.

【Agricultural co-engineering】 To reveal the conditions for a plant's maximum output, we will make it possible to monitor "what a plant wants." We will develop closed-system cultivation devices based on semiconductor manufacturing technology to control the growth environment and draw out the plant responses at high reproducibility. We will also create multimodal sensing technologies to quantify the various responses.

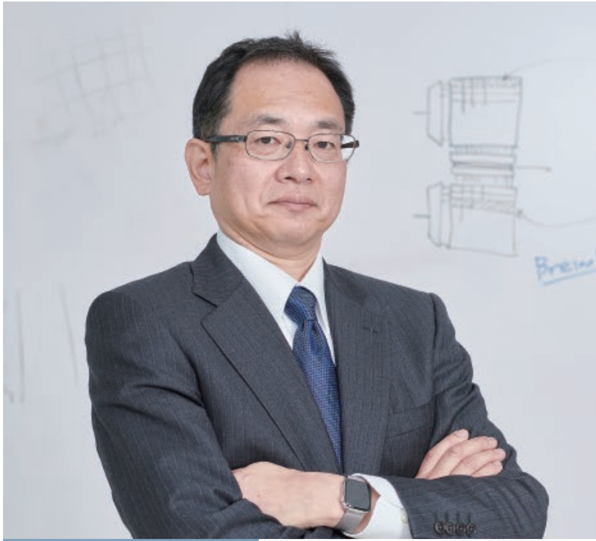
Creating new industries by utilizing semiconductor manufacturing process



AI Computing Unit

Overview

In recent years, great strides in artificial intelligence (AI) have been made, with deep neural networks (DNN) at the center. However, AI computing is not limited to DNN but covers a broad range of machine learning fields, and also extends into data mining and big data processing. To traverse these realms exhaustively and efficiently utilize vastly increasing data, new hardware, rather than an extension of existing hardware, must be developed. The aim of this research unit is to establish the research and development infrastructure for hardware that will make the next generation of AI computing possible: technology that is markedly higher in energy and cost efficiency than what is currently available and also superior in autonomy and safety. We also aim to create a place for more people to participate in this field and flourish in industry-academia collaboration.



Research Unit Leader **Masato Motomura**

Profile

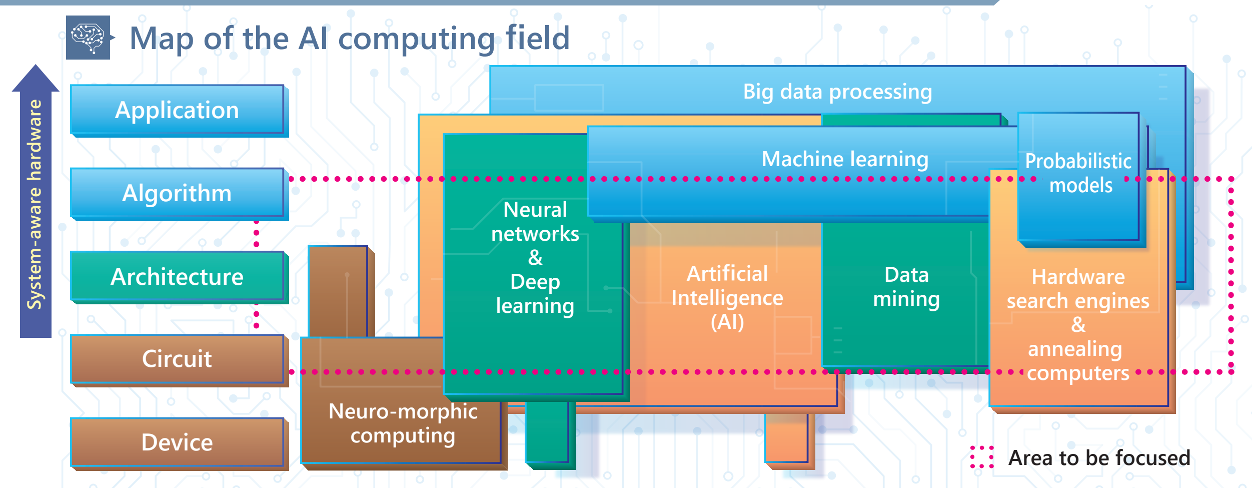
2019 Professor, Institute of Innovative Research, Tokyo Institute of Technology
2011 Professor, Course of Electronics for Informatics, Graduate School of Information Science and Technology, Hokkaido University
2009 NEC System IP Core Research Laboratories
2004 NEC Electronics Corporation
2001 NEC Electron Devices
1996 Doctor of Engineering, Kyoto University
1992 NEC Silicon Systems Research Laboratories
1991 Visiting Researcher, Massachusetts Institute of Technology
1987 NEC Microelectronics Research Laboratories
1987 Master of Science, Kyoto University

WEB www.artic.iir.titech.ac.jp

Research goals

I have worked for many years in reconfigurable hardware, a type of hardware which allows changes to be made to its circuit configuration according to what is being processed. What is special about this architecture is that, since it allows computing to always be performed using the optimum hardware configuration, processing speed is faster than conventionally possible, as well as highly energy efficient. Furthermore, since it can make use of large-scale data processing structures in parallel processing, it is highly compatible with AI computing. Since fiscal year 2018, with this architecture as a basis, we have been advancing AI computing through projects under the Grant-in-Aid for Scientific Research (S), New Energy and Industrial Technology Development Organization (NEDO), and Japan Science and Technology Agency (JST). Though the specific field of AI computing investigated in each project differs, this research unit will provide the R&D infrastructure enveloping all of these fields. In the future, I hope this unit will grow to become Japan's central facility for AI computing research.

An architecture platform that will drive AI computing



Tokyo Tech Research Units

Homeostatic Mechanism Research Unit

Overview

Many organisms have the ability of homeostasis to maintain body temperature, blood pressure, osmotic pressure of body fluids, blood sugar level, and other parameters of their internal environment within a certain range, despite variations in the external environment. This ability, gained through evolution, is crucial to maintaining life. Homeostasis is made possible by the delicate communication of the brain and nervous system with organs, or that of organs with each other. For example, when an organism becomes dehydrated, sodium concentration within the body fluids rises, creating an appetite for fluid and decreasing the amount of urine. However, the mechanisms that trigger these maintenance functions are not fully understood. Our research interests focus on the homeostatic mechanisms especially for the three areas: body fluid homeostasis, blood pressure, and obesity.

Research Unit Leader **Masahiro Noda**

Profile

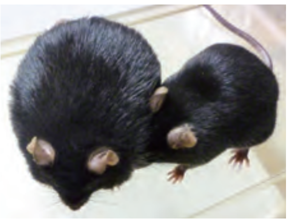
2019 Specially Appointed Professor, Research Unit Leader, Homeostatic Mechanism Research Unit, Institute of Innovative Research, Tokyo Institute of Technology
1991 Professor, Division of Molecular Neurobiology, National Institute for Basic Biology (NIBB); Professor, Basic Biology, the Graduate University for Advanced Studies (Sokendai)
1989 Visiting Scholar, Max Planck Institute for Developmental Biology
1985 Assistant Professor, Kyoto University Faculty of Medicine (Molecular Genetics)
1984 Assistant, Kyoto University Faculty of Medicine (Medical Chemistry)
1983 Researcher, Grant-in-Aid for Encouragement of Scientists, Japan Society for the Promotion of Science (JSPS)
1983 Doctor of Medical Science, Graduate School of Medicine, Kyoto University
1979 Master of Engineering, Graduate School of Engineering, Kyoto University

WEB nodalab.rcb.iir.titech.ac.jp/indexENG.html

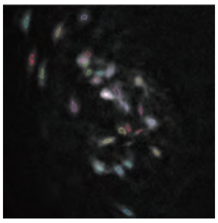
Research goals

- In *body fluid homeostasis*, we discovered that the brain has a system that monitors the fluctuation of sodium concentration in body fluids and that there are neurons that drive intakes of fluids or salts. Our goal is to understand the control mechanisms underlying these nervous systems.
- *Blood pressure* is greatly affected by factors such as salt, stress, and obesity. We have identified the brain mechanisms underlying salt-induced elevations in blood pressure. This unit seeks to uncover the mechanisms responsible for blood pressure elevations caused by stress and obesity. Additionally, we will aim to reveal the mechanisms by which combinations of multiple factors cause even higher elevations in blood pressure.
- In *obesity*, as it progresses, fat accumulates not only in fat cells, but also in the liver and other organs. Since accumulation of ectopic fat causes various diseases, we also intend to elucidate the mechanisms that control fat accumulation.

Understanding the central mechanisms of homeostasis and leading to drug discovery

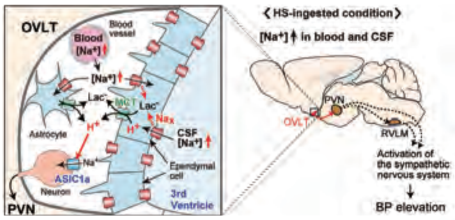


- Control of blood pressure by salt, stress, and obesity
- Control of water/salt-intake behaviors according to body fluid conditions
- Control of obesity and ectopic lipid accumulation



Analysis of neural activity by *in vivo* calcium imaging

- Genetic manipulation
- Optogenetics
- Real-time imaging



Central mechanisms responsible for salt-induced hypertension

Elucidation of brain mechanisms

→ **Development of breakthrough drugs**

Fukushima Reconstruction and Revitalization Unit

Tokyo Tech Research Units

Overview

Under the "Great East Japan Earthquake Reconstruction Project," the reconstruction and revitalization of Fukushima is a key social issue. Because of the accident at the Fukushima Daiichi Nuclear Power Station, a large amount of radioactive material (mainly radioactive cesium (Cs)) was discharged into the environment, and contaminated water and debris generated by melting fuel made it difficult to decommission the reactor. In this research unit, we are pursuing the following three topics to support reconstruction and revitalization of Fukushima.

1. Promoting the decommissioning of the reactor, including treating contaminated water and solid waste, and removing debris
2. Resolving issues related to wide-area contamination caused by the radioactive cesium
3. Rehabilitating industry and developing human resources based on the Innovation Coast Framework

Research Unit Leader **Kenji Takeshita**

Profile

October 2019: Senior Aide to the Executive Vice President for Research, Tokyo Institute of Technology
April 2018: Director (Professor), Laboratory for Advanced Nuclear Energy, Tokyo Institute of Technology
April 2010: Professor, Research Laboratory for Nuclear Reactors, Tokyo Institute of Technology
November 2002: Associate Professor, Chemical Resources Laboratory, Tokyo Institute of Technology
une 1996: Assistant Professor, Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology
June 1992: Senior Researcher, Institute of Research and Innovation
April 1987: Researcher, Institute of Research and Innovation

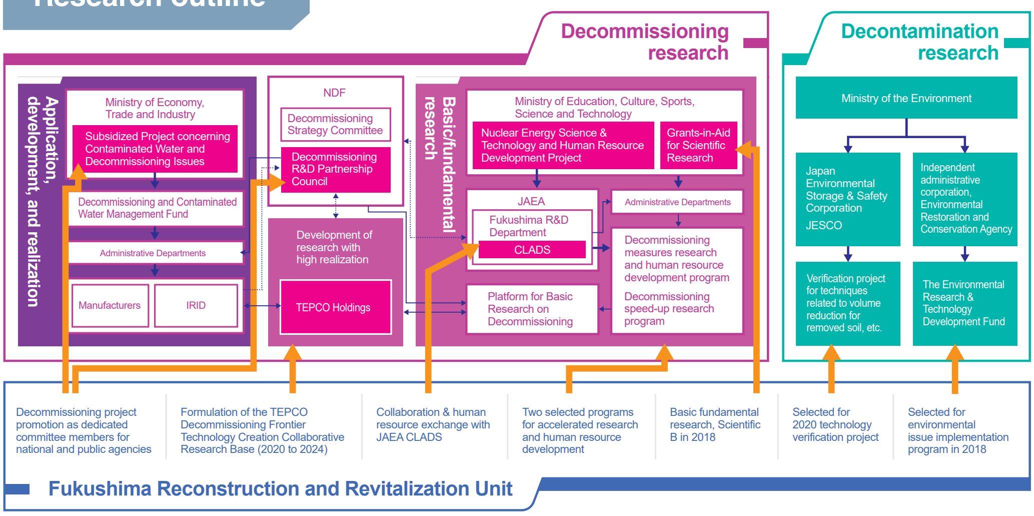
WEB www.nr.titech.ac.jp/~takeshita/index-e.html

Research goals

For our unit's three research topics, we seek to achieve the following goals:

1. Establishing volume reduction and stabilization/solidification techniques for the secondary radioactive waste generated by contaminated water from the Fukushima Daiichi Nuclear Power Station or from treatment of contaminated water generated when removing debris. We will provide vital support in decommissioning the Fukushima Daiichi Nuclear Power Station by gathering expertise at Tokyo Tech for areas such as development of decommissioning techniques appropriate for the disaster site and based on collaboration with TEPCO (Figure: Research outline).
2. Developing basic fundamental technology for recovery and high-volume reduction/solidification methods of radioactive Cs from the 750,000 m^3 of highly contaminated soil, which requires physiochemical treatment. This will make it possible to finalize disposal within 30 years as promised by the national government.
3. Gathering academic knowledge to reconstruct the living environment in the Hamadori area, which was severely damaged by the nuclear power station accident, promoting industrial development contributing to the Innovation Coast Framework, and fostering necessary human resources for the reconstruction of Fukushima.

Research outline



Tokyo Tech Research Units

Nano Sensing Unit

Overview

Healthy and safe food is fundamental to society's happiness and well-being. Our goal is to apply ultrahigh-sensitivity accelerometer systems in providing sustainable medical care and food production. Accelerometers are able to detect temporal changes in three dimensions in physical space, and are already used in various technologies, such as smartphones and self-driving vehicles. The ability to measure minute amounts of acceleration that cannot be detected by existing sensors would make it possible to predict changes in humans and other living organisms, and it is expected that this will lead to ultra-early diagnosis of diseases and improvements in animal welfare. It also has the potential to open up new paradigms in other fields.

Research Unit Leader **Hiroyuki Ito**

Profile

2016 Associate Professor, Institute of Innovative Research, Tokyo Institute of Technology
2013 Associate Professor, Advanced Microdevices Division, Precision and Intelligence Laboratory, Tokyo Institute of Technology
2008 Researcher, Platform Technology Research Laboratory, Fujitsu Laboratories Ltd.
2007 Assistant Professor, Advanced Microdevices Division, Precision and Intelligence Laboratory, Tokyo Institute of Technology
2006 Visiting Researcher, Intel Corporation
2006 Research Fellow (PD), JSPS Research Fellowship for Young Scientists
2006 Ph.D., Department of Advanced Applied Electronics, Tokyo Institute of Technology

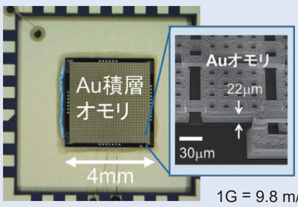
WEB http://ateal.jp/

Research goals

To systematize, commercialize, and industrialize our technology, we are pursuing the following themes: in fundamental research, "development of ultrahigh-sensitivity accelerometer systems", and in applied research, "early diagnosis of intractable neurological diseases based on low-level mechanomyography" and "prediction and early detection of illnesses in cattle" . In ultrahigh-sensitivity accelerometers, we are working on significantly reducing device and circuit noise in order to be able to measure microgravity-level accelerations, equivalent to those in environments such as space stations. For early diagnosis of neurological diseases, we are focusing on Parkinson's disease (PD). There is no basic treatment for PD, but its onset and progress can be delayed through early diagnosis. As for early detection of illnesses in cattle, if we can accurately detect minute changes in the animals' behavior, and simultaneously internal sounds such as ruminal activity, it would be possible to identify risks to production, which could greatly impact the livestock industry. We are also aiming to take the lead in Japan's integrated circuit field in cooperation with other research groups, as well as to train early-career researchers.

Contributing to sustainable medical care and food production for the happiness and well-being of society

Basis Measurement of nano-G acceleration

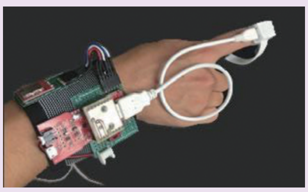


1G = 9.8 m/s²

Seeds

Needs

Application From monitoring to early diagnosis and risk prediction



Intractable neurological diseases

Livestock

Quantum Navigation Unit

Tokyo Tech Research Units

Overview

The introduction of satellite navigation, particularly GPS, has resulted in the stabilization of ship and aircraft operations for marine vessels, public shipping devices, and all land-based traffic systems. However, the navigation precision under the ground or water is much worse than the case on the ground level since we can not utilize the satellite positioning system. Even on the ground surface, there are various problems such as jamming or spoofing, threatening our safety and security. This research unit develops and implements cutting-edge technology covering classical to quantum areas and aims to establish revolutionary navigation technology to expand the human being's active region to the underwater or deep space. Furthermore, cutting-edge navigation technology is fully utilized and pioneered for examining the inner regions of the Earth, thereby assisting in the prevention and reduction of the effects of natural disasters and developing new applications for the practical use of navigation sciences.

Research Unit Leader **Mikio Kozuma**

Profile

- 2021 Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2013 Professor, Department of Physics,Tokyo Institute of Technology.
- 2001 Associate Professor, Department of Physics, Tokyo Institute of Technology.
- 1998 Assistant Professor, Institute of Physics, University of Tokyo.
- 1997 Post-doctoral research fellow at National Institute of Standards and Technology.
- 1997 Completed Doctoral Course from Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology.

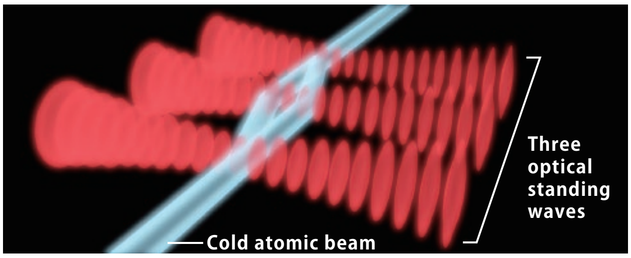
WEB www.qnav.iir.titech.ac.jp/en/

Research Goals

Due to the COVID-19 pandemic, globalization has come to a halt, and society and the economy across the whole world have fallen into disarray and malfunction, beginning in the United States and spreading to Europe. The established world order has been disturbed, and many countries around the world have had struggled in developing new systems to guarantee their country' s safety and security. When designing such a system, the following three factors must be considered: energy, disaster prevention, and food and water rationing. These elements are related to various sustainable development goals (SDGs), although this unit focuses on SDG7 (affordable and clean energy), SDG11 (sustainable cities and communities), and SDG13 (climate action). More concretely, we are planning to realize worldwide contribution from viewpoints of "streamlining marine resource exploration," "risk assessment of the large scale of the earthquake," and "data acquisition under Arctic sea ice." Fusing quantum technologies to traditional navigation methods can realize such contributions to SDGs. The mission of this research unit is to realize a safe, secure, and wealthy society based on quantum navigation technology.

Research for Non-GPS Navigation Underwater, Underground, and Outer Space Regions

Inertial navigation using accelerometers and gyroscopes is a typical example of a non-GPS navigation. Currently, the precision of inertial navigation is limited by the performance of the gyroscope. The ultra-precise gyroscope can be developed using a quantum interferometer, where three optical standing waves are used to split, reflect and combine a cold atomic beam.



atom interferometer gyroscope

Tokyo Tech Research Units

BioMedical AI Research Unit

Overview

Deep learning in the field of artificial intelligence (AI) has been garnering attention as an innovative technology in the circles of both academia and industry. Deep learning is being studied and applied throughout the world to bring about the Fourth Industrial Revolution. Its applications in biomedical fields in particular have been designated as a priority in several countries due to its growth and future potential. Deep learning has also received significant attention from industry because of the rapid expansion of the market scale. The BioMedical AI Research Unit (BMAI) is working to develop new AI fundamental technologies that advance current deep-learning methods, and to promote its applications in the biomedical fields (diagnostic support, imaging, etc.) and their translation in clinical practice.

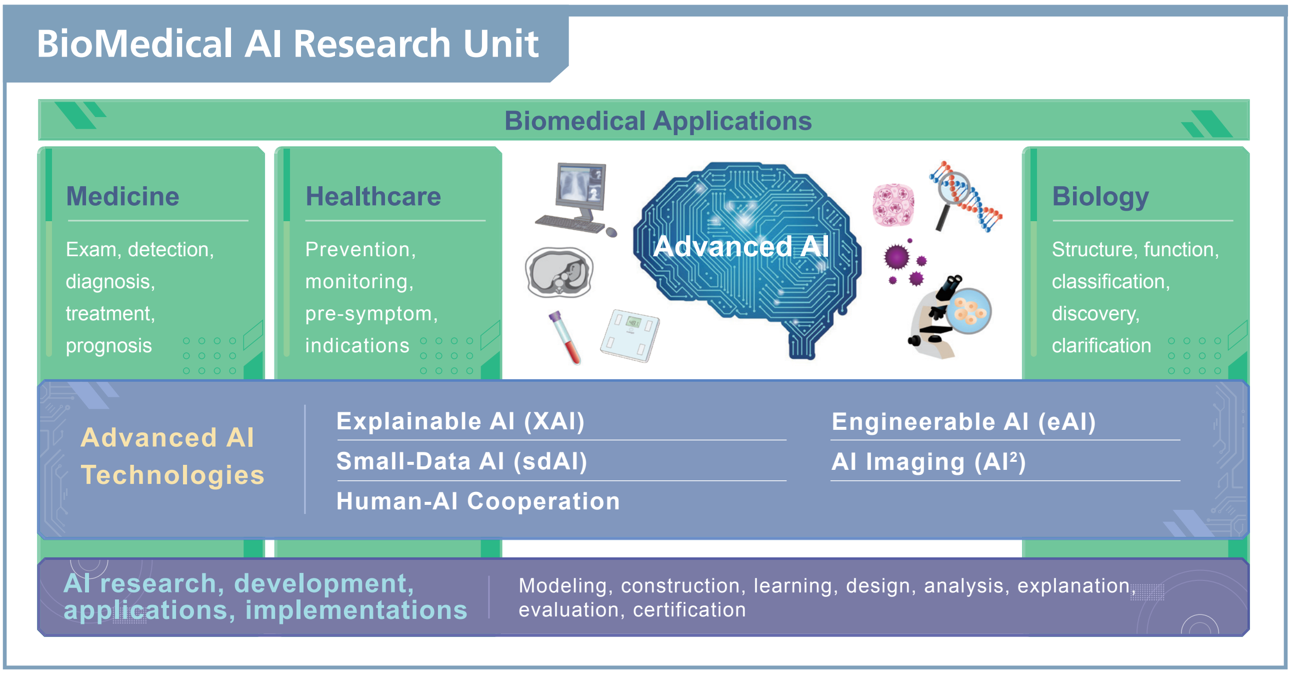
Research Goals

Deep learning is revolutionizing various fields. Things which were not possible with conventional technologies are now achievable, and performance levels that could not previously be reached are now attainable. Simply by providing big data, deep learning can automatically study a problem and produce a final result. Applications of deep learning to biomedicine, however, are hindered by the following major problems: 1) It is difficult to apply deep learning in the areas where acquiring big data is difficult; 2) since a deep-learning model learns everything automatically, the model becomes a "black box;" and 3) since deep learning is data-driven, there is no methodology for designing the model in accordance with requirements. This research unit will develop next-generation deep-learning platforms that solve these problems, and it will promote their biomedical applications and implementations in clinical practice. The research unit will conduct these activities through collaborations with medical schools and industry, while it will also educate and produce world-leading talents in AI.

Research Unit Leader **Kenji Suzuki**

Profile

2021 Professor, Institute of Innovative Research, Tokyo Institute of Technology
2017 Specially Appointed Professor, Institute of Innovative Research, Tokyo Institute of Technology
2014 Associate Professor, Medical Imaging Research Center, Illinois Institute of Technology
2007 Assistant Professor, Graduate Program in Medical Physics, The University of Chicago (joint appointment)
2006 Assistant Professor, Department of Radiology, The University of Chicago
2004 Research Associate (Assistant Professor), Department of Radiology, The University of Chicago
2002 Research Associate, Department of Radiology, The University of Chicago
2001 Visiting Research Associate, Department of Radiology, The University of Chicago
2001 PhD in Engineering, Nagoya University



Tokyo Tech Research Units

VCSEL Photonics Unit

Overview

The vertical cavity surface emitting laser (VCSEL), invented by Professor Emeritus Kenichi Iga of Tokyo Institute of Technology, has become a key component in “Internet-of-Things”
applications such as fiber-optic communications, face recognition in mobile phones, and LiDAR for autonomous driving. At the VCSEL Photonics Unit, we develop core technologies for the next generation of information and communication technology, Beyond 5G.
Ultra-high-speed high-capacity optical communications, high-resolution 3D sensing, and other technologies based on VCSEL photonics are expected to become the foundation of all industries and society by the 2030s. Forty-four years have passed since the invention of the VCSEL. We are working to promote further technological and social developments through VCSEL photonics.

Research Unit Leader **Fumio Koyama**

Profile

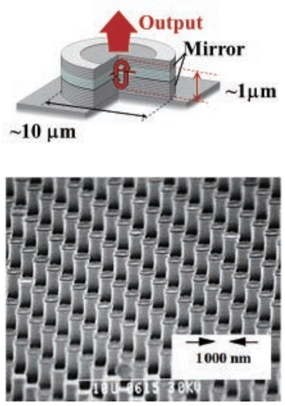
2020 Professor, Institute of Innovative Research, Tokyo Institute of Technology
2018 Director-General/Professor, Institute of Innovative Research, Tokyo Institute of Technology
2016 Director/Professor, FIRST, Tokyo Institute of Technology
2000 Professor, Precision and Intelligence Laboratory, Tokyo Institute of Technology
1988 Associate Professor, Precision and Intelligence Laboratory, Tokyo Institute of Technology
1985 Research Associate, Precision and Intelligence Laboratory, Tokyo Institute of Technology

WEB http://vcsel-www.pi.titech.ac.jp/index-e.html

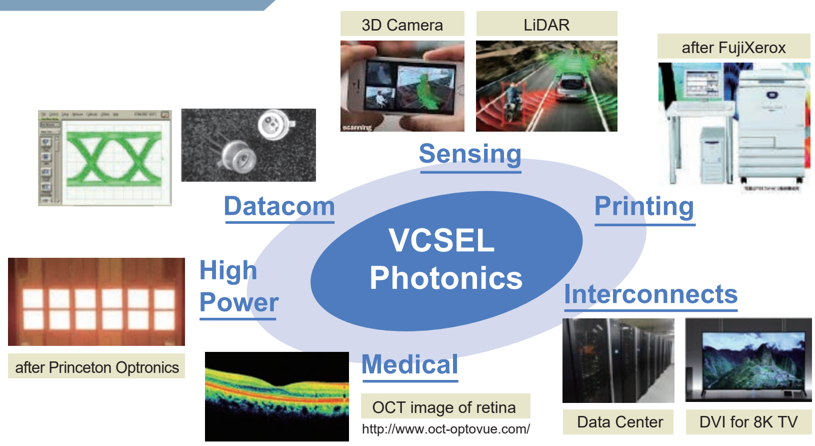
Research Goals

Our research unit will pursue the following goals:
(1) Development of a next-generation edge cloud computing infrastructure that supports Beyond 5G ultra-high capacity wireless communications, particularly research on co-packaged optics and ultra-compact optical transceivers using VCSEL arrays.
(2) Development of ultra-high-speed, low-power consumption, low-cost VCSELs used for large-capacity front hall networks connecting wireless base stations, and ultra-high-speed single-mode optical fiber transmission technology.
(3) Development of the next generation in 3D sensing technology: LiDAR is a key sensing technology in autonomous driving systems that allows for scanning of the surroundings in 3D. We will develop a solid state, ultra-high resolution beam deflector without moving parts.

VCSELs and their Application Fields



VCSEL and their 2D array



Various Applications of VCSEL Photonics

Integrated Green-niX+ Research Unit

Tokyo Tech Research Units

Overview

Semiconductor integrated circuits have advanced speed and power consumption reduction based on device scaling. In our unit, we are conducting research on 3D integration of FETs, thermoelectric elements, and devices using 2D materials, aiming for further miniaturization and higher performance. In particular, FETs using transition metal dichalcogenides, which are atomic layered materials, are attracting attention at academic societies as materials that can maintain high performance even if the generation is 2 nm or less.
In addition to these research activities, we are operating three consortiums, the Integrated Green-niX Research and Human Resource Development Center, Industry-University Consortium for the Integrated Systems and Materials, and the EISESiV Consortium, under a Keep-neutral scheme that maximizes mutual collaboration and cooperation.

Research Unit Leader

Hitoshi Wakabayashi

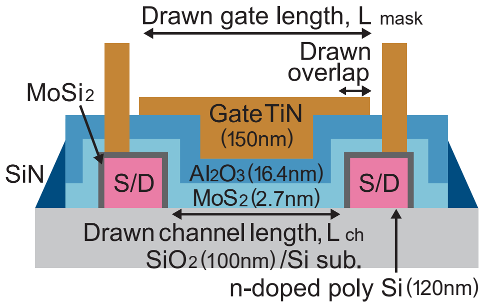
Profile

- 2023 Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2016 Professor, Engineering,Tokyo Institute of Technology.
- 2013 Professor, Interdisciplinary Granduate School of Science and Engineering, Tokyo Institute of Technology.
- 2006 SONY Corporation
- 2000 Massachusetts Institute of Technology, Microsystems Technology Laboratories, Visiting Scientist
- 1993 NEC Corporation

Research Goals

Semiconductor integrated circuits have made dramatic progress for more than half a century, based on the scaling of MOSFETs. On the other hand, in recent years, social issues such as climate change have surfaced, and in the future research and development that considers not only convenience and economic efficiency but also social rationality is desired.
In addition to improving performance, this unit promotes research activities on semiconductor integrated circuits with a focus on greening manufacturing and reducing power consumption of integrated circuits. We are looking to implement.
In the research of two-dimensional semiconductor devices, which is a particular focus, we are proposing new device structures while selecting manufacturing methods such as sputtering and ALD on the assumption that they will be mass-produced by companies in the future, which is our strengths. By implementing this device as an integrated circuit in the generation of 2 nm or less, we aim to become a green semiconductor that achieves significant reductions in power consumption while supporting complex AI calculations.

Cross sectional schematic illustration of FET with MoS_2 channel, which is a typical 2-dimensional material.



source:
K. Matsuura, H. Wakabayashi et.al.,
"Normally-off sputtered-MoS_2 nMISFETs with TiN top-gate electrode all defined by optical lithography for chip level integration."
Japanese Journal of Applied Physics, 59, 2020.

Tokyo Tech Research Units

Digital Twin Unit

Overview

Efforts are being made worldwide to realize Society 5.0 (a super-smart society) by constructing digital twins (integrating physical and cyber spaces) using the latest mathematical and information technologies, thereby addressing various challenges faced by cities, regions, and industries. To this end, our unit collaborates with private companies to advance projects that integrate reality and virtual spaces. We achieve practical applications in collaboration with academia and industry by developing algorithms in mathematical optimization, deep learning, reinforcement learning, graph analysis, high-performance computing, and quantum computing, and by utilizing high-performance computing in the cloud.

Research Goals

We are developing a mobility optimization engine that conducts optimization and simulation in cyberspace using massive amounts of sensor data (such as the movement of people and objects) and open data. Our unit aims to construct a collection of services that contribute to the creation of new industries, reduction of costs and waste, and computation of optimal control schedules for transportation systems, with the goal of providing users with optimal time and space solutions. We focus on the following two types of mobility, that will drive forward the proposal and development of new techniques in mathematics and information technology:

1. **Mobility of People and Goods:** Location detection and tracking (using deep learning), congestion detection, optimization, and visualization of flow.
2. **Traffic Mobility:** Route optimization and delivery optimization.

Moving forward, we plan to build a platform that accelerates social implementation by integrating the latest technologies in manufacturing, optimization, AI, IoT, cloud, and quantum computing.

Research Unit Leader

Katsuki Fujisawa

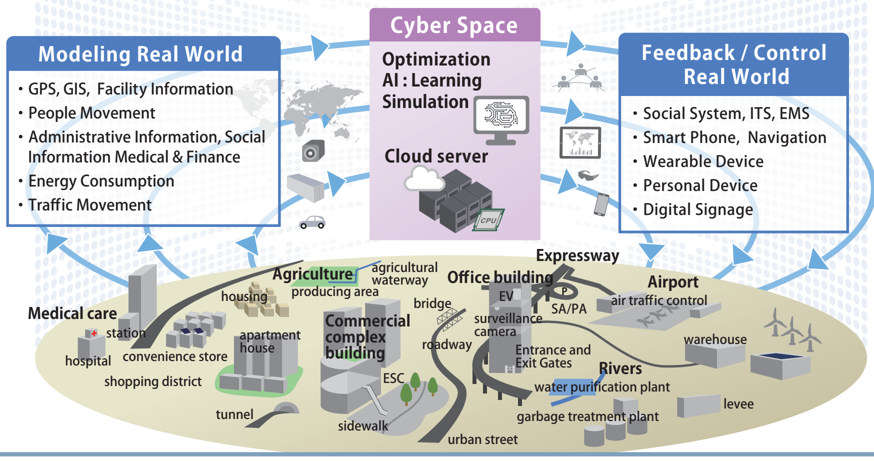
Profile

- 2023 Professor, Institute of Innovative Research, Tokyo Institute of Technology
- 2018 Director, Real World Big-Data Computation Open Innovation Laboratory(RWBC-OIL), AIST
- 2014 Professor, Institute of Mathematics for Industry, Kyushu University
- 2012 Professor, Department of Industrial and Systems Engineering, Chuo University
- 2007 Associate Professor, Department of Industrial and Systems Engineering, Chuo University
- 2002 Associate Professor, Department of Mathematical Science, Tokyo Denki University
- 1998 Assistant Professor, Department of Architecture and Architectural Systems, Kyoto University
- 1998 Doctor of Science, Department of Mathematical and Computing Sciences, Graduate School of Information Science and Engineering, Tokyo Institute of Technology
- 1993 Bachelor of Engineering, Department of Industrial Management, Waseda University

WEB https://sites.google.com/view/fujisawa-lab-en/

Components of Cyber-Physical Systems (CPS)

By digitizing phenomena occurring in the real world, it becomes possible to develop applications aimed at creating a better real-world experience. In CPS, the construction of digital twins is facilitated through the pairing of physical (real-world) and cyber spaces.



国立大学法人 東京工業大学
科学技術創成研究院
www.iir.titech.ac.jp

大岡山キャンパス
東急大井線・目黒線（大岡山駅下車 徒歩1分）
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）