QUANTUM TECHNOLOGY / NEXT-GENERATION IOT SENSORS / FLEXIBLE INTELLIGENT SYSTEM / FLEXIBLE SPINTRONICS SENSORS / CELLULOSE NANOFIBER / SILICON / MULTI-FUNCTIONAL MATERIALS / ADVANCED BATTERIES / QUANTUM-BEAM-INDUCED NANOCHEMISTRY / LASER-DRIVEN PARTICLE ACCELERATION / PHYSICS OF THE LOW-DIMENSIONAL MATERIAL VIA THE CUTTING-EDGE ELECTRON SPECTROSCOPIES / QUANTUM BEAM-DRIVEN DRUG DISCOVERY AND MEDICAL APPLICATION / PHOTOCHEMISTRY / ASYMMETRIC CATALYST / DNA/RNA-TARGETING MOLECULES / CHEMICAL BIOLOGY / COMPUTER VISION / MACHINE LEARNING / SPOKEN DIALOGUE SYSTEMS / ARTIFICIAL INTELLIGENCE / DATA MINING / BIO-INSPIRED MATERIALS / MULTIDRUG RESISTANT BACTERIA / LUMINESCENT PROTEIN / SMELL DIGITIZATION / FUNCTIONAL OXIDE NANOELECTRONICS / QUANTUM BEAM / SINGLE-ATOM SPECTROSCOPY AND SINGLE-MOLECULAR IMAGING / MATERIALS DESIGN / SINGLE-MOLECULE SCIENCE / SIMULATION

ANNUAL REPORT 2024

Year ended March 31, 2024

SANKEN

OSAKA UNIVERSITY

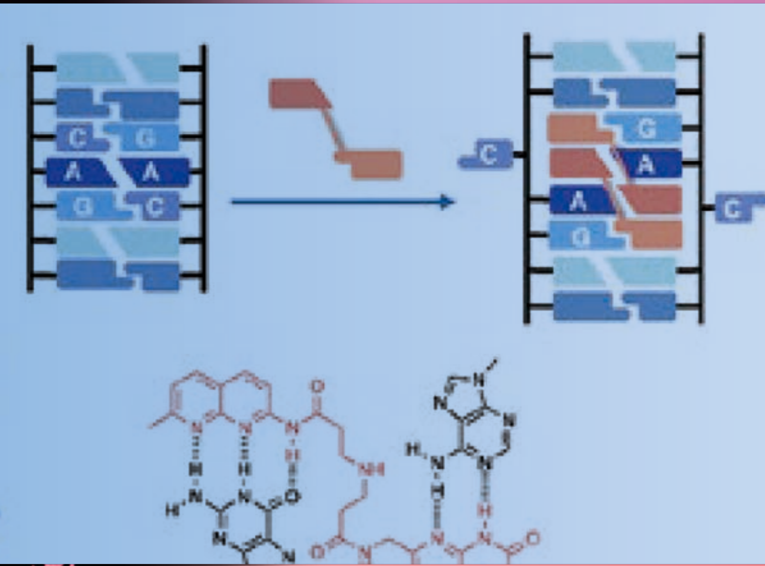
We are aiming to contribute to society by promoting state-of-the-art research and solving environmental, energy medical, safety and security issues.

Quantum Beam

- Quantum-beam-induced Nanochemistry
- Laser-driven Particle Acceleration
- Physics of the Low-dimensional Material via The cutting-edge Electron Spectroscopies
- Quantum beam-driven drug discovery and medical application

Device

- Quantum Technology
- Next-generation IoT Sensors
- Flexible Intelligent System
- flexible spintronics sensors



Molecular Chemistry

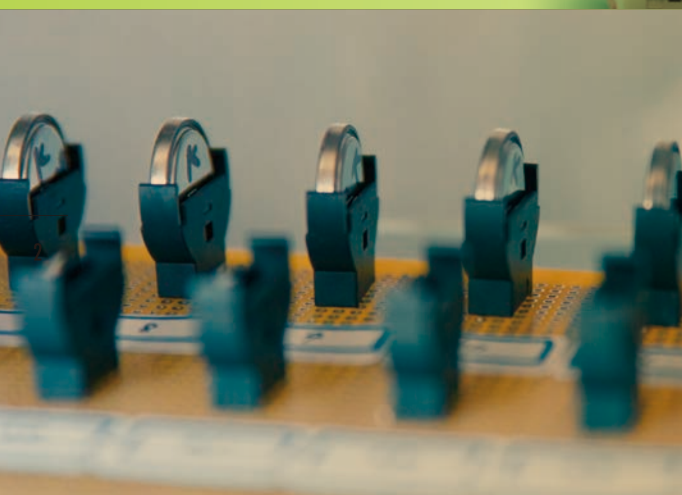
- Photochemistry
- Asymmetric Catalyst
- DNA/RNA-targeting Molecules
- Chemical Biology
- single-cell analysis

Information

- Computer Vision
- Machine Learning
- Spoken Dialogue Systems
- Artificial Intelligence
- Data Mining

Biotechnology

- Bio-inspired Materials
- Multidrug Resistant Bacteria
- Luminescent Protein
- Smell Digitization

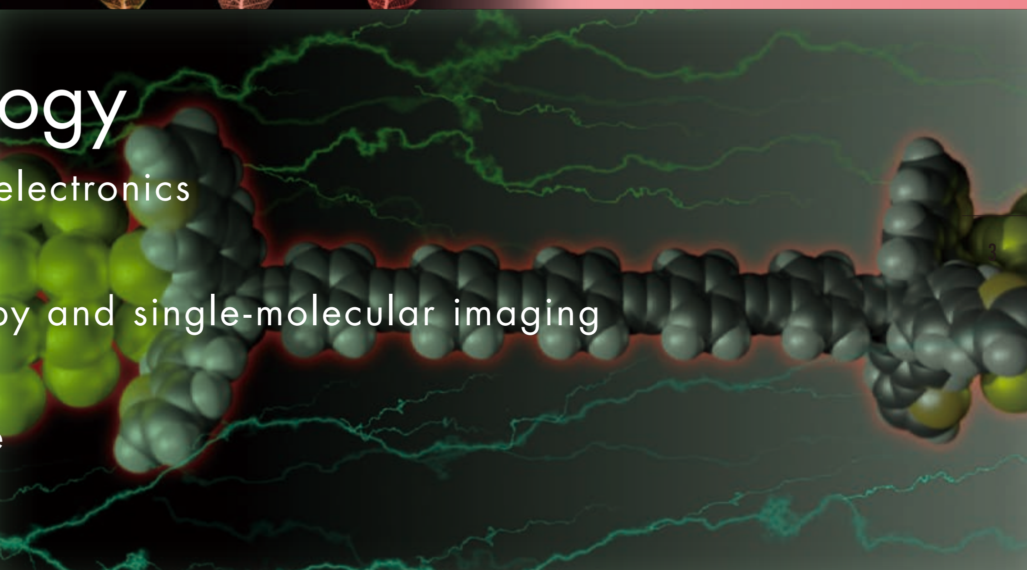


Material

- Cellulose Nanofiber
- Silicon
- Multi-Functional Materials
- Advanced Batteries
- Harnessing untapped infrared solar energy

Nanotechnology

- Functional Oxide Nanoelectronics
- Quantum Beam
- Single-atom spectroscopy and single-molecular imaging
- Materials Design
- Single-molecule Science
- Simulation



The Institute of Scientific and Industrial Research (ISIR) was established in 1939 at Osaka Imperial University, the predecessor of the current Osaka University, in response to the passionate demand and strong support from the Kansai business community to establish a research institute in Osaka on “the basics and applications of natural sciences necessary for industry.” This year marks our 85th anniversary. Our philosophy has remained unchanged through the Showa, Heisei, and Reiwa eras. We have constantly reshaped our organization and expanded our research fields to meet the evolving needs of society and times, with a focus on developing new interdisciplinary fusion research.

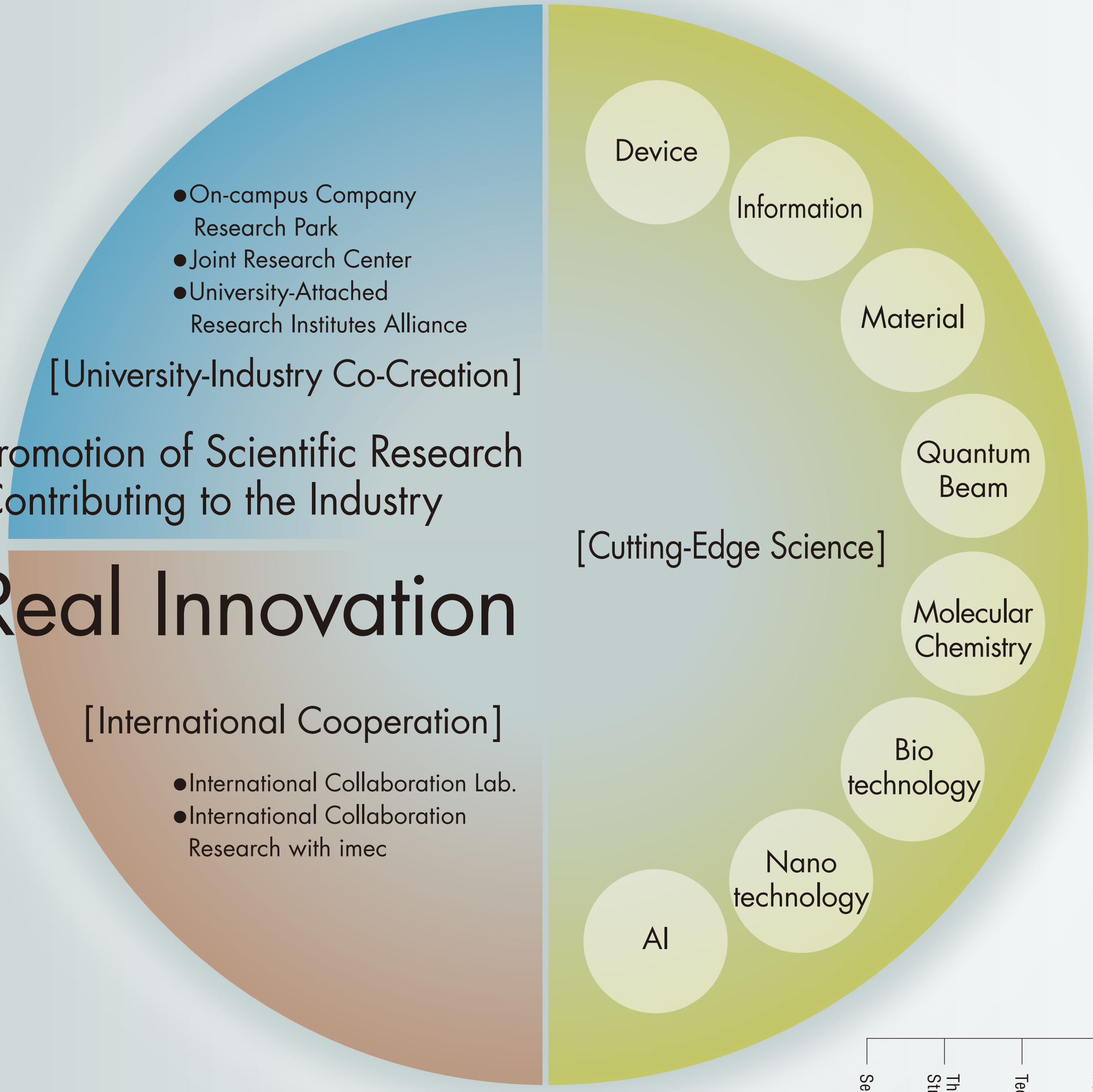
In 2009, we underwent reorganization and expansion, resulting in the establishment of four divisions: Division 1 (Information and Quantum Sciences), Division 2 (Advanced Materials and Beam Science), Division 3 (Biological and Molecular Sciences), and the Center for Nanoscience and Nanotechnology. In 2010, we established Japan’s first inter-institute alliance, the Network-type Joint Research Center (NJRC) for Materials and Devices, comprising RIES (Hokkaido University), IMRAM (Tohoku University), CLS (Tokyo Institute of Technology), IMCE (Kyushu University) and ourselves. This initiative aimed to leverage the outstanding research and facilities of each institute. We also initiated joint research projects, evolving into the Dynamic Alliance for Open Innovation Bridging Human, Environment and Materials (Five-star Alliance) since 2022. Furthermore, we are driving Japan’s first networked “Joint Research Center for Materials and Devices,” operated collectively by the five institutes (with us as the core center from 2022). By enhancing our research capabilities through collaboration with researchers from universities and companies nationwide and nurturing young researchers, we have conducted over 6,400 joint research projects and achieved an “S (top)” grade in the latest year-end evaluation by MEXT.

While the world’s social conditions and industrial structure rapidly evolve, our core philosophy remains steadfast: to swiftly identify the direction of next-generation science and technology and vigorously promote the application of advanced science and leading-edge technology. For instance, in the 1970s, we established research laboratories that paved the way for the current advancement in information science, contributing significantly to academic research development and social implementation. Building upon our rich history and achievements, the Artificial Intelligence Research Center (AIRC) was launched in 2019 to drive AI-driven science and its realization by integrating interdisciplinary research in quantum science, materials science, beam science, biology, molecular science, and nanotechnology science. In 2024, the AIRC will undergo strategic reorganization through the OU Master Plan Realization Acceleration Project to further enhance its capabilities.

In June 2021, we rebranded to “SANKEN” to elevate our international recognition, and in 2023, we refreshed our logo to reflect our commitment to challenging conversions and contributing to society. SANKEN will continue to accumulate knowledge across various scientific domains and strive to be a frontrunner in addressing global social challenges and sustainable development. We will foster collaboration and co-creation with diverse academic communities, universities, research institutions, companies, and stakeholders globally, maintaining our commitment to high-quality, world-class research and education. We sincerely appreciate your ongoing support, guidance, and encouragement.

Director

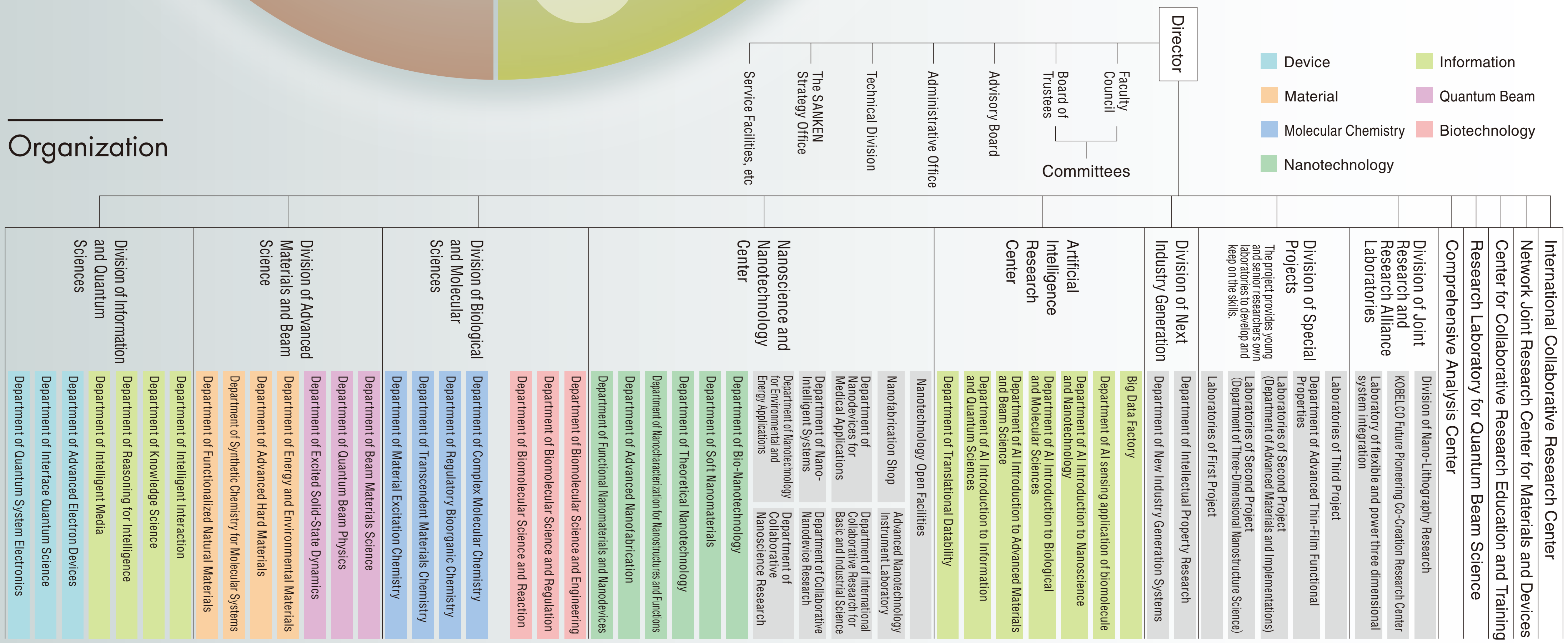
Shun’ichi Kuroda



History

1939	ISIR: SANKEN was established in Sakai City with 3 research departments.
1968	SANKEN has been relocated to Suita City.
1977	Material Analysis Center was established.
1995	Restructured to an Institute composed of 6 divisions with 24 departments for the purpose of promoting sciences on materials, information and biology.
2002	Nanoscience and Nanotechnology Center was founded. The new Center focused its research on nanomaterials and devices, beam science for nanotechnology and industrial nanotechnology. We were awarded the 21 Century COE Program MEXT (the Ministry of Education, Culture, Sports, Science and Technology).
2007	4 institutes’ Alliance (4 institutes’ network) was started. ISIR-REIS (Hokkaido Univ.) alliance laboratory was set up.
2008	Division of Special Projects was launched.
2009	SANKEN was reorganized to 3 divisions and Nanoscience and Nanotechnology Center. Material Analysis Center was reorganized to Comprehensive Analysis Center. SANKEN Incubation Building was constructed and Company Research Park was started.
2010	The Network Joint Research Center for Materials and Devices and 5 institutes’ Alliance (5 institutes’ network) were started. SANKEN was the headquarters of this nation-wide 5 institutes network.
2011	We concluded a research-collaboration agreement with Interuniversitair Micro-Electronica Centrum vzw (imec), one of the world’s largest nanotechnology research institute and “imec office” was opened at SANKEN.
2013	Osaka University has been selected as one of the core universities of the MEXT program, COI STREAM, and ISIR will play a central role of the Osaka Univ.
2016	Dynamic Alliance for Open Innovation Bridging Human, Environment and Materials including ISIR (Osaka Univ.), RIES (Hokkaido Univ.), IMRAM (Tohoku Univ.), CRL (TIT) and IMCE (Kyusyu Univ.) was established. SANKEN is the headquarters of this nation-wide 5 institutes network.
2017	We established “ISIR imec center” in imec of Belgium to promote the global cooperation network.
2019	Artificial Intelligence Research Center was established.
2021	In June 1st 2021, the official English abbreviated name of our institute was changed from “ISIR” to “SANKEN”.

Organization



Company Research Park

We operate a space "Company Research Park."
This space promotes open innovation by companies in cooperation with our research activities. The users can receive state-of-the-art technical counseling for practical application research and can form and utilize networks as an open innovation base.

Alliances among Research Institutes and Network Joint Research Center

Crossover Alliance to Create the Future with People, Intelligence and Materials (Five-star Alliance)

Five university research institutes across Japan Archipelago (Research Institute of Electronic Science at Hokkaido University; Institute of Multidisciplinary Research for Advanced Materials at Tohoku University; the Laboratory for Chemistry and Life Sciences, Institute of Innovative Research at Tokyo Institute of Technology; Institute of Scientific and Industrial Research at Osaka University; Institute for Materials Chemistry and Engineering at Kyushu University) cooperate with each other to organically cross-over rich research resources including human resources, knowledge, technology, and facilities, and promote research aimed at solving social issues and the development of young researchers.

alliance.tagen.tohoku.ac.jp/english/

Network Joint Research Center for Materials and Devices (NJRC)

The Network Joint Research Center for Materials and Devices (NJRC) has been established in FY2011 as a first network of such centers in Japan (a project approved by the Ministry of Education, Culture, Sports, Science and Technology). The five research institutes that make up the center work together to invite researchers from a wide range of research institutions for joint research thorough open recruitment. Taking advantage of the characteristics of the network of centers, we promote joint research with universities, public research institutes, and private companies in Japan and overseas, and strengthen research capabilities and develop human resources in the fields of materials and devices and their related fields.

five-star.sanken.osaka-u.ac.jp/en/

KOBELCO Future Pioneering Co-Creation Research Center

As the labor force continues to shrink due to the declining birthrate and aging population, the manufacturing industry needs to respond to rapid changes in the business environment including decarbonization. In particular, there are urgent needs to evolve the workplace so that workers can demonstrate their ability through operations that generate higher added value.

Therefore, by combining KOBELCO's diverse and realistic manufacturing experience and technology with Osaka University's AI and other cutting-edge science, the research center will develop solutions that enable workers to grow with digital systems and be more creative.

kobelco-fpc.com/

Education

Members of SANKEN participate in graduate education in cooperation with the Graduate School of Science, Engineering, Engineering Science, Pharmaceutical Sciences, Information Science and Technology and Frontier Biosciences. In addition, we provide the lectures in Interdisciplinary Educational Subjects and contribute partly to the advanced human resource development by participating in R³ Institute for Newly-Emerging Science Design, Osaka University.

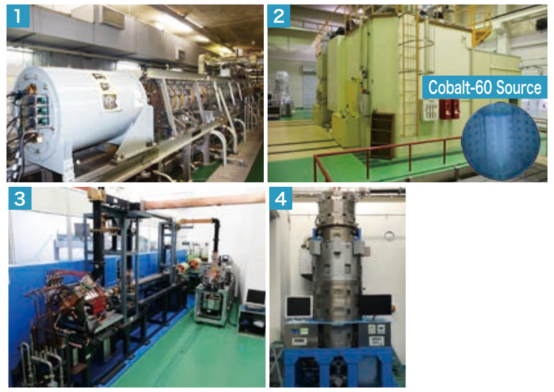
International Cooperation

Academic Exchange Agreements of ISIR with Universities and Research Institutions Abroad (April, 2024)

- Inter-University Exchange Agreements: 16
- Faculty-level Exchange Agreements Based on Inter-University Exchange Agreements: 3
- Faculty level Exchange Agreements: 14
- ISIR Overseas Center: 1

Facilities

Research Laboratory for Quantum Beam Science



Developments and applications of ultimate short-pulsed electron beam, high-brightness electron beam, light source base on FEL and positron beam have been promoted together with an intense Co-60 gamma-ray source in this facility.

Machine List

1. L-band electron linac
2. Co-60 gamma-ray irradiation facility
3. RF-Gun equipped S-band electron linac
4. Time-resolved electron microscope
- THz light source based on FEL of L-band linac

www.sanken.osaka-u.ac.jp/labs/rl/English/

Comprehensive Analysis Center

As a common facility for comprehensively performing composition and structural analysis of various materials, Comprehensive Analysis Center has equipment of composition analysis system, spectroscopic analysis system, electron microscope system, state analysis system.

Machine List

1. Element analyzer
2. Transmission electron microscope
3. Nuclear magnetic resonance
4. X-ray diffractometer
5. Mass spectrometer
- Scanning electron microscope

www.sanken.osaka-u.ac.jp/labs/cac/

Nanotechnology Open Facilities

Nanotechnology Open Facilities totally contributes to creations of novel nano-materials and nano-devices for companies / universities / institutes researchers in nanotechnology research fields with the latest equipment and technical support.

Machine List

1. 125keV EB Lithography
2. Helium Ion Microscope
3. Deep Reactive Ion Etching
4. Pulsed Laser Deposition
5. Scanning Electron Microscope
6. Scanning Probe Microscope

nanoplatform.osaka-u.ac.jp

Artificial Intelligence Research Center (AIRC)

The Artificial Intelligence Research Center（AIRC）was established for realizing laboratory-led "bottom-up type AI introduction" at SANKEN, which has a wide range of research fields in the under-one-roof.
From 2024, AIRC has been started as an acceleration program of OU master plan realization.
Specifically, the AI center (1) trains young researchers as PI in each research field to be suitable for AI co-created research.
(2) establishes an AI co-creation protocol appropriate for each research field,
(3) establishes "AI co-creation liaison office" for returning the fruits to each department of Osaka university, and aiming for implementation in industry and transmission to the world,
(4) conducts researches to lead the solutions obtained by AI to scientific principles without ending them as a black box.

産業科学AIセンター

www.sanken.osaka-u.ac.jp/labs/aic/

SANKEN VISIT 01

Touring industrial laboratories and meeting with research groups

SANKEN has engaged in cutting-edge scientific research and development of contemporary academic-industrial collaborations for nearly 80 years, as a leading multidisciplinary laboratory of science and technology in Japan. At present, the Institute has a focus on three research fields, information/quantum science, material/beam science, and biology/molecular science, and has an industrial nanotechnology center. The Institute has expanded its research interests in response to recent developments in scientific technology, and has obtained world-leading research findings in collaboration with various groups. The research scientists who have produced these great achievements are introduced here, with a description of the latest topics.

Control of Life with Organic Chemistry

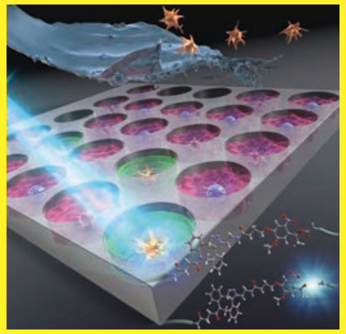
Professor Satoshi Yamaguchi
Division of Synthetic Chemistry for Molecular Systems

Molecular tool for catching floating cells

Floating cells including immunocytes can be adhered while alive and aligned one by one on a culture substratum using irradiation with light. As a result, complex activities of individual living cells can be observed and classified using artificial intelligence (AI), and distinctive cells can be selected for collection. This breakthrough technology was developed through the research of Prof. Yamaguchi.

"This is a technological development for advancement of cell biology, in which cell functions are investigated in individual cells, rather than in a group of cells. I believe that this technology can solve research questions in drug development and medical treatment."

Prof. Yamaguchi's research is in "life control chemistry," which approaches biological science from the field of synthetic organic chemistry. He has established a research model in which light and synthetic molecules are used as a tool to obtain new information. In recent research, a photoactivatable polyethylene glycol [PEG] lipid was synthesized such that part of the molecule could adhere to a cell membrane after a conformational change produced by irradiation with light. This molecule was coated on the surface of a culture substratum to enable capture of immunocytes and cancer cells, which are floating cells without factors that promote adherence to a cell membrane. In addition, the cells can be arranged in an intended pattern by irradiation with light.



The experiments performed using this technology showed remarkable results. The cancer cells were killed by immunocytes, which were aligned close to the cancer cells. Furthermore, a system to sort immunocytes automatically was developed based on the level of damage to cancer cells calculated by AI using images obtained in the experiments.

Activating whole cell functions

Another great achievement of Prof. Yamaguchi is the development of a new method to activate whole functions of cells using light. In a previous method, light-responsive protein genes were implanted into the genome of a cell, but this method could only activate specific functions.

Prof. Yamaguchi has developed a method in which a shell made of molecules sensitive to light was used to cover a whole cell to block outside effects and inhibit cell functions. When the shell was eliminated by irradiation with light, various functions of the cell were activated. In an experiment in which an immunocyte was covered by the shell, it was clearly observed that phagocytosis began when the shell was removed.

Prof. Yamaguchi explained: "Synthetic chemistry enables molecular design at an atomic level, and thus, can produce molecules with various properties and functions. The functions of cells are controlled by interactions of components, such as protein and DNA. However, the functions can be controlled freely using a method with thick caging (covering) of the cell surface using synthetic molecules as tools."

Playfulness is important

Prof. Yamaguchi first encountered synthetic organic chemistry when he was involved in research to produce a large volume of protein in E. coli using recombinant DNA technology, as a student at the University of Tokyo Graduate School. Proteins made by E. coli cohered, and the yield was as low as 3%. Then, an originally synthesized agglutination inhibitor was added based on advice from a laboratory of organic chemistry, which was out of his sphere. The agglutinated protein loosened and formed an active molecular structure. The yield measured at that time was 84%, which was 28 times higher than the previous yield.

Since then, Prof. Yamaguchi has engaged in biotechnology research using synthetic organic chemistry as an Associate Professor at the University of Tokyo, and he came to our university in January this year. He said: "It is important to have playfulness in your research. When you do not have fun with your work, the research cannot be continued."

He likes sports, and joined a basketball club in his elementary, junior high, and high school days, and a boxing club at university. He still likes to play futsal and sandlot baseball. He is a big fan of the Hanshin Tigers. He said: "When big events occurred, such as the Hanshin Tigers winning the pennant, changes also occurred for me; for example, I obtained a degree and changed my location for research. When the Tigers became the No. 1 team in Japan this time, I came to Osaka University - maybe because I was linked by fate."

Written by Yoshinori Sakaguchi, former editorialist and former reporter for Sankei Shimbun, and current Adjunct Professor at Nara Institute of Science and Technology. Covers general science fields, mainly medical science, as a science journalist.

Solar photovoltaic power generation with use of infrared rays

Multipliable renewable energy

Solar photovoltaic power is the most common energy source used to reduce global warming among renewable energies that are important for a decarbonized society. In solar photovoltaic power generation, high energy ultraviolet rays and visible rays with a short wavelength are absorbed by a semiconductor to convert the light into electricity. However, infrared rays, which account for about 43% of sunlight, are not converted to electricity because the energy is low due to the long wavelength. Development of an approach to use this rich unutilized solar resource is an important task.

A new avenue for use of infrared rays has been proposed by Prof. Masanori Sakamoto, who is known for his research in the field of photochemistry. He has successfully developed semiconductor nanoparticles that absorb low energy infrared rays and excite electrons to the level of photoelectric conversion.

Prof. Sakamoto has a vision of the future after practical realization of the method, saying "When infrared rays can be used for solar photovoltaic power generation, the total amount of electric energy will be increased. In addition, since infrared rays are heat rays, the technology will contribute to reduction of global warming if these rays can be collected before they reach the ground. Plants do not use infrared rays for photosynthesis, and thus the technology does not damage plants."

An entrepreneurial venture, OPTMASS, has already been established by the university to promote development and mass production of high-quality nanoparticles. Furthermore, technological development of transparent window glass-like solar cells including the material will generate electricity by absorbing infrared rays. It has been suggested that this technology could be used for all windows of a skyscraper, Abeno Harukas (one of the highest buildings in Japan - 300 meters) in Osaka, that mega-solar power generation (1,000 kW or more) could be achieved, and that the approach may work as an electric power plant in a city.

Prof. Sakamoto says, "The window glass can maintain brightness in a room and block heat waves, unlike existing photovoltaic units. Although forests have decreased due to urbanization, a city can play a role in global environmental protection of forests."

High-performance semiconductor nanoparticles

Prof. Sakamoto thinks back, saying "There were almost no materials that select and absorb only light in the infrared region. Therefore, I heard from some researchers that it would be impossible to collect infrared rays for power generation, and that such research would not be successful. Conversely, this encouraged me to perform research on infrared rays."

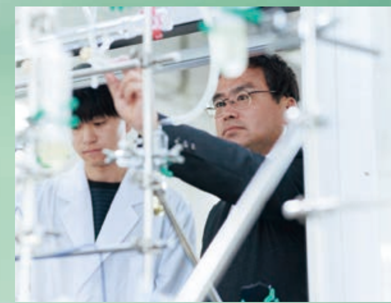
This brave idea to use low energy infrared rays for solar power generation began when Prof. Sakamoto focused on a physical phenomenon, localized surface plasmon resonance (LSPR), that occurs on the surface of a particulate semiconductor with the size of a nanometer (one-billionth of a meter). Plasmon resonance is a phenomenon in which carrier excited by absorbing light increase energy through a collective oscillation in a certain direction. Copper sulfide was selected as the semiconductor material. Since plasmon resonance is transient, nanoparticles were synthesized to transfer carriers with increased energy (hot carriers), and copper sulfide was adhered as semiconductor so that the resonance could be maintained.

Using the nanoparticles as a photocatalyst, an experiment was performed to obtain the "external quantum efficiency," which shows the performance of the photocatalyst, by measuring how many photons (quantum) were used among all incident photons. The efficiency was found to be 3.8%, the highest achieved worldwide, when infrared rays of wavelength 1,100 nanometers were absorbed. It was also shown that infrared rays with any wavelength could be used.

Prof. Sakamoto said, "Since the data were beyond my imagination of what could be obtained, I asked students to repeat the experiment five times for confirmation. The students were against the request. However, the data obtained by the students turned out to be correct, and I had to apologize to them."

Do not hesitate to meet a challenge

Prof. Sakamoto said, "I was interested in research on optical technology, such as recording with use of light, but I often heard in lectures that even plants could not use infrared rays, although use of renewable energy was increasing. Since I was a university student, I have wondered if infrared rays could be used with technologies developed by humans for co-existence of the earth and human beings. When I began the research, it was difficult to obtain favorable data, but so-called discontinuous jumps occurred after approaching the research together with staff and students with enthusiasm and persistence, enabling us to obtain the expected results."



After finishing his Master's degree at the Graduate School of Kyushu University, Prof. Sakamoto earned a doctoral degree at the Graduate School of Osaka University. After working as an Assistant Professor at the University of Tsukuba and as an Associate Professor at the Institute for Chemical Research, Kyoto University, he was appointed to a Professorship at the SANKEN, Osaka University in April this year.

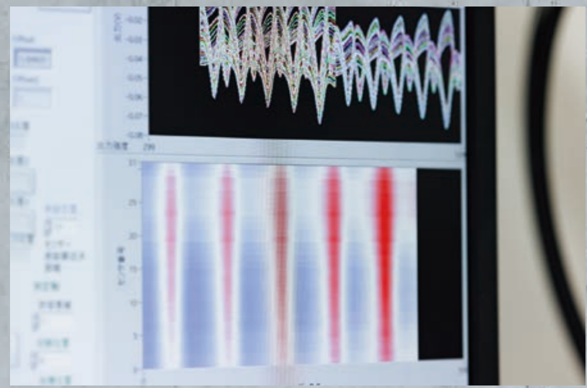
Prof. Sakamoto said, "I believe it is important not to hesitate to take on a challenge. It is also important not to forget to have a sense of awe of nature and science. Nature is an excellent system. We are blessed because we can promote scientific research for the benefit of nature."

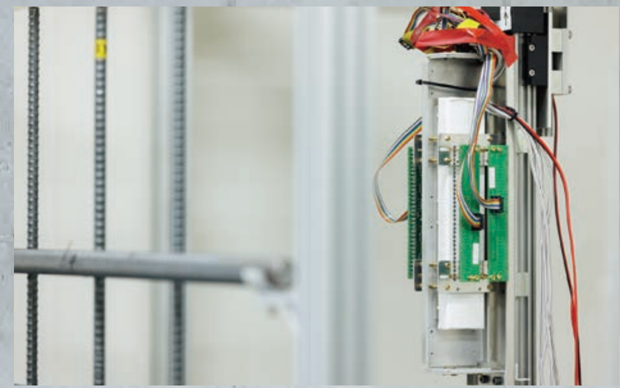
Prof. Sakamoto is very busy as a university professor and chief technical officer of a venture company established by the university. However, he enjoys rest and relaxation in visits to a park or a shopping center with his family on holidays.

坂本雅典
Professor Masanori Sakamoto
Department of
Transcendental Materials Chemistry

Non-destructive visualization of rebars used in 2D reinforcement of concrete: Shortening the test time for rebars embedded in concrete to less than 1/30th of the conventional time

Prof. Chiba's group at the Institute of Scientific and Industrial Research at Osaka University have improved their original permanent magnet procedure and developed a novel sensor that allows visualization of rebars inside concrete structures in a single scan and without destruction of the structure. Using a prototype of a 2D scanner with an installed sensor, the test time for this non-destructive visualization of rebars in concrete structures was shortened to less than 1/30th of the conventional time.





Professor **Daichi Chiba**

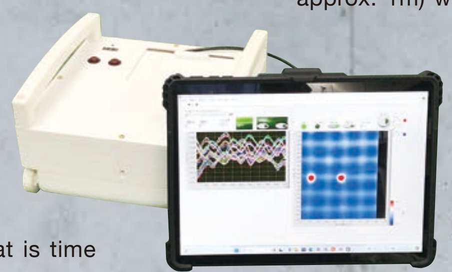
Department of Interface Quantum Science

千葉大地

Prof. Chiba's group and Kyoei Sangyo Co., Ltd. have produced a compact scanner using the above technology. This has streamlined the testing process and is likely to reduce accidents due to antiquated concrete structures, contributing to a safe and secure society.

Scanners using an electromagnetic radar[*1] are commonly used for non-destructive testing of rebars embedded in concrete structures. However, the reflection time of electromagnetic waves depends on the wetness of the concrete and the presence of cavities inside structures, and this can result in incorrect measurement of the depth of rebars embedded in the concrete.

The group have validated the permanent magnet method[*2] using a module combining a permanent magnet with a pair of magnetic sensors. This method is less affected by the degree of wetness of the concrete and the presence of cavities, compared to electromagnetic wave radar. The tests showed that the permanent magnet method gave more accurate measurements of the depth of rebars embedded in the concrete.



In addition, conventional methods such as electromagnetic radar use repeated scanning to collect 1D data with a slight change in the sensor position, after which the rebars are reconstructed as 2D images. This is a major task that is time consuming for measurement. With this background, Prof. Chiba's group has developed technology to evaluate the rebars inside concrete structures using 2D images collected in a single scan[*3].

1 Development of a multi-pair sensor module

Prof. Chiba's group improved the permanent magnet method by integration of multiple magnetic sensors, and then developed a multi-pair sensor module that can visualize rebars as 2D images in a single scan. The multi-pair sensor module has multiple magnetic sensors aligned facing each other, along with rod-like permanent magnets.

2 Validation of high-speed 2D scanning

A prototype of a 2D scanner with a multi-pair sensor module mounted in a robot consisted of electric actuators was used to examine if rebars in concrete structures could be viewed as 2D images. In the permanent magnet method, concrete is similar to air; therefore, measurements do not change regardless of whether the rebars are or are not embedded in concrete. For verification, a simple grid-like rebar sample that was not embedded in concrete was prepared in the laboratory, and the sample was automatically scanned by the sensor module-mounted robot.

In the verification test, a 2D image of the rebars of the sample (vertical 0.5m × horizontal [scanning direction] approx. 1m) was obtained in about 45 seconds. The operation time was shortened to less than 1/30th of the time for the conventional method using repeated scanning of 1D data followed by visualization of the data as 2D images.

In future, Prof. Chiba's group and Kyoei Sangyo Co., Ltd. plan to improve the precision of the method and produce a scanner that can be used by one measurer. This will streamline the test process and reduce accidents due to antiquated concrete structures, which will contribute to a safe and secure society.

*1 Electromagnetic radar
A system to probe rebars in a concrete structure without destruction of the structure, using reflection of electromagnetic waves from rebars, non-metallic pipes, and cavities inside the concrete. This method uses electromagnetic waves incident to the concrete surface, with the distance estimated from the time for return of the reflected waves.

*2 Permanent magnet method
A method to probe rebars in a concrete structure without destruction of the structure, using a sensor module comprising a permanent magnet with a pair of magnetic sensors. The results in this study used a magnetic sensor multi-pair construction. When a permanent magnet is moved close to the rebars, the magnetic field around the magnet changes due to the rebars absorbing the magnetic flux leaking from the magnet. This method can detect the presence of rebars embedded in concrete structures and measure the depth and thickness of the rebars by monitoring changes in the magnetic field with a magnetic sensor. Two pairs of magnetic sensors are located at the position where changes in the magnetic field caused by approaching the rebars are different. The signal can be detected with high sensitivity by measurement and amplification of the difference in force exerted on the two sensors.

*3 Technology to obtain a 2D image from a single scan
Reference movie: https://youtu.be/w254FoNVQ1E

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

Researchers from SANKEN (The Institute of Scientific and Industrial Research), at Osaka University report a dehydration method for cellulose nanofibers that produces a dense powder while maintaining the unique properties of the thickening agent

A new method to keep thickening agents tiny in transport and big in application

能木雅也

Professor Masaya Nogi
Department of Functionalized Natural Materials

Osaka, Japan – Many commercial products such as food, cosmetics, and inks contain cellulose nanofiber (CNF) as a thickening agent. However, CNFs have some limitations that prevent their more widespread use. Now, researchers from Osaka University have demonstrated a method of dehydrating CNFs to a dense powder without affecting their three key properties. Their findings are published in *Macromolecular Rapid Communications*.

Video for your easy understanding
https://youtu.be/PAEd36v_SjI

CNFs are a popular thickening agent because small amounts in water have high transparency, high viscosity, and the viscosity can be controlled. However, the amount of CNF needed in water is very small, so the most efficient way of transporting CNFs is as a dry powder.

Sounds good, but how do we get CNFs into powder form? The water containing the CNFs can be boiled away, but the remaining fibers stick together and redispersing these clumps leads to liquids that are cloudy, unless a lot of energy is used to break up the clumps. If water is removed by freeze drying, the resulting CNF powder is quite fluffy and takes up a lot of space. It is also affected by static electricity, making it difficult to handle.

These are significant drawbacks in industries where efficiency affects profitability. Therefore, the research team from Osaka University devised an improved water-removal method, the first step of which is to form an 'organogel', a type of gel consisting partly of organic molecules.

"Our process involves taking a CNF paste in water and dehydrating it by stirring in ethanol," explains corresponding author Masaya Nogi. "The ethanol is then removed at 30°C, which is a low and cost-effective temperature. After some processing, it can then be redispersed in water simply by stirring."

The redispersed product was shown to retain the three key properties of CNF thickening agents. Its tunable viscosity was demonstrated by spraying it from a pump spray bottle. It was successfully sprayed from the nozzle, which requires a low viscosity, and the ejected droplets did not run from where they landed on an upright surface, which requires high viscosity behavior. Furthermore, the spray doesn't generate dripping, which can be a problem with other sprays.

"The large scale of many industrial processes means that all process improvements can have a big impact on the bottom line," says senior author Masaya Nogi. "Our method of powder creation retains all key properties of CNFs while also enabling effective handling and cheaper transport and storage."

The ease of use of the organogel-derived CNF powders is expected to make them an attractive prospect for application in many areas, including in the food, cosmetics, and sanitation industries.

The article, "Evaporative Dry Powders Derived from Cellulose Nanofiber Organogels to Fully Recover Inherent High Viscosity and High Transparency of Water Dispersion," was published in *Macromolecular Rapid Communications* at DOI: https://doi.org/10.1002/marc.202300186

Fig.1
Evaporated CNF powders have a small volume and no handling issues related to static electricity (upper left). Their water dispersions are colorless and transparent (upper right) and dispersion droplets formed by spraying do not drip (lower).

Fig.2
Evaporated CNF powders recover the inherent dispersion properties and are dense, which reduces the transportation and storage costs (upper).
Freeze-dried CNF powders recover the inherent dispersion properties, but have a large volume and readily stick to surrounding objects (lower).

Topology's Role in Decoding Energy of Amorphous Systems

Researchers show how topological data analysis can be used to predict the properties of amorphous materials using machine learning, which could pave the way for more computationally efficient methods suitable for industrial applications

Professor Emi Minamitani
Department of Theoretical Nanotechnology

Osaka, Japan – How is a donut similar to a coffee cup? This question often serves as an illustrative example to explain the concept of topology. Topology is a field of mathematics that examines the properties of objects that remain consistent even when they are stretched or deformed—provided they are not torn or stitched together. For instance, both a donut and a coffee cup have a single hole. This means, theoretically, if either were pliable enough, it could be reshaped into the other. This branch of mathematics provides a more flexible way to describe shapes in data, such as the connections between individuals in a social network or the atomic coordinates of materials. This understanding has led to the development of a novel technique: topological data analysis.

In a study published this month in *The Journal of Chemical Physics*, researchers from SANKEN (The Institute of Scientific and Industrial Research) at Osaka University and two other universities have used topological data analysis and machine learning to formulate a new method to predict the properties of amorphous materials.

A standout technique in the realm of topological data analysis is persistent homology. This method offers insights into topological features, specifically the "holes" and "cavities" within data. When applied to material structures, it allows us to identify and quantify their crucial structural characteristics.

Now, these researchers have employed a method that combines persistent homology and machine learning to predict the properties of amorphous materials. Amorphous materials, which include substances like glass, consist of disordered particles that lack repeating patterns.

A crucial aspect of using machine-learning models to predict the physical properties of amorphous substances lies in finding an appropriate method to convert atomic coordinates into a list of vectors. Merely utilizing coordinates as a list of vectors is inadequate because the energies of amorphous systems remain unchanged with rotation, translation, and permutation of the same type of atoms. Consequently, the representation of atomic configurations should embody these symmetry constraints. Topological methods are inherently well-suited for such challenges. "Using conventional methods to extract information about the connections between numerous atoms characterizing amorphous structures was challenging. However, the task has become more straightforward with the application of persistent homology," explains Emi Minamitani, the lead author of the study.

The researchers discovered that by integrating persistent homology with basic machine-learning models, they could accurately predict the energies of disordered structures composed of carbon atoms at varying densities. This strategy demands significantly less computational time compared to quantum mechanics-based simulations of these amorphous materials.

The techniques showcased in this study hold potential for facilitating more efficient and rapid calculations of material properties in other disordered systems, such as amorphous glasses or metal alloys.

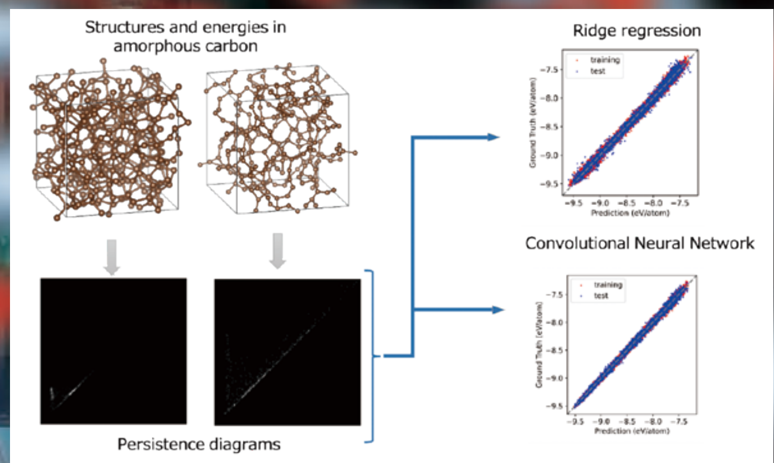


Fig.1
Calculated results using the persistent homology method (persistence diagram) for amorphous carbon structures and the resulting energy predictions.

The article, "Persistent homology-based descriptor for machine-learning potential of amorphous structures," was published in *The Journal of Chemical Physics* at https://doi.org/10.1063/5.0159349

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Research Reports

2023.4.18 Now you can be comfortable in your e-skin
Department of Advanced Materials and Implementations/Teppei Araki
Department of Functionalized Natural Materials/Hirotaka Koga

2023.6.27 A new method to keep thickening agents tiny in transport and big in application
Department of Functionalized Natural Materials/Masaya Nogi

2023.7.18 A new sensor shows brain cells making and then breaking contact
Department of Biomolecular Science and Engineering/Takeharu Nagai

2023.7.26 Are quantum computers the future of genome analysis?
Department of Bio-Nanotechnology/Masateru Taniguchi

2023.8.22 Topology's Role in Decoding Energy of Amorphous Systems
Department of Theoretical Nanotechnology/Emi Minamitani

2023.9.22 Looking near and far without a lens: Radial masks give thin cameras a large depth of field
Department of Intelligent Media/Tomoya Nakamura,Yasushi Yagi

2023.10.17 Sustainable smart agriculture with a biodegradable soil moisture sensor
Department of Functionalized Natural Materials/Takaaki Kasuga

2023.10.26 A new era for accurate, rapid COVID-19 testing
Department of Bio-Nanotechnology/Masateru Taniguchi

2023.12.6 Permselectivity reveals a cool side of nanopores
Department of Bio-Nanotechnology/Makusu Tsutsui

2024.1.19 Making an important industrial synthesis more environmentally friendly
Division of Synthetic Chemistry for Molecular Systems/Shinobu Takizawa

2024.1.23 Organic Electronics Lead to New Ways to Sense Light
Department of Advanced Materials and Implementations/Teppei Araki

2024.2.20 Shortcut to Success: Toward fast and robust quantum control through accelerating adiabatic passage
Department of Quantum System Electronics/Takafumi Fujita, Akira Oiwa

Learn more here

Department of Advanced Thin-Film Functional Rroperties

I was appointed as Associate Professor in the Department of Advanced Thin Film Functional Properties in November 2023, after serving as Associate Professor in the Department of Advanced Electronic Devices (Sekitani Laboratory) for about 9 years until October 2023. My specialty is research and development of devices such as flexible electronics and wearable sensors. In particular, I am working on research into the physical properties and applications of thin-film and lightweight electronics devices that utilize organic semiconductor materials. We will continue to promote research and development to solve social issues by deepening our collaboration with information science for research on physical properties of thin-film electronic devices and their application to sensor devices and utilization of sensor data. We look forward to your continued support.

Awards

"The Young Scientists' Award" in The 2023 Commendations for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology

Department of Advanced Materials and Implementations
Teppei Araki

Study of Creation of Biocompatible Electronics Through Nanomaterial Design

I am very honored to receive this very prestigious award. I would like sincerely appreciate the support and assistance of many people including professors, researchers, students and others who are involved in my study. I will continue to devote myself to research activities with even greater dedication to contribute to the development of the field of flexible electronics.

"Awards for Science and Technology (Research Category)" in The 2024 Commendations for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology

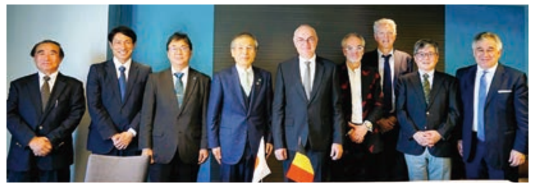
Department of Translational Datability
Yasushi Sakurai, Yasuko Matsubara

Research on Dynamic modeling and Real-time Analysis over Data Streams

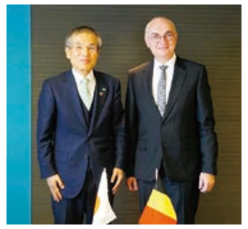
We would like to express our sincere gratitude for this prestigious academic award. We are deeply thankful to the members of our research lab, our co-researchers, and all Sanken members. Our research team has developed dynamic modeling and forecasting techniques for large-scale time-series data. We will continue to dedicate ourselves to our research activities to contribute to the development of new technologies and industries that will advance the IoT and AI fields in the future.

imec and Osaka University agreed to initiate the “second stage” of collaborative partnership, further solidifying mutual commitments to diverse research collaborations and academic exchange programs

On November 9, 2023, Luc Van den hove, President and CEO of imec, a world-famous leading research center in nanoelectronics and digital technologies headquartered in Leuven, Belgium and Shojiro Nishio, President of Osaka University reinforced a close academic relationship at a top executive meeting.



Participants joined at top executive meeting, New Otani

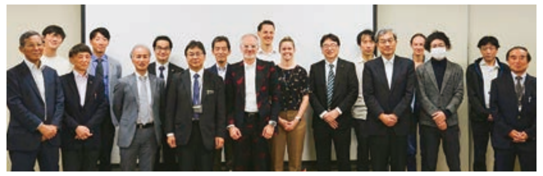


Top executive meeting between Luc van den hove president & CEO of imdc and Shojiro Nishio president of Osaka University

imec and Osaka University have collaborated in a multitude of research fields on a departmental and individual level over an extended period of time since SANKEN entered into Collaboration Framework Agreement with imec in November 2011. Ever since, we have leveraged our advanced research environment to further promote mutual R&D capability through close exchanges of professional expertise, outstanding achievements, and breaking discoveries. This time, in order to accelerate holistic collaboration between imec and Osaka University, top executives on both organizations met together: Both top executives had frank and lively exchange of views and agreed to move toward the “second stage” to expand our collaboration from the departmental level to the institutional level. They will be embodied in mutual collaborative research in high-profile life science, cutting-edge semiconductor packaging, promising smart agriculture and more.

12th imec Handai International Symposium was held at SANKEN

On November 8, 2023, the 12th imec Handai International Symposium was held at SANKEN, Osaka University. This symposium began with keynote speeches by imec Vice President Chris Van Hoof and Professor and Director of SANKEN Tohru Sekino. The symposium included online lectures from the imec side (including imec-NL and OnePlanet), and researchers of Osaka University (the Graduate School of Information Science and Technology, the Graduate School of Human Sciences and SANKEN) provided diverse research findings and topics. Furthermore, there were intriguing presentations from Tokyo Institute of Technology and Hokkaido University, with which SANKEN collaborates as a member of Network Joint Research for Materials and Devices. Totally 70 researchers participated (including online presenters), and there was a lively technical discussion and information exchange, and the event ended with a lab tour of SANKEN: visiting Nagai Lab. and Nogi Lab.



Participants joined at 12th imec Handai International Symposium, SANKEN

Dr. Rachel’s presentation scene at 12th imec Handai Symposium

An international conference Q-BASIS 2023 was held from April 24 to April 27, 2023

An international conference Q-BASIS 2023 (Quantum Beam Application for Sciences and Industries 2023) was held from Monday, April 24 to Thursday, April 27 at SANKEN Auditorium and CReA in collaboration with the JST MIRAI “Development and Demonstration of Laser-Driven Quantum Beam Accelerators” project and SANKEN, and was held in full face-to-face format. The conference included 35 oral presentations and 30 poster presentations covering a wide range of quantum beam applications from fundamental science to industrial applications, including power laser development and applications, materials science applications, medical and biological applications, imaging applications, free electron laser (FEL) applications, high energy physics, and industrial applications.

On the evening of Tuesday, the 25th, a banquet was held at the Senri Hankyu Hotel, where 110 participants (including 30 from the U.S., U.K., France, Germany, Czech Republic, Russia, Ukraine, Spain, and China) enjoyed information exchange and conversation in an international atmosphere. A joint session with U.S.-Japan Advanced Accelerator Forum was also held on Wednesday the 26th, and a laboratory tour of the LAPLACIAN laser acceleration platform at the SPring-8 campus was held on Thursday the 27th. During the conference, 11 quantum beam-related companies exhibited at the SANKEN CReA corporate exhibition booth. The SANKEN Auditorium was almost always filled to capacity throughout the conference days, and lively discussions were held. The kick-off meeting of Q-BASIS 2024 was also held, and the meeting was successfully concluded with the announcement of the next meeting.

The 27th SANKEN International Symposium

At the Awaji Yumebutai International Conference Hall, the 27th SANKEN International Symposium, the 22nd SANKEN Nanotechnology International Symposium, the 5th AIRC-SANKEN International Symposium, and the 19th Handai Nanoscience and Nanotechnology International Symposium on “Science Chat in AI and Metaverse” were held!

From Wednesday, January 10th to Friday, January 12th of the 6th year of Reiwa, the 27th SANKEN International Symposium, the 22nd SANKEN Nanotechnology International Symposium, the 5th AIRC-SANKEN International Symposium, and the 19th Handai Nanoscience and Nanotechnology International Symposium were held at the Awaji Yumebutai International Conference Hall. This time, under the theme of “Artificial Intelligence and Metaverse,” discussions revolved around the latest artificial intelligence and information technology, exploring how they can be applied to devices, information, materials, quantum beams, chemistry, biology, and nanotechnology, areas in which SANKEN academia and industry excel. Held in Awaji for the first time in four years, the event saw participation from 140 faculty, staff, and students, engaging in vigorous discussions over the course of three days.

The symposium’s opening session commenced with a keynote speech titled “Towards Human-Like Conversational AI” by Professor Yun-Nung (Vivian) Chen from National Taiwan University, initiating discussions on the latest advancements in AI. Following that, in sessions covering nanotechnology, biology, physics, and chemistry, topics related to artificial intelligence and information technology were presented, sparking lively discussions among researchers in all these fields. In total, 16 invited speakers from both domestic and international backgrounds shared cutting-edge research findings on the utilization of artificial intelligence technology in industrial science.

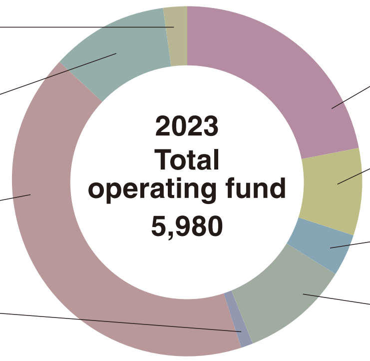
The poster presentation held on the second day afternoon was conducted in a hybrid format combining real-world and metaverse environments. Fifty-five posters from both local and remote locations were simultaneously presented in both real-world and metaverse spaces, leading to enthusiastic discussions. Subsequently, during the banquet in the evening, a concert featuring former SANKEN-exclusive singer Daisuke Shirai was held. Performing songs collaborated with artificial intelligence, it turned into a participatory event where all attendees sang along, significantly elevating the symposium with both research and camaraderie. In the afternoon of the third day, during the excursion, participants visited a resort restaurant farm on the island to observe field trials of wavelength-selective organic solar cells developed at SANKEN, which was well-received as an event leveraging the geographical advantage of Awaji Island.

Lastly, as the chairperson, I would like to express my gratitude once again to all the administrative assistants, staff, members of the technical department, and the administrative department who worked behind the scenes to support the operation, as well as those who kindly cooperated with various cumbersome administrative procedures.

Fact Sheet

Sample (2023)

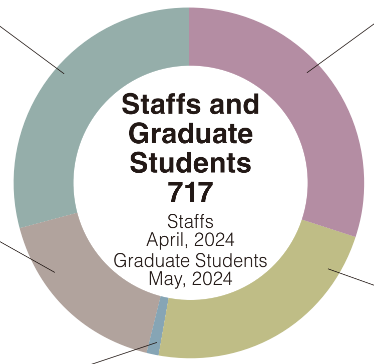
Publications	Application for Patent
371	81



- **Subsidies etc.** 120 (35)
- **Joint Research with Private Sector** 690 (163)
- **Contract Research** 2,500 (111)
- **Donation for Research** 80 (68)
- **Personnel expenses for university administration** 1,300
- **Departmental operating expenses** 460
- **Charge for Facilities Use etc.** 250
- **Grants-in-Aid for Scientific Research** 580 (112)

(in unit of million yen, ( ) number of funds)

Constituent Member



Graduate Students 206

	Master / Doctor
School of Science	30 / 19
School of Engineering	57 / 29
School of Engineering Science	9 / 4
School of Pharmaceutical Sciences	2 / 3
School of Information Science & Technology	27 / 16
School of Frontier Biosciences	10 Doctors

Visiting Researchers 118

Visiting Professor	1
Visiting Associate Professor	0
Guest Professor	62
Guest Associate Professor	24
Guest Academic Staff	12
Guest Researcher	19

Postdoctoral Fellows 10

JSPS Postdoctoral Fellowship	10

Full-time Employees 217

Professor	24
Associate Professor	31
Assistant Professor	36
Specially Appointed Professor(Full-time)	7
Specially Appointed Associate Professor(Full-time)	9
Specially Appointed Lecturer(Full-time)	2
Specially Appointed Assistant Professor(Full-time)	13
Specially Appointed Researcher(Full-time)	43
Administrative Officer	13
Technical Staff	12
Specially Appointed Administrative Officer	17
Specially Appointed Technical Staff	10

Part-time Employees 166

Specially Appointed Professor	17
Specially Appointed Associate Professor	4
Specially Appointed Assistant Professor	1
Specially Appointed Researcher	62
Support Staff	38
Technical Assistant	44

Osaka University Foundation for the Future

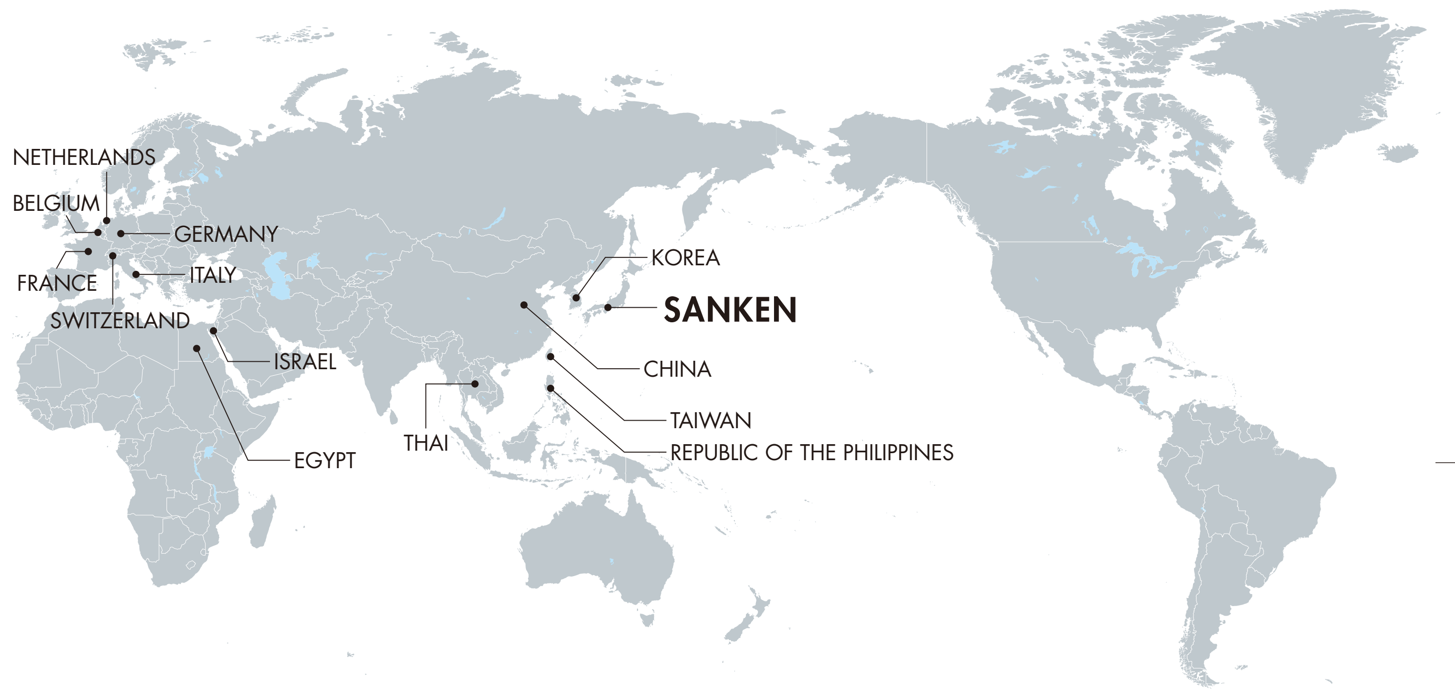
We aim to be a university that offers education and research that responds to the challenges of the new era and meets the needs of society by inheriting the knowledge and individual skills gained through our 90 years of history for the next 50 years, 100 years, and beyond.

When considering the future of Osaka University, it is essential to strengthen a long-term, stable financial foundation and enhance its funds. Our alumni, as well as Osaka University Staff, individuals, corporations, and organizations, we look forward to your warm support and contributions to Osaka University Foundation for the Future.

Academic Exchange Agreements of SANKEN with Universities Abroad

GERMANY	Forschungszentrum Julich GmbH RWTH Aachen University University of Augsburg RWTH Aachen University (Institute of Organic Chemistry) Bielefeld University (Faculty of Chemistry) University of Cologne (Faculty of Mathematics and Natural Sciences)
BELGIUM	Interuniversitair Micro-Electronica Centrum vzw (imec)
NETHERLANDS	Eindhoven University of Technology (Department of Mechanical Engineering) Delft University of Technology
SWITZERLAND	University of Geneva (Faculty of Science)
FRANCE	The National Center for Scientific Research University of Bordeaux Ecole polytechnique Université Paris-Saclay
ITALY	University of Genoa
ISRAEL	The Hebrew University of Jerusalem
EGYPT	Assiut University (Faculty of Science)
KOREA	Chonnam National University Pukyong National University (Basic Science Research Institute) Hanyang University Sun Moon University (Collage of Engineering)
CHINA	Peking University University of Scisce and Technology Beijing (School of Materials Science and Engeneering) Peking University (School of Intelligence Science and Technology) Dalian Jiaotong University Shenzhen University The University of Hong Kong (School of Biological Sciences)
TAIWAN	National Taiwan University National Yang Ming Chiao Tung University, College of Science
THAI	Thammasat University Chulalongkorn University (Department of Computer Engineering, Faculty of Engineering)
REPUBLIC OF THE PHILIPPINES	De La Salle University (College of Computer Studies) University of the Philippines

as of July 2024



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