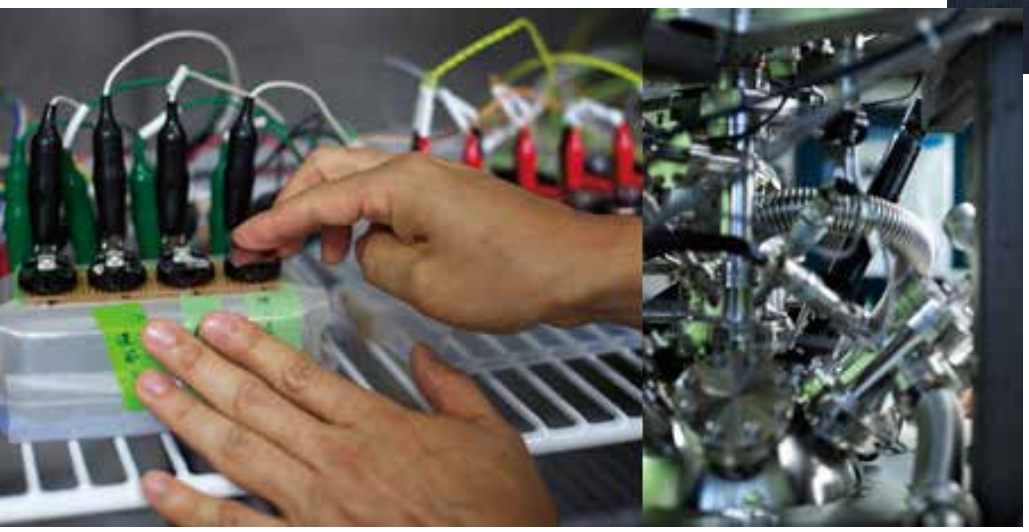
TOKYO UNIVERSITY OF SCIENCE RESEARCH CATALOGUE



研究戦略・産学連携センター
University Research Administration Center

List of Research Catalogue

No.	Affiliation, Position	Name	Research Theme	Field of Study
1	Professor, Department of Chemistry	Koichi TSUKIYAMA	Application of FEL-TUS (free electron laser at Tokyo University of Science) to bioscience	Bio
2	Professor, Department of Applied Physics Associate Professor, Department of Applied Physics Junior Associate Professor, Department of Applied Physics	Soichiro OKAMURA Takashi NAKAJIMA Yoichiro HASHIZUME	Event-driven intelligent system using piezoelectric materials	Device
3	Professor, Department of Applied Chemistry	Hidenori OTSUKA	Nanoparticle for highly cell targeting technology	Medical and bio
4	Professor, Department of Applied Chemistry	Shinichi KOMABA	High performance next generation Na-ion battery – free from rare or poisonous elements	Next-generation battery
5	Professor, Department of Applied Chemistry	Isamu SHIINA	Nonenzymatic, enantioconvergent dynamic kinetic resolution (DKR) of racemic 2-(1H-Pyrrol-1-yl)alkanoic acids as α-amino acid equivalents	Medical and bio
6	Associate Professor, Department of Applied Chemistry	Seiichi FURUMI	New mechanical stress sensing rubbers from paper materials	Nanotechnology
7	Professor, Department of Chemistry	Takashiro AKITSU	Photocatalytic chiral complex reducing heavy metal ions by visible light irradiation	Material
8	Professor, Department of Architecture	Osamu TAKAHASHI	Development of new oil damper for architectural vibration control and experimental research on structural characterization	Architectural devices
9	Professor, Department of Architecture	Osamu TAKAHASHI	Structural design and engineering for future buildings by unknown materials	Architectural devices
10	Professor, Department of Architecture	Osamu TAKAHASHI	Structural design and consulting about aseismic isolation buildings	Architectural devices
11	Professor, Department of Architecture	Takumi ITO	IoT system for disaster prevention, evacuation, and mitigation on urban buildings	Disaster prevention
12	Associate Professor, Department of Industrial Chemistry	Yumi TANAKA	Ceramic electret for electrostatic vibration power generation	Functional materials
13	Professor, Department of Electrical Engineering	Keiichi IWAMURA	An individual controllable secrecy computation system realizing effective use and privacy protection of big data	Telecommunica-tions
14	Professor, Department of Electrical Engineering	Mikio HASEGAWA	Next generation network communication technology based on complex system theories	Communication
15	Professor, Department of Electrical Engineering	Takayuki HAMAMOTO	Object segmentation from videos captured by freely moving camera	Communication and information processing
16	Professor, Department of Electrical Engineering	Yuzuru UEDA	Monitoring and analysis technologies for PV systems	Energy and environment
17	Associate Professor, Department of Electrical Engineering	Nobuyuki YAMAGUCHI	Technology assessment to create value added for power plant operation and electricity retailing business with the liberalization of electricity sales	Energy and environment
18	Professor, Department of Mechanical Engineering	Hitoshi ISHIKAWA	Flow visualization, analysis and control	Device
19	Professor, Department of Mechanical Engineering	Hiroshi KOBAYASHI	Human assist technology cultivating a new market	Medical and welfare

No.	Affiliation, Position	Name	Research Theme	Field of Study
20	Professor, Department of Mechanical Engineering	Shinya SASAKI	Tribology research activities in TUS	Device
21	Vice President and Professor, Department of Mechanical Engineering	Makoto YAMAMOTO	Numerical investigation on diagnosis and treatment system for diseases in blood vessel with CFD	Device
22	Professor, Department of Mechanical Engineering Associate Professor, Department of Mechanical Engineering Professor, Department of Industrial Chemistry	Shigeka YOSHIMOTO Masaaki MIYATAKE Yukishige KONDO	Precision fluid film lubrication bearings and small-sized non-contact support devices	Tribology
23	Professor, Department of Mechanical Engineering	Kuniharu USHIJIMA	Ultra-light cellular (micro lattice) structure manufactured by metal 3D printer	Machinery
24	Associate Professor, Department of Mechanical Engineering	Masaaki MIYATAKE	Low-wear, low-friction material; urushi lacquer containing a solid lubricant	Tribology
25	Associate Professor, Department of Mechanical Engineering	Masaaki MIYATAKE	Newly developed aerostatic porous bearings manufactured using direct metal printing technology	Machinery
26	Professor, Department of Pharmacy Junior Associate Professor, Department of Pharmacy Junior Associate Professor, Department of Pharmacy	Sei-ichi TANUMA Ryoko TAKASAWA Akira SATO	In silico platform for pharmacogenomics “COSMOS”	Bio
27	Professor, Department of Pharmacy	Chikamasa YAMASHITA	Development of central delivery technology of peptides by intranasal administration based on new concept	Bio
28	Professor, Department of Medicinal and Life Science	Shin AOKI	Solution for multi-drug resistance bacteria	Bio
29	Professor, Faculty of Pharmaceutical Sciences Professor, Department of Materials Science and Technology	Shin AOKI Atsuo YASUMORI	Development of a separation system for circulating tumor cells (CTC)	Bio
30	Professor, Faculty of Pharmaceutical Sciences	Yoshikazu HIGAMI	Development of medicine for ischemia/reperfusion injury with a novel mechanism	Bio
31	Professor, Department of Medicinal and Life Science	Takeshi WADA	New molecular technologies for stabilization and activation of nucleic acid drugs	Bio
32	Associate Professor, Department of Information Sciences	Kouichi KATSURADA	Quick spoken term detection system	Communication and information processing
33	Associate Professor, Department of Information Sciences	Satoshi IRIYAMA	Secure, fast, light encryption based on non-commutative algebra	Communication and information processing
34	Professor, Department of Applied Biological Science Assistant Professor, Department of Applied Biological Science	Kazuyuki KUCHITSU Nobutaka KITAHATA	High-throughput screening and identification of novel chemicals enhancing plant defense against pathogens/pests	Bio
35	Junior AssociateProfessor, Department of Applied Biological Science	Sachihiro MATSUNAGA	World’s first visualization of the switching mechanism of plant tip growth using novel fluorescence imaging without recombinant DNA technique	Bio
36	Junior AssociateProfessor, Department of Applied Biological Science	Sachihiro MATSUNAGA	Active learning software for automatic classification to take over proficient farmers as smart cultivation management	Bio
37	Associate Professor, Department of Applied Biological Science	Kazuya NAKATA	New applications of photocatalysis	Functional materials
38	Professor, Department of Pure and Applied Chemistry	Hideki SAKAI	Silica hollow particles prepared with facile process and their application	Material

List of Research Catalogue *(continued)*

No.	Affiliation, Position	Name	Research Theme	Field of Study
39	Professor, Department of Pure and Applied Chemistry JAssociate Professor, Department of Pure and Applied Chemistry	Makoto YUASA Takeshi KONDO	Nano/micro-seized dual drug capsule for enhancing efficacy of supplements	Bio
40	Associate Professor, Department of Pure and Applied Chemistry	Kenjiro FUJIMOTO	High-throughput screening of multicomponent functional materials using combinatorial technology based on the electrostatic spray deposition	Device
41	Associate Professor, Department of Pure and Applied Chemistry	Takeshi KONDO	Pinpoint electrolysis unit with conductive diamond ink electrode for dental treatment	Medical
42	Associate Professor, Department of Pure and Applied Chemistry	Kenichi SAKAI	Developments of functionalized amphiphilic molecules and active control of interfacial properties	Colloid and interface chemistry
43	Associate Professor, Department of Pure and Applied Chemistry	Isao SHITANDA	Multi-in-situ electrochemical impedance monitoring system for healthcare of lithium battery	Device
44	Associate Professor, Department of Pure and Applied Chemistry	Isao SHITANDA	Wearable healthcare devices based on printable electrochemistry	Device
45	Professor, Department of Electrical Engineering	Yohtaro UMEDA	Wireless power transfer with electromagnetic waves for remote charge of wearable terminal	Electrical
46	Professor, Department of Electrical Engineering	Shinichi KIMURA	Reconfigurable module type robot	Device
47	Professor, Department of Electrical Engineering	Shinichi KIMURA	Low cost high performance on-orbit equipment using commercial-off-the shelf devices	Device
48	Professor, Department of Electrical Engineering Associate Professor, Department of Electrical Engineering	Nobukazu HOSHI Noboru KATAYAMA	Sodium tetrahydroborate power (STEP) system	Energy and environment
49	Professor, Department of Electrical Engineering	Joji MAEDA	All-optical downlink re-modulation in optical access network	Communication and information processing
50	Professor, Department of Electrical Engineering	Mutsumi SUGIYAMA	Material design for novel-concept-based solar cells -sulfurization or oxidization of “cheap” metals-	Energy and environment
51	Associate Professor, Department of Electrical Engineering	Noboru KATAYAMA	Preparation of polymer electrolyte membrane fuel cell catalyst layers using electro spray deposition	Nanotechnology
52	Professor, Department of Mechanical Engineering	Masanori HAYASE	Miniature fuel cell with monolithically fabricated Si electrodes – Multi-layer catalyst by electrochemical atomic layer deposition –	Manufacturing technology
53	Associate Professor, Department of Mechanical Engineering	Hiroshi TAKEMURA	The image processing technology related to cancer cell region extraction for automatic pathological diagnosis	Image processing
54	Associate Professor, Department of Mechanical Engineering	Ryosuke MATSUZAKI	Three-dimensional printing of continuous-fiber composites	Machinery
55	Professor, Department of Civil Engineering Professor, Department of Industrial Administration	Hirohito KOJIMA Hayato OHWADA	An image-feature enhancement and interpretation system for crack detection of concrete surface based on feature composite moving image inducing visual illusion	Disaster prevention
56	Professor, Department of Civil Engineering	Shintaro TERABE	Safety performance measures for railway stations	Safety
57	Professor, Department of Civil Engineering	Yasuo NIHEI	Development and installation of new type of river and tsunami embankment that withstands various forces, and evaluation of evacuation action under actual flood conditions	Disaster prevention

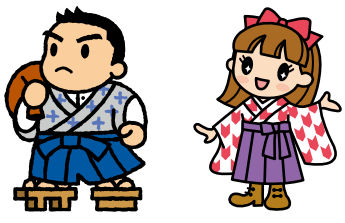
No.	Affiliation, Position	Name	Research Theme	Field of Study
58	Professor, Department of Applied Electronics	Naoyuki AIKAWA	Medical application of image processing technology	Communication and information processing
59	Professor, Department of Applied Electronics	Naoyuki AIKAWA	Particle size analyzer technique using image processing	Communication and information processing
60	Professor, Department of Applied Electronics	Jun TANIGUCHI	Multifunctional film fabrication by nano-scale rapid transfer technologies	Nanotechnology
61	Professor, Department of Applied Electronics	Hiroki FUJISHIRO	Development of a next-generation low-power transistors capable of operating at frequencies ranging from gigahertz to terahertz	Device
62	Associate Professor, Department of Applied Electronics	Takashi IKUNO	Color sensors based on wavelength-dependent bipolar photodetectors	Device
63	Associate Professor, Department of Applied Electronics	Kenji SHIBA	Wireless energy transmission	Device
64	Professor, Department of Materials Science and Technology	Kohei SOGA	OTN (over 1000 nm)-NIR in vivo imaging system	Medical and bio
65	Professor, Department of Materials Science and Technology Professor, Department of Materials Science and Technology Professor, Sanyo-Onoda City University	Keishi NISHIO Tsutomu IIDA Hiroaki ANNO	Thermoelectric waste heat recovery by environmentally benign materials	Energy and environment
66	Professor, Department of Materials Science and Technology	Keishi NISHIO	Electrical and optical hydrogen gas sensor with Pt/WO_3 thin films	Measurement technology
67	Professor, Department of Biological Science and Technology	Hiroaki SHIMADA	F1-ATPase relieves the damage caused by a high temperature stress during seed development	Bio
68	Professor, Department of Biological Science and Technology	Hiroaki SHIMADA	Translational enhancer that promotes protein biosynthesis and leads to enriched grain production	Bio
69	Professor, Department of Biological Science and Technology	Gen-ichiro ARIMURA	Plant aroma-mediated, biological interactions: development of agri-aroma plants and medical-aroma plants	Bio
70	Professor, Department of Biological Science and Technology	Gen-ichiro ARIMURA	Application of plant aroma-mediated biological interactions to agri-system and healthy food science	Bio
71	Professor, Research Institute for Biomedical Sciences	Yoichiro IWAKURA	Suppression of intestinal inflammation by short chain β-glucans	Bio
72	Professor, Research Institute for Biomedical Sciences	Yoichiro IWAKURA	The regulation of chondrogenesis via Adiponectin receptors and the therapeutic agents for osteoarthritis	Medical/Drug Discovery
73	Professor, Research Institute for Biomedical Sciences	Daisuke KITAMURA	Development of novel anti-tumor antibodies using tumorinfiltrating B cells cultured with an original system	Bio
74	Professor, Research Institute for Biomedical Sciences	Etsuko MIYAMOTO-SATO	Analyses of unknown protein–target interactions	Bio

University Research Administration Center

provides support that integrates basic research,

applied research projects, and returning benefits to society

through industry-academia cooperation.



University mascots

Bio

Application of FEL-TUS (free electron laser at Tokyo University of Science) to bioscience

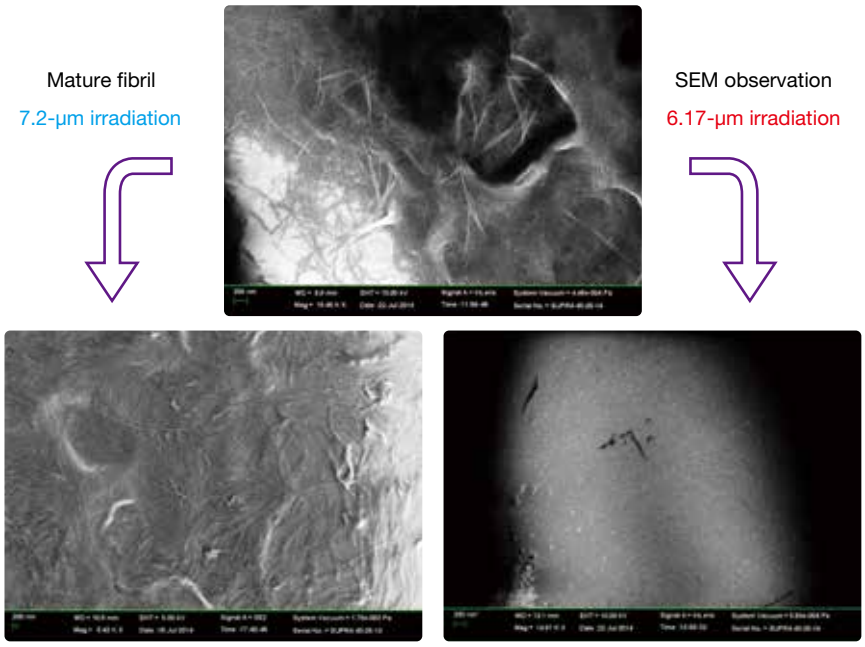
Koichi TSUKIYAMA (Professor, Department of Chemistry, Faculty of Science Division I, Tokyo University of Science)
Takayasu KAWASAKI (Project Researcher, FEL-TUS, Tokyo University of Science)

Purpose of Research

An infrared free electron laser (FEL) located at our Noda campus is a high-intensity pulsed light source with complete linear polarization and tunable frequency in the mid-infrared (MIR) range. Most substances have an absorption spectrum in the MIR range based on vibrational excitation. Using various analytical methods to investigate phenomena occurring after MIR excitation, basic and applied research in a wide variety of research areas, from cutting-edge measurement technology development to spectroscopy, chemistry, material science, solid state physics, and biological science, are promoted at the Infrared Free Electron Laser Research Center at Tokyo University of Science (FEL-TUS).

Summary of Research

As an example of FEL applications to life sciences/medicine, we show a SEM image that indicates the effect of FEL irradiation on amyloid fibrils, which are considered to be the causative substance of amyloidosis diseases. Mature fibrils (top figure) disappear after irradiation with 6.17-μm-wavelength laser light (bottom right figure). This effect is only effective at specific wavelengths proven by the fact that it is not significant at 7.2-μm wavelength (bottom left figure).



Points

- **Development of novel therapeutic methods for amyloidosis disease using infrared laser**
- **Interaction between bio-related substances and high-intensity infrared laser**

Comparison with Conventional or Competitive Technologies

Conventionally, biochemical methods (inhibition of amyloid fibril growth by drugs) are common, but no effective therapeutic method has been found. A physical engineering approach using infrared free electron laser is an entirely novel methodology.

Expected Applications

Expected applications include therapy for diseases triggered by aggregation of amyloid fibrils such as Alzheimer's disease and other serious amyloidosis.

Challenges in Implementation

Direct laser irradiation of model mice brains requires the determination of the optimal laser wavelength according to the disease and development of a bedside type fiber laser dedicated to that wavelength and the development of an irradiation system.

What We Expect from Companies

Even though laser irradiation effect has been shown in theory, we consider that elucidation of the molecular science underlying the reaction system will lead to true innovation.

Future Developments

2016–2017
Screening of laser irradiation in bio-irradiation
Microscopic elucidation of interaction between bio-related substances and FEL
2017 onwards
Irradiation of live cells, clinical applications, and development of therapeutic methods

■ Associated System: MEXT Project for Creation of Research Platforms and Sharing of Advanced Research Infrastructure (Light Beam Platform)

■ Related Publication: Picosecond pulsed infrared laser tuned to amide I band dissociates polyglutamine fibrils in cells
T. Kawasaki, G. Ohori, T. Chiba, K. Tsukiyama, K. Nakamura
Lasers Med. Sci., 31, 1425-1431 (2016)

Device

Event-driven intelligent system using piezoelectric materials

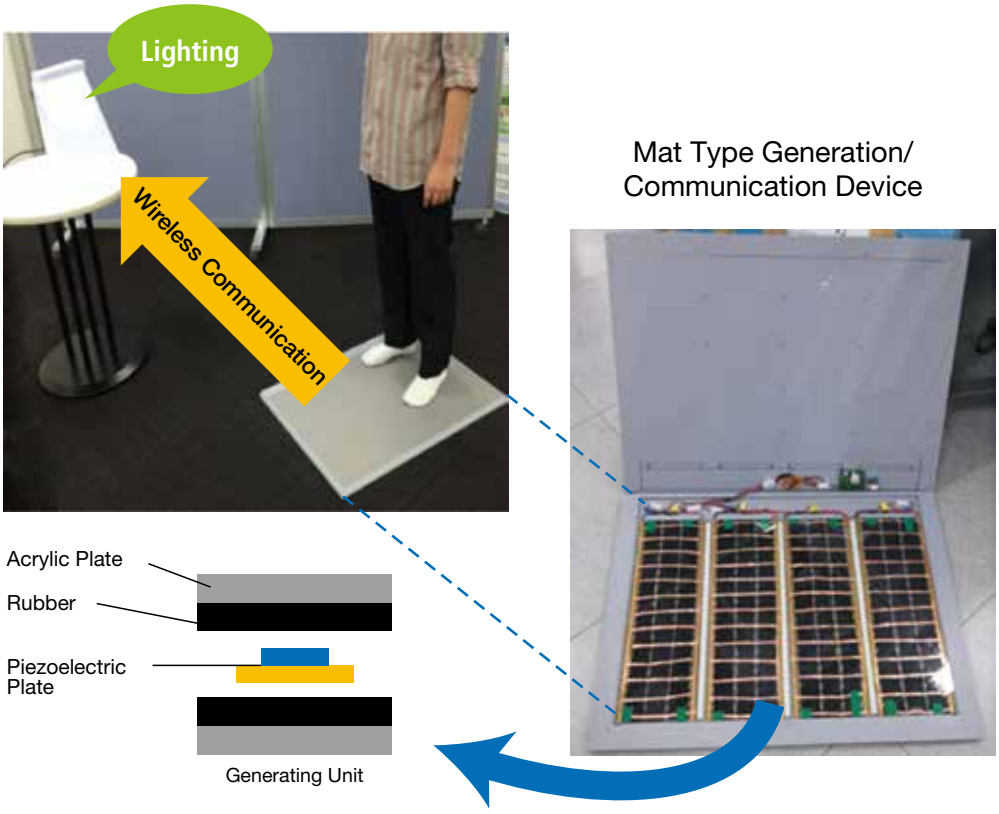
Soichiro OKAMURA (Professor, Department of Applied Physics, Faculty of Science Division I, Tokyo University of Science)
Takashi NAKAJIMA (Associate Professor, Department of Applied Physics, Faculty of Science Division I, Tokyo University of Science)
Yoichiro HASHIZUME (Junior Associate Professor, Department of Applied Physics, Faculty of Science Division I, Tokyo University of Science)

Purpose of Research

To develop a monitoring system in order to solve problems of graying society and social anxiety, and to implement a simple diagnosis system for aging infrastructure.

Summary of Research

We have developed a mat generating electricity with a force brought by human or automobile passing on the mat. This technology can provide various pieces of information associated with walking or traffic via wireless communication using the electricity generated by such mat "without a battery or a wiring."



Comparison with Conventional or Competitive Technology

A battery has been generally used when sensor information needs to be sent by wireless. However, it is able to supply electricity to the wireless communication element almost permanently without charging or replacing the battery by employing this technology.

Expected Applications

- Walking sensor mat for monitoring hospital patients or persons in need of in-house nursing care (available to be adopted even at a location where a human-body detecting infrared sensor cannot be installed)
- Automatic door
- Alarm/warning system for roadways, platforms or plants

Challenges in Implementation

Application method and communication device/protocol should be developed and improved to establish more stable transmission.

What We Expect from Companies

Undertake collaborate projects for improving the wireless communication device/protocol, and for proving benefits to create use cases.

Points

- **Capable of sending sensor information semipermanently at a location where the battery is difficult to be charged or replaced**
- **Provide a wireless communication system operable independently even at the time of a disaster or emergency**
- **Available to be employed under cryogenic, high-temperature or vacuum environment where the battery is difficult to be used (the piezoelectric materials can generate electricity in a high-temperature region covering from ultralow temperature to several hundred degrees)**

Future Developments

Researches will be proceeded to improve wireless communication distance and traffic with upgraded characteristics, and to attain miniaturization and light-weighting.

■Intellectual Property:
Japanese Patent Application No. 2014-238235 "Generator"

Medical and bio

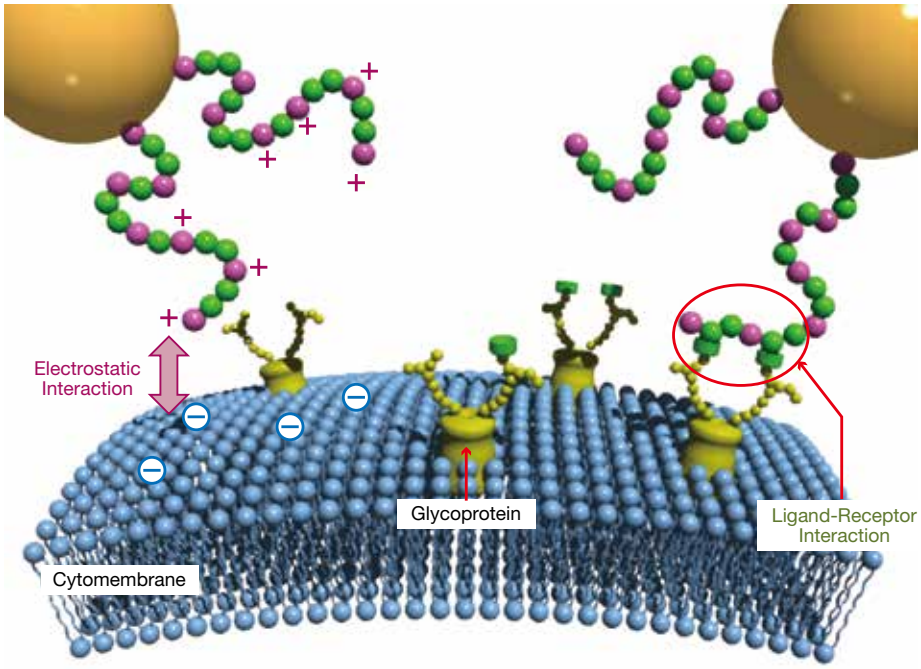
Nanoparticle for highly cell targeting technology

Hidenori OTSUKA (Professor, Department of Applied Chemistry, Faculty of Science Division I, Tokyo University of Science)

Purpose of Research

Photothermal therapy is a treatment for curing cancer using external light stimuli, which wins attentions as a minimally-invasive therapy since it does not need a surgical treatment. For efficiently achieving the hyperthermic therapy, nanoparticles need to be designed so as to have excellent in vivo biocompatibility (avoidance of capture by reticuloendothelial system (RES) around a liver or a spleen), tumor clustering and heating efficiency. In this study, we aim at implementation of more effective hyperthermia therapy through synthesizing nanorod particles having such functions. The surface of golden nanorod with high heat-exchange efficiency is subjected to surface modification which allows the surface to accumulate tumor electrostatically and receptor-specifically. Compared with the conventional technology, this novel therapy is able to promote incorporation into cell with three-orders higher specificity and to provide the safer hyperthermia therapy.

Summary of Research



All-in-one Particle in Photothermal Therapy

Electrostatic Interaction

Since the cellular surface is negatively charged due to dissociation of carboxylic group or phosphoric group, the cation unit is nonspecifically accumulated on a surface of tumor cell by the electrostatic force.

Sugar Chain-Receptor Interaction

The sugar chain is bound to the protein on the cellular surface; it is specifically bound to various receptor molecules and selectively transferred into the cell.

Photothermal Effect

It is possible to convert the absorbed optical energy to the thermal energy. The tumor cell can be cured by effective hyperthermic impact.

Points

- **Accumulation on cellular surface by electrostatic interaction of cation unit**
- **Selective coupling and cell transfer due to ligand unit**
- **Effective hyperthermia therapy**

Future Developments

- Pharmacokinetic studies are currently in progress. After the pharmacokinetic experiment is finished, in vivo pharmacology tests using model animals are expected.
- Cytomembrane-specific cellular surface of this study is confirmed to be useful for delivery of cytotoxic antitumor agent.
- We aim at undertaking collaborate projects with pharmaceutical and DDS R&D companies, and acquiring sponsored research funds.

■ Associated System:
NEDO Next Generation R&D for Function Substitution Technologies

■ Awards:
Award for Encouragement of Research in Materials Science 2011, 2010 and 2001 by MRS-Japan
Japan Biomaterial Science Encouragement Award 2005
STAM Highlights 2013 (the most popular articles 2013)

■ Intellectual Property:
Japanese Patent Application No. 2014-045240 “Molecular Carrier for Intracellular Delivery”

■ Prototype: Present ■ Sample: Available

Next-generation battery

High performance next generation Na-ion battery – free from rare or poisonous elements

Shinichi KOMABA (Professor, Department of Applied Chemistry, Faculty of Science Division I, Tokyo University of Science)

Purpose of Research

In the 1980's, secondary batteries with metallic lithium were commercialized as power sources with high voltage and large capacity. However, since the lithium metal anode was highly reactive, advanced technology had been required to solve the safety issue without sacrificing the benefits of this system. In 1991, the Japanese company Sony released the first commercial lithium-ion (Li-ion) battery in which lithium metal was replaced by carbon materials, and it has been become an essential power source for various equipment from portable electric devices including mobile phones to large applications such as electric vehicles and home stationary backup power system. The Li-ion battery is now a promising candidate to be a part of grid energy storage incorporated with wind and solar power systems. However relatively expensive Li-price hampers to realize this system because an extremely large battery is needed and cost reduction becomes the priority rather than performance. In addition, deposits of lithium are concentrated in a few locations in the world and Japan completely relies on imports from North/South America and China. Thus, an alternative to lithium is greatly desired for large-scale battery, and the Na-ion battery is now attracting much attention as a feasible technology since sodium is abundant everywhere on earth.

Summary of Research

Points
- No toxic elements
- Low cost and high power storage capacity
- Fast discharge and recharge

Our laboratory developed a 3 V-class Na-ion battery that uses $Na[Ni_{1/2}Mn_{1/2}]O_2$ as the positive electrode and hard carbon as the negative electrode. This battery is capable of operating at room temperature without any hazards and its energy density has reached 60–80% that of widely used graphite/$LiCoO_2$ batteries.

Na belongs to the alkali metal group in the periodic table, just below Li, and has weaker Lewis acidity and lower electrostatic interaction with negative charge than Li, resulting in faster Na^+ migration in the electrode, electrolyte and interface. Thus, the Na-ion batteries have the potential to realize ultrafast charge/discharge operation. This is one of the advantages of the Na-ion batteries and they contentiously demonstrate tremendous results, making them the likely choice for the next generation secondary battery.

Future Developments

Develop scarce-metal free Na-ion batteries for commercialization as high power storage devices, with financial support from Japanese government and the cooperation of industries.

■ Grant Program: JSPS Funding Program for Next Generation World-Leading Researchers
■ Awards: The 11th JSPS Prize (FY2014)
■ Intellectual Property: WO2012/060295 "COMPOSITE METAL OXIDE, PROCESS FOR PRODUCING THE COMPOSITE METAL OXIDE, POSITIVE ACTIVE MATERIAL FOR SODIUM SECONDARY BATTERY, POSITIVE ELECTRODE FOR SODIUM SECONDARY BATTERY, AND SODIUM SECONDARY BATTERY"
■ Prototype: Present
■ Sample: Available

Medical and bio

Nonenzymatic, enantioconvergent dynamic kinetic resolution (DKR) of racemic 2-(1H-Pyrrol-1-yl)alkanoic acids as α-amino acid equivalents

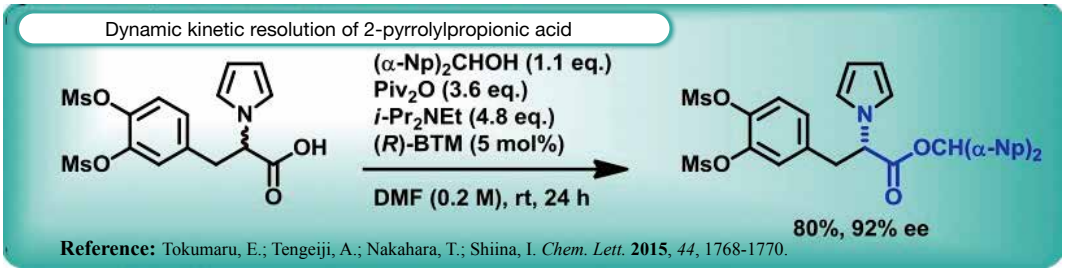
Isamu SHIINA (Professor, Department of Applied Chemistry, Faculty of Science Division I, Tokyo University of Science)

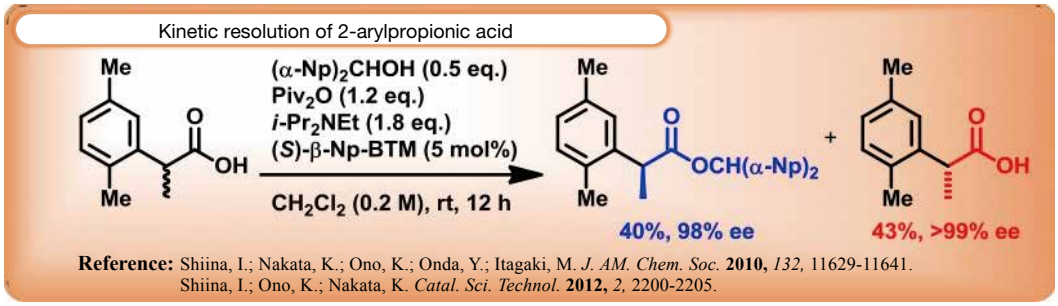
Purpose of Research

We have developed "dynamic kinetic resolution (DKR)" in which optically-active ester can be obtained at a yield of almost 100% by combining asymmetric esterification with recemization (I. Shiina, K. Ono, K. Nakata, Catalysis – Science & Technology, 2, 2200–2205 (2012). [Cover Feature Article] [Hot Article] [Most Accessed Article]).

Furthermore, we have also developed a novel synthesizing process which provides optically-active amino acid equivalent with excellent selectivity by realizing DKR in a manner of applying the racemic 2-(1H-Pyrrol-1-yl)alkanoic acid to this reactions.

Summary of Research





- Convert racemic carboxylic acid to optically-active carboxylate ester
- Synthesize optically-active 2-arylpropionic ester at a yield of almost 100%
- Synthesize optically-active α-amino acid ester at a yield of almost 100%
- Capable of selective synthesizing one of enantiomers directly without racemic form separation following synthesis of racemic drug or medicinal intermediate

Points

- **Selective synthesis of racemic α-amino acid**
- **Need not to separate/divide synthesized racemic form**
- **Yield of almost 100%**

Future Developments

- Find other synthesis processes or solutions for shortening of synthesis time
- Expand a range of application of substrate
- Produce novel catalysts
- Undertake collaborate projects with pharmaceutical, food development or medicinal intermediate companies while aiming for acquiring sponsored research funds

■ Associated System:
JST A-STEP "High-risk Challenge" type (in 2014–2017)
■ Awards:
The Chemical Society of Japan Award for Creative Work 2013
The Inoue Prize for Science 2014, The Ichimura Prize for Science 2014
The Prize for Science and Technology from the Ministry of Japan 2015
■ Intellectual Property:
Japanese Patent Application No. 2014–018887 "Method for Preparing Optically-active Carboxylate Ester"
■Prototype: Present
■Sample: Available

Nanotech-nology

New mechanical stress sensing rubbers from paper materials

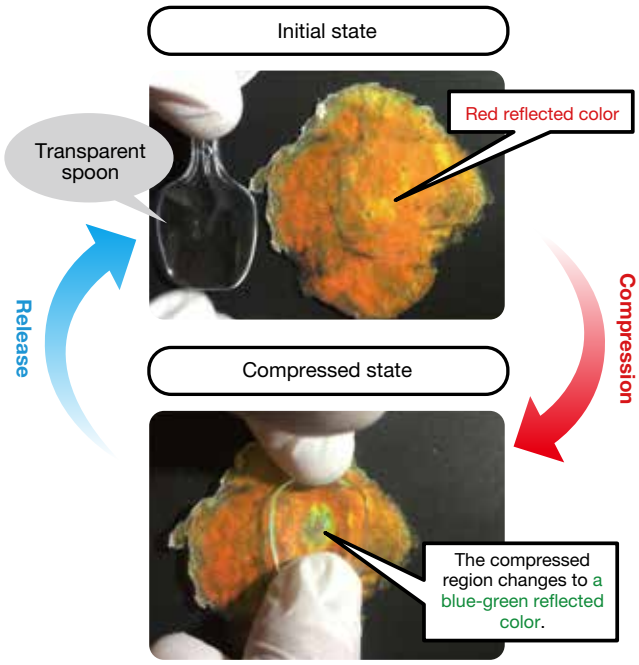
Seiichi FURUMI (Associate Professor, Department of Applied Chemistry, Faculty of Science Division I, Tokyo University of Science)

Purpose of Research

Cellulose, the main component of paper, cotton and wood, is a natural polymer in which glucose is polymerized as a straight chain, and it has long been a familiar material in our daily lives. In this study, we synthesized a new cross-linking cellulose derivative into which a functional group has been introduced that has an unsaturated bond in the lateral chain; through this means we succeeded in producing a cellulose liquid crystal elastomer film that has both special visible light reflection properties and rubber elasticity. Furthermore, we also discovered that this can be used for strain sensors capable of sensing mechanical pressure in real time.

Summary of Research

In this study, we have developed a new rubber material (elastomer) that can sense mechanical pressure through reflected color, and which uses cellulose—the main component of paper—as its raw material. Focusing on the features of low cost cellulose, which is friendly both to the environment and human body, we have created a new cellulose liquid crystal elastomer film that—due to its unique molecular design—exhibits Bragg reflection throughout the whole visible wavelength range, and also possess rubber elasticity. For example, when mechanical compressive force is applied to this cellulose liquid crystal elastomer film, one of its characteristics is that reflected color changes reversibly from red to blue-green in the compressed region only, allowing verification of the visualization of stress sensing.



Comparison with Conventional or Competitive Technology

- Conventional: Exhibits reflection characteristics derived from cholesteric crystals.
- This study: Achieved rubber elasticity in addition to reflection characteristics.
- Conventional liquid crystal elastomer: Manufactured mainly by chemical synthesis performed on materials derived from petroleum.
- Liquid crystal elastomer in this study: Can be created using cellulose, a natural polymer, as the raw material.

Expected Applications

- Sensors for social infrastructure capable of detecting distortion, such as in concrete.
- Wearable sensors that can be affixed to human skin.
- Inexpensive reflective displays with a low burden on the environment.

Challenges in Implementation

- Quantitative evaluation of interrelation between rubber elasticity and reflection characteristics of cellulose liquid crystal elastomer film.
- Optimization of cellulose liquid crystal elastomer film conditions such that it exhibits excellent rubber elasticity.

What We Expect from Companies

- We are hoping to conduct collaborative research with private companies specializing in chemistry, precision instruments, architecture, and medical care.

Points

- **Raw material is cellulose, which is abundant on earth, and is friendly to the human body and environment**
- **The cellulose liquid crystal elastomer film, with its special reflection characteristics and rubber elasticity, can be prepared using a simple chemical reaction**
- **It can be used not only in displays and as a coloring material, but also as a distortion sensor**

Future Developments

In cooperation with various private companies, we aim not only to research and develop new cross-linking cellulose derivatives but also use them in sensors and displays.

- Associated System: Grant-in-Aid for Scientific Research, Basic Research (B), JST Adaptable and Seamless Technology Transfer Program through Target-driven R&D (A-STEP)
- Intellectual Property: Japanese Unexamined patent Application Publication No. 2018-048289 Japanese Patent Application No. 2018-014066, Japanese Patent Application No. 2018-063259
- Prototype: Available
- Sample: Available
- Awards: 12th Funai Academic Award, 2nd IMRA JAPAN Award, and 10 others

Material

Photocatalytic chiral complex reducing heavy metal ions by visible light irradiation

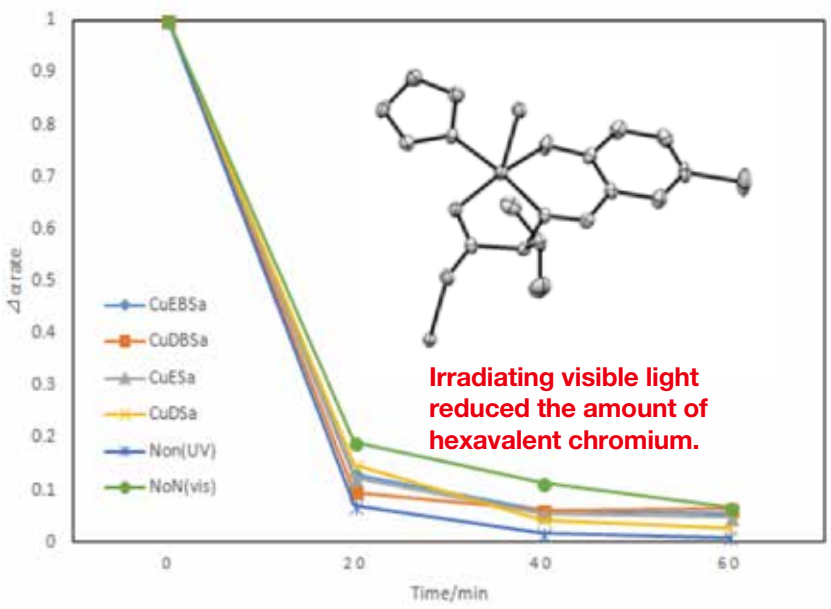
Takashiro AKITSU (Professor, Department of Chemistry, Faculty of Science Division II, Tokyo University of Science)

Purpose of Research

Heavy metals are used in many industrial fields. However, some of them are very toxic and are said to be harmful to humans and the environment. There is a demand for technologies that can easily and efficiently remove heavy metals contained in industrial waste and wastewater. This laboratory discovered an innovative catalyst, amino acid-derivative chiral copper (II) complex, which reduces hexavalent chromium, a highly toxic heavy metal, to less-toxic trivalent chromium by visible light irradiation.

Summary of Research

We have discovered a photocatalyst composed of amino acid-derivative chiral Schiff base copper (II) complex that reduces environmentally harmful hexavalent chromium by visible light irradiation. In addition, the scope of the reaction was expanded to include a visible light-irradiated solvent of methanol and promotion of the reaction was enhanced. An analysis using the diphenyl-carbazide method of hexavalent chromium demonstrated that 20-min visible light irradiation significantly decreased a peak near 540 nm from the level before irradiation, and after that, irradiation continued to decrease the peak intensity.



Comparison with Conventional or Competitive Technologies

The ordinary homogeneous photocatalyst titanium oxide mainly works as a catalyst for oxidation using UV light, which makes up only part of the spectrum of sunlight, while this complex photocatalyst uses visible light, which makes up about half of the spectrum of sunlight.

Expected Applications

- Applying this catalyst to a methanol solvent reduces the load of pre-treating wastewater.
- Other than that, this catalyst has the effect of oxidizing methanol.

Challenges in Implementation

Laboratory-scale reactions have been verified. In order to put this catalytic reaction to practical use, it is necessary to establish a technology that utilizes it in wastewater treatment equipment.

What We Expect from Companies

We would like to conduct joint research with companies that have wastewater treatment equipment technologies. This technology is useful for companies that need to conduct treatment for heavy metal ions.

Points

- **Visible light can be used instead of UV**
- **It provides a catalytic reaction in methanol instead of water**
- **An appropriate molecule design will make it possible to apply this catalyst to light-absorbing materials such as sunscreen cosmetics**

Future Developments

To put this technology to practical use, we will look into joint activities with companies conducting related businesses such as plating and heavy metal wastewater treatment.

■ Awards: Dr. Radhakanta Kajal Sen Merit Scholarship Award, 2014
■ Prototype: Completed
■ Sample: Available

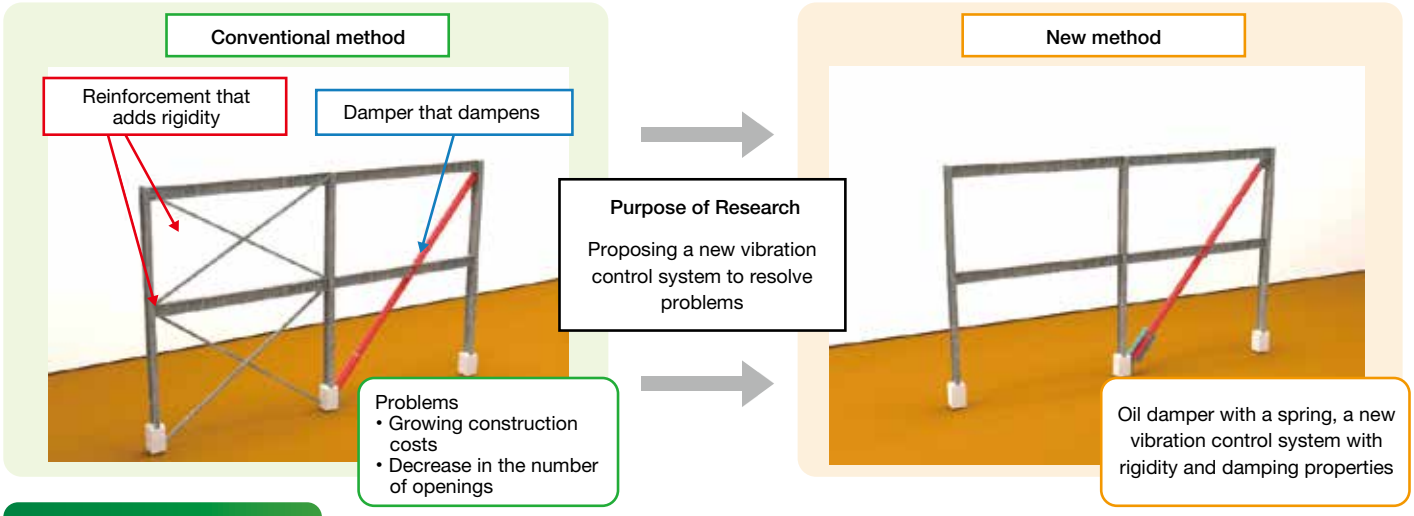
Architectural devices

Development of new oil damper for architectural vibration control and experimental research on structural characterization

Osamu TAKAHASHI (Professor, Department of Architecture, Faculty of Engineering, Tokyo University of Science)

Purpose of Research

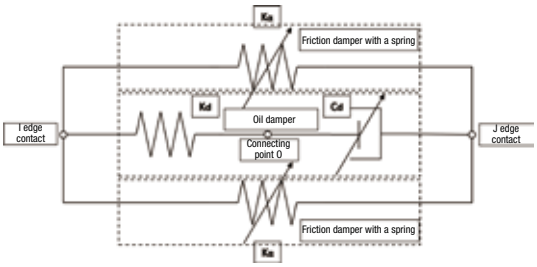
Develop a new vibration control system to solve problems with methods used when reinforcing buildings based on old earthquake standards.



Summary of Research

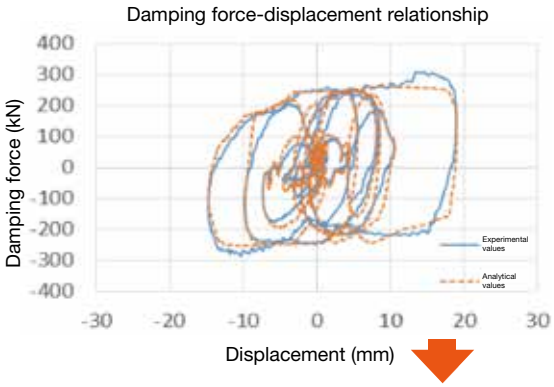
The oil damper with a spring is a new vibration control damper that combines an oil damper for building vibration control and visco-elastic and highly damping materials.

Oil damper with a spring as a test body



Analytical model of the oil damper with a spring

Comparison of the results of experiments and those of analysis



- With respect to random input waves, the results of analysis enable tracing of the results of experiment with sufficient accuracy.
- Use of the analytical model of the proposed oil damper with a spring enables analysis of vibration in the structural design of actual buildings.

Points

- **The new oil damper with a spring is more rigid and damping than the conventional type of building oil damper**
- **At the time of design, temperature dependency does not need to be considered in the range of temperatures at which the damper is expected to be used (room temperature to +50°C)**

Future Developments

We will examine the vibration characteristics and structural safety of the damper in order to apply it to actual buildings.

Architectural devices

Structural design and engineering for future buildings by unknown materials

Osamu TAKAHASHI (Professor, Department of Architecture, Faculty of Engineering, Tokyo University of Science)

Purpose of Research

Our laboratory conducts research to find new materials not often used as structural members of buildings, and use them as architectural structural materials.

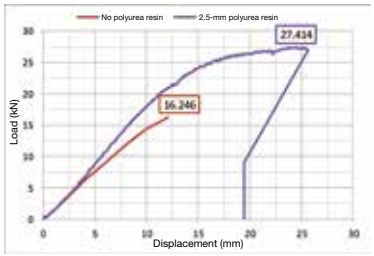
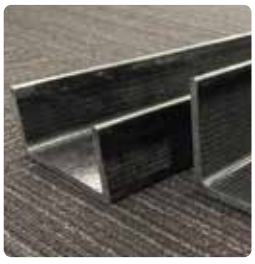
Usage as architectural structural materials

(1) High-performance rope intertwined with high-strength aramid fiber

(2) Polyurea resin (synthetic resin coating)

(3) Carbon fiber reinforced plastic (CFRP)

Summary of Research

Material	Outline	Key points	Usages, advantages and issues
 **High-strength aramid fiber (para-aramid fiber)**	 Used as a bracing member for timber framing	• High-strength aramid fiber is light and very strong in comparison with steel frames and other common structural members. • High-strength aramid fiber is highly flexible and can withstand acid and alkali.	**Usage** • Seismic reinforcement and maintenance **Advantages** • Lightness • Outdoor usage is possible. **Issues** • Weight reduction of joint parts • Jointing methods
 **Polyurea resin (synthetic resin coating)**	 **Relationship between load and displacement (timber)** Comparison based on the thickness of polyurea resin	• Polyurea resin is very strong and elastic. • The load-bearing capacity of a specimen with polyurea resin applied increases by up to 1.7 times compared with that of a specimen without polyurea resin applied.	**Advantage** • Increased bending strength and deformation-following characteristic **Issue** • Reinforcement of timber and concrete block walls
 **CFRP**	**Comparison of the physical values of CFRP and steel** CFRP (NCF): Tensile strength (kN/mm²) 0.60; Specific gravity (kg/m³) 1550 Steel (SS400): Tensile strength (kN/mm²) 0.40; Specific gravity (kg/m³) 7850 * NCF: Non-crimp fabric	• The tensile strength of CFRP is 1.5 times that of steel. • The specific gravity of CFRP is approximately one fifth that of steel. • CFRP is light and very strong compared with steel.	**Advantage** • Increased member strength • Reduced fixed load • Reduced seismic load • Reduction of transportation and construction cost **Issue** • Methods of jointing members • Usage in actual designs

Future Developments

Continuing research for practical use

Architectural devices

Structural design and consulting about aseismic isolation buildings

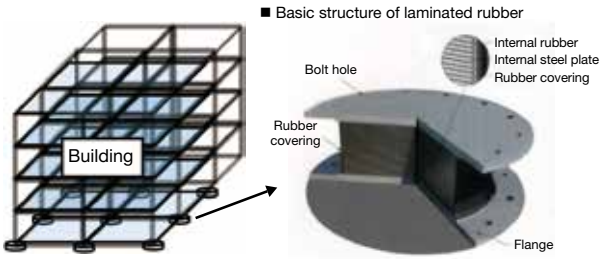
Osamu TAKAHASHI (Professor, Department of Architecture, Faculty of Engineering, Tokyo University of Science)

Purpose of Research

We conduct research on seismic isolated structures that are effective against the risk of earthquake.

Problems with existing seismic isolators

- Laminated rubber with metal plugs: Negative effects of lead on humans and the environment
- High-damping rubber: Needed to be replaced due to the mislabeling incident



Research conducted in our laboratory

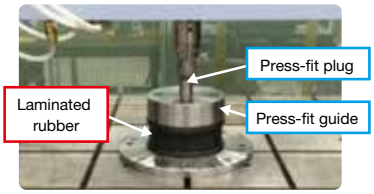
(1) Development of laminated rubber with the use of plugs made of materials that are not toxic to humans or the environment, and can be manufactured and discarded at low cost

(2) Research on structural safety when laminated rubber is replaced

Summary of Research

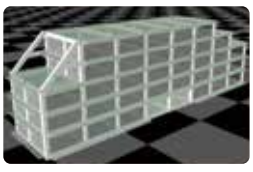
(1) Development of laminated rubber with foam metal used as a plug

Foam metal

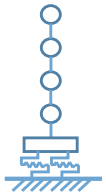


Press-fitting of a foam metal plug

Compression sheer test of laminated rubber



Three-dimensional model of an analytical building



Analytical model

Primary characteristic period (seconds) by eigenvalue analysis

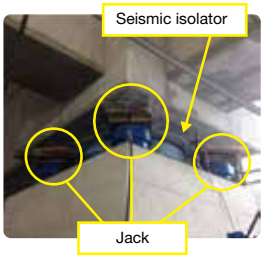
Laminated rubber	Longitudinal direction
eRB	2.71
LRB	3.21
HDR	4.36
SnRB	2.91
Foam metal and silicone rubber	**3.15**
Only foam metal	**3.42**

(White: Manufactured product, Yellow: Developed product)

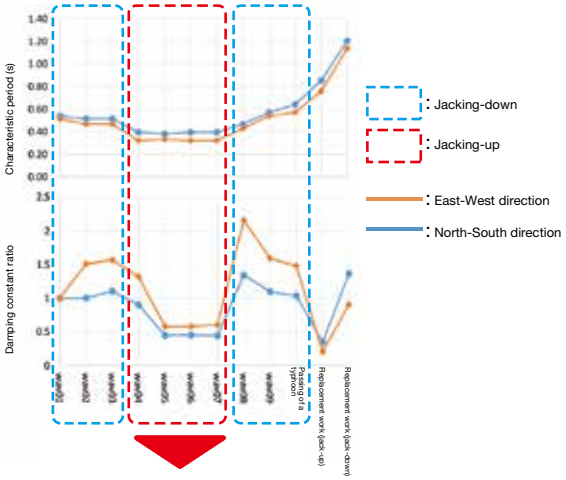
- The effect of seismic isolation of the developed product was confirmed.
- The damping function of the developed product was unsatisfactory.
- It is necessary to reconsider using nickel chrome and silicone rubber.

(2) Structural characteristics when replacing laminated rubber

When we replaced the laminated rubber, **we measured the microtremors** while the building was being jacked up and jacked down.



We evaluated **the natural period and the damping constant** through frequency analysis of the measurements.



During jacking-up,

(1) the natural period gets shorter and the rigidity gets larger, and

(2) the damping constant gets smaller.

Future Developments

Improving the performance of plugs for practical use

Disaster prevention

IoT system for disaster prevention, evacuation, and mitigation on urban buildings

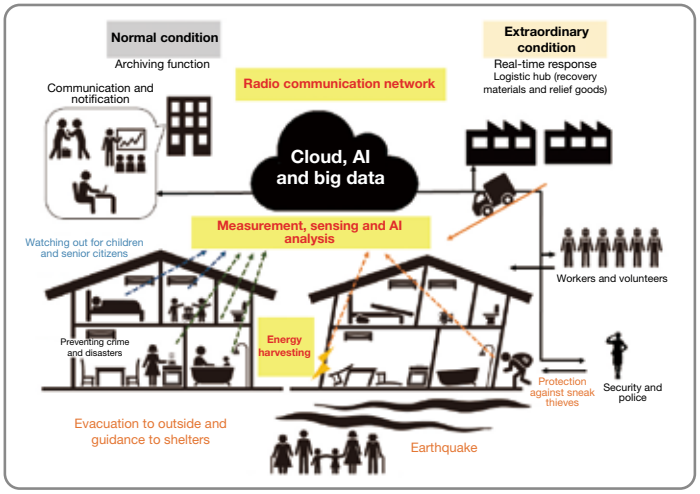
Takumi ITO * (Professor, Department of Architecture, Faculty of Engineering, Tokyo University of Science *Research leader)
Takahiro YAMAMOTO (Associate Professor, Liberal Arts, Faculty of Engineering, Tokyo University of Science)
Takayuki KAWAHARA (Professor, Department of Electrical Engineering, Faculty of Engineering, Tokyo University of Science)
Mikio HASEGAWA (Professor, Department of Electrical Engineering, Faculty of Engineering, Tokyo University of Science)
Takashi NAKAJIMA (Associate Professor, Department of Applied Physics, Faculty of Science Division I, Tokyo University of Science)
Yoichiro HASHIZUME (Junior Associate Professor, Department of Applied Physics, Faculty of Science Division I, Tokyo University of Science)

Purpose of Research

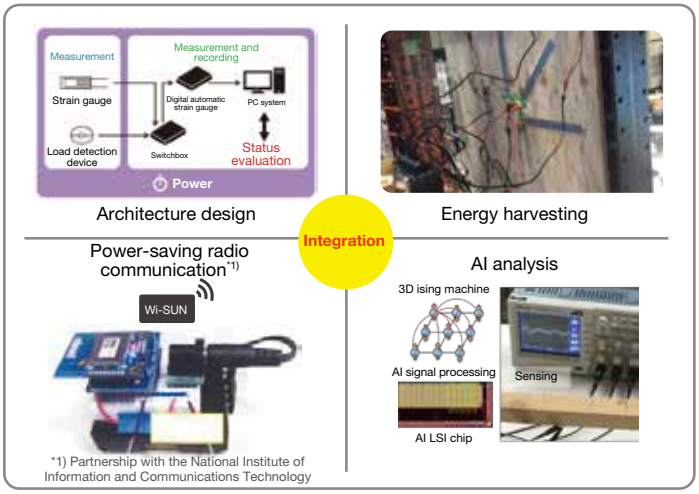
Japan is at the forefront of seismic technology. Still, the damage from recent earthquakes calls for viable measures for ensuring safety in damaged buildings and cities, going beyond the traditional assumption of the perfect avoidance of seismic damage. The development of an intelligent house in this research applies the concept of IoT so that buildings can sense and report any pain or discomfort.

Summary of Research

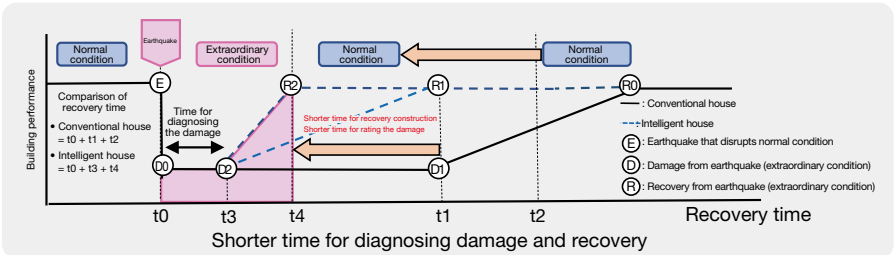
We propose a new IoT-based building system that detects, analyzes, diagnoses and notifies human activities and damage from earthquakes. Such an intelligent house features: 1) energy harvesting to supply power to sensor and radio devices, 2) power-saving radio communication network and 3) AI analysis and diagnosis system in order to effectively prevent disaster (seismic design of building), facilitate evacuation (quake diagnosis, life protection, and relief) and mitigate disaster (resilience to ensure rescue and quick recovery of the building).



Schematic illustration of an intelligent house applying IoT



Element technologies for achieving an intelligent house



Shorter time for diagnosing damage and recovery

Characteristics of Our Intelligent House

- Energy harvesting for powering sensor and radio devices
- Power-saving radio communication network
- Big data analysis with AI

Advantages of Our Intelligent House

- Quick information of damage and recovery status
- Quick recovery of affected building
- Monitoring of children and senior citizens, and protection against crimes, sneak thieves and disasters

What We Expect from Companies

- Joint research on element technologies
- Proposal of new research fields

Points

- **An intelligent house that embodies IoT**
- **Energy harvesting, power-saving radio communication, and AI analysis**
- **Quicker damage diagnosis and recovery from earthquakes**

Future Developments

- Consolidation of element technologies based on discussing performance target and on-site research
- Consolidation of architectural design method for installing an IoT system

■ Associated System: JST Strategic Basic Research Programs (Sakigake)
■ Intellectual Property: Patent application PCT/JP2016/080628
■ Prototype: A demonstration unit is available
■ Sample: A test building for on-site research can be visited

Functional materials

Ceramic electret for electrostatic vibration power generation

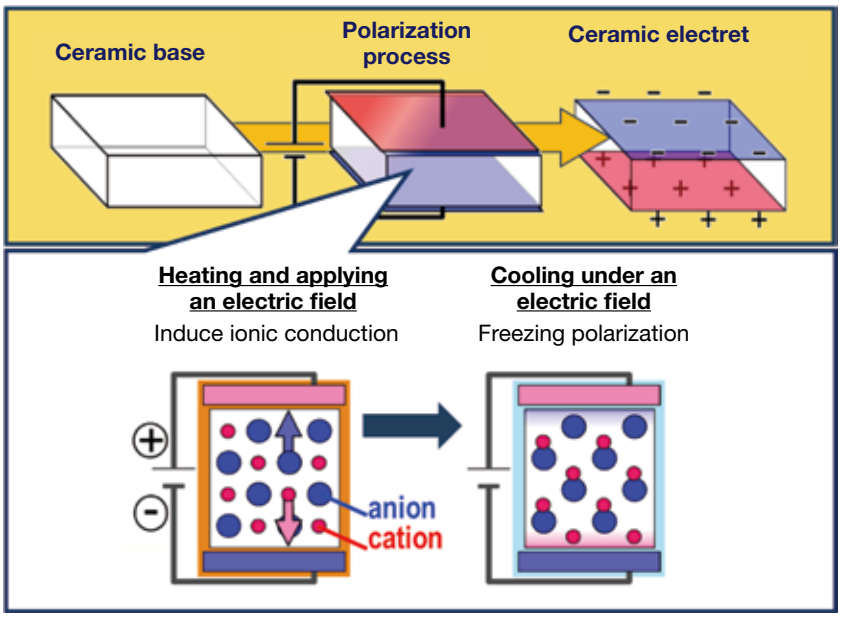
Yumi TANAKA (Associate Professor, Department of Industrial Chemistry, Faculty of Engineering, Tokyo University of Science)

Purpose of Research

Some small-size vibration power generators use what is known as "environmental vibrations," which are generated by the movement of people, vehicles, and machines, as a power source. Recently, there has been a move to put this type of generator to practical use. Electrostatic vibration power generation is a vibration-to-power conversion method that uses an electret, which is a material that stably holds static electricity. This research aims to develop a ceramic electret for electrostatic vibration power generation.

Summary of Research

While many types of electrets use polymers as the base material, this research uses a ceramic base material that exhibits properties that are in between those of dielectrics and ionic conductors depending on temperature. To turn a ceramic base into an electret, apply a DC electric field and heat to the material to induce ionic polarization in it, and then cool it under the electric field to room temperature to freeze the polarization. Using this method, we have developed an electret that holds a surface potential exceeding ± 4000 V.



Points

- Generates a surface electric potential of ± 4000 V or higher on a planar element
- Has a heat resistant property superior to polymers (maintains the surface electric potential up to about 80°C)
- The surface electric potential can be increased by laminating multiple films

Comparison with Conventional or Competitive Technologies

- Surface charge density is dramatically increased (double-digit increase or more).
- Surface charge stability is dramatically improved (semi-permanent).

Expected Applications

- Vibration power generators for devices with a power consumption of microwatts to milliwatts (Such as sensor nodes for wireless sensor networks)
- Special substrates that exhibit a peculiar selective adsorption property for ions and molecules using a local electric field

Challenges in Implementation

We have developed a high-performance bulk ceramic electret with a thickness of about 1 mm. Making a thin-film electret is the main challenge before this technology can be put to practical use. It is necessary to establish a technology that applies a high surface electric potential to a film with a thickness of tens of microns.

What We Expect from Companies

We hope to conduct a joint research program with a company that holds a ceramic thin film manufacturing technology or a company that is developing vibration power generators and plans to advance into the IoT market.

- Associated System: JST's CREST program, Grants-in-Aid for Scientific Research
- Intellectual Property: Japanese Patent Application No. 2014-141797 "Electret Materials and Manufacturing Method," and others
- Prototype: Completed

Telecommu-nications

An individual controllable secrecy computation system realizing effective use and privacy protection of big data

Keiichi IWAMURA (Professor, Department of Electrical Engineering, Faculty of Engineering, Tokyo University of Science)

Purpose of Research

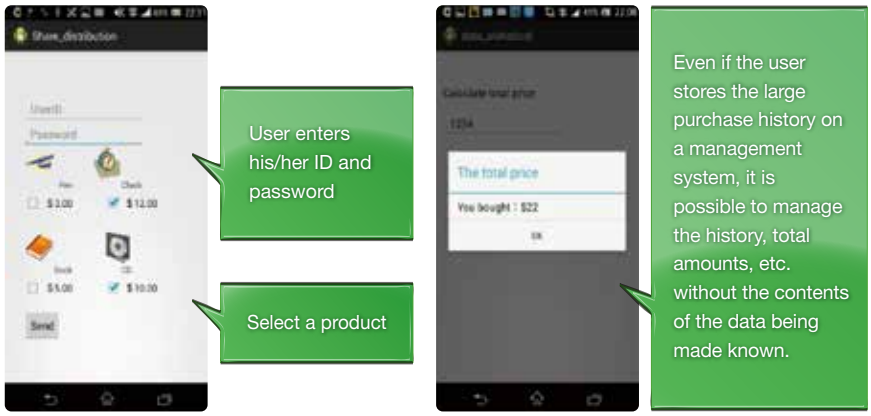
The effective use of big data is one of the keywords in the present technology. However, because big data includes personal and confidential information, there is a need to protect privacy while using this data. One of the technologies for realizing this is secrecy computation. However, because the data is processed while being kept secret, the processing is generally heavy, and due to the huge amount of data, conventional technology cannot be easily used. Thus, I am researching a method that can be controlled by even a smartphone.

Summary of Research

When users store data in the cloud, it is encrypted in order to protect the data. However, when it is time to use the data, the data must decrypt itself, so it cannot be processed in the cloud. In recent years, much research has been conducted into secrecy computation, which utilizes the secrecy sharing scheme to enable processing in the cloud using secret data while maintaining the secrecy of the data. However, when management of the cloud is outsourced to a single company, users cannot escape the insecurity that the secretly shared data may be collected and decrypted. Therefore, I propose a system in which secrecy computation using the secrecy sharing scheme cannot be performed without the data that is managed by the user. Even for a huge volume of data, as long as the user manages a single key, the system realizes high-speed secrecy computation.

Life log system using a smartphone

Because of the light weight and small volume, it is possible to create an application that secretly manages an individual's own records (life log) on a smartphone



Points

- **Generate a huge volume of shares from a secret key without storing the data**
- **High-speed secret sharing scheme can be realized using just addition and subtraction**
- **Owner of the secret data can control the secrecy computations**

Comparison with Conventional or Competitive Technology

- The huge volume of data that should be managed on the server can be consolidated into a single key data that the user can manage.
- Proposing a high-speed secrecy sharing scheme that enables sharing and restoration through just addition and subtraction.
- Because the user only needs to manage a single key, secrecy computations using smartphones and other similar devices are possible.

Expected Applications

- Managing household expenses online (can average and tabulate monetary amounts, which is personal information, while maintaining the secrecy)
- Life log application (every time data is created, it can be shared, secretly computed and decrypted using a smartphone)
- Statistical processing while maintaining the secrecy of the personal information in the medical and other fields (enables both a reduction in record volumes and statistical processing)

Challenges in Implementation

The basic secrecy calculations has been realized, but study needs to be conducted into the practical applications.

What We Expect from Companies

Companies that want to use this research for a specific application are asked to contact me.

Future Developments

October 2015:
Demonstration at the Computer Security Symposium 2015
2016: Presentation at an international conference
=> Acquire an international evaluation (target)
2016: Realize the world's smallest and fastest secrecy computation (target)
2016: Specialize specific applications (target)

■Associated System: Grants-in-Aid for Scientific Research, Basic Research (C)
■Intellectual Property: Patent application filed in Japan
■Prototype: Available
■Sample: Can be provided subject to the conclusion of an agreement
■Awards: Fellowship from the Information Processing Society of Japan

Communica-tion

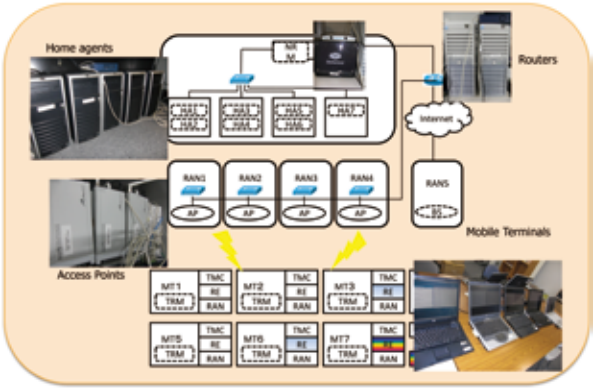
Next generation network communication technology based on complex system theories

Mikio HASEGAWA (Professor, Department of Electrical Engineering, Faculty of Engineering, Tokyo University of Science)

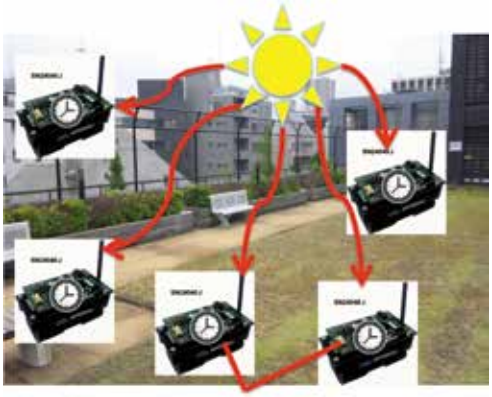
Purpose of Research

Advances in ICT have brought into service a variety of wired/wireless networks throughout society. Such networks are now being applied to not only inter-human but also inter-device communication, e.g. in information collection and systems control. To deal with emerging problems associated with the more diversified types and larger scale of networks and their applications, we are applying new complex mathematical modeling theories to develop a novel paradigm for information communication systems.

Summary of Research



Experimental system of optimized wireless network



Wireless inter-node synchronization based on natural environmental noise

Rigorous Optimization of Operating Efficiency of Wireless Communication Networks

A typical modern communication device such as a smartphone usually contains more than one wireless module and can access more than one network. Finding and changing to the optimal network at a location can improve the entire communication quality of networks.

To realize such optimal wireless network selection, we are studying various optimization schemes based on autonomous distributed algorithms, machine learning, and rigorous optimization algorithms.

In a selection problem with a huge number of possible combinations, an approx-imate solution by an algorithm with no theoretical guarantee is usually used. In contrast, we have formulated this as a minimum cost flow problem and developed a new algorithm that can rigorously obtain the optimal state even of a large scale network.

Novel Synchronization Method Based on Nonlinear Oscillation Theory

In order to establish a wireless communication link, transmitter and receiver have to be synchronized. This is conventionally done by means of a synchronization signal, but the overhead is not small. We have developed a novel natural environmental noise-based synchronization technique which requires no synchronization signal. The basic concept is that when the same noise is applied to the limit cycle of nonlinear oscillators, phase synchronization occurs. A nonlinear oscillator is run on each terminal, and highly correlated environmental noise is added thereto to achieve phase synchronization, based on which the clocks in each device are adjusted. Thus, synchronization occurs without any synchronization signal interaction. We have demonstrated the feasibility of this type of synchronization in an actual wireless sensor network.

Points

- **Algorithm for rigorous optimal wireless network selection**
- **Inter-node synchronization using natural environmental noise in actual wireless network**

Future Developments

- 5th gen. wireless optimization technology
- Further applications of complex systems theories

■Awards:
IEICE Communications Society Best English Paper Award (May 2015) and SR Society Best Paper Award (May 2012)

Communication and information processing

Object segmentation from videos captured by freely moving camera

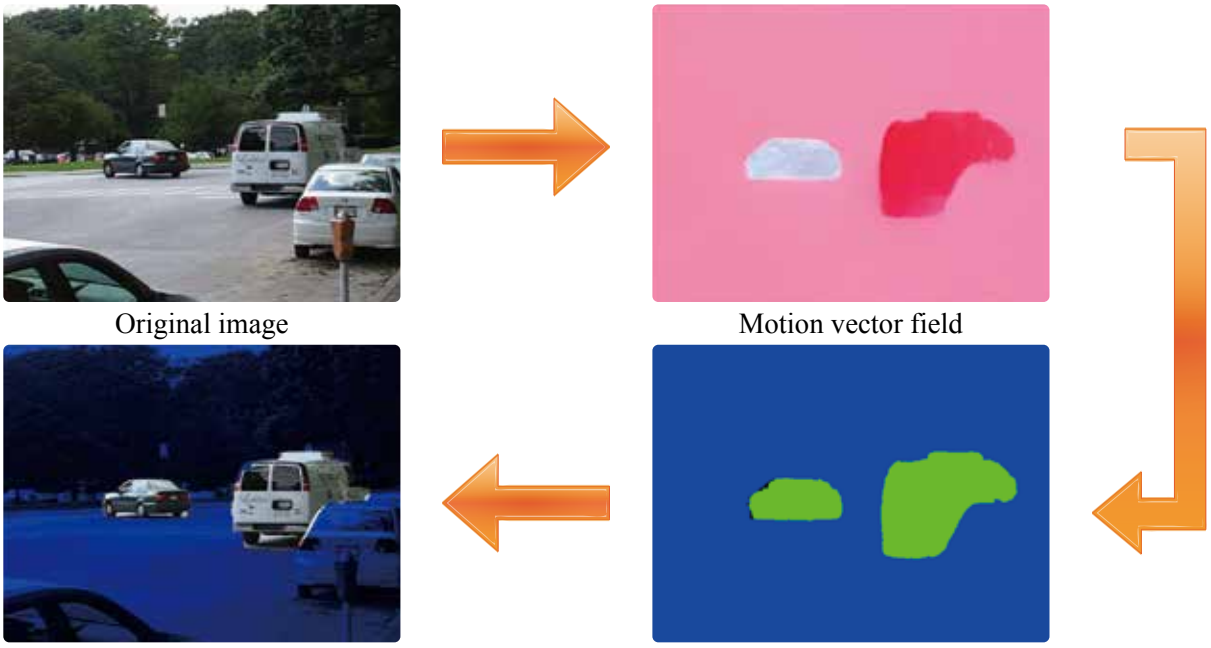
Takayuki HAMAMOTO (Professor, Department of Electrical Engineering, Faculty of Engineering, Tokyo University of Science)

Purpose of Research

Moving object extraction is one of the most important techniques because a wide range of applications can be expected, such as video surveillance system, etc. Previous methods have assumed that a video was captured with a stationary camera. In contrast, the proposed system allows us to extract moving objects from a video captured with a freely-moving camera. The proposed system will be applicable to a wide range of applications such as automatic digest generation of a video, etc.

Summary of Research

By analyzing motion information (motion flow fields) acquired from a video, the proposed system separates such motion flow fields into the motions of the moving objects and those of background regions. In particular, clustering of the motion flows is performed by using a histogram of oriented gradients that is computed using the motion flow fields. Unlike the previous methods that require an analysis of long-term motion information of a video, the proposed system can discriminate the motions of the moving objects by only using the two consecutive frames. Therefore, the proposed system is able to capture the small motions of objects. Based on the results obtained by this motion field analysis, the proposed system enables us to extract regions of the moving objects using an algorithm called "graph cut," which is a well-known method for image segmentation.



Original image

Motion vector field

Extracted moving objects

Motion detection result
(green: foreground; blue: background)

Points

- **A novel method for extracting moving objects from a video captured with a freely-moving camera is proposed**
- **Only the two consecutive frames are used for an analysis for discriminating the motions of the moving objects from those of background regions**
- **Small motions of objects can be differentiated**

Future Developments

- Explore an effective approach when the camera moves toward the forward-and-backward direction or rotates
- Verify the effectiveness of the proposed system using various videos
- Real time processing implementation

Energy and environment

Monitoring and analysis technologies for PV systems

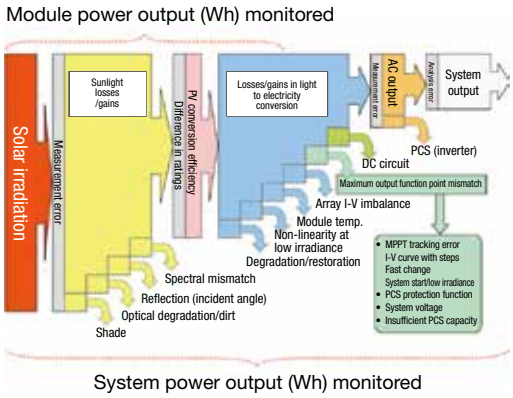
Yuzuru UEDA (Professor, Department of Electrical Engineering, Faculty of Engineering, Tokyo University of Science)

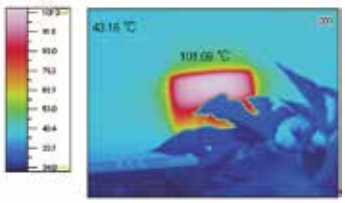
Purpose of Research

For great utilization of renewable energy resources, many PV (Photovoltaic) systems, with high reliability and a lifetime of 20 years or more, are expected to be installed. However, daily weather changes can greatly affect their power output, and thus the problem occurs that a PV system may not be noticed. Accordingly, in order to maintain the performance of a PV system for many years, it is essential to monitor the system and analyze the monitoring data. Our group is developing a failure detection system which can monitor and diagnose a wide range of PV systems (from rooftop to mega-solar plants) at low cost and in a simple manner.

Summary of Research

To effectively diagnose a PV system, its power output and the energy input (solar irradiance) must be monitored. However, an on-site pyranometer is rarely installed in a typical rooftop PV system. We have developed and are using a Web-based self-diagnosis support system, which diagnose PV systems based on the data from pyranometers installed at nearby weather stations and public buildings. For mega-solar and other large power plants that are often monitored by on-site pyranometry, we are developing a method to detect a small (a few %) power decrease by detailed analysis of data obtained by measuring over periods of 1 min.





Points Advanced analysis system to detect a problem in a PV system based on minimal monitoring data.

Comparison with Conventional or Competitive Technology

From web-based self-diagnosis for domestic PV systems to complex analysis of mega-solar plants, the energy conversion of a PV system is analyzed and its health is evaluated using our model. Our model can also predict power output based on weather information with high accuracy.

Expected Applications

- Self-diagnosis support for actual PV systems.
- Evaluation of health of large PV plants.
- Pre-construction power generation prediction and profitability assessment for a new plant.

Challenges in Implementation

- Make server environment and optimize system to enable use of the self-diagnosis support system by many users.
- More pyranometer sites required.

What We Expect from Companies

- Pyranometer installation and provision of data by power plants.
- Joint study proposals for server system installation and web system optimization.

Future Developments

Use satellite data for better solar irradiance estimation. Deploy the self-diagnosis support system throughout Japan.

■ Associated System:
Participated in JST CREST EMS "System Theory for Harmonized Power System Control Based on Photovoltaic Power Prediction" (April 1, 2015–March 31, 2017) as the chief joint researcher

Energy and environment

Technology assessment to create value added for power plant operation and electricity retailing business with the liberalization of electricity sales

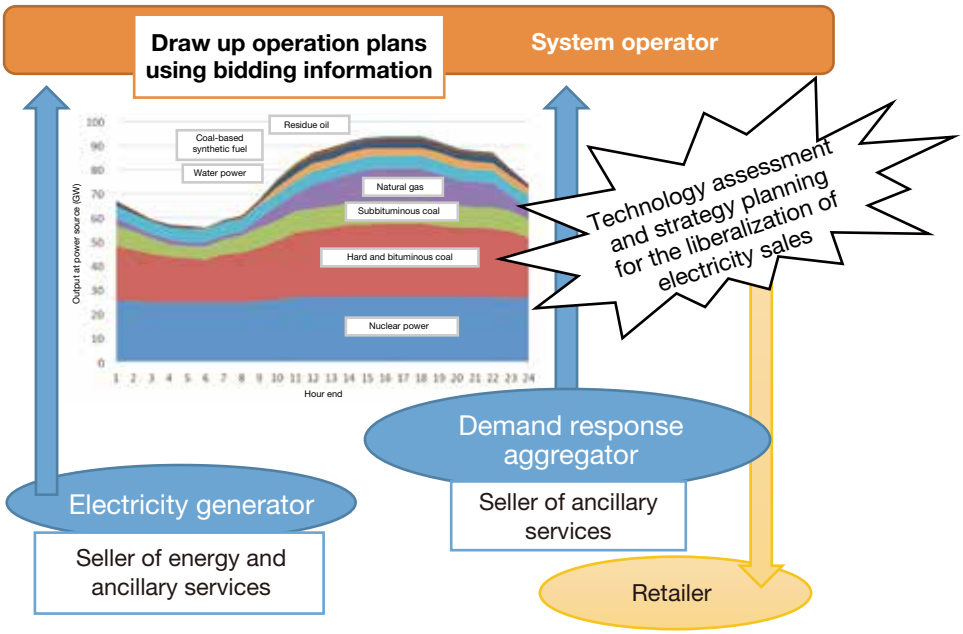
Nobuyuki YAMAGUCHI (Associate Professor, Department of Electrical Engineering, Faculty of Engineering, Tokyo University of Science)

Purpose of Research

In Japan, the phased liberalization of electricity sales (electricity system reform) is under way with its completion scheduled for 2020. As a result, any company will be able to enter power generation, power transmission and distribution, and electricity retailing businesses if it obtains a license. With this deregulation, an electricity market worth ¥7.5 trillion is expected to emerge according to the Ministry of Economy, Trade and Industry. In Europe and North America, where the electricity market was liberalized earlier, not only electric energy (kWh), but also electric system control called an "ancillary service" is procured or traded openly, and this is attracting public attention as something that suggests how electricity business and technology assessment in Japan should be in the future.

Summary of Research

This research uses mathematical programming to formulate operation plans aimed at cost minimization taking complicated technical restrictions at power plants into consideration and proposes optimal agreements for electricity users using demand response by adjusting power consumption according to wholesale electricity prices. It also assesses the value of ancillary services for electricity system control in order to support interconnected photovoltaic and wind power generation systems whose output fluctuate widely.



Points

- **Enabling reviews focusing on technical restrictions and policy/market risks to which analyzers pay attention**
- **Analyzing power generation, power transmission and distribution, and electricity retailing businesses in an integrated manner**
- **Examining suggestions to Japan through research and analysis of overseas electricity business**

Comparison with Conventional or Competitive Technologies

Setting questions in a way that is consistent with the technical restrictions of power plants, power transmission networks, distribution networks, etc. and with electric business policy in Japan and abroad and enabling strategy planning transcending the boundaries between engineering and policy-making

Expected Applications

- Formulating a wholesale electricity trading strategy with ancillary services in mind
- Examining power source investment strategies taking future policy risks into account
- Lowering wholesale electricity procurement costs utilizing demand response

Challenges in Implementation

Verifying the effectiveness and refining models based on not only sample data but also actual data

What We Expect from Companies

Considering corroborative joint research using field data

Future Developments

- Sophistication of analysis according to the progress in electricity system reform
- Establishment of a body to promote wide-area electricity use
- Creation of an hour-ahead market and full liberalization of electricity sales
- Creation of a real-time market and removal of pricing regulations

■ Associated System:
Participating in the research project in the JST-CREST EMS area, named "Building System Theory for Harmonized Power System Control based on Photovoltaic Power Prediction" as its principal joint researcher
(From April 1, 2015 to March 31, 2017)

Device

Flow visualization, analysis and control

Hitoshi ISHIKAWA (Professor, Department of Mechanical Engineering, Faculty of Engineering, Tokyo University of Science)

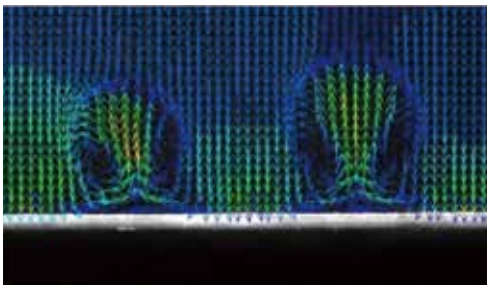
Purpose of Research

Fluid machinery, such as pipelines, wings, pumps and blowers, are widely used in engineering application. But it is difficult to study and analyze the behavior of their working fluids, such as air, water and oil, since most of them are invisible. By using dedicated measuring instruments and utilizing our expertise, our laboratory can visualize flows and efficiently measure flow velocity and flow structure. We propose flow control technologies and develop devices that are useful for improving the efficiency of fluid machinery.

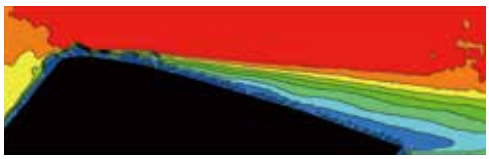
Summary of Research

We can visualize flows using smoke-wire, tracer and other techniques, and can measure flow rates and flow velocities using flowmeters, hot-wire anemometers, and particle image velocimetry (PIV), etc. Objects brought into our laboratory can be measured using our wind tunnel equipment, and we can also conduct analysis under multiple conditions using numerical simulation.

Wind tunnel equipment with 400 × 400 mm outlet



Flow visualization (flow control jet)



Flow visualization (separation from a wing)

Comparison with Conventional or Competitive Technologies

- Ability to visualize invisible fluids
- Measurement instruments specifically designed for measuring flow rates and flow velocities
- Abundant expertise regarding fluid control
- Two approaches to analysis: experiment and numerical simulation

Expected Applications

- Proposing design specifications for equipment
- Performance evaluation and improvement of equipment
- Proposing and developing control methods and devices to suppress flow transition and separation

Points

- **Flow visualization**
- **Flow velocity measurement using hot-wire anemometers and PIV, and vector analysis**
- **Wind tunnel equipment with an outlet of 400 × 400 mm, and other advantages**

Future Developments

Development of new types of flow control devices.

- Research Structure: Successful history of conducting joint research with public and private institutions
- Awards: Awarded for our contributions by the Fluids Engineering Division, Japan Society of Mechanical Engineers
- Technical Guidance: Abundant experience in providing technical guidance

Medical and welfare

Human assist technology cultivating a new market

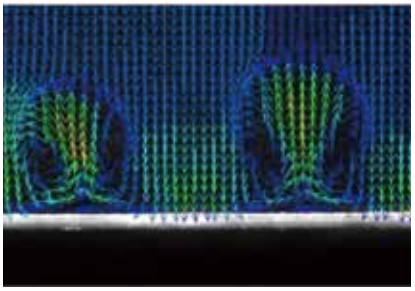
Hiroshi KOBAYASHI (Professor, Department of Mechanical Engineering, Faculty of Engineering, Tokyo University of Science)

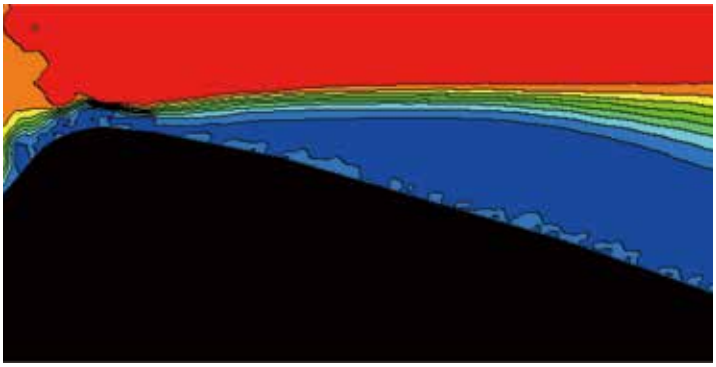
Purpose of Research

To research & develop seeds for innovative technologies to realize the world where "whoever lives can live independently."

Summary of Research

- Develop a wearable robot assisting muscle force: muscle suit
- Active walker which allows a person with gait disorder to walk in a right posture without falling
- Develop a teacher robot which can communicate with hyper-realistic facial expressions
- Develop a toilet with new buttock-fitting mechanism
- Develop a swallowing robot





Muscle suit for lower back support

Points **Our university actively collaborates with the companies to proceed R&D of "Only One," worldwide unique robots and machines for actually helping and assisting people in viewpoint of the human, considering productization**

Future Developments

We have established a venture corporation "INNOPHYS" in collaboration with KIKUCHI SEISAKUSHO CO., LTD., a listed enterprise whose main business is to manufacture prototype and has undertaken a joint research with our university for producing the muscle suit, on December 27, 2013. The new products are released in a market via INNOPHYS.

■ Intellectual Property:
Japanese Patent No. 05505740 "Waist Assistance Device," and many others

■ INNOPHYS CO., LTD. (Representative: Takashi Fujimoto)
Address: c/o Tokyo University of Science, 4-2-2 Kagurazaka, Shinjuku-ku, Tokyo
Tel. +81(0)3-5225-1083
Main Businesses: Development, Design and Sale of Motion Support Devices

Device

Tribology research activities in TUS

Shinya SASAKI (Professor, Department of Mechanical Engineering, Faculty of Engineering, Tokyo University of Science), etc.

Purpose of Research

The tribology can be applied to various fields, and it requires broad knowledge of science and technology. Since the systematized techniques in order have not been established yet, this subject tends to be shunned by field researchers. However, there are lots of unavoidable problems related to the tribology existed within mechanical system design and machine maintenance. Hence, we have been working on the research in order to develop unique key technology from the viewpoint that tribology is one of the strategically important technologies for enhancing competitiveness of industrial products.

Summary of Research

- Evaluate tribological features (Standardization, development of evaluation equipment)
- Fundamental mechanism (Super low friction, zero wear, tribo-chemical reaction)
- Surface analysis (Chemical and mechanical analysis of tribo-surface and layers)
- Evaluate nano-properties of surfaces (Nanoindentation, SPM)
- Develop a lubrication system for special environments by using new lubricants (Ionic liquid as a lubricant for high-temperature and high vacuum conditions)
- Develop technology for producing a functional surface by using a metal 3D printer
- Surface modification (Soft-mater and hard coatings, surface texturing)
- Design and evaluate high-functional bearings (Sliding bearing, rolling bearing or novel bearings)

Production: metal 3D printer, laser fine processing, coating, etc.

Tribology feature evaluation: develop international standard and evaluation device

Analysis/interpretation: shape measurement, nano-property evaluation (SPM), adsorption property (QCM), wettability evaluation and various surface analyses

Points

Tribology is very important and fundamental technology within a wide range of science and technology for creating the new product groups. Tribology is useful for improving mechanical system performances (high-energy efficiency, high reliability, long service life, high accuracy and low cost)

Both investigation and understanding the tribological phenomenon must to be understood correctly in order to perform troubleshooting or maintenance of the products. When the new product is developed, the tribo-element which is an essential component of the machine system tends to become a problem. Such a problem should be solved by the design technique based on the tribology. If you find any problems or obstacles related to the tribology or you want to get more information on mechanism and evaluation, please contact us

Future Developments

Open “Tribology Center” at Katsushika Campus on April 2015
International Tribology Conference 2015 (held by Japanese Society of Tribologists, Site: TUS Katsushika Campus)

■ Associated System:
Support project of open platform construction in university, one of 2013 Local Innovation Promotion Projects supported by Ministry of Economy, Trade and Industry
Subsidy for collaborative creation program (support for maintenance of facilities and equipments within university)

Device

Numerical investigation on diagnosis and treatment system for diseases in blood vessel with CFD

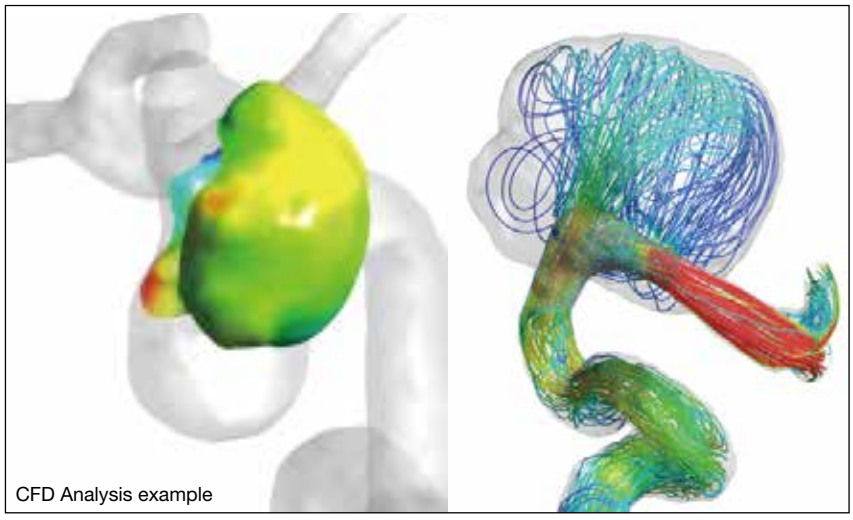
Makoto YAMAMOTO (Vice President and Professor, Department of Mechanical Engineering Faculty of Engineering, Tokyo University of Science)

Purpose of Research

The human blood vascular system can be suffered by various diseases under the influence of blood circulation state. In the past, how to diagnose or treat these diseases have been determined almost depending on experiences of the physician. The diagnosis/treatment techniques based on scientific knowledge are demanded to be proposed and developed. This study is intended to confirm the diagnosis criterion for vascular diseases with computational fluid dynamics (CFD) algorithm, and to develop a diagnosis/treatment system for predicting efficacy of therapy using a coil or a stent.

Summary of Research

This study deals with growth or rupture of cerebral aneurysm, efficiency of stent therapy for cerebral aneurysm, atherosclerotic lesion in a carotid artery, etc. The blood vessel shape model is created from the images obtained by MRI or CT. The blood circulation state is analyzed in detail based on the model with the CFD algorithm. Using this analysis data, the quantitative diagnosis criterion is confirmed for each disease, and the diagnosis/treatment system is structured and developed based on the scientific knowledge.



CFD Analysis example

Points

- **Scientific diagnosis and treatment are realized!**
- **Diagnosis/treatment criteria are made based on enormous patient data!**
- **Diagnosis is made at the same time as the patient is subject to MRI or CT scan!**
- **The therapeutic efficiency can be confirmed scientifically!**
- **This system can be introduced in every hospital in the world!**

Comparison with Conventional or Competitive Technology

Out university is able to create/propose the diagnosis criterion based on enormous patient data through the collaborative project with the Jikei University School of Medicine. Though the blood flow analysis is not technically difficult, it is impossible to establish the reliable diagnosis criterion without patient data.

Expected Applications

- Scientific diagnosis for various vascular diseases
- Planning of treatment policy
- Core or software for diagnosis/treatment system

Challenges in Implementation

The fundamental blood flow analysis technique is established, but the blood vessel shape model cannot be automatically created from MRI or CT image. If the automatic model creation becomes possible, the diagnosis/treatment system construction will be achieved as a supplement system of MRI and CT.

What We Expect from Companies

We are looking for a company as a collaborative project partner who is willing to deal with development of diagnosis/treatment system for vascular diseases together with us.

Future Developments

- Reflect verification examples and establish diagnosis/treatment criteria
- Develop diagnosis/treatment system
- Develop a prototype system
- Introduce such system in every hospital in the world

■ Research Structure:
Tokyo University of Science and Jikei University School of Medicine
■ Awards:
Annual Meeting of the Japanese Society for Neuroendovascular Therapy (Golden Award)
Japan Society of Mechanical Engineers Award in the Category of Computational Dynamics (Prize Awarded for Achievement)
110th Anniversary Meeting of the Japan Society of Mechanical Engineers (Achievement Award) JACM (Fellow Award)
■ Blood Flow Analysis Skill: Offerable

Tribology

Precision fluid film lubrication bearings and small-sized non-contact support devices

Shigeka YOSHIMOTO (Professor, Department of Mechanical Engineering, Faculty of Engineering, Tokyo University of Science)
Masaaki MIYATAKE (Associate Professor, Department of Mechanical Engineering, Faculty of Engineering, Tokyo University of Science)
Yukishige KONDO (Professor, Department of Industrial Chemistry, Faculty of Engineering, Tokyo University of Science)

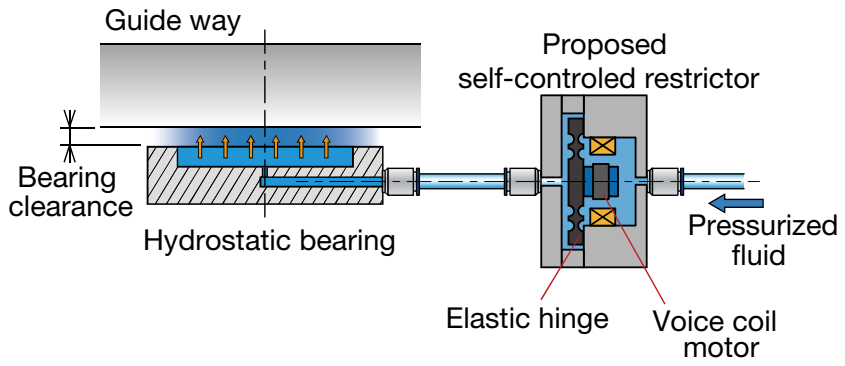
Purpose of Research

To present solutions of problems related to tribology

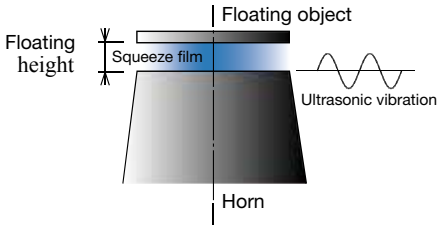
Summary of Research

Research area of our laboratory is related to one of machine elements, a fluid film lubrication bearing (FFLB) to support or guide an object using a lubricant such as oil, water and air. Therefore, the object can be supported by a lubricant without any direct contact between bearing and object surfaces. A newly developed FFLB can control the bearing clearance very precisely by controlling the flow rate entering the bearing clearance. A noncontact chuck we proposed can support a small object using ultrasonic levitation technique and hold a small object both horizontally and vertically without any contact. Moreover, a magnetic ionic liquid has been developed for a magnetic fluid seal used in a vacuum environment.

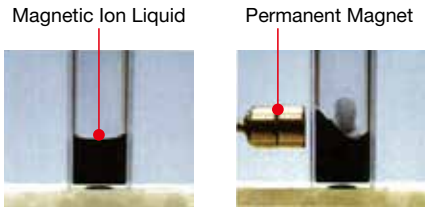
Hydrostatic Bearing & Flow Rate Control Unit



Non-contact Chuck



Magnetic Ionic Liquid



(a) Without Permanent Magnet

(b) Move Permanent Magnet Closer to Liquid

Comparison with Conventional or Competitive Technology

A proposed FFLB has a small-sized flow control unit with high-speed response to control the bearing clearance with the nanometer order of accuracy. When this proposed bearing is applied to a guideway of machine tools, higher accuracy of movement of the guideway table can be achieved compared with conventional hydrostatic bearings during cutting process. A developed non-contact chuck can hold a floating object without any contact by using the ultrasonic squeeze effect. The proposed chuck does not need an external air source such as a compressor which a Bernoulli chuck does.

Expected Applications

- Ultra-precision machine tools
- Ultra-precision measuring equipment
- Non-contact conveying device

Points

- **A fluid film lubrication bearing (FFLB) can support a shaft and a guideway table by a fluid film. FFLBs can achieve low friction and high accuracy of movement of a supporting object even when an imposed load on the object is varied**
- **We proposed a flow control unit that could precisely control the flow rate of lubricant entering a FFLB, and a very precise positioning control of the object became possible**
- **We developed a small noncontact handling device by using the ultrasonic squeeze effect**

Future Developments

Open "Tribology Center" at Katsushika Campus on April 2015
International Tribology Conference 2015 (held by Japanese Society of Tribologists, Site: TUS Katsushika Campus)

■ Intellectual Property:
Japanese Patent No. 04376737 "Non-contact Chuck"
Japanese Patent Application No. 2014-226961 "Compound, Method for Preparing the Same, Magnetic Fluid Composition, Method for Preparing the Same, and Magnetic Fluid Sealing"

Machinery

Ultra-light cellular (micro lattice) structure manufactured by metal 3D printer

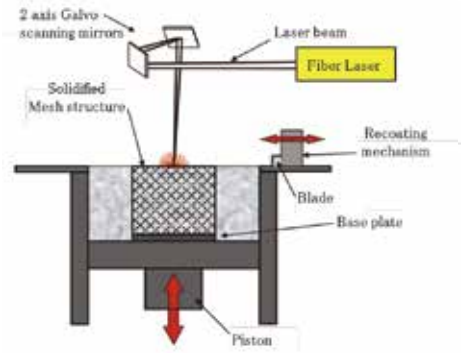
Kuniharu USHIJIMA (Professor, Department of Mechanical Engineering, Faculty of Engineering, Tokyo University of Science)

Purpose of Research

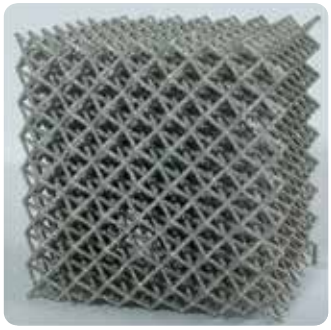
In order to realize the main purpose of material mechanics—namely, utilizing materials safely without waste—this study was undertaken with the aim of developing a manufacturing technology with a refined structure through the use of a metal 3D printer and to evaluate the mechanical characteristics of formed objects using numerical simulation analysis.

Summary of Research

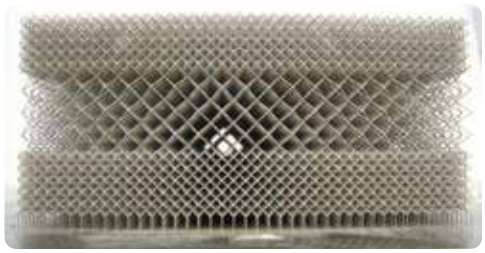
An ultra-light cellular (micro lattice) structure, which is expected to be widely applicable in fields ranging from medicine to aerospace, was produced using a metal 3D printer utilizing an additive manufacturing (AM) technology. The mechanical properties of the formed objects were then evaluated using numerical simulation analysis.



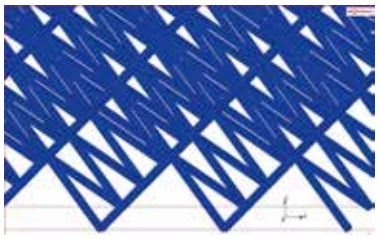
Modeling of a lattice structure by exploiting the characteristics of a metal 3D printer



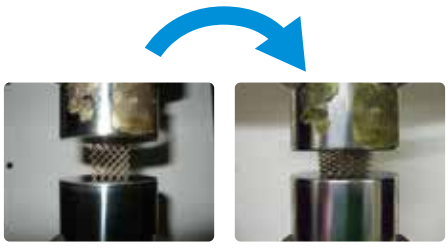
Example lattice structure #1



Example lattice structure #2



Numerical simulation analysis



Strength evaluation test

Comparison with Conventional or Competitive Technologies

- The lattice structure has a specific strength that is equivalent to a honeycomb structure but is more lightweight.
- The lattice structure has a large surface area, offering improved heat radiation.

Expected Applications

- Can be used as an impact absorption material for vehicles
- Can be used to manufacture a highly efficient heatsink since it can be designed to have an internal structure that allows for thermal conductivity control

What We Expect from Companies

We are now searching for companies with which we can carry out joint research to develop new applications for lattice structures.

Points

- **Optimization of lattice structures using numerical simulation analysis technologies**
- **Formation of an actual lattice structure using the metal 3D printer at the Tokyo University of Science's Tribology Center and performing of an evaluation test**

Future Developments

- Development of a heat insulation structure and a heat radiation structure using the new cell structure
- Development of a new light-weight metal structure using a textile structure
- Development of a spatially expandable structure by imitating origami (the Japanese art of paper folding)

■ Prototype: Completed
■ Sample: Available

Tribology

Low-wear, low-friction material; urushi lacquer containing a solid lubricant

Masaaki MIYATAKE (Associate Professor, Department of Mechanical Engineering, Faculty of Engineering, Tokyo University of Science)

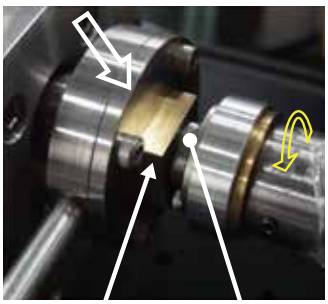
Purpose of Research

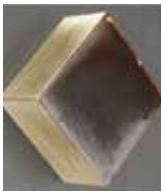
Urushi lacquer is a natural resin material, which has long been used in Japan as a hard coating material for tableware, armor and other items. As a resin material with excellent chemical and wear resistance, this research focuses on urushi lacquer, and aims to study the friction and wear properties of sliding materials made from urushi lacquer with PTFE added as a solid lubricant.

Summary of Research

In this research, we prepared a sliding material by hardening urushi lacquer with PTFE added as a solid lubricant, and conducted friction tests using a ring-on-plate friction tester under dry conditions. The results indicated that adding PTFE to urushi lacquer resulted in a low friction coefficient equivalent to that of 100 wt% PTFE, and a high degree of wear resistance equivalent to that of hardened urushi lacquer.

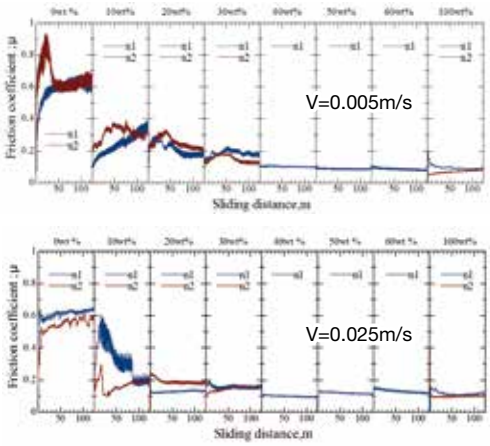
Ring-on-plate friction tester



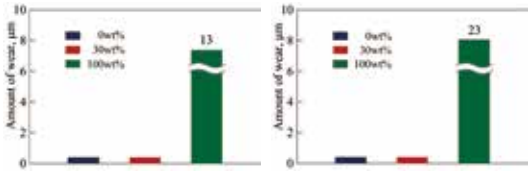


Test piece

Mating material



Friction coefficient measurement results



Wear measurement results

Comparison with Conventional or Competitive Technologies

Materials with a low effect on human health are required for the resin sliding parts of food processing machines, since, in manufacturing processes, small amounts of harmful substances may elute from the synthetic resins used in machine parts. In addition, there is a need for resin materials that are resistant to the chemicals in cleaners. This research aims to solve these issues.

Expected Applications

- Bearings for the reciprocating sliding parts and rotating parts of food processing and water treatment machines, etc.
- Materials applied to and hardened on metal and other base materials (wear-resistant coatings)
- Impregnants for lamination and hardening of woven and unwoven fabrics, such as cotton cloth (fiber reinforcing resins)

Challenges in Implementation

- Optimization of hardening conditions of urushi lacquer and PTFE
- Performance measurements under a wide variety of test conditions (load, temperature and various environmental conditions)
- Testing of materials containing solid lubricants other than PTFE, and testing for comparison with competing materials

What We Expect from Companies

- With the aim of utilizing this material for the bearings in the reciprocating sliding parts and rotating parts of food processing and water treatment machines, etc., we would like to conduct joint research with companies involved in this area.

Points

- **The effects of wear debris on human health are low, due to the use of urushi lacquer, a natural material with a long and successful history as a coating material for tableware**
- **Low-friction, low-wear sliding materials are produced by adding PTFE solid lubricant to urushi lacquer**

Future Developments

- Investigation to optimize the hardening conditions for urushi lacquer mixed with PTFE or other solid lubricants
- Conduction of performance evaluations under environmental conditions that have not been examined before, such as high-temperature and water circulation environments

■ Intellectual Property: Japanese Patent Application No. 2016-093303
"Sliding composites, sliding part materials and their manufacturing methods"
■ Prototype: Available
■ Sample: Available

Machinery

Newly developed aerostatic porous bearings manufactured using direct metal printing technology

Masaaki MIYATAKE (Associate Professor, Department of Mechanical Engineering, Faculty of Engineering, Tokyo University of Science)

Background of Research

Metal powder sintering 3D printers are not only able to produce durable, complex shapes, but are also able to provide air permeability to arbitrary places of the processed part by adjusting the laser intensity when sintering the metal powder. In this study, we tried to improve the performance of a mechanical element called an aerostatic porous bearing using a metal powder sintering 3D printer, which can not only manufacture parts by adding shapes but also to "add functions," such as making it air permeable, to arbitrary places of the manufactured part.

Summary of Research

An aerostatic porous bearing is a mechanical element that floats moving parts of a mechanical device in a noncontact manner by a pressurized film of air, and is widely used for precision processing machines and precision measurement instruments. By utilizing the advantages of the metal 3D printer, it is possible to (1) simplify the structure by integrally manufacturing the porous material and the support structure, and (2) to control the air permeability at arbitrary place of the porous material by adjusting the laser intensity at the time of molding.

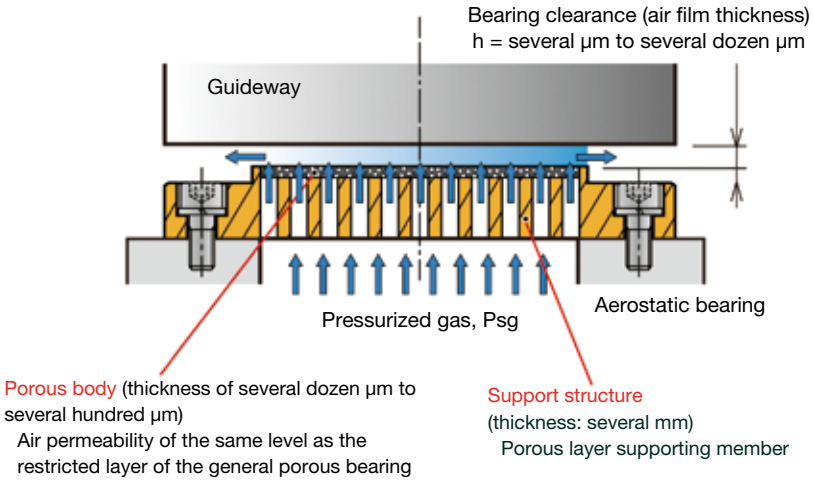


Figure: Aerostatic porous bearings in which the porous layer and the support structure are manufactured integrally using a metal powder 3D printer

Points

- **Simplification of structure by integral manufacturing of porous material and support structure**
- **Control of air permeability at arbitrary places in the porous material by adjusting the laser intensity at the time of molding**

Comparison with Conventional or Competitive Technology

○ Porous air bearings currently on the market
- Fabricated using several mm thick porous material.
- Surface choking modification is necessary to prevent unstable vibrations (pneumatic hammer).
- It is necessary to control air permeability and choking level of the porous material at the time of mass production, and will be cost consuming.

○ New technology
- The structure is simplified by manufacturing the porous layer to be 1 mm thick or less, and the support structure integrally using metal 3D printer.
- It is possible to arbitrarily adjust the air permeability of the porous layer during manufacturing.
- Bearings with higher performance than conventional products can be manufactured.

Expected Applications

- Guide mechanism of precision processing machines
- Guide mechanism of precision measuring instruments
- Noncontact levitation device

Challenges in Implementation

- Application to radial bearings supporting rotating shaft
- Optimization of porous layer air permeability
- Cost reduction of metal powder used in the 3D printer

What We Expect from Companies

- We hope to collaborate with companies that are considering the use of static pressure air bearings in movable parts such as precision processing machines and measuring instruments or the manufacturing of hydrostatic gas bearings.

Future Developments

- Currently, application to radial bearings supporting rotating shaft is proceeding.
- We are working on optimizing porous layer permeability to realize greater performance.

■ Intellectual Property: Japanese Patent Application No. 2018-085277
"Aerostatic porous bearings and manufacturing method of the same"
■ Prototype: Available

Bio

In silico platform for pharmacogenomics "COSMOS"

Sei-ichi TANUMA (Professor, Department of Pharmacy, Faculty of Pharmaceutical Sciences, Tokyo University of Science)
Ryoko TAKASAWA (Junior Associate Professor, Department of Pharmacy, Faculty of Pharmaceutical Sciences, Tokyo University of Science)
Akira SATO (Junior Associate Professor, Department of Pharmacy, Faculty of Pharmaceutical Sciences, Tokyo University of Science)

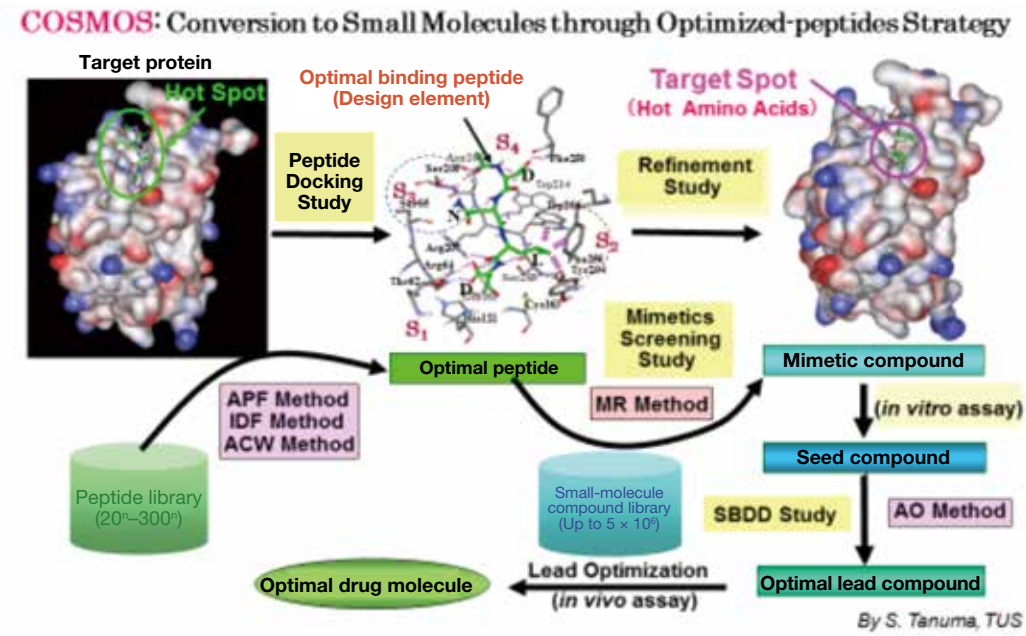
Purpose of Research

"Personalized medicine" based on disease genomic big data analysis is anticipated for genome medicine in the twenty-first century. To make this a reality, it is essential to establish a platform for "personalized drug discovery" based on a novel drug discovery methodology that allows molecular design of optimal pharmaceutical lead compounds against disease target molecules in individuals. Currently, the conventional drug discovery method of high-throughput screening of combinatorial chemistry (HTS/CC) conducted in many pharmaceutical companies requires enormous amounts of work, time, and cost; however, in reality, it has a low success rate. To radically change this situation, we have established a novel in silico genome-based drug discovery system "COSMOS" and are conducting research to achieve higher success rates in drug discovery.

Summary of Research

We have developed a novel drug discovery methodology implementation system, the COSMOS method, targeting protein-protein interactions, which are considered to be difficult to target by conventional drug discovery methods. The concept is to identify an optimal binding peptide that interacts with the active/regulatory site (Hot Spot) of the target drug discovery protein by using in silico methods. Using this as a design element, transformation design to small molecule and automatic optimization is possible by refining the unique binding 3D coordinates.

Novel Drug Discovery Strategy Targeting Protein-Protein Interactions



Future Developments

Validation of the applicability of COSMOS method and discovery of novel lead compounds will be done in collaboration with pharmaceutical companies to develop novel drugs.

- Associated System: Grants-in-Aid for Scientific Research
  2015 Basic Research (C)
  2016 Basic Research (B)
- Intellectual Property: Japanese Patent No. 4612270 "Design method and applications for physiologically-active peptides"
- Highly experienced in collaborative research with companies

Bio

Development of central delivery technology of peptides by intranasal administration based on new concept

Chikamasa YAMASHITA (Professor, Department of Pharmacy, Faculty of Pharmaceutical Sciences, Tokyo University of Science)

Purpose of Research

Most of the intranasal formulations for improved CNS delivery have not been put to practical use. This is primarily because the anatomical features of the human nasal mucosa have not been taken into consideration. The nasal mucosa consists of the olfactory epithelium and respiratory epithelium, each of which accounts for approximately 50% in rodents. In humans, on the other hand, the olfactory epithelium accounts for 2% and the respiratory epithelium for 98%. We created neuropeptides containing various functional sequences, seeking to develop the central delivery technology via the trigeminal nerve in the respiratory epithelium.

Summary of Research

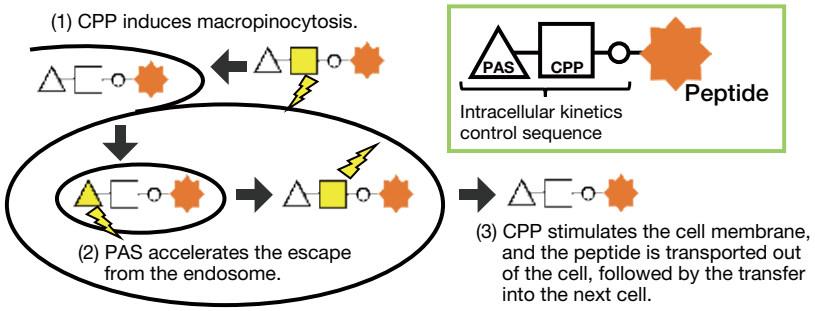


Fig. 1. Concept of derivatization

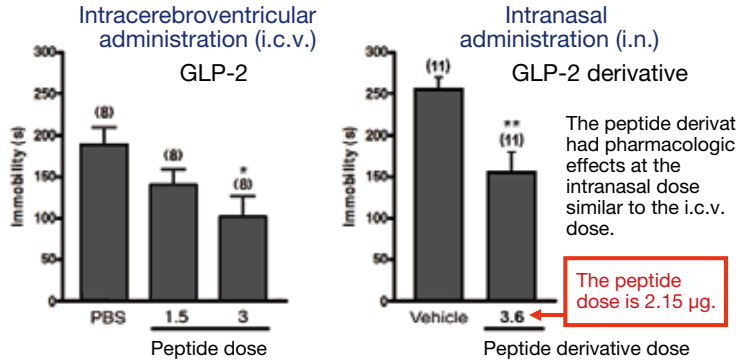


Fig. 2. Pharmacological effects by different administration routes

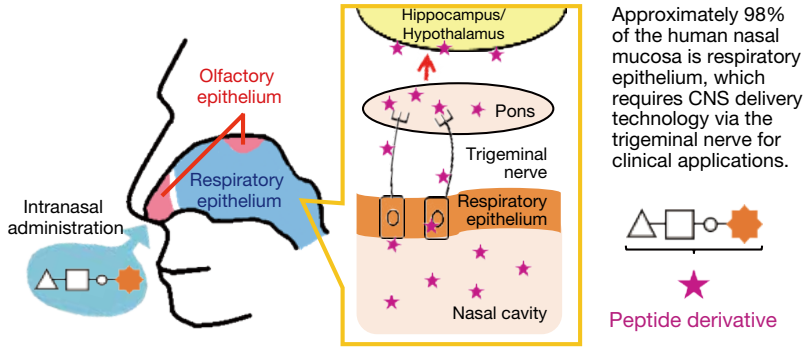


Fig. 3. Delivery route of peptide derivative to the CNS

Results

- Peptide derivatives are taken up by macropinocytosis and efficiently escape from endosomes.
- Peptide derivatives had CNS effects at the intranasal dose similar to the i.c.v. dose.
- The novel central delivery technology was used for intranasal administration to achieve CNS effects via the trigeminal nerve.
- The same results have been demonstrated with other peptides.

Points

- **Macropinocytosis that can take up 1-μm particles is expected to be applied to nucleic acids and antibody drugs as well as peptides and proteins.**
- **The central delivery technology of neuropeptides via the trigeminal nerve that is suitable for the human nasal mucosa is the first successful technology of its kind in the world.**

■ Patent:
C. Yamashita et al., US2017/0253643
C. Yamashita et al., EP 3 190 129, 2017

■ Applicants:
Tokyo University of Science Educational Corporation

Bio

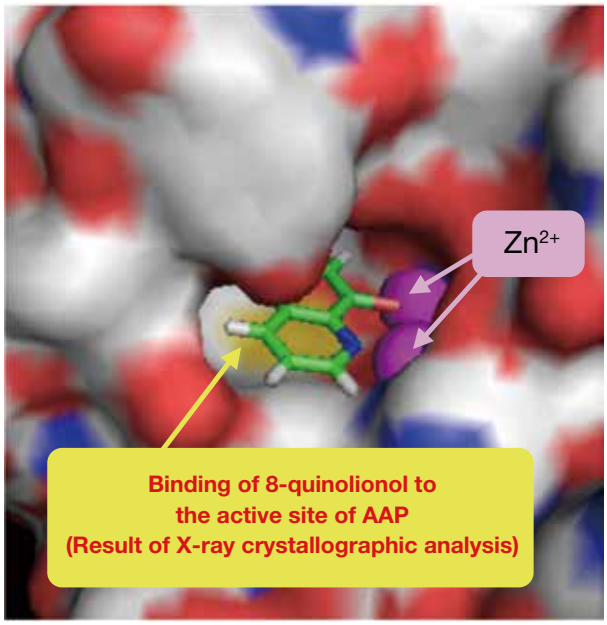
Solution for multi-drug resistance bacteria

Shin AOKI (Professor, Department of Medicinal and Life Science, Faculty of Pharmaceutical Sciences, Tokyo University of Science)

Purpose of Research

With the introduction of antibiotics, it was thought that the battle against infection had ended. However, antibiotic-resistant microbes (drug-resistant bacteria) have appeared and is now an issue of global challenge since there are no effective therapeutic methods against them. In addition, the appearance of multi-drug resistant bacteria has become a new threat and effective countermeasures are required. Recently, inhibiting "metallo-β-lactamase," an enzyme that leads to multi-drug resistance in pathogens, is gaining interest. At our laboratory, through research on metallic zinc complexes, we have focused on enzymes that selectively inhibit enzymes that contain zinc and are developing drug agents to inhibit the activity of enzymes that contain zinc such as metallo-β-lactamase. At the same time, we are designing molecules with lower toxicity and developing a reactivation method.

Summary of Research



Metallo-β-lactamases are considered to be the most dangerous among β-lactamases and degrade almost all antibiotics that include penicillins, cephams and carbapenems. Bacteria (*Pseudomonas aeruginosa*, *Acinetobacter*, *E. coli* and *Klebsiella pneumoniae*, etc.) that carry the gene for this enzyme on a transmissible plasmid have strong pathogenicity and may cause infection not only in the hospital, but also to the general public.

Among metallo-β-lactamases, there are dinuclear zinc enzymes with two zinc molecules in the active center (Class B) and there are currently few drugs (inhibitors) that effectively inhibit these enzymes.

Our laboratory is applying basic research on metallic zinc complexes to develop dinuclear zinc enzyme inhibitors. Specifically, we have analyzed the structure of the active site of these enzymes in detail and searched for inhibitors that can bind to the zinc ions. However, inhibitors to metal enzymes are metalloligands which lead to toxicity. Therefore, we are investigating prodrugs that protect the ligand site to lower toxicity but can also be deprotected and reactivated at the right time and place.

Through these activities, we are aiming to develop a novel antibacterial agent against dinuclear zinc enzymes such as β-lactamase while avoiding multi-drug resistance.

Points

- **Search for compounds that bind to the active site of dinuclear zinc enzymes and analyze mechanism of binding in detail using X-ray crystallography**
- **This compound was found to inhibit the dinuclear zinc enzyme AAP (Amino-peptidase from *Aeromonas Proteolytica*)**
- **A protective group was introduced to reduce toxicity of these compounds and we developed a method to eliminate the group under physiological conditions**
- **Knowledge, techniques and know-how which are related to complex chemistry in water**

Future Developments

- Selection of optimal compound from those known to bind to the active site
- Evaluation of enzyme inhibitory potency of the selected compound *in vitro*
- Molecular design and synthesis to lower toxicity (prodrug)
- Safety and efficacy evaluation *in vivo*
- Collaborative research with domestic and global partners

■ Research Organization: This research is a collaborative study with Kengo Hanaya at the Faculty of Pharmacy, Keio University.

Bio

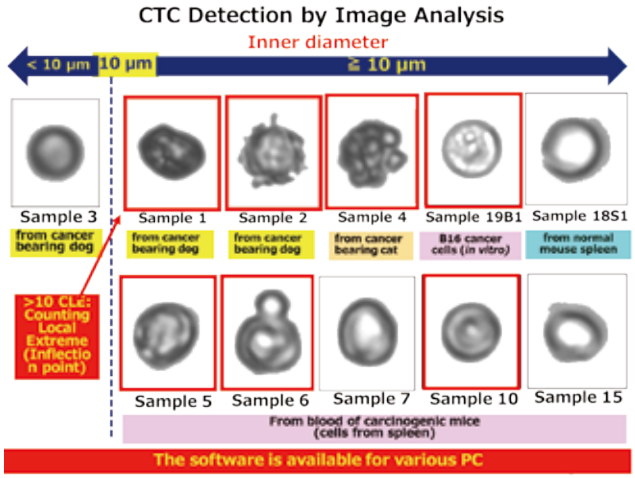
Development of a separation system for circulating tumor cells (CTC)

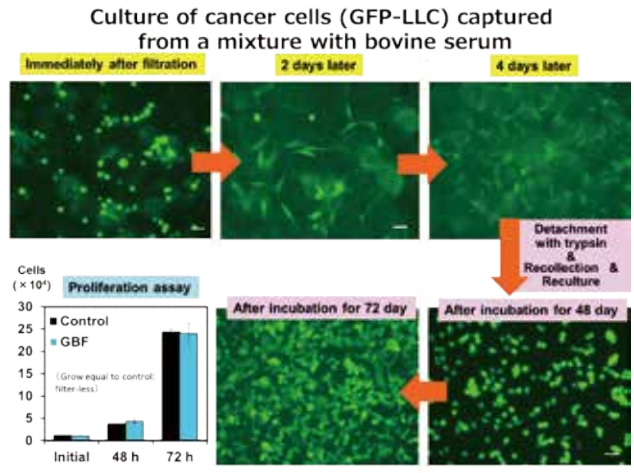
Shin AOKI (Professor, Faculty of Pharmaceutical Sciences, Tokyo University of Science)
Atsuo YASUMORI (Professor, Department of Materials Science and Technology, Tokyo University of Science)

Purpose of Research

Circulating tumor cells (CTCs) are cancer cells that leak into the blood from primary tumor sites. CTCs are considered to be deeply involved in cancer malignancy, such as metastasis and recurrence. The detection and analysis of CTCs are difficult as there is only a small number of them in the body. The purpose of our research is the development of convenient and efficient methods to *detect, trap, and reculture CTCs*, to elucidate their nature, to test anticancer drugs against the trapped CTCs, and to remove CTCs from patients' blood.

Summary of Research





(1) A new algorithm has been developed to detect cancer cells from blood cells using their size and shape (marker-free detection).

(2) Convenient and efficient methods have been developed to separate and culture cancer cells.

Comparison with Conventional or Competitive Technology

- This technology is independent of a CTC's antigens and the results of CTC detection are not affected by surface proteins.
- The biological & immunological properties of CTCs can be analyzed.
- The recovery rate of CTCs is ca. 80%–90%, with only minor damage to both CTCs and red blood cells.

Expected Applications

- Cancer diagnosis by CTC detection and evaluation of therapeutic efficacy for personalized cancer therapies.
  Diagnosis of primary tumor by analysis of CTCs.
  Development of anticancer drugs targeting CTCs.
- New cancer treatments (prevention of metastasis) by filtration of CTC from cancer patient's blood.
- The detection of cancer cells spiked in animal blood has been successful and CTC detection in cancer-bearing animals is now in progress.
- The detection accuracy up to greater than 95% would be required.

What We Expect from Companies

- This technology would be useful for companies that develop PC software and plan new entry to medical markets.
- Collaboration with companies that are strong at dialysis, apheresis (human, animal) technologies is highly appreciated.

Points

- **Cancer cells can be detected from cell images taken on various microscopies**
- **Trapping and reculturing of cancer cells are possible under physiological conditions**

Future Developments

The detection, isolation (reculture), and filtration of CTCs from cancer patients (animal and human).

■ Patent Process: Underway
■ Collaboration: Welcome
■ Prototype: Available for rent

Bio

Development of medicine for ischemia/reperfusion injury with a novel mechanism

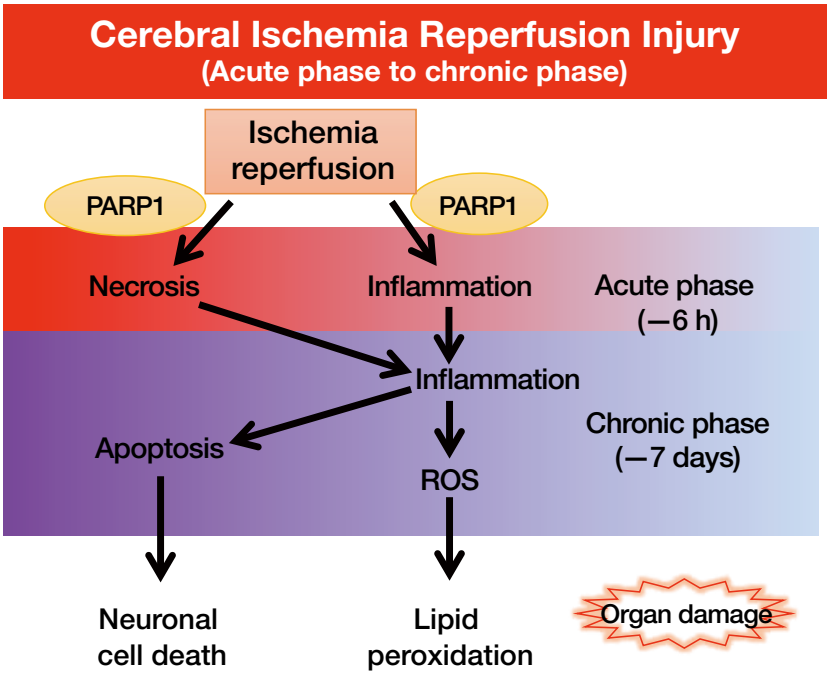
Yoshikazu HIGAMI (Professor, Faculty of Pharmaceutical Sciences, Tokyo University of Science)

Purpose of Research

Various organs may be damaged when blood flow resumes after the treatment of cerebral and myocardial infarctions. In ischemia/reperfusion injuries, excessive activation of the poly (ADP-ribose) polymerase 1 (PARP1) molecule, which acts as a repair enzyme for healthy DNA, induces tissue damage. Therefore, there is demand for the development of a PARP1 inhibitor. However, conventional therapeutic agents for ischemia/reperfusion injury cause side effects due to their mechanism of action, and effective medication has yet to be developed. Our laboratory is developing a new drug with a novel mechanism for the treatment of ischemia/reperfusion injury.

Summary of Research

Ischemia/reperfusion injury is organ damage caused by the resumption of blood flow during the treatment of and/or recovery period after the treatment of ischemic diseases, which include cerebral infarction and myocardial infarction, and transient ischemia due to organ transplantation. This injury results from tissue damage by free radicals and inflammatory cytokines, which are caused by an excess of reactive oxygen species produced in the presence of fresh blood after ischemia. Cell death accompanied by the excessive activation of PARP1 is a known cause of this. Therefore, PARP1 inhibitors are considered to be effective drugs for ischemia reperfusion injury. So far, many PARP1 inhibitors have been clinically evaluated. However, most of those have side effects on organs other than the one targeted, due to their competitive inhibitory mechanism. The candidate PARP1 inhibitor found in this study has a novel mechanism which degrades the PARP1 protein. This compound is expected to become a drug for ischemia/reperfusion injury treatment, which acts with different molecular mechanism.



Comparison with Conventional or Competitive Technologies

Almost all available PARP1 inhibitors are NAD^+ mimetics, i.e. aimed at binding to the catalytic domain of PARP1 and competition with NAD^+. The candidate PARP1 inhibitor found in this study has a novel mechanism which degrades the PARP1 protein in both p53 protein and proteasome-dependent manners. This compound is expected to become a drug for ischemia/reperfusion injury treatment with few side effects, because it is potentially effective at low concentrations.

Expected Applications

- A drug for ischemia/reperfusion injury
- An anticancer agent, particularly breast cancer with BRCA mutations

Future Developments

A detailed analysis of the PARP1 degradation mechanism in collaboration with interested companies.

■Intellectual Property: Japanese Patent No. 5954839
■Sample: Available

Bio

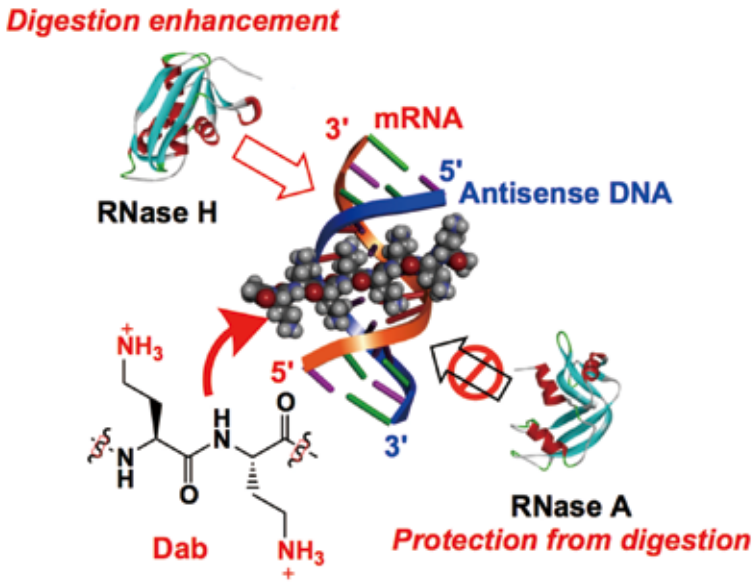
New molecular technologies for stabilization and activation of nucleic acid drugs

Takeshi WADA (Professor, Department of Medicinal and Life Science, Faculty of Pharmaceutical Sciences, Tokyo University of Science)

Purpose of Research

Recently, there has been an increase in the development and research on nucleic acid drugs, such as antisense nucleic acid, ribonucleic acid interference (RNAi) medicine, and aptamers. Problems that must be solved for implementation of nucleic acid drugs include improvement in in vivo stability of nucleic acid molecules and establishment of delivery technology. As one methodology to solve these problems, this research focuses on the development of artificial cationic molecules that specifically bind to nucleic acid drugs with double-stranded nucleic acid, such as short interfering RNA (siRNA) and deoxyribonucleic acid (DNA)/RNA heteroduplex oligonucleotide (HDO), and not only protect these molecules from degradation enzymes in vivo but also improve physiological activity itself.

Summary of Research



Novel artificial cationic oligosaccharide and artificial cationic peptide

Points

- **Binds to double-stranded nucleic acid drugs and significantly improved thermodynamic stability and nuclease resistance of the double strand**
- **Improves activity of RNase H, which digests target mRNA**

Conventionally, cationic carrier molecules used as drug delivery system (DDS) for nucleic acid drugs require excessive administration. The ratio of the number of cationic functional groups and number of anionic functional groups in a complex is expressed as the N/P ratio, but normally, N/P of 2 or above is required to ensure sufficient in vivo stability of nucleic acids. We are developing molecules that specifically recognize and strongly bind to nucleic acid molecules with defined higher-order structure in this research. In particular, anticipating application to double-stranded nucleic acid drugs such as siRNA and DNA/RNA heteroduplex oligonucleotide, we have developed artificial cationic molecules (artificial cationic oligosaccharides and artificial cationic peptides) that recognize specific higher-order structure of such double-stranded nucleic acids and specifically bind to them.

It was found that cationic peptides that recognize defined structures of double-stranded nucleic acids and selectively bind to them can selectively inhibit the activity of nucleic acid-degrading enzymes such as RNase A, and conversely, has the ability to improve specific nuclease activity such as RNase H. Using the cationic peptides developed in this research, it is anticipated that effective methodology to achieve stabilization and high activity of nucleic acid drugs can be developed.

Future Developments

Nuclease resistance, RNase H activity, intracellular introducing efficiency, and gene-expression suppression effect of artificial cationic molecule and double-stranded nucleic acid drug complexes have been evaluated in vitro.

In the future, we plan to conduct in vivo functionality evaluation, synthesize conjugates with ligand molecules, and evaluate organ-specific delivery and gene-expression inhibition.

■ Associated System: JST-CREST
Establishment of Molecular Technology towards the Creation of New Functions
* This research is in collaboration with Professor Takanori Yokota at Tokyo Medical and Dental University

Communication and information processing

Quick spoken term detection system

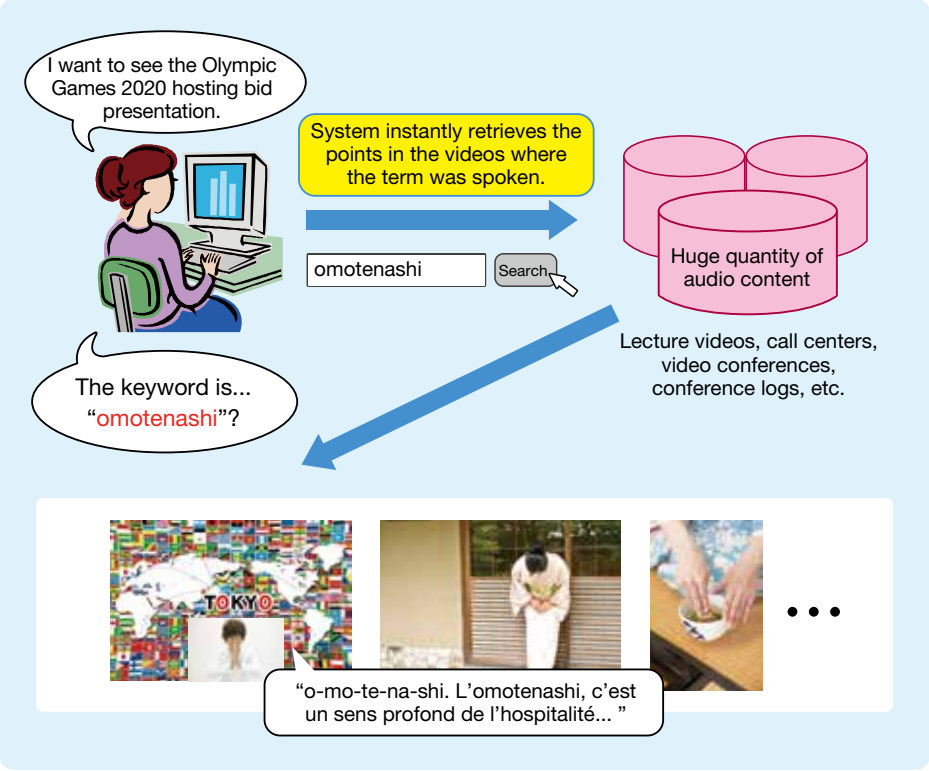
Kouichi KATSURADA (Associate Professor, Department of Information Sciences, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

This research aims to develop a keyword search system that works very quickly (several milliseconds to one second) on large-scale spoken documents (tens of thousands to hundreds of thousands of hours). Due to its compact data structure, the system can run on general personal computers if searching for spoken terms in data of approximately ten thousand hours. This technology enables searching based on the content of video and audio data, and is expected to dramatically improve the convenience of audio and video data searching.

Summary of Research

In this research, we use a suffix array data structure to enable quicker searching with a more compact system. We also utilize ambiguous searching, keyword separation and multiple voice recognition devices to achieve high-speed and high-performance searching. Furthermore, through development of an optimum keyword separation algorithm for quick searching, etc., we are working to establish theoretical assurance of the high speed and high performance of searching.



Comparison with Conventional or Competitive Technology

- Uses suffix arrays to achieve a quick, compact search system
- A keyword separation method has been formulated that is not used in conventional systems, and there is theoretical assurance of performance

Expected Applications

- Searching cases at call centers
- Searching lectures in e-learning materials
- Searching content at broadcasting stations
- Searching discussions at various kinds of conferences and assemblies
- Searching videos in hard-disk video recorders for home use

Challenges in Implementation

Since high-precision voice recognition devices are necessary for utilization of this technique, we need to cooperate with companies that are developing these devices.

What We Expect from Companies

We would like to cooperate with companies that are developing high-precision voice recognition devices, which serve as the basis for this system. This technology can also be utilized effectively in the video content and education industries, and by broadcasting related companies.

Points

- **Ability to search spoken terms quickly**
- **System can be run on general personal computers, due to its compact data structure**
- **Theoretical assurance of high speed and high performance**

Future Developments

December 2017: Completion of development of theory regarding keyword separation

March 2019: Achievement of 80% search performance

■ Associated System: SCOPE ICT Innovation Creation Challenge Program
JST Research Grant for Promoting Technological Seeds
■ Prototype: Available
■ Sample: Please enquire

Communication and information processing

Secure, fast, light encryption based on non-commutative algebra

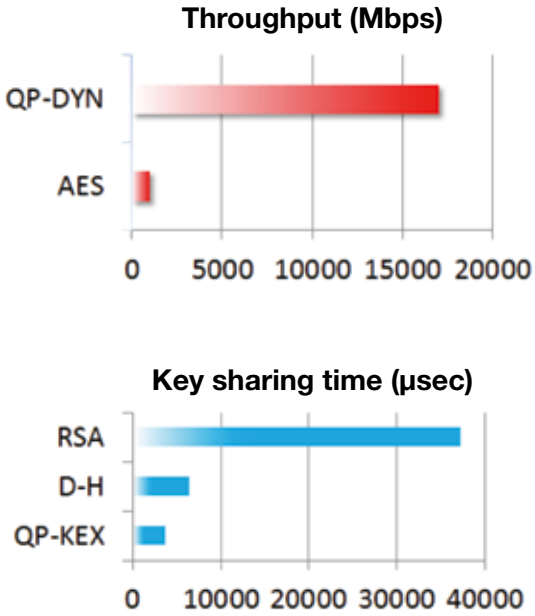
Satoshi IRIYAMA (Associate Professor, Department of Information Sciences, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

Prof. Emeritus Ohya (TUS) and Prof. Accardi (University of Rome II) have developed a novel encryption method as a result of their more than 20 years of study on mathematics (noncommutative algebra and noncommutative probability theories). We are studying a cipher based on noncommutative algebra and an encryption method based on a new principle.

Summary of Research

The shared key stream cipher (QP-DYN), based on a unique mathematical theory, can generate high-quality random numbers. The public key exchange (QP-KEX) is based on mathematics that can be reduced to a matrix type discrete logarithm problem and is safe. It does vector calculation and allows parallel processing for fast encryption.



Cryptobox
(8 cm x 8 cm, 500 g)

Comparison with Conventional or Competitive Technology

Throughput more than 10 times faster than AES was achieved. Key generation and key exchange was about 10 times faster than RSA. When implemented on FPGA, the circuit size was about 75% that of AES.

Expected Applications

- High-speed processing by a cloud server, etc.
- Higher safety in a mobile environment
- Real-time processing for 4K/8K video distribution

Challenges in Implementation

- Development of attractive services
- Registration as an encryption standard
- Standardization of specifications

Points

- Safer One-Time-Pad cipher
- Faster key generation, key exchange, and encryption
- Smaller and lighter circuit

What We Expect from Companies

Collaboration on the installation on a smaller chip and the product/service/application development of the new encryption method.

Future Developments

Many pilot products are being developed. These will be broadly publicized both in Japan and overseas.

■Prototype:
Portable encryption device “Cryptobox,” Email encryption (compatible with Outlook and Google), and mobile App.

Bio

High-throughput screening and identification of novel chemicals enhancing plant defense against pathogens/pests

Kazuyuki KUCHITSU (Professor, Department of Applied Biological Science, Faculty of Science and Technology, Tokyo University of Science)
Nobutaka KITAHATA (Assistant Professor, Department of Applied Biological Science, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

Control of pests and diseases is a critical issue in crop production, since biotic factors cause economic losses of $220 billion. Since traditional chemical pesticides have disadvantages such as the emergence of drug resistant organisms and the toxicity to beneficial symbiotic organisms and insects, i.e. possible disturbance of ecosystem, an entirely novel approach to protect crops from pathogens and pests is needed.

Plant defense activators, chemicals that boost defense/immune responses of plants, have excellent advantages as new type of low-toxicity pesticides which does not lead to emergence of drug resistant organisms. The plant immune system consists of two major pathways, involving salicylic acid (SA) and jasmonic acid (JA)/ethylene (ET). Only a few plant defense activators that activate only the SA pathway are available in the market, and these have only narrow application, mostly limited to rice pests.

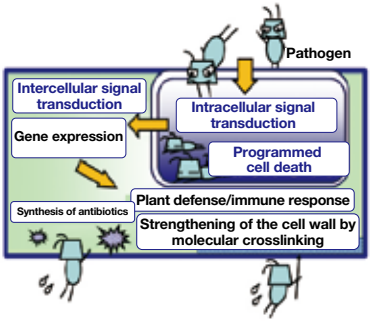
Summary of Research

Advantage of plant activator as pesticide

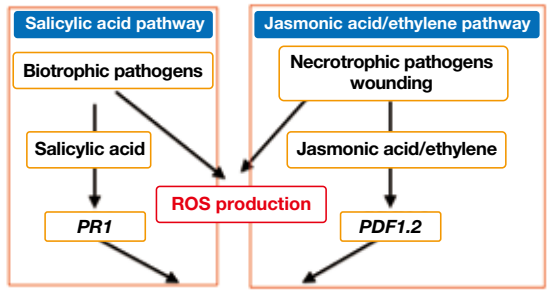
Fungicides/insecticides
Chemicals directly kill pathogens or pests

Plant defense activators
Chemicals activate plant's immune system

Plant immune responses



New plant defense activators for jasmonic acid/ethylene pathway



We have developed a novel high throughput screening system for plant defense activators (PCT filed), and have discovered novel putative plant defense activators that activate the JA/ET pathway or both of the above pathways, and that are expected to enhance defense responses against a wider spectrum of necrotrophic pathogens and pests.

Comparison with Conventional or Competitive Technology

Traditional chemical pesticides have disadvantages of toxicity to beneficial symbiotic microorganisms and insects, as well as disturbance of eco-system. In contrast, Plant defense activators, chemicals that boost defense/immune responses of plants, have excellent advantages as new type of low-toxicity, environment-friendly pesticides to avoid emergence of drug resistant organisms. We have developed a novel efficient high throughput screening system for plant defense activators.

Expected Applications

- Development of novel pest control methods for organic and pesticide-free farming.
- Reduction of the dose of traditional pesticides by the enhanced plant defense/immune responses.

Challenges in Implementation

- Identification/optimization of more lead compounds from a larger chemical library.
- Field test of the identified activator candidates.

What We Expect from Companies

Partnership opportunities are open to interested corporations.

Points

- Plant defense activators are a novel type of pesticides which can preserve the ecosystem and environment in a field and avoid the emergence of drug resistant organisms
- We have established a high-throughput system for screening plant defense activators
- We have identified putative novel plant defense activators that can activate two major immune pathways in plants

Future Developments

In vivo (whole plant) testing of the identified chemicals (secondary evaluation) is now going on.
Select high-potency activator candidates (2015).
Field test start (2016).

■ Intellectual Property: JP2013-510162 "Method for plant defense activators, plant defense activators, and method for enhancing immune responses"

Bio

World's first visualization of the switching mechanism of plant tip growth using novel fluorescence imaging without recombinant DNA technique

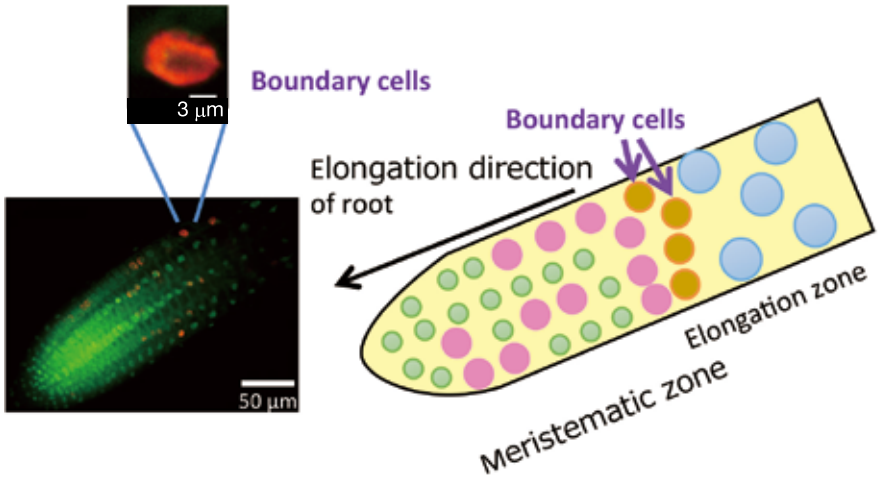
Sachihiro MATSUNAGA (Junior Associate Professor, Department of Applied Biological Science, Faculty of Science and Technology,Tokyo University of Science)

Purpose of Research

This imaging method which simply applies a small-molecule compound and a fluorescent label to plant tissue, visualizes plant growth process in a non-invasive and real-time manner, without recombinant DNA technique. Using this method, we have identified distinctive boundary cells which switch cells from proliferation to elongation in root and other meristems, for the first time in the world. This imaging method will be an effective, easy-to-handle tool in developing novel useful plants. It will also help develop "digital plants" and other plant simulations and provide a tool for minute and efficient soil/fertilizer assessment, breeding, etc.

Summary of Research

Imaging that clearly reveals plant growth processes and structures has great potential to aid in breeding and many other processes in agriculture. Conventional live imaging of cell division and elongation requires recombinant DNA technique. In our method, a tested plant is simply soaked in a solution of the thymidine analog EdU (5-ethynyl-2'-deoxyuridine), which is incorporated into the chromosomal DNA in dividing cells and then detected with a fluorescent azide label. Thus, plant growth processes in a whole plant can be analyzed successively in a non-invasive, real-time manner. In addition, this method can be widely used because it only requires commercial reagents.



Points

- Non-invasive, real-time imaging of plant growth process
- No recombinant DNA technique required
- Fast and easy
- Possible application to digital plant models

Comparison with Conventional or Competitive Technology

Conventional imaging methods are time-consuming (recombinant DNA technique methods) and/or invasive (biochemical methods). Our method has the following advantages:

- No recombinant DNA technique required;
- Non-invasive, real-time observation possible; and
- Fast and easy.

Expected Applications

- Soil/fertilizer assessment.
- Novelbreeding focused on plant growth process.
- Digital (virtual) plant model.

Challenges in Implementation

No particular problem. The method only requires commercial reagents and so has not been patented.

What We Expect from Companies

Development of new applications of this imaging method. We can optimize/customize the method on request.

■ Articles:
"Imaging of plant growth process" Nikkei Sangyo Shimbun, October 16, 2013; "Associate Prof. Matsunaga and colleagues of TUS visualize plant growth without recombination and discover boundary cells" Nikkei Biotech ONLINE, October 14, 2013
■ Publication:
"The boundary of the meristematic and elongation zones in roots: endoreduplication precedes rapid cell expansion" Hayashi, K. Hasegawa, J. Matsunaga, S. Scientific Reports 3 2723 (2013)

Bio

Active learning software for automatic classification to take over proficient farmers as smart cultivation management

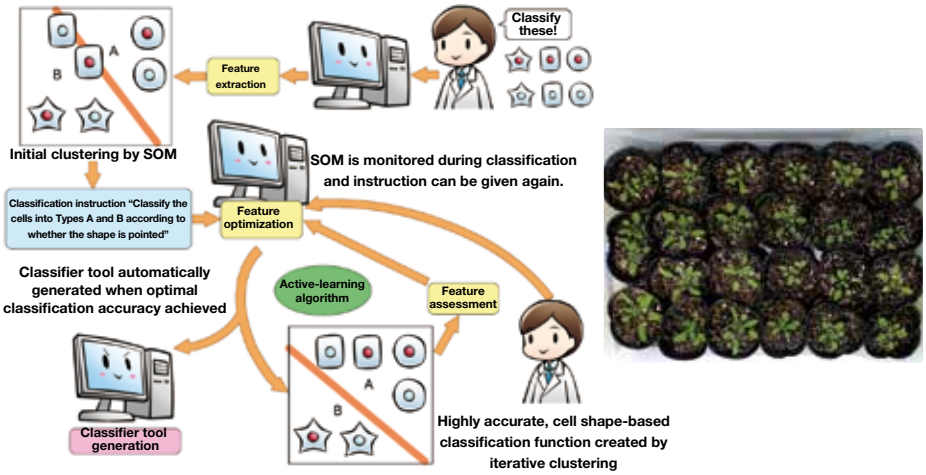
Sachihiro MATSUNAGA (Junior Associate Professor, Department of Applied Biological Science, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

The active learning software of the present study can automatically classify bioimage data to achieve "amateur-friendly agriculture," by converting a wide spectrum of skills and hidden knowledge of proficient farmers to standardized objective data. Growth management of agricultural plants (e.g. seedling selection) has been a labor-intensive task of proficient farmers. In their place, the present software, which has learned from their "skilled eyes," can achieve standardized growth management, labor-saving, improved productivity, and a higher level of quality control. When combined with a portable imaging device, it also allows remote growth management. The present software does not limit itself to images of certain organisms, making it a versatile tool for the rationalization of the production/distribution of agricultural and fishery product

Summary of Research

Humans (even infants) can identify the items of a sample group which are different from the others even though no selection criteria has been set, something conventional learning software cannot do well. Our "active learning" software automatically classifies any kind of bioimage data, like humans do. Once given a small amount of "training data," it iterates analysis of this data and learns the standards of "professional skills" and "skilled eyes" so as to classify any bioimage, whatever animal, plant, or cells. This is an outstanding feature not found in conventional systems and software.



Automatic growth monitoring system: automatic image recording of a cultivation shelf by a Web camera, automatic image upload, and image analysis by a remote PC

Comparison with Conventional or Competitive Technology

Conventional image analysis requires separate software for each type of object and a lot of "training data." In contrast, our software

- operates without much training data;
- can be used for automatic classification of any kind of bioimage;
- is amateur-friendly and simple.

Expected Applications

- Smart management of agricultural and fishery production.
- Smart management of agricultural and fishery product distribution.
- Labor saving by remote monitoring.

Challenges in Implementation

- Customization/optimization for particular purposes and incorporation into systems if necessary.
- Acquiring patents for the above.

What We Expect from Companies

Proposal of new applications of the software. We can optimize/customize the software on request.

Points

- **Highly reliable growth management not dependent on high skill of the user**
- **Labor saving, simple growth management**
- **Widely applicable to all processes from production to distribution**

■ Patent: JP04521572 "Cell evaluation method, cell measurement system, and cell measurement program" (basic patent of this method)
■ Publication: "Active learning framework with iterative clustering for bioimage classification" Kutsuna, N. Higaki, T. Matsunaga, S. Otsuki, S. Yamaguchi, M. Fujii, H. & Hasezawa, S. Nature Communications 3, Article number: 1032 28 August 2012

Functional materials

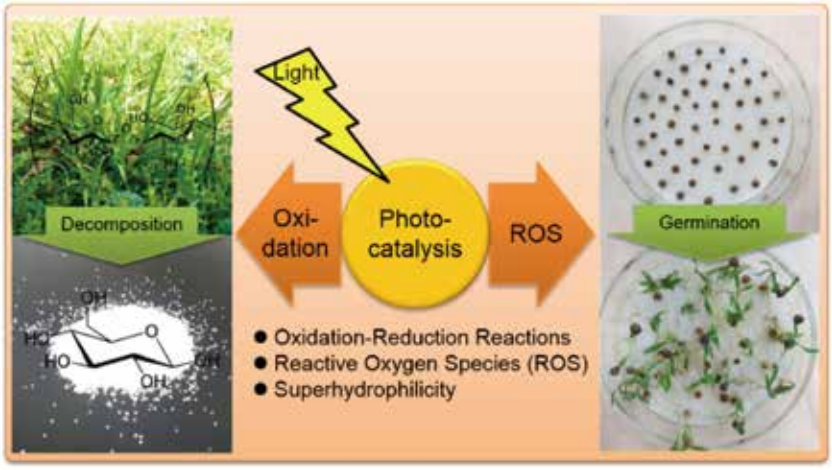
New applications of photocatalysis

Kazuya NAKATA (Associate Professor, Department of Applied Biological Science, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

Photocatalysts are functional materials that convert photo-energy to chemical energy. They exhibit oxidation-reduction reactivity and convert surface wettability into superhydrophilicity when illuminated. Those properties can be exploited for production of useful chemicals, environmental purification, etc. For example, hydrogen as a fuel can be produced from water using the oxidation-reduction reaction. Furthermore, a surface shows self-cleaning when it is given superhydrophilicity. Those properties are very unique and are already applied in many commercialized products. Applications for photocatalysis are expanding into new areas, where they are in great demand.

Summary of Research



Points

- **Glucose and other useful rare sugars can be produced from biomass resources using photocatalytic oxidation**
- **Germination of seeds can be improved with reactive oxygen species produced from photocatalysis, benefiting agriculture**

Our group is developing new applications of photocatalysis in biological and agricultural research areas.

1) Production of useful sugars from biomass using photocatalysis

Sugar is not only a necessary source of nutrition but recently also resource of bio-ethanol, electricity, and PLA plastics. Thus, recent demand for sugars in various purposes is significantly increasing. Our group succeeded in producing glucose and rare sugars from cellulose-based biomass using photocatalysis. This finding should lead to cheap industrial production of value-added sugars.

2) Improvement of germination rate of seeds using photocatalysis

Improvement of the germination rate of seeds of plants is key to improving the efficiency and costs of agriculture. Our group used TiO_2 photocatalyst to produce active oxygen species which induced dormancy release of seeds, and successfully improved germination. This finding can be applied to improve germination of seeds such as medical plants which have low germination rates.

Future Developments

- Large scale, cheap production technology of glucose and useful rare sugars will be developed, which can be used for industrial and medical applications.
- Technology for growing value-added plants using photocatalysis will be developed.

- Associated System: JST Strategic International Collaborative Research Program (SICORP)
- Awards: Young Researcher Award of The ElectroChemical Society of Japan (Sano Award) (2012)
  The Japanese Photochemistry Association Prize for Young Scientist (2013)
- Intellectual Property: N.A.
- Prototype: Present
- Sample: Available

Material

Silica hollow particles prepared with facile process and their application

Hideki SAKAI (Professor, Department of Pure and Applied Chemistry, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

Silica hollow particles have excellent characteristics such as low density, low refractive index, substance encapsulation ability, etc., and are used in lightweight materials and heat insulation materials. If the particle size can be controlled to be 100 nm or smaller, they can be expected to be applied to anti-reflection coatings and the carriers of drug delivery systems (DDS). One method of synthesizing silica hollow particles is the soft template method, which uses molecular assemblies formed by surfactant as templates, and research into this method has been actively conducted in recent years as this process is easy to do and substances are easily encapsulated in the hollow space. However, the low dispersion stability of the manufactured hollow particles has been a challenge in improving this method. In this study, we used vesicles as a soft template and aimed to synthesize silica hollow nanoparticles with excellent dispersion stability by changing pH stepwise during the forming period of silica.

Summary of Research

This technology is related to the soft template method for producing hollow silica particles, using vesicles formed by surfactant as templates. By changing the pH of the manufacturing process stepwise, hollow silica particles with a uniform diameter of 100 nm or below can be obtained. In this method, vesicles are used as templates so that various substances can be supported inside the hollow silica particles. By controlling retention and release, the particles can be made to adapt to various applications.

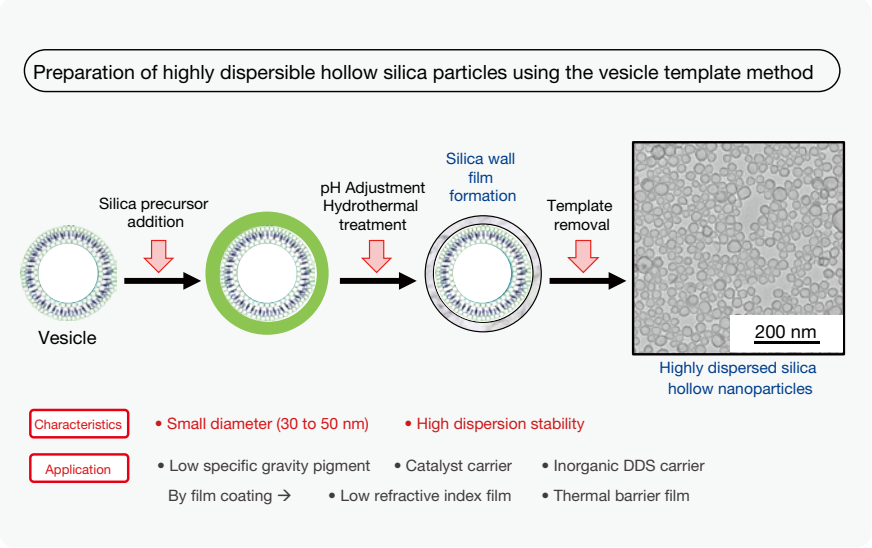


Figure: Preparation of silica hollow nanoparticles with vesicles as templates

Comparison with Conventional or Competitive Technology

- Conventional: The majority is manufactured by the hard template method.
- Conventional method: It is difficult to encapsulate substances inside the silica particles, and applications were limited to their properties as "hollow" silica particles.
- This technology: Both "hollow" and "encapsulating substances" silica particles can be developed to meet various needs.

Expected Applications

- Inorganic anti-reflection film making use of low refractive index characteristics
- Inorganic DDS material for diagnosis
- Development into thermal barrier/thermal insulation paint
- Supported type catalyst

Challenges in Implementation

- Small amount of surfactant remains even after washing → Establishment of complete removal method

What We Expect from Companies

We seek cooperation with industries in fields working in low refractive index inorganic films, transparent thermal barrier films, highly dispersible pigments, etc. in hollow particle formation and application of not only silica, but also other various materials.

Also, we hope to cooperate with industry for the development of silica particles for DDS, which include diagnostic reagents.

Points

- **Nano-sized hollow particles can be prepared by a facile process**
- **Substances can be supported inside hollow silica particles**
- **Excellent dispersion stability is retained in water system (Stable dispersion for 1 year or more)**
- **Suitable for coating processes etc. and superior in environmental affinity**

Future Developments

November 2017	Start cooperation with companies
October 2018	Completed method for preparing hollow particles other than silica
January 2020	Start sales of silica hollow particles

■ Awards: JACM Annual Conference, Gold Poster Awards
■ Intellectual Property: Japanese Patent Application No. 2014-166604, Japanese Unexamined patent Application Publication No. 2016-041643
"Method for Producing Hollow Silica Particles and Hollow Silica Particles"
■ Prototype: Not available
■ Sample: Available

Bio

Nano/micro-seized dual drug capsule for enhancing efficacy of supplements

Makoto YUASA (Professor, Department of Pure and Applied Chemistry, Faculty of Science and Technology, Tokyo University of Science)

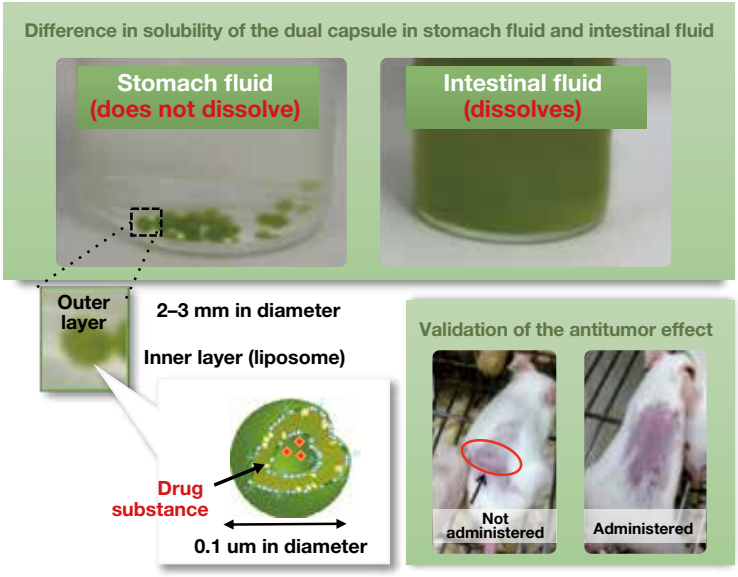
Takeshi KONDO (Associate Professor, Department of Pure and Applied Chemistry, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

To date, a vast number of pharmaceuticals and supplements have been developed to treat diseases and maintain health. In order to deliver such drugs into the body so they can realize their effect, it is necessary for them to be smoothly absorbed into the body. Also, the method for ingesting the drugs should not involve any labor or stress. In this research, with the aim of enhancing the efficacy of existing drugs, we are developing a capsule that can be ingested orally and delivers the drug to the intestines, which has a high absorption rate.

Summary of Research

We have developed a capsule that can be ingested orally and promotes the absorption of the drug substance. The main feature of this capsule is its dual layer structure. The first layer (outer layer) is a microscopic spherical capsule that is made from a gelatinous substance derived from seaweed. The second layer (inner layer) is a nano-sized capsule which holds the drug substance. The first layer is resistant to stomach acid and does not dissolve in the stomach. This protects the drug substance and limits dissolution in the stomach. Also, this layer is expected to provide the benefit of limiting any deterioration of the drug substance. Once the capsule reaches the intestines, the outer layer immediately dissolves, releasing the inner nano-capsules. Using this dual layer capsule, it is possible to deliver drug substances, such as existing supplements, to the intestines without waste, and this is expected to increase the concentration of the drug substance in the intestines and promote absorption.



Biomater. Sci. 3, 861–869 (2015)

Points

- Transport drug substances to the intestines using a gel derived from seaweed
- Nano-capsules can encapsulate substances with poor water solubility within the gel

Comparison with Conventional or Competitive Technology

- Drug substances can be ingested orally.
- Possible to encapsulate a wide range of drug substances, including substances with poor water solubility.
- The size of the drug substance can be adjusted (from micro to millimeter in size), making it easy to swallow.

Expected Applications

- Make it possible to orally ingest substances with beneficial pharmaceutical effect.
- Increase the absorbability of existing supplements.
- Limit the "bad taste," such as bitterness, of particular drug substances, and make easy to ingest such substances orally.

Challenges in Implementation

We are currently validating the antitumor effect of a model drug in mice, but because no pharmaceutical effect trials have been conducted in humans, it is necessary to study formulations for humans.

What We Expect from Companies

Companies with a drug substance they would like to use with this capsule should feel free to consult with us.

Future Developments

We will test the encapsulation of a wide range of drug substances other than the model drug and confirm what properties the drug substances that can be encapsulated and released have. Based on this data, we will present a formulation as a universal drug capsule.

- Intellectual Property: Patent application 2014-093428 "Oral treatment drug"
- Prototype: Available
- Sample: Requires consultation

Device

High-throughput screening of multicomponent functional materials using combinatorial technology based on the electrostatic spray deposition

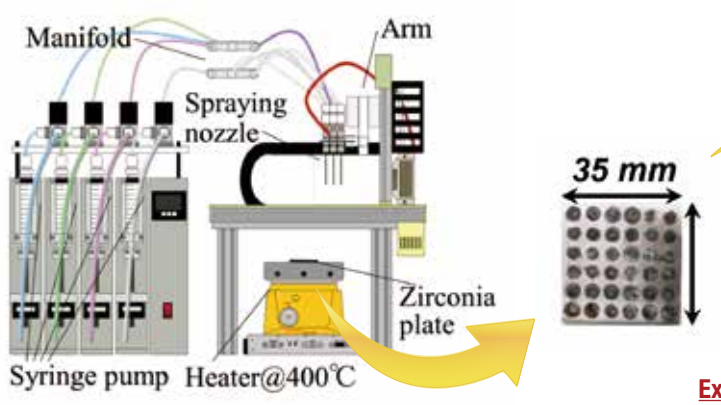
Kenjiro FUJIMOTO (Associate Professor, Department of Pure and Applied Chemistry, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

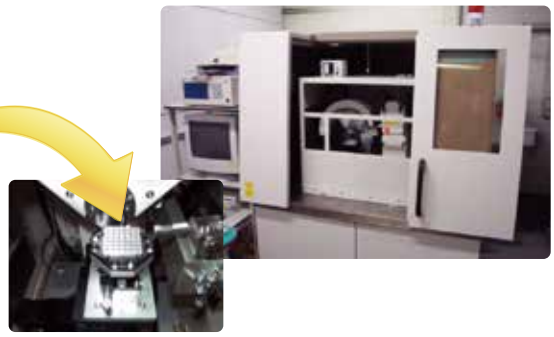
A broad range of multicomponent functional materials are a subject of extensive study and screening. However, as more components are included in a material, the combinations of parameters to be screened (component ratio, temperature, atmosphere, pressure, etc. in the case of composite materials) exponentially increase. In 1960s, peptide synthesis by Dr. Merrifield led to the rise of combinatorial technologies. In the late 1990s, automated synthesizers using multiple inorganic/metal material components were developed, allowing the use of thin films and bulk samples for high-speed material screening. We have developed the electrostatic atomization-type high-speed material screening system "M-ist Combi," which allows screening of liquid, film, or bulk samples of materials. Using this system, we are investigating novel multicomponent functional materials and obtaining findings that may provide clues for next-generation materials.

Summary of Research

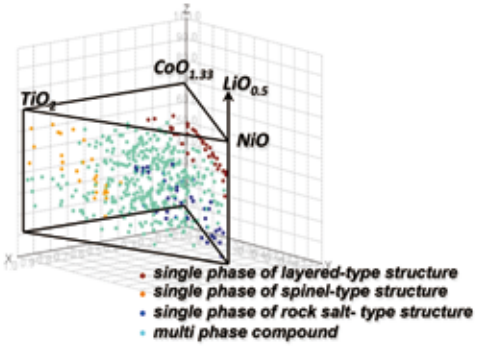
Combinatorial material screening system based on electrostatic atomization: M-ist Combi



Combinatorial high speed X ray powder diffraction



Example: Screening for lithium secondary battery cathode material
Reaction of quasi-quaternary Li-Ni-Co-Ti oxide (@ 700ºC)



Our system can achieve 100-fold faster material synthesis, 1000-fold lower reagent cost. Because its core technology, electrostatic atomizer, has a simple configuration, post-screening larger scale synthesis of candidate materials is easy

Future Developments

Not only lithium secondary battery cathode materials and oxide thermoelectric materials, but also environmental cleanup materials will be studied. Because our system is compatible with various sample forms (powder, thin film, liquid), screening for optimal paint and building materials (plaster, etc.), plating solutions, conductive paste compositions, and polymers will be possible.

- Awards: Intl. Solid Reactivity Assoc. Best Poster Award, etc., invitation lectures at conferences, companies
- Intellectual Property: Japanese Patent No. 5016960 "Electrostatic atomizer and method of producing samples from main agents"
- Prototype: made
- System demonstration: can be viewed

Medical

Pinpoint electrolysis unit with conductive diamond ink electrode for dental treatment

Takeshi KONDO (Associate Professor, Department of Pure and Applied Chemistry, Faculty of Science and Technology, Tokyo University of Science), etc.

Purpose of Research

Conductive diamond electrodes are generally made by the CVD method, but with this method, the types of substrate materials are limited and manufacturing is expensive. In this research, we have developed an ink that contains conductive boron doped diamond powder. By coating various substrate materials with this ink, we have succeeded in simply manufacturing diamond ink electrodes in a wide range of shapes.

Summary of Research

Conductive boron doped diamond is a functional electrode material with excellent chemical stability and bioaffinity. Using this technology, by combining conductive diamond power with a polymer material, we developed a conductive diamond ink which can be used to coat various substrate materials to create electrodes. The conductive diamond ink was applied to the tip of a metallic needle, and an electrode unit was created by then wrapping the tip with an ion exchange membrane and aluminum ribbon cathode. By applying voltage to this electrode unit in water, it is possible to efficiently generate electrolytic ozone, and it has been shown that this unit can be used as a dental treatment instrument for localized disinfection.

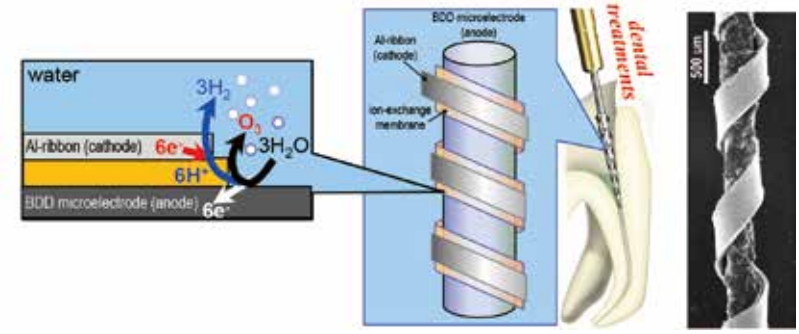


Fig. 1 Structure of the electrolysis unit and principle of electrolytic ozone generation

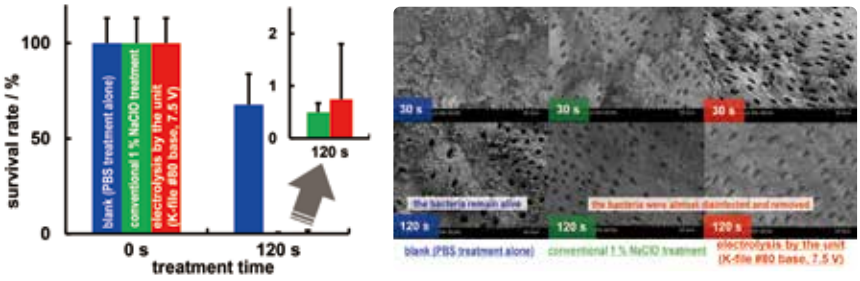


Fig. 2 Survival rate and SEM image of *P. gingivalis* in the root of a cow tooth after treatment

Points

- **Disinfection through the localized generation of electrolytic ozone**
- **Uses diamond with excellent bioaffinity**
- **Can be used with a wide range of materials, shapes and sizes**

Comparison with Conventional or Competitive Technology

- By applying the conductive diamond ink to substrate materials with a wide range of types and shapes, it is easy to manufacture electrodes.
- Compared to other materials, it is possible to efficiently generate electrolytic ozone, thereby enabling disinfection treatments.

Expected Applications

- Dental treatment instruments (root treatments, gingivitis treatments)
- Electrochemical sensors for medical use (electrocardiogram, electromyogram, blood sugar level, measuring uric acid levels)
- Electrolytic water treatments (sterilization, produce drinking water, generate water with electrolytic function)

Challenges in Implementation

Collaboration with a company that creates prototype dental treatment instruments

What We Expect from Companies

- Create a prototype dental treatment instrument (prototyping).
- Develop new applications for the conductive diamond ink other than dental treatment instruments.

Future Developments

- Manufacture of electrodes with an even smaller tip
- Trials using human teeth
- Study with the aim of commercialization and pharmaceutical approval
- Development of sensors and electrodes for electrolysis

- Research System: Photocatalyst Group at the Kanagawa Academy of Science and Technology, Tsurumi University School of Dental Medicine, Healthcare Oral Instruments and Materials Research Center
- Associated System: Grants-in-Aid for Scientific Research, Young Researcher (B)
- Intellectual Property: International patent application filed
- Prototype: Available
- Sample: Provision of conductive diamond power samples is subject to prior consultation

Colloid and interface chemistry

Developments of functionalized amphiphilic molecules and active control of interfacial properties

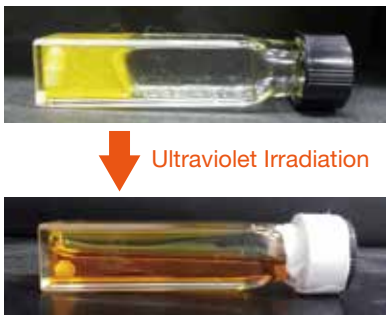
Kenichi SAKAI (Associate Professor, Department of Pure and Applied Chemistry, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

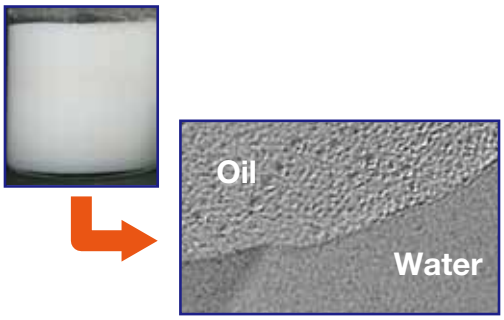
Every material has an "interface." The key point of the "interface chemistry" is to freely control the interfacial properties by selectively using (or molecularly designing) suitable amphiphilic material. Our laboratory aims at developing functionalized amphiphilic material (surfactant) and achieving precise control of various interfaces with such material.

Summary of Research

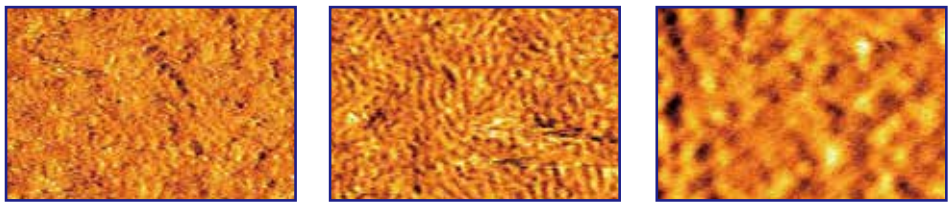
1) Developing novel amphiphilic materials (Gemini type, amino acid-based, stimulus-responsive, or polymerizable surfactant)
2) Preparing emulsion focused on saving resources and energy
3) Analyzing adsorption of amphiphilic material at a solid-liquid interface (experimental analysis using atomic force microscope, quartz crystal microbalance and friction force measurements)



Photoviscosity Control of Stimulus-responsive Surfactant Solution



TEM Image of Emulsion Sample



AFM Images of Surfactant Adsorption Layer Formed at Solid-liquid Interface

Points

- **We have developed the amphiphilic material which is eco-friendly or has distinctive additional values**
- **Correct understanding of properties of the amphiphilic material leads to appropriate formulations in product development**
- **We expect to assist to solve the problems occurred during development works by evaluating or analyzing interfacial phenomenon**

Comparison with Conventional or Competitive Technology

Out laboratory has advanced research on interfacial phenomenon in order to take advantage of obtained information in manufacturing. We also willingly accept the collaborative project with private companies to share the research results for the common good, while emphasizing basic research.

Expected Applications

- Developing surfactants (detergent, emulsifier, dispersant, thickening agent, lubricant additive, etc.)
- Developing formulations using the surfactants (cosmetics, foods, medicaments, paint, ink, etc.)
- Developing particle dispersion system (emulsion or suspension)

What We Expect from Companies

We are finding the company as a collaborative project partner. We are also willing to offer tech support if you want more information on interface chemistry.

Future Developments

We want to approach complicated boundary study fields (e.g. tribology) from the aspect of interface chemistry.

■ Awards:
Innovation Award (2012) in Oil Technology of Japan Oil Chemist's Society
Best Paper Awards (2010)
CSI Medallion of Japan Society of Colour Material (2007)

■ Intellectual Property:
Japanese Unexamined Patent Application Publication No. 2011-131137
"Cationic Surfactant, Blend Composition of Anionic/Cationic Surfactants and Hair Cosmetics"

Device

Multi-in-situ electrochemical impedance monitoring system for healthcare of lithium battery

Isao SHITANDA (Associate Professor, Department of Pure and Applied Chemistry, Faculty of Science and Technology, Tokyo University of Science)

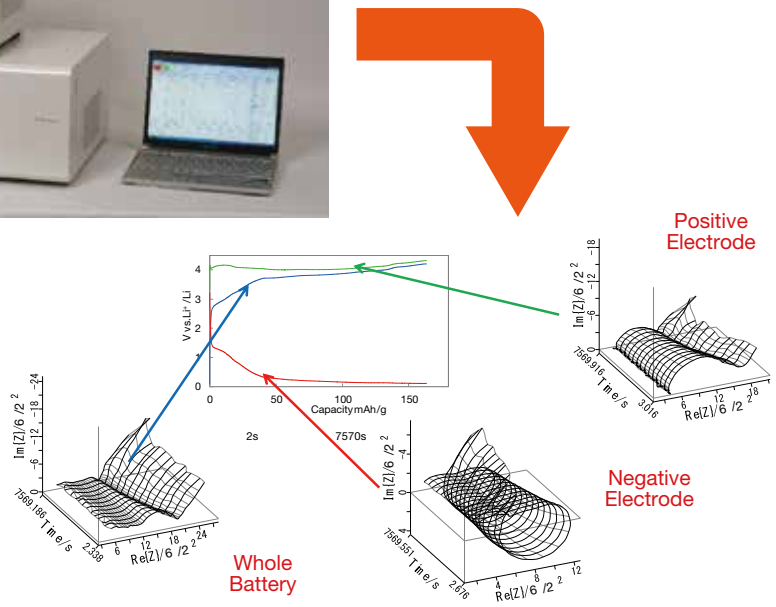
Purpose of Research

The method for determining replacement timing or reusability of built-in batteries is demanded along with the popularization of a hybrid car. In this study, we propose a multi-in-situ electrochemical impedance monitoring system which is able to diagnose deterioration without breaking a secondary battery.

Summary of Research

We have developed a measurement system which can measure quantitative internal deterioration parameters of a lithium ion battery in a charge/discharge cycle using an electrochemical impedance measurement without disassembling the battery. This system separately measures interfacial resistance of each of positive and negative electrodes within the lithium ion battery when internal deterioration evaluation for the battery is performed by multi-in-situ electrochemical impedance method.

We have developed a novel and revolutionary method for evaluating positive and negative electrodes individually while charging or discharging.



Points

- **This technology enables to evaluate a natural state of the battery**
- **The information on positive and negative electrode can be obtained individually without breaking the battery**
- **Since various equivalent circuit models are provided, battery performance parameters can be evaluated in detail by automatic fitting**

Comparison with Conventional or Competitive Technology

- The battery state can be evaluated in real-time while charging and discharging the battery.
- The positive and negative electrodes, components of the battery, can be evaluated status quo.

Expected Applications

- State evaluation for battery installed in an electric car or an aircraft
- Deterioration diagnosis for a big-scale lithium battery module

Challenges in Implementation

It is necessary to figure out the individual features of positive and negative electrodes in the lithium battery during charging/discharging cycle in situ, and to collect the data on quantitative evaluation, with the developed product.

What We Expect from Companies

We are finding a collaborative project partner for evaluating a correlation between a secondary battery states and a measuring result obtained by the developed product.

Future Developments

- Establish deterioration diagnosis algorithm through evaluation of actual batteries mounted on the hybrid car or the electric car.
- Utilize this theory to development a battery with functions of high-speed charging and discharging.

■ Intellectual Property:
Japanese Patent Application No. 2014-173644
"Method and Device for Evaluating Battery Features"

Device

Wearable healthcare devices based on printable electrochemistry

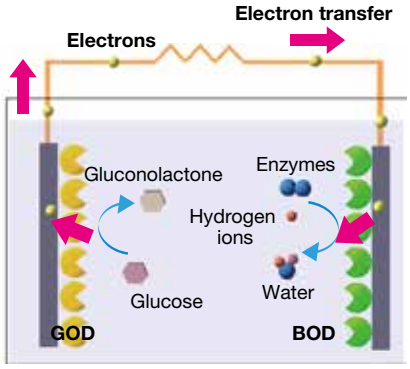
Isao SHITANDA (Associate Professor, Department of Pure and Applied Chemistry, Faculty of Science and Technology, Tokyo University of Science)

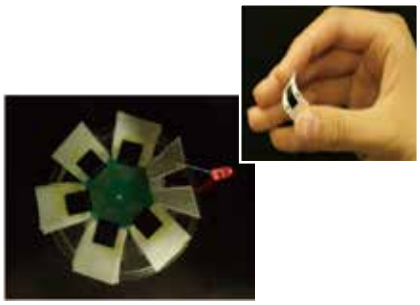
Purpose of Research

To develop thin biological information monitoring devices (wearable healthcare devices) equipped with self-driven biofuel cells, which generate electric energy at the same time as monitoring by using the biological substances found in sweat and urine. We will use advanced printing technologies to make wearable devices significantly thinner, lighter, more productive, and less expensive than the wearable devices that are already on the market, and we will make them able to catch the first signs of diseases, assist in day-to-day health management, prevent lifestyle diseases, and help manage other healthcare issues by measuring various vital signs (such as activity level, pulse (heart rate), and amount of sweat).

Summary of Research

This technology offers a mechanism in which the device serves as both the power source and the sensor. The device reacts with enzymes to generate electric energy using substances in body fluid such as glucose, and then it uses that energy to send signals from a transmitter. Furthermore, the devices are composed of inexpensive materials, such as paper, so they can be manufactured with a simple printing process.





Diaper battery

5 cells in series (0.34 mW)

Bandage battery

4x4 cells are arrayed (1 mW)

Comparison with Conventional or Competitive Technologies

We are proposing new self-driven wearable devices that contain a power generator that offers high biological compatibility and is easy on the human body, as well as being completely environment-friendly, convenient, and inexpensive.

Expected Applications

- Day to day health management and prevention of lifestyle diseases
- Prevention of heat stroke and measurement of fatigue level during sport activities and mountain climbing
- Monitoring of the health of workers in special working environments
- Reduction of the burden on caretakers by embedding the devices in diapers

Challenges in Implementation

We have confirmed that the urinal sugar cells are able to generate electric energy and wirelessly transmit data by using artificial urine. In the future, we need to implement and evaluate the devices in diapers.

What We Expect from Companies

We believe this technology will be beneficial for companies developing biosensors and those seeking to expand their businesses into the healthcare field.
We hope to collaborate with companies that have the technologies to communicate with wearable devices as well as companies that focus on integrating technologies into IoT systems.

Points

- **Enables measurement of the level of biological substances**
- **Costs less but has better performance than other methods of energy harvesting**
- **Simple, safe structure and disposable as it is made of paper**

Future Developments

January 2016 to March 2021
Material development → Manufacture and evaluation technology development → Mounting technology development
(We are planning to demonstrate the devices in the year of the 2020 Tokyo Olympics and Special Olympics, which is the last year of the A-STEP Project)
We always welcome ideas for new applications and proposals for collaborative research.

■ Associated System:
JST Adaptable and Seamless Technology Transfer Program through Target-driven R&D
A-STEP Strategic theme-focused type
(Project period: January 2016 to March 2021)
■ Partners: Tsukuba University, Riken, and other institutes
■ Prototype: Completed

Electrical

Wireless power transfer with electromagnetic waves for remote charge of wearable terminal

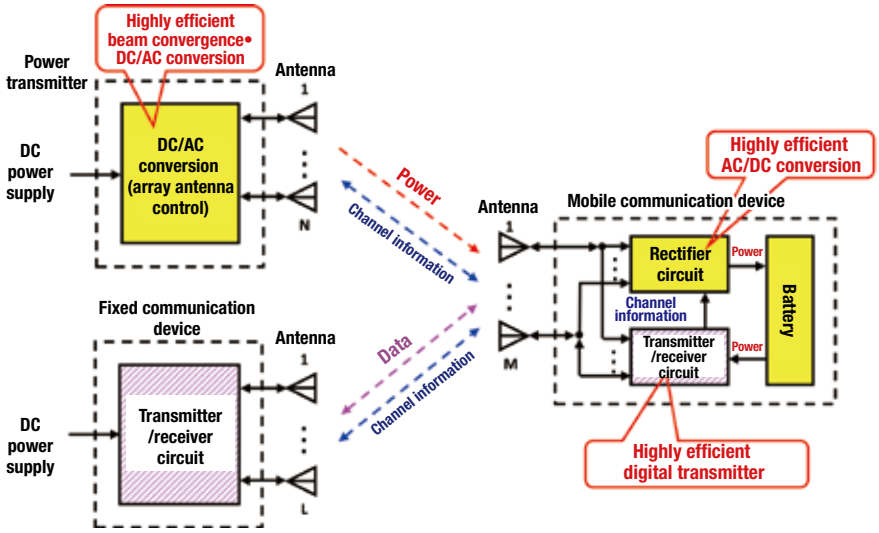
Yohtaro UMEDA (Professor, Department of Electrical Engineering, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

Wearable communication terminals, which are powered by a small embedded battery, must be frequently charged. Currently, a wireless charging method using a nearby magnetic field is employed in some devices, but the usability of such devices is significantly limited during the charging. This problem can be solved by a long-range RF power transfer. However, this transfer method has poor efficiency. In addition, the transmitter in current terminal devices consumes a large amount of power and thus requires a large supply of power. The present study aims at solving these problems and developing a chargerless wearable terminal that is powered by 24-hour wireless power transfer.

Summary of Research

In our research, we are building a wireless RF charging system which charges a wearable terminal several meters away with unprecedented high efficiency. In addition, all-digital envelope pulse width modulation technology is applied to the transmitter in the terminal, to easily and consistently achieve highly efficient communication. A millimeter or quasi-millimeter wave band array antenna is used to improve the beam convergence for more efficient charging, so that lower power transmission is sufficient.



Points

- **Highly efficient wireless charging and power-efficient communication, based on a millimeter or quasi-millimeter wave band and a multi-element array antenna**
- **Simple, constant usability, high efficiency digital communication with less energy consumption**

Comparison with Conventional or Competitive Technology

A millimeter or quasi-millimeter wave band, shorter than that conventionally used, improves the beam convergence for more efficient power transfer. Using a digital instead of an analog transmitter lowers terminal power consumption and thus the amount of power to be charged.

Expected Applications

- Remote wireless charging for wearable devices e.g. watch, bracelet, glasses, or sewn-in-clothes
- Remote wireless charging of mobile phone, laptop, and other mobile devices

Challenges in Implementation

Design and control of a highly efficient multi-element plane array antenna for RF wireless charging. Reducing quantization noise of the digital transmitter. Radiation exposure and EMC assessments will be necessary.

What We Expect from Companies

Collaboration on RF wireless charging systems using a multi-element plane array antenna, and on power-efficient digital transmitters.

Future Developments

Continued development of high efficiency signal/power transmission using an easy, continuously usable, highly efficient all-digital transmitter and RF propagation control.

- Associated System: Grants-in-Aid for Scientific Research C.
- Intellectual Property: JP2014-204904 “Signal processing device and transmitter device”
- Prototype: Not made
- Sample: Not available

Device

Reconfigurable module type robot

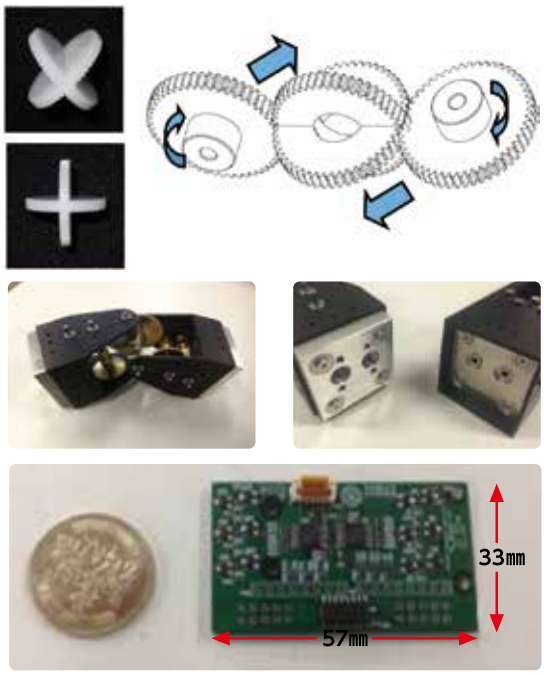
Shinichi KIMURA (Professor, Department of Electrical Engineering, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

A robot used to repair/recover a satellite in orbit is itself hard to repair when any malfunction occurs. Such a robot needs to be able to autonomously adapt to a failure of a part, short power failure, etc. It should also have many degrees of freedom in order to carry out a wide range of tasks, but at the same time be as small as possible for good mountability. We are developing a small connection mechanism that can maintain a joint angle in the absence of driving torque but has many degrees of freedom, and a self-disassembly function.

Summary of Research

Based on the skills accumulated during our previous projects on in-orbit maintenance robots, we have developed a multi-module robot that is smaller, has high flexibility of movement and assembly/disassembly, and does not harm humans if there is accidental contact.



Cross-gear universal joint

The cross-gear is composed of two gears that intersect at a right angle. Another two gears sandwiching the cross-gear are each driven by a motor to move the joint in a rack and pinion-like manner. This enables an ultra-small drive mechanism with two degrees of freedom at one point. Using a worm gear, the joint angle can be maintained even in the absence of a driving torque due to a malfunction, a change in configuration, etc.

Magnet-based connection

We have adopted a connection mechanism using magnets so that the modules separate if there is accidental contact, etc., providing safety upon contact. No sensor is required for the parts to detach from each other at each connection, further ensuring safety.

Ultra-small controller

An ultra-small, distributed controller (57 mm × 33 mm) in each module allows autonomous, flexible motion. Each module has a battery, a wireless communication device, and autonomous function, and thus can adapt to the failure of a part.

Points

- **Driving mechanism with 2 degrees of freedom at one point**
- **Distributed autonomous function based on an ultra-small, decentralized controller**

Future Developments

- Safety on contact, free module assembly/disassembly, and complex movements make this usable as an educational toy.
- Application in rescue operations, utilizing flexibility in configuration and high degree of movement freedom.

- Associated System: JST Intellectual Property Utilization Promotion Highway (2013) “Prototype of jointed device”
- Intellectual Property: JP5435676 “JOINTED DEVICE”
- Prototype: Joint mechanism demonstration model made

Device

Low cost high performance on-orbit equipment using commercial-off-the shelf devices

Shinichi KIMURA (Professor, Department of Electrical Engineering, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

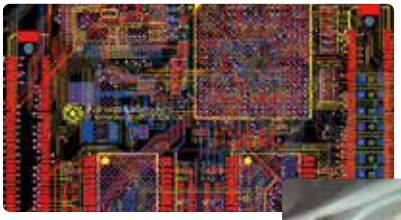
To repair/recover an artificial satellite in orbit, highly autonomous search for and approach to the satellite is necessary. On the other hand, outer space devices have limited functions and are also extremely expensive, making the above difficult. We have investigated commercial parts (of automobiles, mobile phones, etc.) that can work in outer space and developed systems with software that can deal with malfunctions, for low-cost high-performance satellite-borne devices which we have made and which have been adopted for IKAROS, Hayabusa 2, and many other missions.

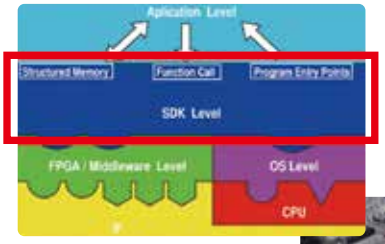
Space computer

World's smallest space camera

Summary of Research

In the present study, we are developing high-performance, satellite-borne devices at low cost based on the following three technologies and our experience in many satellite missions.





1) Orbit environment compatibility evaluation technology for commercial devices

Before a commercial device is put into orbit, its compatibility with the orbit environment (radiation, high vacuum, etc.) must be evaluated. We have established such an evaluation technology and a collection of commercial devices which have successfully operated on orbit. Using these resources, we can develop a camera and a computer suitable for a wide range of missions.

2) Satellite-borne circuit board design technology

In order to manufacture ultra-small, high-performance, satellite-borne devices from commercial parts, a circuit/board design technology is required. The world's smallest space camera, etc. developed in our laboratory shows the excellence of our satellite-borne device design technology.

3) Software technology for advanced AI

High performance and reliability depend on not only hardware but also software technologies. Based on our software resources nurtured over many missions, a flexible and reliable software platform has been developed. Our software simulator, when connected to hardware, can reproduce the behavior of a satellite under various conditions. This provides a system for effective hardware testing.

Points

- **Outer space computer**
- **World's smallest outer space camera**

Future Developments

- Ultra-small, deployable outer space camera module.
- Controller/image acquisition and processing unit for extreme environments.

- ■ Successfully participated in IKAROS, Hayabusa 2, and many other satellite missions
- ■ Prototype: engineering modules, etc. made

Energy and environment

Sodium tetrahydroborate power (STEP) system

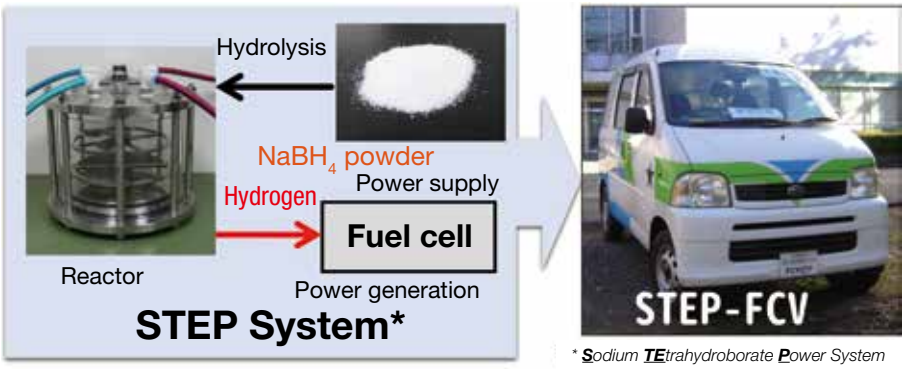
Nobukazu HOSHI (Professor, Department of Electrical Engineering, Faculty of Science and Technology, Tokyo University of Science)
Noboru KATAYAMA (Associate Professor, Department of Electrical Engineering, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

The building cost for a typical hydrogen station, which is required to feed hydrogen to fuel cell vehicles (FCVs), is estimated to be as high as 400 to 500 million yen. Thus, hydrogen stations are planned to be constructed primarily in metropolitan areas and it likely will take many years for FCV to become popular in provincial areas. In the present study, we propose a power supply system for FCVs and stationary power generation facilities which runs on a hydrogen storage compound so that there is no need for large, expensive infrastructure.

Summary of Research

In the present research, $NaBH_4$ (sodium borohydride) powder is used as a hydrogen fuel to establish a hydrogen supply system with a high volumetric energy density. We are developing an FCV and a stationary power supply system based on this system.



* *Sodium TEtrahydroborate Power System*

Points

- **We developed an FCV fueled by $NaBH_4$ powder as fuel The fuel is hydrolyzed into hydrogen which is converted into electricity by the fuel cells on the vehicle; and vehicle runs by the electricity. Test run is successful**
- **3 kW power supply system based on the proposed system is under development**
- **We aim for a society that recycles $NaBH_4$ powder produced/rehydrogenated overseas, etc. for use as a hydrogen carrier**

Comparison with Conventional or Competitive Technology

Because the hydrolytic reaction in this system is exothermic, no external high energy source is required to produce hydrogen.

Expected Applications

- FCV.
- Power supply for prefab housing, onsite offices, etc.
- Power generation in remote islands.

Challenges in Implementation

- Smaller reactor.
- Water recycle system.
- Fuel cartridge.
- By-product collection system.
- Fuel regeneration.

What We Expect from Companies

We seek companies for joint research toward a hydrogen-based society.

Future Developments

A smaller hydrogen generator is necessary for practical application. This will be installed in a miniature car and subjected to a test run, and used in a power generation system for remote islands.

■Awards:
Outstanding Paper Award in the 1st International Conference on Renewable Energy Research and Applications, Nagasaki 2012

Communication and information processing

All-optical downlink re-modulation in optical access network

Joji MAEDA (Professor, Department of Electrical Engineering, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

Optical fiber networks for high-speed internet connection are now used even at home. To achieve increased speeds in the future access networks, WDM (wave division multiplex), which assigns one wavelength to each user, is thought to be effective. The biggest problem associated with WDM is that a tunable laser, which is too expensive, is required in each user terminal. We are trying to achieve the next generation optical access system at lower cost, by suppressing the data component of the downlink signal from the central office to the user and carrying out "downlink re-modulation" in an all-optical manner which generates an uplink signal from the user.

Summary of Research

By combining a semiconductor optical amplifier (SOA) with a Fabry-Perot filter (FP), the modulated component of downlink signals over a wide frequency band can be suppressed, and subsequent optical modulation generates an uplink signal. We have already achieved the suppression of a downlink signal of 10 Gbps, and the generation of an uplink signal therefrom, which is a benchmark of the next-generation access system. The evaluation of the signal quality is in progress.

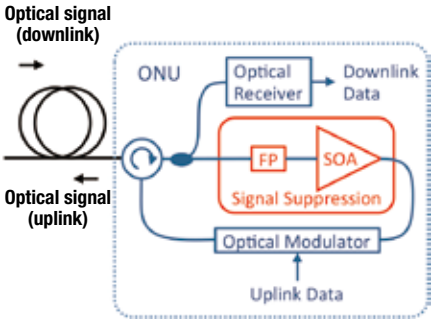


Fig. 1. Downlink re-modulation of the present study.
FP: Fabry-Perot filter
SOA: Semiconductor optical amplifier

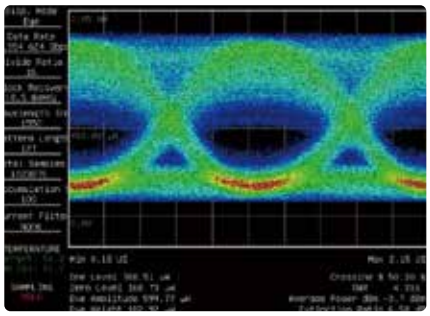


Fig. 2. Re-modulated optical signal.
Data transfer speed for uplink/downlink signal = 10 Gbps.

Comparison with Conventional or Competitive Technology

A downlink re-modulation method using only SOA is well known, but the response speed of SOA limits its application to signals of 1 Gbps or less. The present method can be used to construct a front-end which accommodates future increased network speeds.

Expected Applications

- Subscriber terminal (ONU) for the next generation optical access network.
- Simple optical terminal useful at times of natural disaster, etc.

Challenges in Implementation

Technology to match the etalon transmission spectrum to the downstream signal wavelength. High-gain amplifier is also required to deal with a wide range of downstream signal power.

What We Expect from Companies

Putting our system in packages or modules; proposals for devices suited to our system.

Points

- **All-optical processing, so it is compatible with future increases in network speed and various modulation methods**
- **No laser: long lifetime**

Future Developments

2015: Automatic tuning of the system
2016: High-gain amplifier mounting technology

■Associated System:
Grant-in-Aid for Scientific Research C "Colorless optical terminals in next generation WDM-PON networks" (2013–2015)

Energy and environment

Material design for novel-concept-based solar cells —sulfurization or oxidization of "cheap" metals –

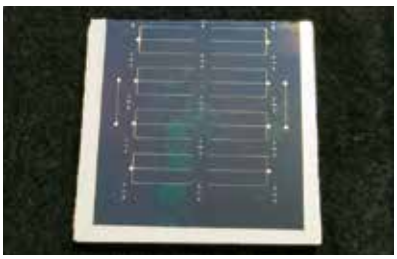
Mutsumi SUGIYAMA (Professor, Department of Electrical Engineering, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

- We have developed a novel method for fabricating a solar cell, which is safe and stable from manufacturing point of view as well as environmental friendly while disposing. The materials used for fabricating the solar cell are available at general hard-ware store that are inexpensive and harmless.
- We have proposed new ways to use the solar cell of oxide semiconductor (not limited to nickel oxide) as a transparent energy harvesting device.

Summary of Research

- We have considered an entire process (bottom to top approach) to develop novel concept-based solar cell. It includes searching a proper semiconductor material, investigating its electronic properties and engineering the materials for device fabrication. For example, SnS and Cu_2SnS_3 solar cells were fabricated by subjecting a copper (Cu) or tin (Sn) film or both to a heat process under a sulfur atmosphere.
- The solar cell fabricated using nickel oxide (NiO) is a transparent solar cell, which absorb only ultraviolet rays that is harmful to humans, and generate electricity. This type of solar cells can be installed even at location where the conventional solar cell cannot be used, for example windows or plastic greenhouses. Furthermore, they can also be used for preparing an invisible camera or sensor by combining with a transparent diode or transistor.



Points

- **We have proposed a solar cell whose transparency gradually changed (NiO-based solar cell, photo on the left) and "a transparent intelligent glass" with high added value, which is made by combining transparent transistors (p-type TFT, photo on the upper right) and sensors**
- **We have managed the entire process from material development to device design e.g. fabricating solar cell with a safe and inexpensive materials like SnS (photo on lower right)**

Comparison with Conventional or Competitive Technology

Since the silicon semiconductor, which constitutes approximately 90% of the solar cells currently produced requires highly pure silicon, hence the manufacturing cost increases. In a contrast, we have developed a next-generation solar cell which is safe, risk-free and has excellent performances that can be manufactured at a low cost.

Expected Applications

- Transparent window glass which generates electricity using ultraviolet rays
- Shade-type power generation window glass
- Employ such solar cell in the energy harvesting device (for example, a sensor which doesn't need electricity or an invisible security camera)

Challenges in Implementation

- Need to improve power generation efficiency and develop a way to use in new fields (proposals).
- Selection of safe and eco-friendly materials is important to develop environment-friendly, low cost, next-generation solar cell.

What We Expect from Companies

We are looking for collaborative project work with companies to develop safe, risk-free and inexpensive next-generation solar cell in not only field stated above but also in other various fields.

Future Developments

The currently available solar cells have several "economic" problems such as use of harmful materials, dangerous production processes, which result high manufacturing/materials costs. This study has a purpose to realize an inexpensive "next-generation solar cell" which can be safely manufactured and used with no risk.

- Intellectual Property:
  Japanese Unexamined Patent Application Publication No. 2013-109076 "Photovoltaic Light Control Element and Method for Manufacture the Same"
- Prototype: Present
- Sample: May be provided. Decision on this made after discussion with requester.

Nanotech-nology

Preparation of polymer electrolyte membrane fuel cell catalyst layers using electro spray deposition

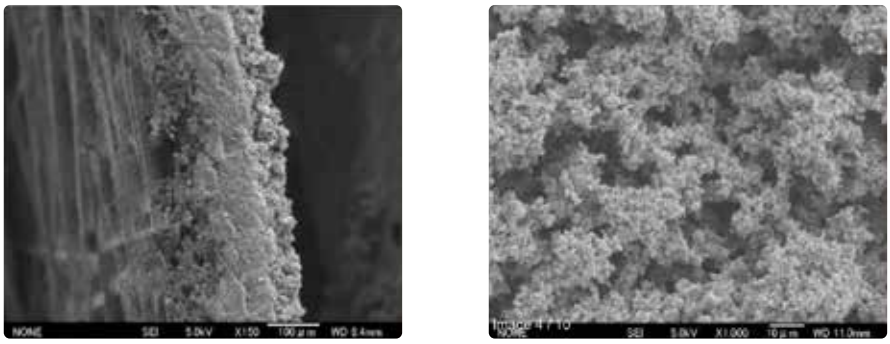
Noboru KATAYAMA (Associate Professor, Department of Electrical Engineering, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

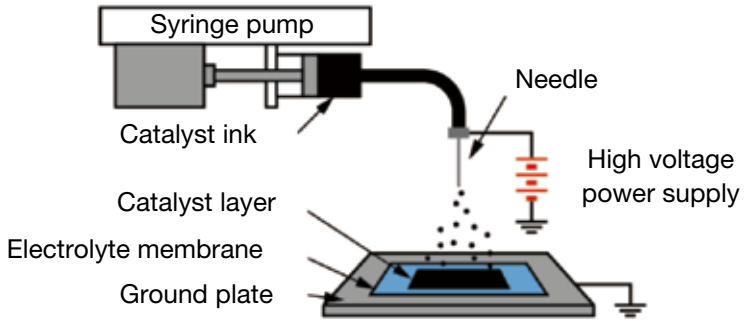
Conventional catalyst layers for PEMFC (polymer electrolyte membrane fuel cell) are usually prepared by air spraying or screen printing. We employed electrostatic spraying to form the PEMFC catalyst layer, which enables increased surface area and control of the structure to improve the power generation of PEMFC.

Summary of Research

In the electrostatic spraying method, a high voltage of several kV is applied to a needle which drips out catalyst ink. Droplets of ink are broken up by Coulomb force into submicrometer droplets. These droplets are electrically charged and thus attracted to the target to be coated (ground plate), resulting in a resource-efficient, uniform coating.



The cross section (left panel) and surface (right panel) of a catalyst layer prepared by electrostatic spraying



Outline of electrostatic spraying method

Points

- **Catalyst layer preparation under various conditions**
- **Much less waste of catalyst ink**
- **Uniform coating**

Comparison with Conventional or Competitive Technology

Conventionally used air spraying or screen printing methods do not allow fine-tuning of coating conditions. In electrostatic spraying, the degree of atomization can be controlled by regulating the voltage and ink flow, and coating under various conditions can be carried out. Because the droplets are attracted by electrostatic force, there is much less waste of the catalyst.

Expected Applications

- Production of fuel cells
- Forming thin films
- Production of microparticles

Challenges in Implementation

For industrial production, the method may need further improvements such as larger coating area, shorter coating time, and higher stability.

What We Expect from Companies

We seek to collaborate with companies in industrial applications of the present method.

Future Developments

- Application of the method to a larger coating area in a shorter coating time.
- Manufacture of a high-power, low-platinum PEMFC based on a catalyst layer prepared by the method.

■ Awards:
Kenjiro Takayanagi Foundation Young Researcher Award (2014)
■ Prototype: Made
■ Sample: Available

Manufacturing technology

Miniature fuel cell with monolithically fabricated Si electrodes – Multi-layer catalyst by electrochemical atomic layer deposition –

Masanori HAYASE (Professor, Department of Mechanical Engineering, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

There are increasing expectations regarding compact power sources for the industrial use of drones and utilization of various types of robots. However, despite the clean energy image of fuel cells, they are fueled by hydrogen produced mainly from fossil fuel. In light of this situation, we are developing miniature fuel cells that can be fueled by biomass-derived hydrogen. In this research, we have, in order to achieve compatibility with biomass-derived hydrogen, developed a catalyst that is highly resistant to carbon monoxide and requires little platinum.

Summary of Research

In order to miniaturize fuel cells using MEMS technology, catalytic layers were previously formed by depositing porous platinum on silicon substrates. Although this achieved high power density fuel cells, reducing the amount of platinum used remained a problem. At the same time, the search continued for a catalyst that is highly resistant to carbon monoxide, a large quantity of which is contained in biomass-derived hydrogen. Excellent properties were obtained by depositing a small amount of platinum on porous palladium, but it was found that hydrogen absorbed into and discharged from the palladium caused the catalytic layer to break. This research aims to create a catalytic layer using electrochemical atomic layer deposition, with palladium and platinum being precisely deposited on the superficial layer of a core made of porous gold.

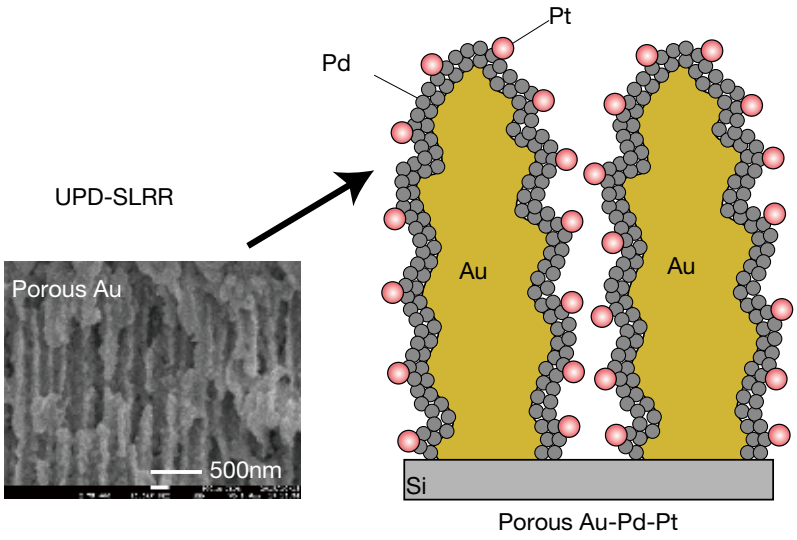


Figure: Third-generation Au-Pd-Pt catalyst

Points

- **Reduction in amount of platinum used (approx. 5 μg/cm²)**
- **High resistance to carbon monoxide**
- **High-power MEMS fuel cells**

Comparison with Conventional or Competitive Technology

- This is a unique technology that forms high-performance catalyst using a porous gold structure—suitable for MEMS fuel cells—as a base.
- In our previous research, a core shell structure was formed on metal microparticles through electrochemical atomic layer deposition.
- There is little research that uses porous gold as a base.
- Using porous gold as a base allows precise electrochemical atomic layer deposition to be achieved.

Expected Applications

- Portable power sources
- Moderately quiet power sources for drones and robots
- Promotion of use of biomass-derived hydrogen

Challenges in Implementation

- It is currently unclear how competitive this technology is with respect to the performance and cost of fuel cells for general-purpose devices.
- Optimization of the catalytic layer structure (number of UPD-SLRR processes, porous Au layer)

What We Expect from Companies

- We would like companies to offer popular products that use biomass hydrogen fuel cells.

Future Developments

Until 2018: Prototyping cells prepared with Au-Pd-Pt catalyst
Until 2019: Increasing power of fuel cells (demonstration with smartphones)
Until 2020: Studying combination with fuel tanks and other accessories
From 2018: Seeking partners and venture companies

■ Intellectual Property: Japanese Patent Application No. 2016-159735 "Silicon substrates with catalytic layer, fuel cells, and method for manufacturing silicon substrates with catalytic layer"
■ Prototype: Available
■ Sample: Samples of cells prepared with Au-Pd-Pt catalyst

Image processing

The image processing technology related to cancer cell region extraction for automatic pathological diagnosis

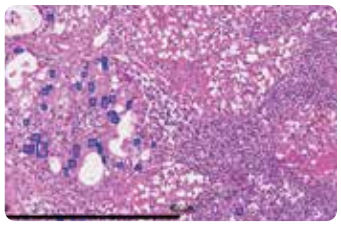
Hiroshi TAKEMURA (Professor, Department of Mechanical Engineering, Faculty of Science and Technology, Tokyo University of Science)

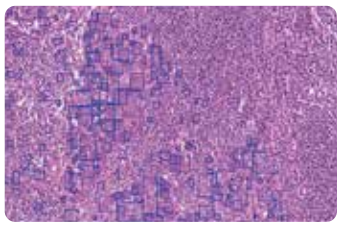
Purpose of Research

In recent years, the number of cancer patients is increasing, and with this increase, the number of pathological diagnoses, which identify the type of cancer, that pathologists perform is increasing as well. However, Japan suffers from a chronic shortage of pathologists as there are only about 2,300 of them. The purpose of this research is to develop an automatic pathological diagnostic technology in order to overcome this situation.

Summary of Research

In this research, we will employ new technologies that resolve issues with conventional technologies, and promote the application of the technology in a pathological diagnostic system after improving its accuracy. More specifically, this research is being conducted to construct a system for accurate pathological diagnoses using virtual slides to automatically detect cancers. The system imports microscopic images as digital data by scanning them, changes their format to a special image format, and processes them into super high-resolution images (for example, 2,400 times the resolution of a Full HD monitor). This technology also addresses the shortage of pathologists.





← Conventional technology

○ Because it only focuses on the nuclear cells and differentiates them by their sizes:
- Some nuclear cells are not detected.
- Normal areas remain as noise.
- The threshold differs from image to image due to the different background colors.

← New technology

○ By using multiple color spaces, it:
- extracts the background – Bipolarization of the intensity of the HSV color system
- extracts the cytoplasm and red blood cells – RGB color system
- extracts normal nuclear cells – Binarization with the YCrCb color system
- removes contour noise with a local binarization method

⇨ Very effective as pre-processing for machine learning

Points

- **Succeeded in reducing the influence of staining level, one of the issues hindering the conventional technologies**
- **Supplements the lowered recognition accuracy caused by human errors and improves the accuracy of the automated diagnostic system**

Future Developments

- FY2015 Overcame the challenges in improving the accuracy
- FY2016 and 2017 Validated the reproducibility based on clinical trial data

Comparison with Conventional or Competitive Technologies

The technologies that have already been put into practice use a technique that combines the heuristic technique, which mimics the pathological determination process, with machine learning and other technologies. However, they have not spread because they have issues such as:
- differences in colors (albeit caused by differences in staining), and
- the inconvenience of creating training data.

Expected Applications

- This technology can be used for the preprocessing of existing machine learning technologies, increasing the accuracy of the existing systems.
- By using the creation support system for training data for deep learning, recognition at the cellular level will be possible.

Challenges in Implementation

Currently, the false negative is 79% and the false positive is 99%. In order to put this technology into practice, we need to increase the under-detection accuracy to 100% and establish a technology that further increases the over-detection accuracy.

What We Expect from Companies

- We hope to collaborate in research with companies that have database construction technologies and that develop automated imaging devices such as microscopes.
- We believe the adoption of this technology will prove effective for companies that require microscopic counting of materials and cells, as well as companies seeking to expand their businesses into the recognition field.
- To further enhance the accuracy, we need a large amount of data. We hope to collaborate with companies that can provide data to us.

■ Associated Research: Collaborative research with National Cancer Center Hospital East, Japan (2014–2015) and others

■ Intellectual Property: Japanese Unexamined Patent Application Publication No. 2013-238459 “Cancer cell region extraction device, method, and program”

Machinery

Three-dimensional printing of continuous-fiber composites

Ryosuke MATSUZAKI (Associate Professor, Department of Mechanical Engineering, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

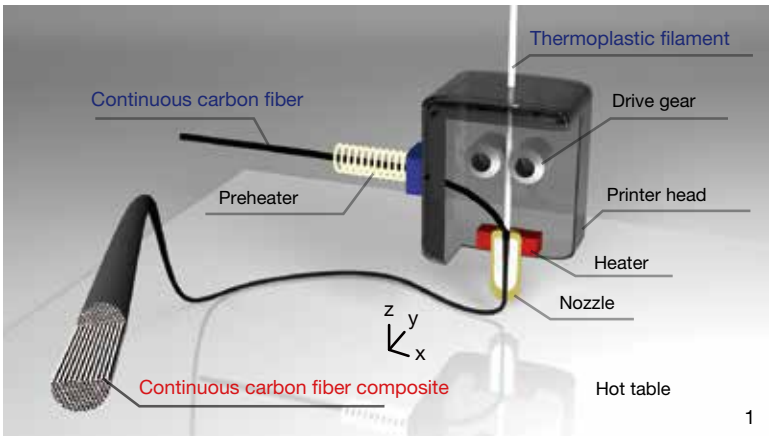
Three-dimensional (3D) printers that use resin are now available on the market. It is well known that they easily form simple and complicated 3D objects without using molds or jigs. However, they can only produce structures that are too low in strength to be used as high-quality components for industrial products. This research uses continuous fiber-reinforced resin composite materials to develop 3D printers that can make high-strength and high-rigidity products that support people's lifestyles, such as structural members of automobiles and aerospace equipment as well as medical and welfare equipment.

Summary of Research

This technology not only enables single-stroke drawing using continuous carbon fiber composites, but also controls the directions of fibers and the fiber content in local regions of an object in accordance with how it will be used. It also computes and proposes optimal material conditions, leading to new product structures and usages.

High-strength 3D shape forming with a continuous carbon fiber 3D printer

• A printing nozzle blends continuous carbon fiber with thermoplastic resin.



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Test piece

Appearance when printing

Comparison with Conventional or Competitive Technologies

- Using continuous carbon fiber dramatically improved the tensile strength and rigidity of a structure compared with commercially available industrial use 3D printers (powder sintering, photo-fabrication, and fused deposition modeling).
- Using thermoplastic resin significantly reduced production cost and lead-time compared with conventional thermosetting CFRP.

Expected Applications

- Structural members of automobiles and aerospace equipment
- Medical equipment and welfare equipment such as rehabilitation assist devices
- Sports gear and recreational facilities

Challenges in Implementation

We have already developed elemental technologies such as continuous carbon fiber 3D printing, fiber cutting, and optimization of fiber orientation. To put the technology into practice, we will increase the volume content of fiber to the level equivalent to that of conventional CFRP products.

What We Expect from Companies

This technology is useful for companies that need to manufacture a large variety of high-strength components in small lots. We would like to conduct joint R&D activities with companies that have the technologies to manufacture finished devices or those who plan to expand their business into the 3D printer field. We would also appreciate the support needed to start a venture firm.

Points

- **Lightweight, high strength, and high rigidity**
- **Controlling the orientation and content of reinforcing fiber**
- **Significant reduction in production cost by on-the-spot impregnation of fiber into thermoplastic resin**

Future developments

August 2016: Finalize the specifications of a large prototype.

March 2017: Complete assembly of the prototype.

April 2017–: Exhibit the prototype at an event and ship samples.

(Plan to develop a small-type concurrently.)

■Associated System: Strategic Core Technology Advancement Program
(Supporting Industry Program)
: NEDO Project, Next Generation Structural Material Creation
–Development of Processing Technology
■Associated Institutions:
Tokyo Institute of Technology, Nihon University, JAXA, and others
■Intellectual Property: PCT/JP2015/65300, and others
■URL of This Project: http://www.rs.tus.ac.jp/composites2/

Disaster prevention

An image-feature enhancement and interpretation system for crack detection of concrete surface based on feature composite moving image inducing visual illusion

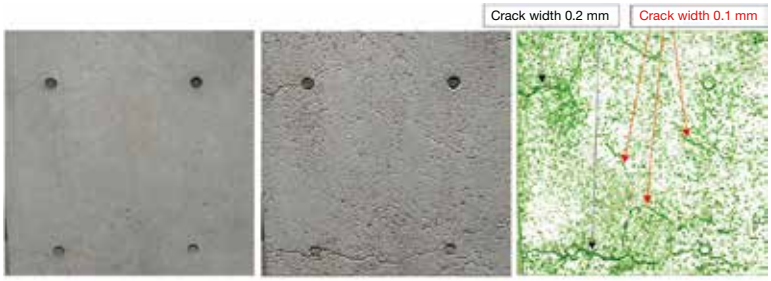
Hirohito KOJIMA (Professor, Department of Civil Engineering, Faculty of Science and Technology, Tokyo University of Science)
Hayato OHWADA (Professor, Department of Industrial Administration, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

Images of concrete surfaces that are taken to find cracks are basic data for maintenance management of a concrete structure. Features included in such an image are often hard to interpret and thus are generally processed for image enhancement. However, conventional processing methods are not effective and tend to result in image degradation. To facilitate the crack detection of concrete surfaces, we have developed an optical illusion-inducing image interpretation support system. This allows real-time feature enhancement/support for interpretation of a video taken during inspection.

Summary of Research

We developed a method for combining images of features which maintains image quality and creates an afterimage optical illusion whose effect is to sharpen the whole image and thus make cracks on a concrete surface more visible. Spatial frequency components corresponding to changes in density among the frames of the feature composite moving image are calculated, and the power (amplitude) of each spatial frequency component is determined, allowing objective evaluation of the image visibility. Inspection of actual concrete surfaces demonstrated that this system composed of general-purpose devices such as a video camera and laptop performs adequately.



Original image | Optical illusion-inducing feature composite moving image (composite-imaged features are dispersed) | Moving image for visibility evaluation

<System components>
- PC (laptop or tablet)
- Video camera (UV, visible light, or near IR)
- Hyperspectral camera

Video recording & real-time analysis

Points

- **Fast inspection, even in dark places such as inside a tunnel or underneath a bridge**
- **Compatible with both on-site, real-time analysis and subsequent analysis/graphing**
- **Applicable to both still and video images (UV, visible, and near IR)**

Comparison with Conventional or Competitive Technology

In our system, embossed images (virtually irradiated from 8 directions) are sequentially displayed to the user to provide a composite moving image of particular features that induces visual illusions (i.e., pseudo-rotational and persistent of vision). Conventional feature enhancement processing has the problem of image degradation. This optical illusion inducement provides image enhancement/sharpening while maintaining the quality of the original image. In addition, using DFT to calculate spatial frequency components, our system can quantitatively and objectively evaluate image visibility, which is evaluated subjectively in conventional methods.

Expected Applications

- Crack inspection of concrete structures.
- Interpretation, detection and graphing of crack propagation (in RC beam bending/shear test videos, etc.).
- Inspection aid in dark places (tunnel, etc.) (IR image acquisition and analysis available).

Challenges in Implementation

- Development of more portable systems, e.g. mountable on a UAV.
- Application to ultraviolet cameras and hyperspectral cameras.

What We Expect from Companies

Seeking for a joint research companies, local government or structure maintenance firms in evaluating the VIS system's applicability.

Future Developments

June 2016	Test of UAV camera implementation. Use in concrete surface inspections and apply public projects.
November 2016	Production of sales software (VIS system) started.
From April 2017	VIS system sales started.
From June 2017	Expansion and deployment of applicable field of VIS system.

■Intellectual Property:
Japanese Patent No. 04868509, Japanese Patent No. 05046119, Japanese Patent No. 05246770, Japanese Patent No. 5769295, Japanese Patent No. 6021053
■Patent license agreement entered into with three companies.
■Technical instruction contracts are available.

Safety

Safety performance measures for railway stations

Shintaro TERABE (Professor, Department of Civil Engineering, Faculty of Science and Technology, Tokyo University of Science)

Purpose of Research

The railway system in Japan is generally safer than that in other countries. However, falling and from the platform of the passengers, the contact accident between train is generated not a little, it is necessary to establish safety strategy. The purpose of this study, station structures and equipment, and its usage is, is to establish a quantitative evaluation methods the impact of the passengers safety and trusty.

Summary of Research

In order to improve the pleasantness and safety of public transport services, We developed ICE (Index of Comfortable and Easeful Public Transportation)[1] along with the Ministry of Land, Infrastructure and Transport (MLIT). In the present study, the safety level of railway platforms, which was not included in ICE, is evaluated based on four major indices: structure, passenger flow, train movements, and passenger characteristics. From these indices, sub-indices were set which can be quantitatively evaluated.

Index	Sub-index
Platform structure factor	①～⑤
Passenger flow factor	⑥～⑨
Train movement factor	⑩～⑬
Passenger characteristics	⑭～⑯

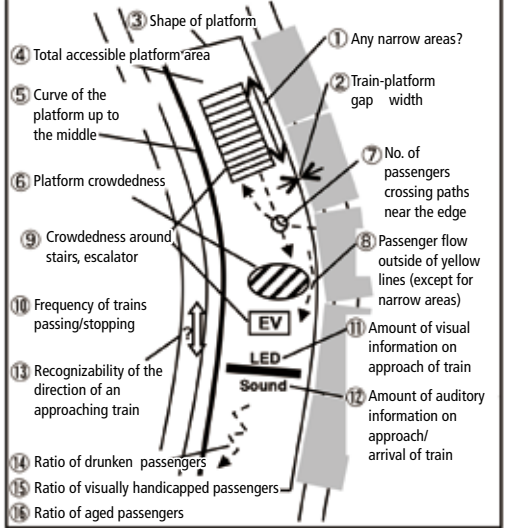


Fig. 1. Platform safety indices.

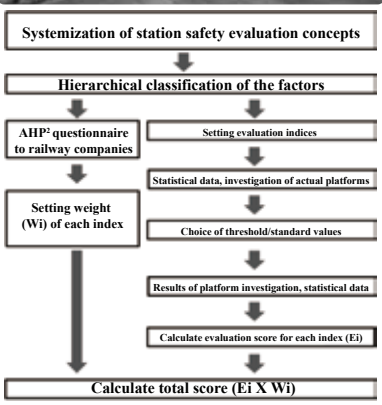


Fig. 2. Flow of safety evaluation score calculation steps

Comparison with Conventional or Competitive Technology

In a previous attempt to evaluate the safety of a railway system, statistical data on actual railway accidents were used to calculate their probability distribution, and causes of and countermeasures against serious accidents (crash, derailment, etc.) were investigated. However, human injury or death in a station, though more frequent, was not investigated. Another study set up a method to comprehensively evaluate the convenience, pleasantness, and execution certainty of train change in a Shinkansen station that was the same as the present study except that it did not include safety evaluation. The present study is the first to quantitatively evaluate the safety level of a railway station from the viewpoint of passengers.

Expected Applications

Can evaluate the relative safety level before and after a safety measure by the railway company or the relative safety of each platform side to decide the order in which new measures are executed.

Challenges in Implementation

Use actual data to make this quantitative safety evaluation method more useful and convenient.

What We Expect from Companies

Collaboration with a railway company or safety management firm to apply the present method to an actual platform.

Points

- **Indices weighted in accordance with multivariate analysis of actual data. Good reproducibility**

Future Developments

June 2015 Started further study to improve usefulness of the present system based on actual data.

1) MLIT Transport Consumer Policy Division: Investigation into improved “pleasantness and safety” of public transport services, 2004
2) AHP: Analytic Hierarchy Process

Disaster prevention

Development and installation of new type of river and tsunami embankment that withstands various forces, and evaluation of evacuation action under actual flood conditions

Yasuo NIHEI (Professor, Department of Civil Engineering, Faculty of Science and Technology, Tokyo University of Science)

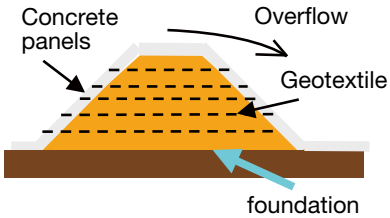
Purpose of Research

There is great concern about huge damage due to flood and debris flow caused by storms and tsunami compounded with earthquakes, all over the world. It is necessary to replace disaster prevention measures with disaster mitigation measures, but fundamental technology for disaster mitigation has not been sufficiently established. The present study aims to develop hardware and software measures of disaster mitigation which can deal with huge floods and compound disasters, and minimize the risks to life and property caused by flood and tsunami.

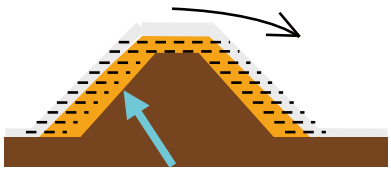
Summary of Research

One of the world's largest flow flumes

A new type (GRS) of river levee



<Full reinforcement>



Existing cross section

<Partial reinforcement>

Hardware Measures

Development and installation of new type of river and tsunami embankment that withstands overflow erosion of huge floods

Connecting many geotextile layers to concrete panels covering the embankment increases resistance against overflow erosion and earthquakes. A new type low-cost embankment effectively blocks huge floods with a steep slope and a small cross-section. Our laboratory recently built one of the world's largest wave testing channels (left photograph) in addition to a large wave maker for tsunami testing. Using this and a small flume, we conduct model tests to develop new types of levees that will actually protect against disasters.

Software Measures

Evaluation of evacuation action under actual flood conditions

To evaluate property of evacuation activities after floods and landslides, we conducted tests of flood evacuation, recreating flood conditions using the large-scale channel. Based on these experimental results, we developed models of flood evacuation that will save lives in an actual flood disaster.

Points

- **Embankments made with very earthquake-proof geosynthetic reinforced soil (GRS) and integrated with concrete covering the embankment, greatly increases resistance to flow erosion**
- **Embankments reinforced and made erosion resistant with a small cross-section at low cost**
- **Structure adapted to specific conditions (partial reinforcement, etc.)**

■Laboratory Apparatus:
Large-scale open channel
(length: 20 m, width: 10 m, height: 1.8 m)
Small open channel
(length: 4.0 m, width: 0.2 m, height: 0.4 m)
Two-dimensional wave flume with tsunami maker
(length: 36 m, width: 1.0 m, height: 1.2 m)

Communication and information processing

Medical application of image processing technology

Naoyuki AIKAWA (Professor, Department of Applied Electronics, Faculty of Industrial Science and Technology, Tokyo University of Science)

Purpose of Research

To develop a "medical front-end processor" in order to provide an interface that enables definite early detection of pathological lesions while reducing the burden on doctors and laboratory technicians. More specifically, we have been working to develop efficient analytical methods and presentation methods for high-dimensional image information, as well as a display and input device that incorporate the method and the means to construct a highly visual interface that uses shapes and designs to engage with feelings and senses.

Summary of Research

Use of the contrast adjustment method for the target site using conversion functions, the region extraction method using Gabor filters and morphological filters, the clustering method, or other methods enables efficient medical diagnostic imaging and image analyses.

Original image with contrast agent

Processed image without contrast agent

Points

- Efficient recognition using multidimensional information
- Image analysis, extraction, and recognition using mathematical methods
- Lower burdens on the patients and doctors

Comparison with Conventional or Competitive Technologies

Conventional methods had issues such as low contrast of the extracted target site and indefinable edges, leading to low accuracy extraction, which consequently made them difficult to use in medical diagnostic imaging. However, by employing this technology, the extraction accuracy will be higher and the efficiency of medical diagnostic imaging and image analyses will be increased.

Expected Applications

- Vascular extraction without using a contrast agent
- Efficient detection of abnormal sites such as cancer cells
- Support in diagnoses
- Measurement and sorting of blood cells

Challenges in Implementation

- Development of a human-centered device (tablet device) without a high-end CPU
- Extraction of small blood vessels
- Integration of a learning function to increase detection accuracy

What We Expect from Companies

We are looking for companies to collaborate with in the development of input/output devices and presentation methods.

Future Developments

2016 Improved the vascular extraction accuracy

2017 Develop a human-centered device

2018 Enable detection of abnormal sites such as cancers and thrombus

■ Awards: Incentive award of the technical committee of the Institute of Electrical Engineers of Japan (3/7/2013), etc.
■ Intellectual Property:
Japanese Patent No. 5618129 "Medical image display control device and program"
Japanese Unexamined Patent Application Publication No. 2013-103080 "Medical image processing device, method, and program"
Japanese Patent Application No. 2014-252388 "Target detection device and program"

Communication and information processing

Particle size analyzer technique using image processing

Naoyuki AIKAWA (Professor, Department of Applied Electronics, Faculty of Industrial Science and Technology, Tokyo University of Science)

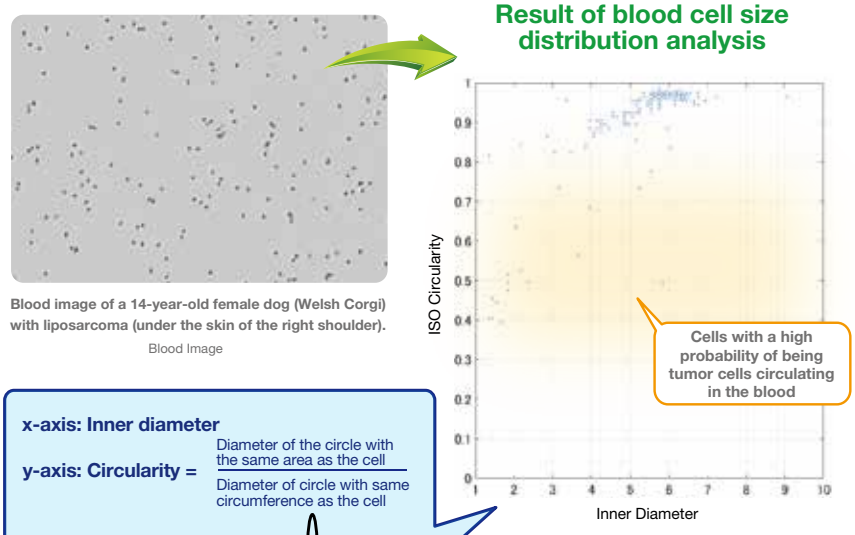
Purpose of Research

Detection of tumor cells circulating in the blood is usually conducted by visualization using reagents and microscopic observation by physicians. However, it requires effort and cost, and individual differences may occur during microscopic observation; therefore, a convenient method to detect tumor cells is required. Tumor cells circulating in the blood are large and distorted compared with normal cells, and a particle size analyzer may aid in detection to some degree. However, commercial particle size analyzers target industrial products and are not appropriate for blood cell analysis. Therefore, this study aimed to develop a particle size analyzer technique that was appropriate for blood cells. In addition, the analysis technique placed an emphasis on versatility.

Summary of Research

Using an image processing technology, the size and shape of blood cells were measured from the images of blood, and the particle size distribution for each shape was obtained. Based on this information, an algorithm that detects cells that have a high probability of being tumor cells circulating in the blood was developed. Compared with conventional particle size analyzers, the analyzer used in our research has a higher resolution. In addition, the software used for conventional particle size analyzers can only be used for that specific analyzer; however, our software can be used with ordinary personal computers, and as long as a microscope image of blood is available, detecting cells with a high probability of being tumor cells circulating in the blood is possible.

Analysis of a blood image using the software



Blood image of a 14-year-old female dog (Welsh Corgi) with liposarcoma (under the skin of the right shoulder).
Blood Image

Comparison with Conventional or Competitive Technologies

- Shape, size, and distribution in a blood image of 3840 × 2748 pixels are measurable in approximately 2 s.
- Robust to noise
- High resolution

Expected Applications

- Software to detect tumor cells circulating in the blood using a blood image.

Challenges in Implementation

- Increasing the number of detection experiments to improve precision and to validate robustness to noise

What We Expect from Companies

We are looking to collaborate with a company that would develop the user interface of this software and work on it commercialization.

Points

- **Optimal for particle size distribution measurement of blood cells**
- **Usable with an ordinary personal computer (does not require specialized equipment)**
- **Measurement is possible with a microscope image of blood (no blood sample required)**

Future Developments

- Speeding-up of processing with a graphics processing unit (GPU)
- Classification of detected blood cells

■Awards:
- The Institute of Electrical Engineers of Japan, Prize of Progress from the Technical Committee (2013.03.07)
- IEEE Information Theory Society Japan Chapter Travel Support Award for Young Researchers (2012.10.30), etc.

Nanotech-nology

Multifunctional film fabrication by nano-scale rapid transfer technologies

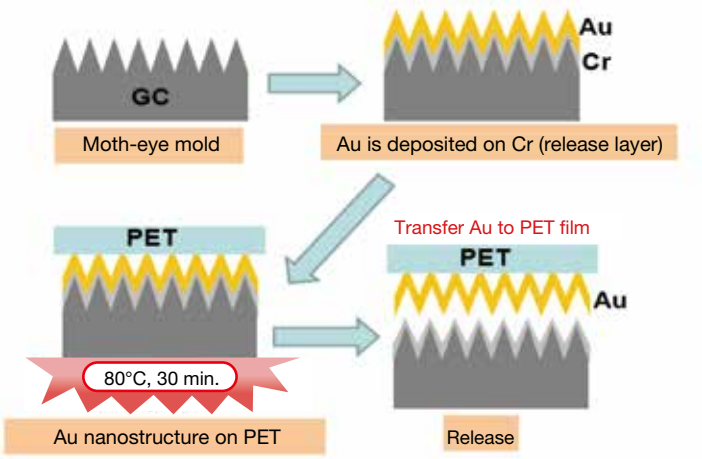
Jun TANIGUCHI (Professor, Department of Applied Electronics, Faculty of Industrial Science and Technology, Tokyo University of Science)

Purpose of Research

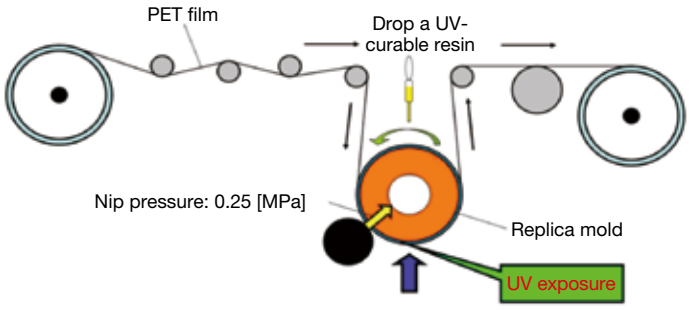
Nanoimprinting is the one of the most common technique for transferring a nanostructure. However, this technique is for forming a pattern on a resin; thus it is not suitable for transfer to metal. In recent years, a "printed electronics," i.e. a bendable electronic device manufactured by distributing a metal wiring on a plastic substrate, has been developed, and a technique for transferring nanometer order metal pattern using a mold also grows in importance. This study aims at satisfying these technical needs with the nanoimprinting.

Summary of Research

Technologies for preparing the nanostructure includes manufacturing a moth-eye (antireflection) structure by irradiating glassy carbon (GC) with oxygen ion beam; and transferring patterns to resin and metal from the manufactured moth-eye mold. Nanoimprinting for the resin and the meal release layer for the metal can allow the patterns to be formed on PET. Moreover, the researchers have advanced the research to achieve the roll-to-roll continuous transfer. It will enable the rapid (with a speed similar to printing) and bulk production of the metal nanostructure as well as the resin nanostructure.



Metallic moth-eye structure can be transferred by NIL



Roll-to-roll Nanoimprint lithography (RTR-NIL)

Comparison with Conventional or Competitive Technology

Releasing (demolding) is the one of the most important points in transferring nanometer order pattern to resin or metal. Out laboratory formulates a proper releasing method and enables transfer from the metal. Nanotransfer using a roll, like a printing, and rapid transfer are also established.

Expected Applications

- Printable electronics (e.g. IC tag, sensor, etc.)
- Wearable devices (e.g. sensor, etc.)
- Optical film (e.g. antireflection film, etc.)

Challenges in Implementation

The mold cost tends to be too high, but our laboratory possesses a technology which enables to prepare a plurality of transfer molds from only one master by creating replicas. Moreover, a large-area mold is difficult to manufacture but our laboratory succeeds to extend the single mold by tiling, provided that the joints are improperly visible.

What We Expect from Companies

We are finding the company as a collaborative project partner, who is willing to build new articles.

Future Developments

A functional film with a nanostructure provides greater novel values to products in various fields including but not limited to displays, automobile components, touch-screens and mobile device. We are willing to cooperate with the companies who demand such new functions and technologies.

- Associated System: JST A-STEP "High-risk Challenge" type
- Awards: MNE 2014 "Best Poster Awards"
- Intellectual Property: Japanese Patent No. 04550089 "Antireflection Structure Body, Method for Preparing the Same, and Method for Preparing Optical Member" US8328371 "Anti-reflection structure body, method of producing the same and method of producing optical member" EP2065736 "Antireflection structure, process for producing the same and process for producing optical member"
- Prototype: Present
- Sample: Available

Device

Development of a next-generation low-power transistors capable of operating at frequencies ranging from gigahertz to terahertz

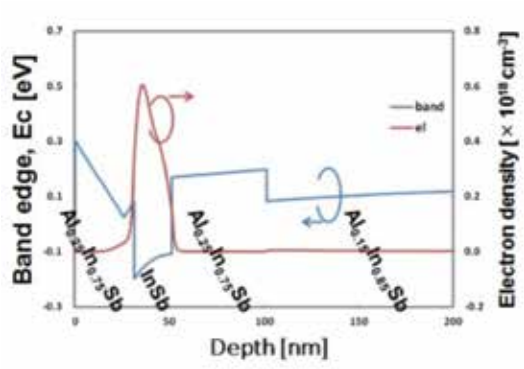
Hiroki FUJISHIRO (Professor, Department of Applied Electronics, Faculty of Industrial Science and Technology, Tokyo University of Science)

Purpose of Research

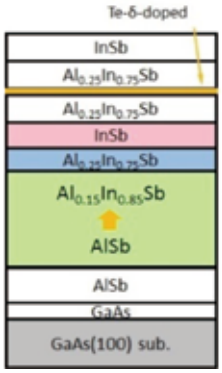
For technologies such as next-generation communications, unexplored sensing technologies, and ultimate computing to be achieved, new high-frequency low-power transistors are required. To develop such devices, we are conducting research into transistors using Sb-based compound semiconductors that exhibit high electron mobility.

Summary of Research

To develop a high electron mobility transistor (HEMT) that can operate at frequencies ranging from the millimeter-wave band to the terahertz wave band (30 GHz–1 THz) using Sb-based compound semiconductors, we carried out the design and analysis of the device by means of a Monte Carlo simulation of HEMT using an InSb-based material, fabricated and evaluated the HEMT epitaxy structure using a molecular beam epitaxy (MBE) apparatus, and then fabricated and evaluated the device.



Simulation results for the band structure and electron density distribution of the strain-controlled InSb HEMT



Layer structure of an InSb quantum well channel for which the electron mobility has been increased by strain control

Cross-sectional TEM image of the prototype strain-controlled InSb HEMT (gate electrode length: 80 nm)

Points

- **High-frequency operation (30 GHz–1 THz)**
- **Low-power consumption**

Comparison with Conventional or Competitive Technologies

InSb exhibits electron mobility that is more than 50 times higher than that of Si, and it is attracting attention as the third-generation electronic material following GaAs- and InAs-based materials. It is possible to produce a material that will deliver a world-leading performance that is superior to that of GaAs- and InAs-based materials by applying the following: a device structure design that makes full use of band engineering and strain engineering; thin film growth at the atomic layer level that realizes the design; and ultrafine processing at the nanometer level.

Expected Applications

The terahertz range of the invisible light and electromagnetic spectrum is regarded as being a suitable bandwidth for unexplored sensing technologies, next-generation communications, ultimate computing, and the like. It is expected to be applied in a variety of fields, including manufacturing, telecommunications, medicine, biotechnology, agriculture, and security. InSb-based HEMT can make a significant contribution to the realization of applications such as an ultimate-performance low-power transistor that is capable of operating in the terahertz range.

Challenges in Implementation

We aim to stably achieve a high-level transistor performance in the terahertz range and further pursue the formation of an IC.

What We Expect from Companies

The InSb-based material is attracting attention not only as a high-speed high-frequency transistor, but also as a channel material for LEDs, light detectors, and the like in the terahertz to far-infrared range. We are searching for companies and research institutions that can work together on developing practical uses for this material.

Future Developments

2015: Test production of an ultimate-performance InSb-based transistor that operates in the terahertz range
2016: Evaluation of properties and improvements to performance
2016: Test production of a low-noise IC

- Intellectual Property: Japanese Unexamined Patent Application Publication No. 2014-045024 “Production Method for Semiconductor Devices”
- Awards: Distinguished Services Award for Electronics Society Initiatives received from the Institute of Electronics, Information and Communication Engineers (2011)

Device

Color sensors based on wavelength-dependent bipolar photodetectors

Takashi IKUNO (Associate Professor, Department of Applied Electronics, Faculty of Industrial Science and Technology, Tokyo University of Science)

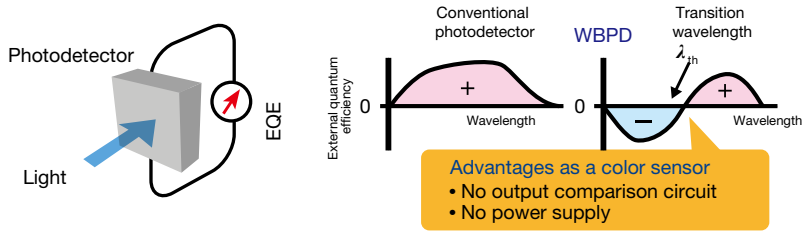
Purpose of Research

Wavelength-dependent bipolar photodetectors (WBPDs) are attracting attention as color sensors and building blocks for optical logic circuits. Conventional WBPDs are photoelectrochemical devices mainly composed of an electrolyte and organic molecules, and suffer from the problems of having a slow response (due to their principle) and of having a transition wavelength—at which the polarity is reversed—that is limited by the optical properties of their materials. In order to overcome the problems posed by conventional technologies, this research aims to improve response speed and control the transition wavelength by using an inorganic semiconductor.

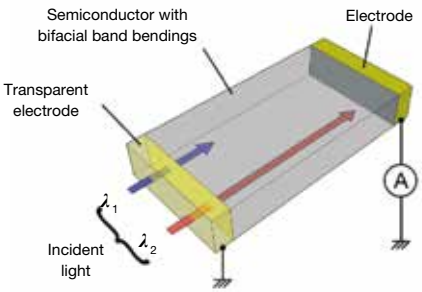
Summary of Research

Through precise control of surface band bending of a general inorganic semiconductor material, our device is given characteristics whereby the output polarity changes depending on the wavelength of incident light. For example, a positive current is output when red light is detected, and a negative current when blue light is detected. The advantages of the device are that it can respond faster than conventional devices and can be seamlessly tuned to detect different colors by changing the size of the semiconductor.

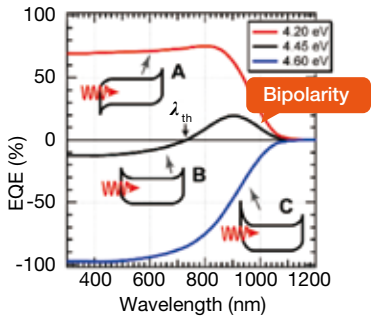
Comparison between a conventional photodetector and WBPD



Schematic illustration of device developed in this research



Simulation results



Comparison with Conventional or Competitive Technology

- Successfully increases response speed—which is a problem with conventional devices—by more than 100 times.
- Our device can be seamlessly tuned to detect different colors by changing the size of the semiconductor, while conventional devices can detect only limited colors.

Expected Applications

- Discrimination of traffic light colors for self-driving cars
- Discrimination of product colors for production lines
- Building blocks of optical logical circuits

Challenges in Implementation

We have already completed proposal of the device's principle, execution of operation simulations and development of prototype components. We need to establish an integration technology in order to enable practical use.

What We Expect from Companies

We require partners who will work with us to develop various applications.

Points

- **Output polarity changes depending on wavelength of incident light**
- **Ability to control the transition wavelength at which polarity is reversed**
- **Quick response (tens to hundreds of microseconds or less)**

Future Developments

March 2018: Achievement of color sensor arrays

March 2019: Creation of prototypes suitable for applications

■ Awards: Poster Award from the Japan Society of Applied Physics (JSAP Autumn Meeting, 2016) and other awards

■ Prototype: Available

Device

Wireless energy transmission

Kenji SHIBA (Associate Professor, Department of Applied Electronics, Faculty of Industrial Science and Technology, Tokyo University of Science)

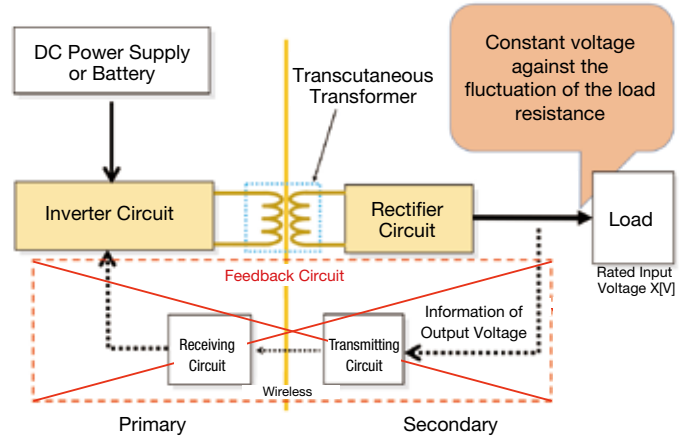
Purpose of Research

The wireless energy transmission using electromagnetic induction or magnetic resonance has already been put into practical use. However, this technology has the following problems: 1) output voltage is fluctuated depending on distance between coils, 2) transmission efficiency decreases depending on distance between coils, 3) output voltage is fluctuated due to load fluctuation, 4) electromagnetic radiation noise is high, and 5) safety to the human body is not confirmed yet. Thus it can be used on the limited condition. This study has a purpose to overcome such a conventional problem and to develop the technology for wireless energy transmission which enables safe and risk-free charging.

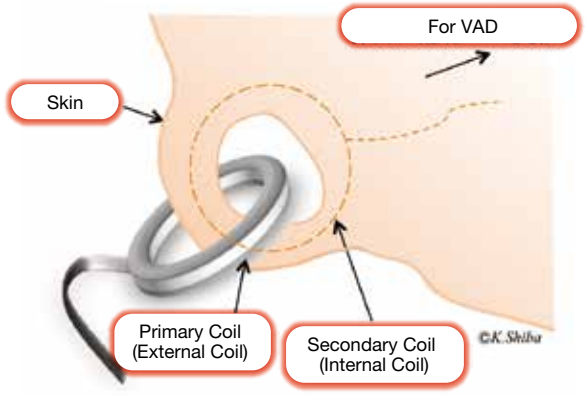
Summary of Research

This wireless energy transmission system has excellent features such as high energy transmission efficiency (98% between coils), output voltage (= electrical power) never changes even when the load varies, it is kept at constant level even when relative locations between primary coil and secondary coil are changed and lower electromagnetic noise, and so on.

Our Proposal Wireless Energy Transmission System



Example of Energy Transmission for Ventricular Assist Device



Comparison with Conventional or Competitive Technology

Since it has a structure that a ring of the secondary coil is clamped by a ferrite core wound by the primary coil, the physical distance between the primary and secondary coils is limited. However, higher transmission efficiency and secure electrical insulation are achieved, and they are able to be detachable very easily.

Expected Applications

- Wirelessly charging household appliances with several tens- or hundreds-watt (charging mobile device, in particular mobile phone or smartphone, rechargeable vacuum cleaner, rechargeable electric power tools, etc.)
- Wireless energy transmission for implantable medical equipments (such as ventricular assist device)
- Charging connector for electric vehicle, etc.

Challenges in Implementation

The implantable medical equipment has a main problem that the medical equipment requires design and manufacture of a specific medical packaging. When it is used for the household appliance or the electric vehicle, finally, dosimetry evaluation and EMC evaluation are also needed according to the output voltage.

What We Expect from Companies

We are finding collaborative project partner companies which intend to jointly develop a wireless energy transmission system with a medical equipment manufacture. This technology would be effectively introduced in companies which want to develop charging device for the household appliances and electric vehicle, so we are willing to undertake joint project with such companies.

Future Developments

Energy can be transmitted wirelessly only by clamping even when the electric vehicle or the mobile device is charged. Thus safe charging can be realized since it can be insulated even outdoors. Furthermore, the AC-AC energy transmission efficiency is 98% or higher. We can offer advices in accordance with the desired applications. Please do not hesitate to contact us.

- Awards:
  JSAO Best Paper Awards (2001) in Circulatory System, etc.
- Intellectual Property:
  Japanese Patent Application No. 2014-146119 “Wireless Energy Transmission Apparatus and Electrical Device”
- Prototype: Present
- Sample: May be provided. Decision on this made after discussion with requester.

Medical and bio

OTN (over 1000 nm)-NIR in vivo imaging system

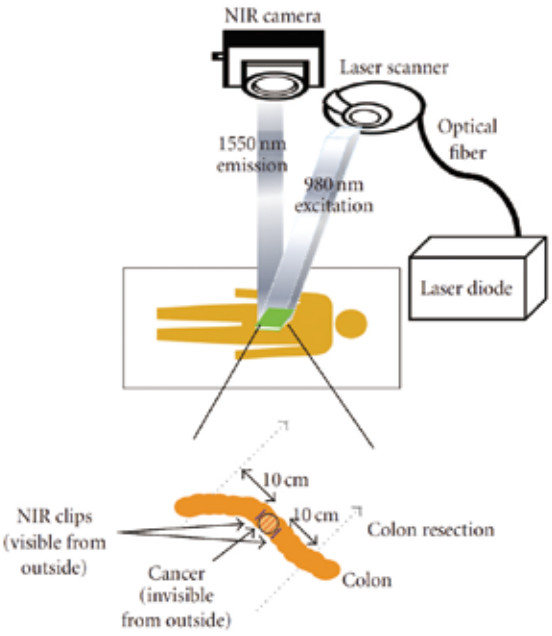
Kohei SOGA (Professor, Department of Materials Science and Technology, Tokyo University of Science, Imaging Frontier Center)

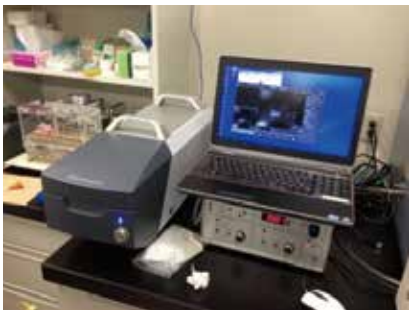
Purpose of Research

Fluorescent imaging is one of the most important basic technologies in fields of biology and medicine. Visible or near-infrared light with a short wavelength, either of which is currently used, has limitations in observation depth and clearness due to strong light scattering and autofluorescence. Meanwhile, the 1000-nm or more near-infrared light (OTN-NIR) is expected to provide the observation depth of several centimeters, compared favorably with conventional depth of several millimeters. However, the wavelength region 1,000 nm or more cannot be observed because a silicon CCD camera can only capture the images with a wavelength less than 1000 nm.

Summary of Research

This technology achieves to realize OTN-NIR fluorescence in-vivo bioimaging, in so-called "the second biological window" by developing an imaging system equipped with InGaAs CCD camera and a diode laser excitation and rare earth-containing ceramics nanoparticles (RED-CNP) as fluorescent probes at the same time.





Portable OPT
(jointly developed with Shimadzu Corporation)

Comparison with Conventional or Competitive Technology

- Bioimaging in OTN-NIR
- Enable measurement insensitive to light scattering and autofluorescence
- Imaging with several cm depth

Expected Applications

- Imaging for small animals
- Imaging for diagnosis and medical care
- DDS kinetic analysis in the pharmaceutical field

Challenges in Implementation

- The imaging device for small animal research has been already developed with Shimadzu Corporation and launched onto the market.
- We will do the projects on 1) implementing the imaging device for diagnosis and medical care, and 2) developing various kinds of the fluorescent probes.

What We Expect from Companies

We are finding the company as a collaborative project partner, who is willing to develop the imaging device for diagnosis and medical care, the novel fluorescent probes, and 3D imaging technology utilizing the depth imaging.

Points

- **Capable of imaging deep part of a living body**
- **Capable of highly-accurate measurement without effecting cell or vital environment**
- **Capable of real-time measurement or long-time measurement**

Research Schedule

December 2014: Launch the imaging device for small animal onto the market (Shimadzu Corporation)

April 2017: Produce a prototype of the imaging device for diagnosis and medical care

April 2022: Start the clinical applications & Launch the imaging device for diagnosis and medical care onto the market

December 2027: Launch the imaging device for diagnosis and medical care onto the market

■ Awards:
JSDMD Symposium, "Best Lecture Awards" (April 11, 2009)
Japanese Bioimaging Society, "Best Image OLYMPUS Awards" (November 2, 2006)

■ Intellectual Property:
Japanese Unexamined Patent Application Publication Nos. 2013-103080 "Medical Image Processing Device, Method, and Program" 2014-115151 "Optical Imaging Device"

■ Prototype: Present ■ Sample: Available

Energy and environment

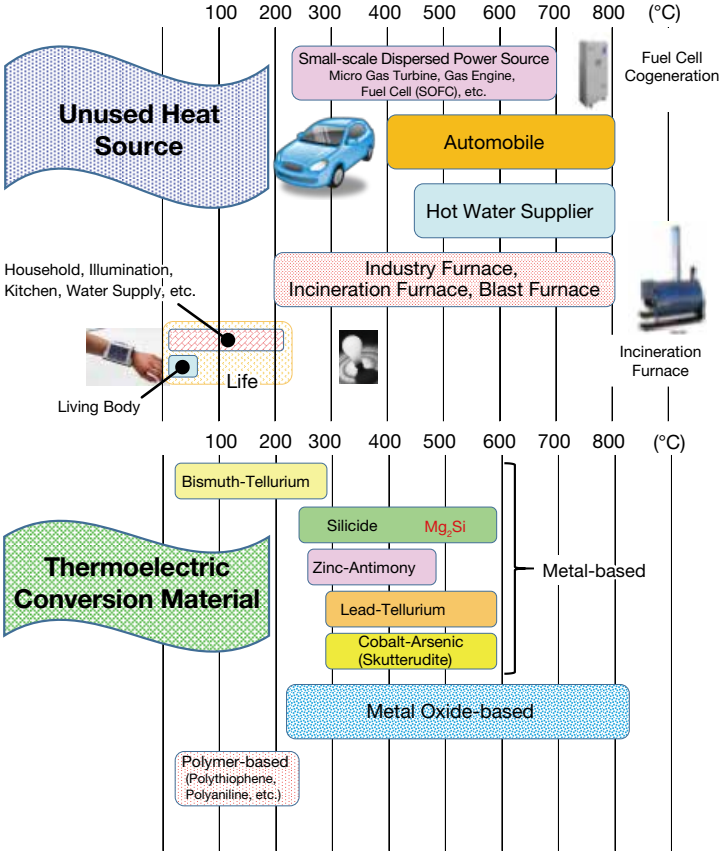
Thermoelectric waste heat recovery by environmentally benign materials

Keishi NISHIO (Professor, Department of Materials Science and Technology, Faculty of Industrial Science and Technology, Tokyo University of Science)
Tsutomu IIDA (Professor, Department of Materials Science and Technology, Faculty of Industrial Science and Technology, Tokyo University of Science)
Hiroaki ANNO (Professor, Department of Electrical Engineering, Faculty of Engineering, Sanyo-Onoda City University)

Purpose of Research

Waste heat is one of the important energy sources. Establishing thermoelectric conversion technology that generates highly useful electric energy from waste heat is important to develop the elemental technology essential for reducing carbon dioxide by improving energy utilization efficiency. The researchers have focused on molecular architecture, crystal structure, electronic property, etc. of the material, controlled semiconductor characteristics exhibition, electrical conductivity and heat conductivity, in order to implement high-performance thermoelectric conversion material, and searched proper material satisfying the conditions considering availability and safety as the raw material while securing high performance. Moreover, the researchers promote industry-academia-government cooperation at home and abroad, and work on development of power generation system, i.e. module which can efficiently utilize exhaust heat from automobiles or industry furnaces, and natural heat such as solar heat, ground heat and bioheat.

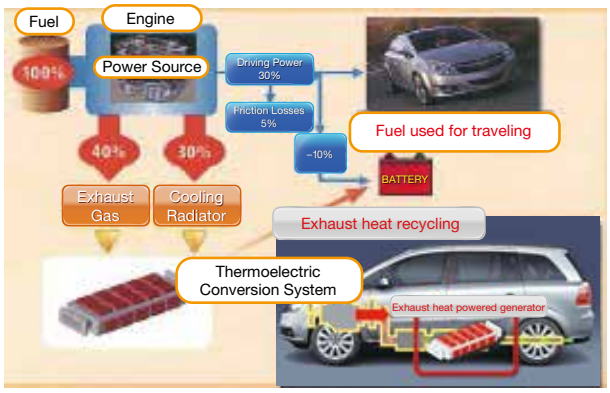
Summary of Research



Points

- **Research on thermoelectric conversion materials corresponding to heat sources in various temperature regions**
- **Good for the ecology and resources**

We have studied how to find, how to improve, and how to utilize various thermoelectric conversion materials, including but not limited to inorganic, silicide, organic materials. The power generation module for automobile has been developed using magnesium silicide (Mg_2Si) among such materials, via industry-academia-government cooperation at home and abroad.



Expected Applications

Fuel consumption is improved and CO_2 emission is reduced by converting exhaust heat from the automobile to electricity and recollecting it as the energy. This technology is expected to utilize the exhaust heat from the industry furnace or the incineration furnace, as well as from the automobile.

Comparison with Conventional or Competitive Technology

The conventional thermoelectric conversion material typically includes scarce or toxic elements, but this new material uses easily-available and safe elements only. The future subject is to realize recycling the exhaust heat from the automobile.

Challenges in Implementation

- Further improve thermoelectric conversion characteristics
- Evaluate and improve mechanical properties, durability and service life
- Evaluate and improve economic efficiency

What We Expect from Companies

We are finding a partner who is willing to develop the materials usable in the various fields.

Future Developments

We have studied various materials; especially regarding Mg_2Si, we carry out the performance improvement and preparation of a module prototype.

For corresponding to CARS 2020 Action Plan, we promote the development through industry-academia-government cooperation.

■ Associated Institution: Unused Heat Energy Conversion Division of GUAS

■ Intellectual Property: Japanese Patent Application No. 2012-517173 "Method for Manufacturing Thermoelectric Conversion Module and Thermoelectric Conversion Module" (filing several applications associated to organic and inorganic thermoelectric conversion material and modules at home and abroad)

Measure-ment technology

Electrical and optical hydrogen gas sensor with Pt/WO_3 thin films

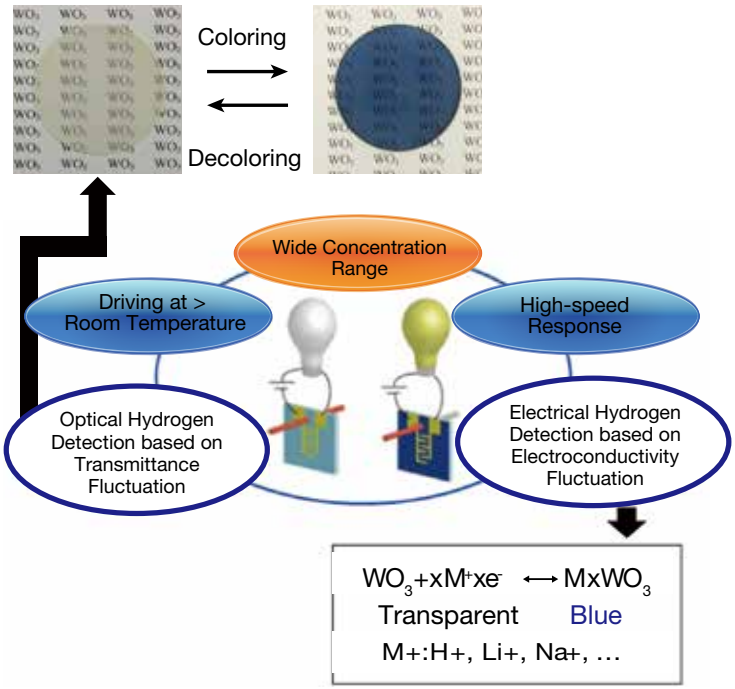
Keishi NISHIO (Professor, Department of Materials Science and Technology, Faculty of Industrial Science and Technology, Tokyo University of Science)

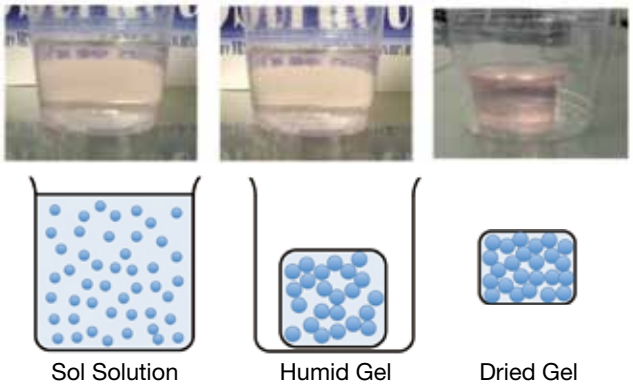
Purpose of Research

Hydrogen energy is one of the most prospective energy sources since it has been employed in various applications, such as a fuel cell, a hydrogen vehicle, etc. However, the hydrogen gas reaches the flammability limit when about 4% to 74% of the hydrogen is contained in the atmosphere, and thus leakage prevention becomes very important. The electrical type or catalytic-combustion type hydrogen sensor has been conventionally used, but it has disadvantages that a detectable concentration range is limited and a detection speed is slow. An object of this study is to implement the hydrogen gas leakage detection with high-speed in the wide concentration range. The study focuses on a material structure, characteristics usable for detection and a device structure.

Summary of Research

A film of oxide (WO_3) is prepared with a sol-gel method, and Pt/WO_3, WO_3 carrying platinum, is further formed on a glass substrate. The researchers have discovered that the hydrogen gas can be detected within the wide concentration range by making the optical/electrical synergy sensor using gas chromism of Pt/WO_3, that is, by combing two physical properties, light and electricity. The high-speed response is realized by controlling microstructure and crystalline of the film prepared with the sol-gel method.





Adjusting Metal Oxide Film by Sol-Gel Method

Only a portion sprayed with hydrogen gas is colored.

Points

- **It can distribute to safe management of hydrogen which attracts attention as the future energy**
- **Good for the ecology and resources**

Expected Applications

- Hydrogen gas sensor: measuring and managing under the concerning conditions including fixed quantity from thin concentration close to the flammability limit, which especially requires the high-speed response

Challenges in Implementation

- Collaboration with measuring techniques
- System architecture

Future Developments

We have a plan to utilize especially the Pt/WO_3 film formed on the glass substrate as the hydrogen gas sensor in the industry-academia-government cooperation, and to search and develop other materials.

What We Expect from Companies

We are finding a partner who is willing to employ and utilize this technology in the various fields.

Bio

F1-ATPase relieves the damage caused by a high temperature stress during seed development

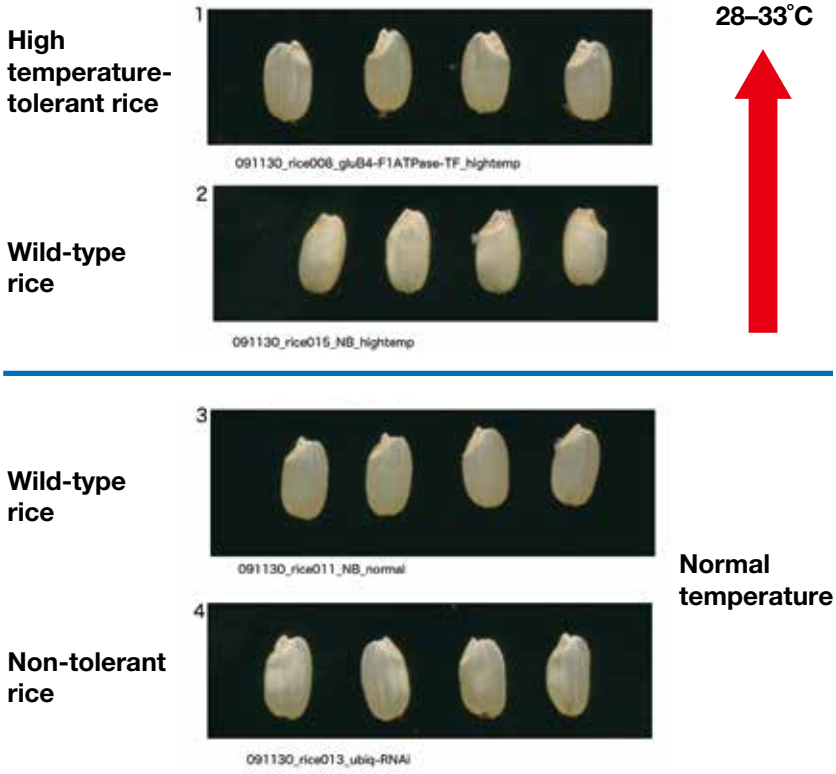
Hiroaki SHIMADA (Professor, Department of Biological Science and Technology, Faculty of Industrial Science and Technology, Tokyo University of Science)

Purpose of Research

Molecular Genetic Approach to the Exploitation of Plant Resources

All living species on the earth depend on plant biomass such as carbohydrates. Our goal is to develop novel technologies that enable plants to exert their maximum abilities. To fully exploit plant resources and achieve a sustainable and stable society that can withstand the global warming, we are studying the key factors crucial to the productivity of plant biomass, plant genes involved in the tolerance to environmental stresses, and molecular agriculture techniques for producing medicines and chemicals using plants.

Summary of Research



Overexpression of F1-ATPase β in Rice Seeds Confers Tolerance to High Temperature

High-temperature stress during seed development resulted in reduced grain quality with chalky endosperm, which was caused by insufficient storage starch synthesis possibly because of shortage of ATP supply and inadequate energy status in developing seeds. In this case, since the expression of genes involved in F1-ATPase was significantly decreased, it is suggested that change in the amount of F1-ATPase and therefore reduction in the ATP content in developing seeds largely affected the grain quality. We created rice transformants in which an F1-ATPase β gene was overexpressed specifically in the endosperm of immature seeds, which relieved the high temperature damage.

Points

- **Creation of high temperature-tolerant plants by overexpressing F1-ATPase**
- **Screening for/breeding of high temperature-tolerant rice plant lines**
- **Breeding of high temperature-tolerant rice plant lines**

Future Developments

- Collaboration with seed companies, JA, and other organizations and application for governmental research grants.
- Field testing of the overexpression lines on a collaborative basis.

■ Associated System:
SIP (Cross-ministerial Strategic Innovation Promotion Program)
Agri-innovation Program
■ Awards:
JSPCMB Excellent Paper Award (2013)
■ Intellectual Property:
JP2014-102528 “Translational Enhancer”
■ Prototype: present
■ Sample: available

Bio

Translational enhancer that promotes protein biosynthesis and leads to enriched grain production

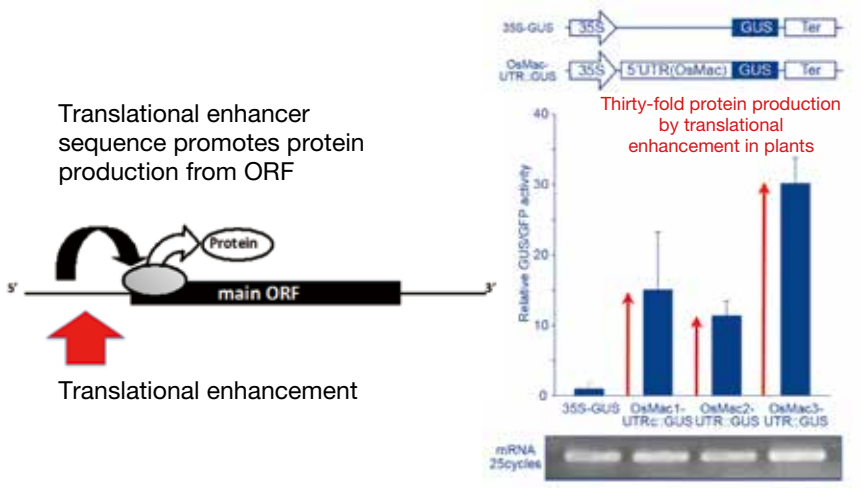
Hiroaki SHIMADA (Professor, Department of Biological Science and Technology, Faculty of Industrial Science and Technology, Tokyo University of Science)

Purpose of Research

[POINT] Enhanced crop production by promoting protein biosynthesis from mRNA without increasing gene transcription. Most of conventional technologies to efficiently produce proteins do so by promoting mRNA production (gene transcription). Our technology is unique in that it depends on translational enhancers that promote protein synthesis from mRNA (translation). We have identified a novel translational enhancer derived from the Oryza sativa OsMac1, OsMac2, and OsMac3 genes. This enhancer produced a 5- to 30-fold increased amount of a reporter protein encoded by its downstream ORF. Currently we are working on the construction of a high-efficiency production system based on the function of such translational enhancers. The future goal is to establish a method applicable to highly efficient production of substances in various cell systems.

Summary of Research

We investigated the usefulness of translational enhancers by testing the effect of one of them on the production of a reporter protein. The enhancer sequence was inserted in the 5'UTR that was located upstream of the coding region of a temperature-sensitive elastin-like peptide (ELP) fusion protein gene, to construct plasmids that expressed the reporter from a CaMV 35S promoter. These plasmids were introduced into Nicotiana benthamiana and Oryza sativa. Both of the resultant transformants showed a several fold increase in the amount of the ELP fusion reporter protein, compared to a control. This indicated that translational enhancers can promote translation in these plants.



Points

- **Our system yields increased protein production by promoting mRNA translation**
- **Our system may give a synergistic effect using a enriched transcription because it targets the translational process**
- **Our system also efficiently works on the protein production by cell-free protein synthesis system**

Comparison with Conventional or Competitive Technology

Conventional high-efficiency protein production technologies usually increase gene expression (transcription). The present technology is unique in that it enhances protein production from mRNA (translation). When combined with conventional technology, the present technology can greatly raise protein production through the synergistic effect of increased gene transcription and translation. It also enhances protein production in cell-free protein synthesis systems.

Expected Applications

- Novel research reagents/kits (for high-efficiency protein production).
- Production of valuable proteins in a living plant.
- Research reagents for protein arrays using cell-free protein synthesis systems.

Challenges in Implementation

- Research needed for practical applications, e.g. in nucleotide sequence optimization.

What We Expect from Companies

Please contact us if you are interested in industrial application of the present technology.

Future Developments

- Fiscal 2015:
  Application to various cell types
- Fiscal 2016:
  Research for practical applications (research reagents)

■ Intellectual Property: Japanese Patent No. 5598899 "translational enhancer" Registered Japanese Patent Application No. 2014-102528 "translational enhancer" Application unpublished

■ Reference: Hiromi Aoki, Hiroshi Teramura, Mikhail Schepetilnikov, Lyubov A Ryabova, Hiroaki Kusano, Hiroaki Shimada "Enhanced translation of the downstream ORF attributed to a long 5′ untranslated region in the *OsMac1* gene family members, *OsMac2* and *OsMac3*" *Plant Biotechnology* Vol. 31 (2014) No. 3 p. 221-228

Hiroshi Teramura, Yusuke Enomoto, Hiromi Aoki, Tadamasa Sasaki, Hiroaki Shimada

A long 5' UTR of the rice OsMac1 mRNA enabling the sufficient translation of the downstream ORF. *Plant Biotechnology* 29, 43-49 (2012)

Bio

Plant aroma-mediated, biological interactions: development of agri-aroma plants and medical-aroma plants

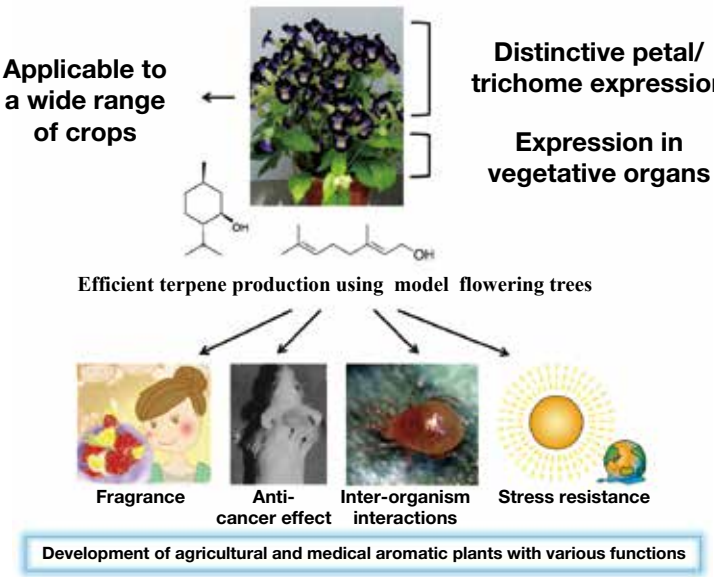
Gen-ichiro ARIMURA (Professor, Department of Biological Science and Technology, Faculty of Industrial Science and Technology, Tokyo University of Science)

Purpose of Research

In the present study, we used gene recombinant flowering plants that regularly emit volatile terpenes, which are a large class of natural organic compounds produced by plants, to elucidate the pharmaceutical (anti-cancer aromatherapeutic), anti-stress, and other advantageous effects of terpenes and to establish the basis for applications of such "medical aromatic plants." These recombinant plants also can be used as "agricultural aromatic plants" that can promote attraction of natural enemies of harmful insects and promote inter-plant communication.

Summary of Research

Among aromatic chemicals produced by plants, terpenes have anti-inflammation, anti-cancer, relaxation (anti-stress), and many other health-promoting effects and are therefore attracting worldwide attention from researchers and physicians. In recent years, development of terpene production systems using plant factories and microorganisms such as yeast, and basic research to incorporate inter-organism communication via volatile terpenes as agribio technology in production systems have progressed rapidly. We are developing agricultural aromatic plants which regulate communications between plants and pest natural enemies and between plants, and medical aromatic plants which are expected to have health-promoting and anti-cancer effects, using the flowering plants torenia and tobacco as models.



Points

- **Novel applications of aroma-based plant communication**
- **Use of anti-pest and health-promoting effects of volatile terpenes**
- **Creation/production of agricultural and medical aromatic plants with novel functions**

Comparison with Conventional or Competitive Technology

Conventionally, one terpene compound is isolated and used as the active ingredient in a drug compound. Because our product is a live plant, the active ingredients of the plant are all utilized, and multiple functions are realized.

Expected Applications

- Agricultural aromatic plants can protect co-cultivated crops from pests.
- Medical aromatic plants can promote human health when incorporated in daily life, reducing medical care expenditure.

Challenges in Implementation

- Identification of genes that produce and regulate effective aromatic components.
- Creation/production of functional plants.
- Genome editing (using CRISPR/Cas9).

What We Expect from Companies

Testing and commercialization of the agricultural and medical aromatic plants generated by the present study.

■ Publication: Arimura G., Yazaki K., Takabayashi J., Kawakita A. (2014) Frontiers in Plant Aromascience: Why do plants emit various scents? published by Fragrance Journal Ltd.

■ Reference: Shimoda T., Nishihara M., Ozawa R., Takabayashi J., Arimura G. (2012) The effect of genetically enriched (E)-beta-ocimene and the role of floral scent in the attraction of the predatory mite *Phytoseiulus persimilis* to spider mite-induced volatile blends of torenia. *New Phytologist* 193:1009-1021

Bio

Application of plant aroma-mediated biological interactions to agri-system and healthy food science

Gen-ichiro ARIMURA (Professor, Department of Biological Science and Technology, Faculty of Industrial Science and Technology, Tokyo University of Science)

Purpose of Research

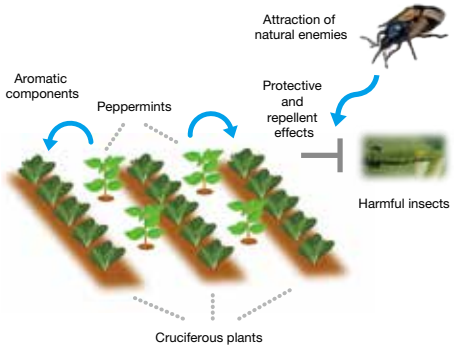
In the present study, we used transgenic plants and medicinal plants that emit volatile terpenes to elucidate the pharmaceutical (such as anti-inflammatory effects on the colon), anti-stress, and other advantageous effects of terpenes and to establish a basis for applications of such "medical aromatic plants." In addition, aromatic plants including mints can also be used as "agricultural aromatic plants" that can promote the attraction of the natural enemies of harmful insects and promote inter-plant communication.

Summary of Research

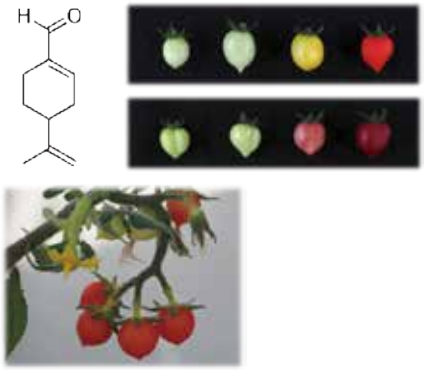
Among the aromatic chemicals produced by plants, terpenes have anti-inflammation, anti-cancer, relaxation (anti-stress), and many other health-promoting effects and are therefore attracting worldwide attention from researchers and physicians. In recent years, the development of terpene production systems using plant factories and microorganisms such as yeast, and basic research for incorporating inter-organism communication via volatile terpenes as agri-biotechnology in production systems have progressed. A patent application has been filed for some results of the research and a specific commercialization project is being considered. We focus on terpenes that have various physiological activities and are developing agricultural aromatic plants that regulate communications between plants and the natural enemies of harmful insects and between plants, and medical aromatic plants that are expected to have health-promoting effects including anti-inflammatory effects using tomatoes and other plants.

Development of production systems using mints as companion plants

Pest control technology for cruciferous vegetables using aromatic components emitted from peppermints (Japanese Patent Application No. 2017-214231)



Development of plants producing secondary metabolites that have health-promoting effects



Specific Examples

- Anti-inflammatory functions of tomatoes containing a large amount of betalain (plant pigment)
- Improvement of intestinal environment by aromatic components of Perilla frutescens

Comparison with Conventional or Competitive Technologies

Conventionally, some unique terpenes are used as the active components for foods and drugs. Because our product is a live plant, the active ingredients of the plant are of ease to be utilized and functional for multiple purposes.

Expected Applications

- Agricultural aromatic plants (including mints) can protect co-cultivated crops from pests without using agricultural chemicals.
- Medical aromatic plants can be used to provide scientifically proven health-promoting components at low costs.

Challenges in Implementation

- Identification of genes that produce and regulate effective aromatic components.
- Creation/production of functional plants.
- Genome editing (using CRISPR/Cas 9).

What we Expect from Companies

Practical applications and marketing of the agricultural and medical aromatic plants generated by the present study.

Points

- **Novel applications of aroma-based plant communication**
- **Use of anti-pest and health-promoting effects of volatile terpenes**
- **Creation/production of agricultural and medical aromatic plants with novel functions**

■ Intellectual Property: Japanese Patent Application No. 2017-214231 "Methods of immune activation of cruciferous plants and production methods of immune-activated cruciferous plants"
■ Publication: Arimura G., Nishihara M. (2018) Plant Plot: Botany of Aroma and Color published by Beret Publishing Co., Ltd. (Tokyo) pp. 159
■ Reference: Uemura T., Yashiro T., Oda R., Shioya N., Nakajima T., Hachisu M., Kobayashi S., Nishiyama C., Arimura G. (2018) Intestinal anti-inflammatory activity of perillaldehyde. Journal of Agricultural and Food Chemistry 66:3443-3448
Sukegawa S., Shiojiri K., Higami T., Suzuki S., Arimura G. (2018) Pest management using mint volatiles to elicit resistance in soy: mechanism and application potential. The Plant Journal, in press

Bio

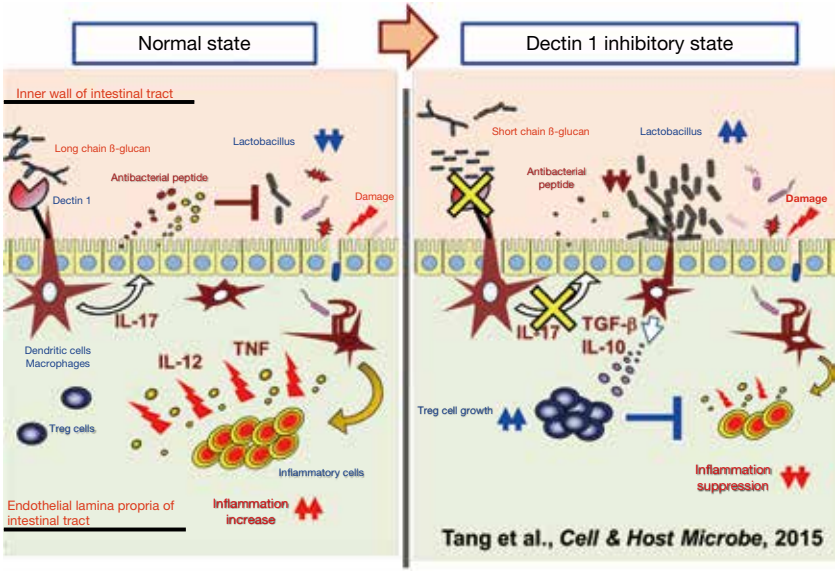
Suppression of intestinal inflammation by short chain ß-glucans

Yoichiro IWAKURA (Professor, Research Institute for Biomedical Sciences, Tokyo University of Science)

Purpose of Research

The number of patients with inflammatory intestinal diseases such as ulcerative colitis is annually increasing and has increase by two-fold over the last 20 years. In contrast, in recent years, improvements in the intestinal environment have been shown to be effective in preventing and treating allergies, autoimmune disease, cancer, and infection. We discovered that binding of short chain β-glucan to Dectin 1 in the intestinal tract suppresses the production of antibacterial peptides and as a result, increases Lactobacillus growth in the intestines and suppresses inflammatory intestinal disease. We are currently developing functional foods with these actions.

Summary of Research



Suppression of inflammatory colitis by short chain β-glucan

Dectin 1 in the inner wall cells of the intestinal tract promotes the secretion of antibacterial proteins and suppresses the growth of Lactobacillus spp. that are important for a healthy intestinal environment.

In contrast, short chain β-glucan binds to and suppresses Dectin 1, leading to an increase in the number of Lactobacillus and anti-inflammatory (Treg) cells, suppressing inflammation.

- Dectin 1, a protein present in the inner wall of the intestinal tract, promotes antibacterial peptide secretion after recognizing long chain β-glucan from the cell walls of fungi such as Candida and suppresses the growth of certain Lactobacillus spp.
- Dectin 1 knock-out mice have a lower tendency of having colitis, and we found that this was because of an increase in the number of certain Lactobacillus spp., which increase regulatory T (Treg) cells in the large intestine, leading to the suppression of inflammation.
- Short chain β-glucans, such as laminarin in kelp, inhibit the function of Dectin 1. Therefore, we found that the intake of short chain β-glucan increases the number of Lactobacillus and suppresses the onset of colitis.

  However, an excessive increase in the intake of kelp may have adverse effects on the body. We developed a method to safely produce short chain β-glucan from yeast and showed that mice have a lower tendency of having colitis and food allergies when taking this short chain β-glucan.

Future Developments

- We are developing highly functional foods which improve the intestinal environment and prevent various inflammatory intestinal disease.
- Recently, improvements in the intestinal flora have been shown to be effective in preventing various disease. We are looking to collaborate with a food company that would develop such foods.

- Associated System: Ministry of Agriculture, Forestry and Fisheries, Science and Technology Research Promotion Program for Agriculture, Forestry, Fisheries and Food Industry
- Awards: Hideyo Noguchi Memorial Award for Medical Science (2015)
  Rheumatism Society Award (2009)
- Intellectual Property: Many applications and country transfers

Medical/ Drug Discovery

The regulation of chondrogenesis via Adiponectin receptors and the therapeutic agents for osteoarthritis

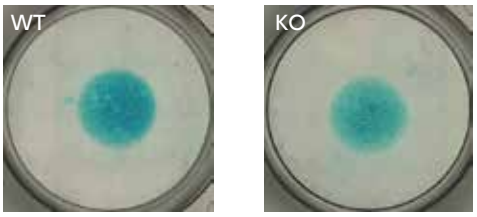
Yoichiro IWAKURA (Professor, Research Institute for Biomedical Sciences, Tokyo University of Science)

Summary of Research

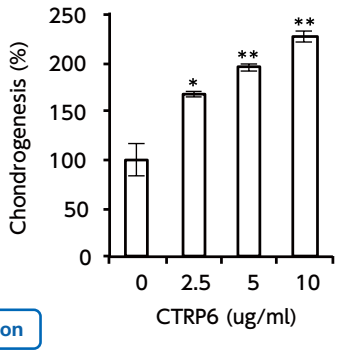
Osteoarthritis is a disease affecting many elderly people that is characterized by the deformity and degeneration of the articular cartilage, causing poor QOL and hindering the activities of daily life, substantially affecting healthy life expectancy. Osteoarthritis poses a great concern with the advent of the aging society because no radical treatment is available. In the present study, we have discovered that the adiponectin family of molecules and their receptors enhance the proliferation of chondrocytes. This finding is considered to be useful in developing new therapeutic agents for osteoarthritis.

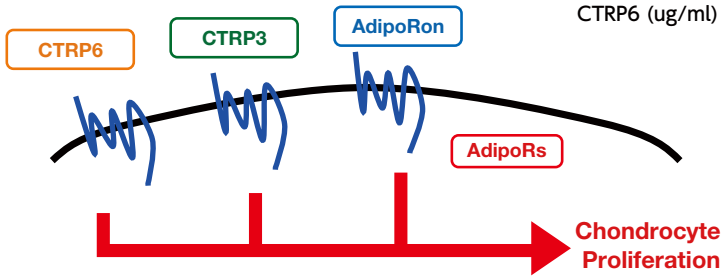
Details of Research

No radical treatment is available for osteoarthritis. Regenerative medicine has received much attention recently, but there are still many problems that need to be worked out, and it will be some time before it can be used for practical applications. We found that a deficiency of CTRP6, a molecule in the adiponectin family of molecules, resulted in the spontaneous development of osteoarthritis and we analyzed its pathogenetic mechanism. As a result, we discovered that CTRP6 is a factor that enhances chondrocyte proliferation via adiponectin receptors. We also revealed that CTRP3 and AdipoRon, an adiponectin receptor agonist, have the same action. These findings strongly suggest that the drug discovery targeting the adiponectin family of molecules and their receptors is promising for the development of drugs/therapy for osteoarthritis.



CTRP6 enhances cartilage formation.





Points

- **Chondrocyte proliferation enhanced by the adiponectin family of molecules/receptors**
- **Development of drugs/therapy for osteoarthritis**

Comparison with Conventional or Competitive Technologies

- Conservative therapy: Physical therapy, medication, and others
- Surgical therapy: Arthroscopic surgery, replacement arthroplasty, and others
  → These are not radical treatments and impose a heavy burden.
- Regenerative medicine: Stem cell therapy and others
  → Stem cells derived from patients have a low proliferative capacity.

Expected Applications

- Direct application to the site of disease as a proliferation promoting agent for chondrocytes
- Proliferation promoting agents for chondrocytes derived from iPS cells and stem cells (improvement in quality of regenerative medicine)

Challenges in Implementation

- Investigation of the effects on chondrocytes derived from patients.
- Creation of a more specific agonist than ever before.

What We Expect from Companies

Osteoarthritis is one of the diseases requiring immediate action in association with the growing concern for the aging society. To solve this problem, we are willing to start a research collaboration program (basic/clinical research) to develop drugs/therapy.

Future Developments

Based on the findings obtained from the basic research to date, we wish to investigate the effects on chondrocytes derived from patients (including stem cells/iPS cells) with osteoarthritis and to conduct research and development aiming at clinical application.

- Intellectual Property: Japanese Patent Application No. 2018-024297 "Proliferation promoting agents for chondrocytes, methods for enhancing chondrocyte proliferation, and screening methods for proliferation promoting agents for chondrocytes"
- Awards: Hideyo Noguchi Memorial Award for Medical Science (2015)
  Ando & Tajima Prize (2012)
  Rheumatism Society Award (2009)
- Other: Mice with modified CTRP6 or CTRP3 genes, etc. can be provided.

Bio

Development of novel anti-tumor antibodies using tumorinfiltrating B cells cultured with an original system

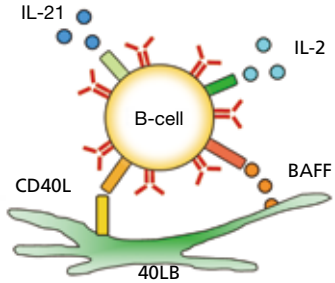
Daisuke KITAMURA (Professor, Research Institute for Biomedical Sciences, Tokyo University of Science)

Purpose of Research

On the surfaces of cancer cells that constitute a tumor, there are antigen proteins peculiar to cancer cells which are involved in cancer proliferation and malignant transformation. However, it is thought that B lymphocytes from the outside of tumor tissues infiltrate the tissues, produce antibodies specific to cancer cell surface antigens. These antibodies then attack the cancer cells. Using our proprietary B cell culture technology, we aim to develop novel antibody drugs effective against cancer by culturing B cells that produce such anti-tumor antibodies.

Summary of Research

[Fig. 1] Inducible Germinal Center B Cell (iGB) Culture Method



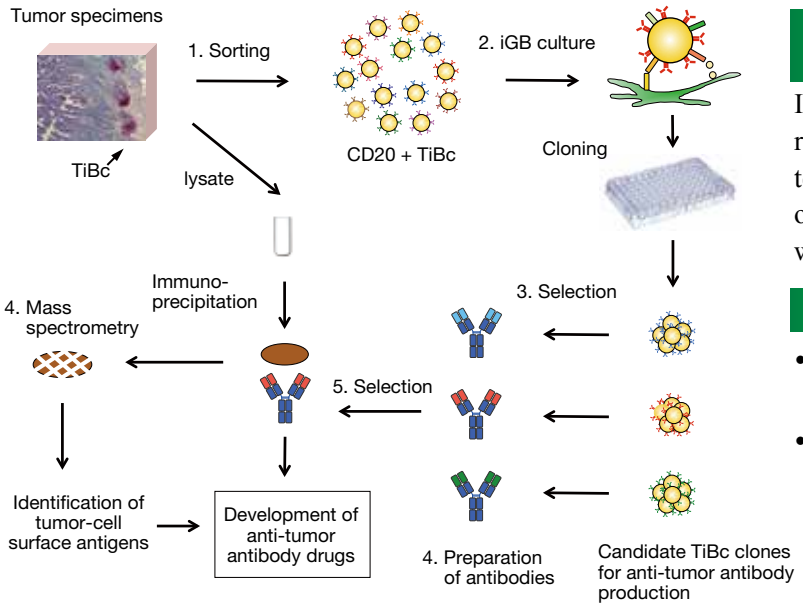
Our B cell culture technology, "inducible germinal center B cell culture method" allows for the long-term cultivation of B cells on 40 LB cells expressing molecules that enhance B cell proliferation, in a specific culture medium containing cytokines (Fig. 1)

Tumor-infiltrating B cells (TiBc) are considered to be B cells which produce antibodies that bind to tumor antigens. We believe that by culturing TiBc using this technology, we can obtain antibodies against antigenic proteins on the tumor surface (Fig. 2).

This antibody can serve as the seed of an antibody drug or a chimeric antigen receptor (CAR) used for immune cell therapy.

Furthermore, using the antibody obtained, it is possible to identify the corresponding antigen, and to clarify the mechanism of action of the antibody drug under development.

[Fig. 2] Research Outline



Comparison with Conventional or Competitive Technologies

In the prior art, it was necessary to fuse mouse-derived B cells with other cells. However, with this technology, it is possible to cultivate B cells originating from humans (or the desired animal) without cell fusion.

Expected Applications

- Development of antibody drugs for cancer treatment.
- Development of chimeric antigen receptor for immune cell therapy

■ **Intellectual Property: Japanese Patent No. 05550132**

(This study is being carried out in collaboration with Dr. Nakatsura, the head of field of immunotherapy development of the National Cancer Research Center.)

Bio

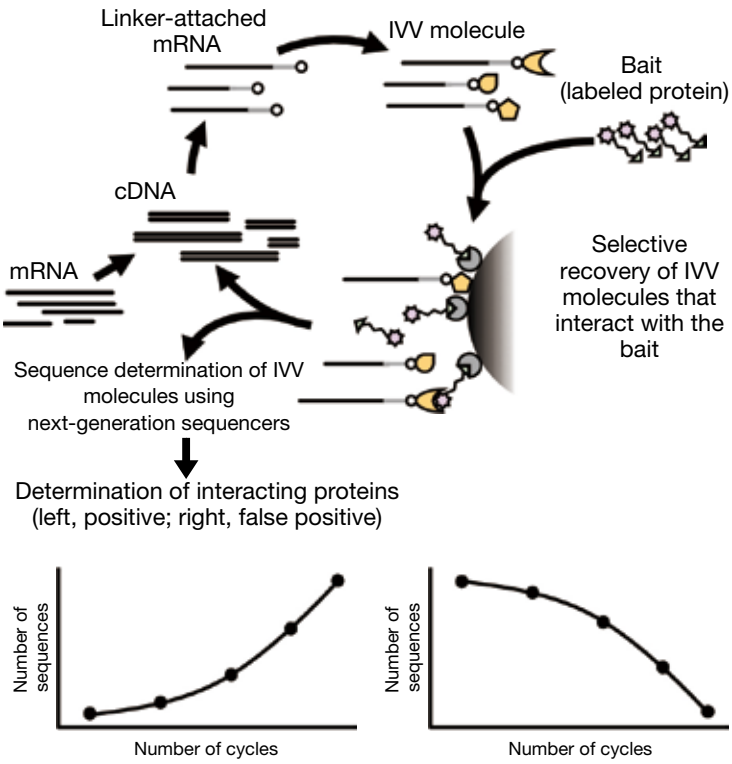
Analyses of unknown protein-target interactions

Etsuko MIYAMOTO-SATO (Professor, Research Institute for Biomedical Sciences, Tokyo University of Science)

Purpose of Research

Genome projects and whole genome analysis using next-generation sequencers have made genome information of various organisms available. As a result, expressing all genes that are expressed in an organism's body by using bacteria and cultured cells is possible. However, regarding a protein coded by a particular gene, it is necessary to quickly identify the interacting proteins to elucidate its function in vivo. This technology reduces false negatives and positives that are a common problem for many interaction analyses and achieves high-throughput.

Summary of Research



This technique uses in vitro virus (IVV) molecules to detect proteins that interact with a particular protein.

- The cDNA library is transcribed, and a puromycin linker is attached to the 3' terminus. When RNA is translated using a cell-free translation system, it leads to a combined IVV molecule of a protein joined by a linker to RNA that is the blueprint for that protein.
- The protein in focus is labelled with a peptide tag to use as bait. The bait and IVV molecules are mixed to allow interaction and pulled down using a carrier that binds to the peptide tag.
- cDNA of IVV molecules that bind to the bait is obtained and becomes the template for IVV molecules used in the next cycle.
- The template cDNA can be amplified if levels in the original library are low or if the recovery rate is low because the interaction is weak, so that it can then be detected.
- Sequence analysis of cDNA obtained at each cycle using next-generation sequencers can identify the sequences of all interacting proteins at the same time.

It is easy to exclude false positives by evaluating the appearance frequency of each sequence.

Points

- **Reduction of false negatives using the enormous amount of sequence information obtained by next-generation sequencers**
- **Reduction of false positives by confirming the transition of IVV molecules per cycle**

Future Developments

This technique can be applied not only to protein–protein interaction analysis but also to interaction analysis between compounds and proteins. It is anticipated that it will facilitate the analysis of mechanisms of drug effects and adverse effects.

Please contact us for details.

- Associated System: Grants-in-Aid for Scientific Research, MEXT Genome Network Project
- Awards: The 3rd Shiseido Female Researcher Science Grant
- Intellectual Property: Japanese Patent No. 5712382 "Composition of biomolecular interaction analysis tool and its analysis method," Japanese Patent No. 5896511 "Detection method of proteins interacting with a target molecule"
- Technological Instruction: Highly experienced

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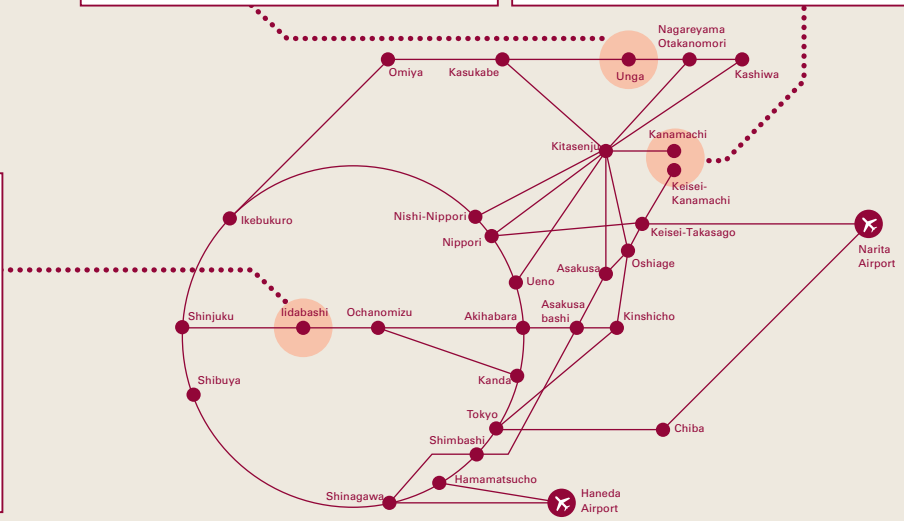

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2019.03