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東京大学生産技術研究所
Institute of Industrial Science, The University of Tokyo

Thinking hybrid!

Insights into the fabrication of biohybrid systems based on integrating biofunctional materials with micro and nano-devices

Shoji Takeuchi is focused on devising approaches to produce biohybrid systems by integrating biofunctional materials with micro and nano-devices. "I am the principle investigator of an interdisciplinary research group of approximately 60 people," says Takeuchi. "In addition to scientists with expertise ranging from informatics and mechanical engineering to biophysics and cell biology, we also members who are media artists and business administrators. We are dynamic and internationally minded with strong links groups all over the world, including CNRS in France. Some members of the group pursue multiple themes. Our 'flat system' of management has yielded many innovative ideas. One of our major goals is to produce living cells and in particular muscles from scratch. We think-hybrid."

Takeuchi recalls that his first real involvement in bio-systems was part of an undergraduate project where he designed and fabricated the world's first cyborg insect robot, whose movements during walking he controlled by attaching a tiny electrical circuit to stimulate its antenna. "This was a biohybrid system for neuroscience studies," says Takeuchi. "This experience of combining electrical circuits with living cells left a tremendous impression on me. It sparked my imagination and eventually led to my current research."

Recent research highlights

Research topics being pursued by members of the Takeuchi group include biohybrid-sensors, -reactors, and -actuators. The aims are production of biomaterials; design and control of biocompatible reactions; and self-healing and reproduction of cells.

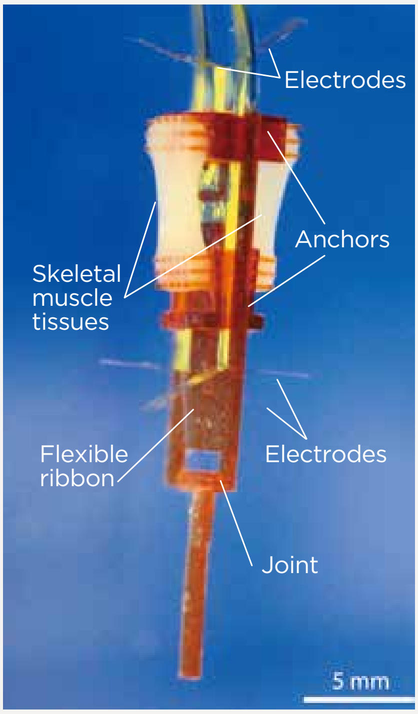
Biohybrid robot incorporating living muscle cells

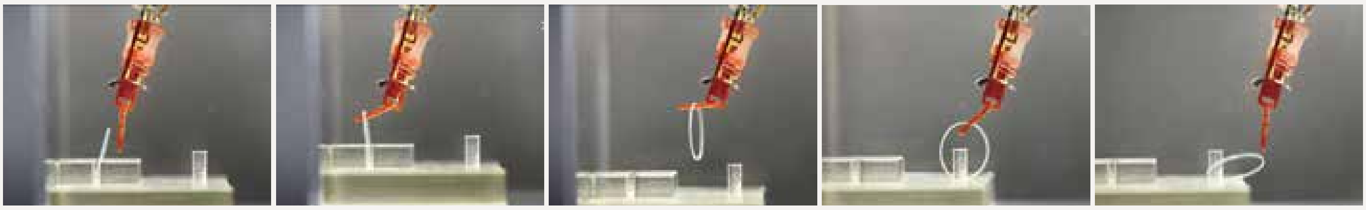
One of the fundamental distinguishing features of the biohybrid systems research at the Takeuchi group is that their designs are based on integrating living tissues, such as muscle fibers, with mechanical parts. An example of such research was recently published in the journal Science Robotics [1] where Takeuchi and colleagues produced a biohybrid robot incorporating living muscle cells that functioned as actuators for more than a week, thereby overcoming the limitations of previous work of insufficient force and short life time of the muscles.

Importantly, in this research the muscles attached to the robot skeleton were made from scratch by using hydrogel sheets that contained myoblast (precursors of muscle cells) and the resulting muscle fibers were aligned into the same direction by stripes in the sheets. Furthermore, the skeleton was designed to enable rotation and the application of electrical currents to the muscles.

The actuation principle of the biohybrid robot was based on the action of antagonistic pairs of muscles, like the human body where limbs are moved when one muscle contracts and the other in the pair relaxes—for example the biceps and triceps in arm movements. Notably, the generation of opposing forces during antagonistic action of a pair of muscle fibers stopped the muscles from shrinking, as has been reported in previous research.

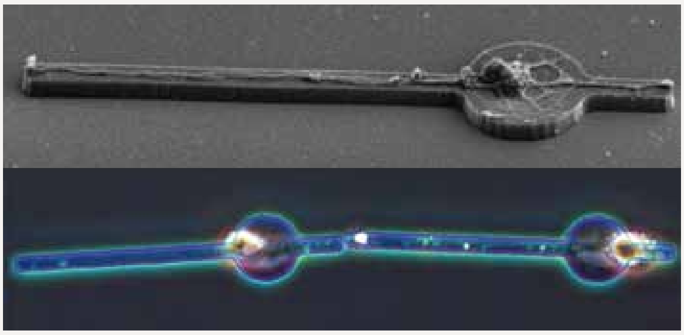
The muscles produced actions resembling 'finger flexing' at 90 degrees, thereby opening up the possibilities robots working in synchronization to lift and move objects.





Shoji Takeuchi, Professor

Artificial brain on a microplate



In vitro models for neuroscience research based on cultures in dishes are in principle excellent tools for investigating neuron interactions and brain function. However, in practice it is very difficult to control connections between neurons in cell cultures—the tendency is for neurons to form random and uncontrolled interconnections.

Recently, Takeuchi and colleagues reported on a major advance in culturing neurons where their new approach enabled the connection of neurons together one cell a time on microscopic plates [2]. This protocol is promising for research on in vitro of brain function.

The procedure consisted of using microscopic plates that were made of a synthetic neuron-adhesive material. Importantly, the shape of microscopic plate was critical in enabling control of the alignment of neurons to form neural circuits. “The microplates enabled morphological control of neurons by their shapes and bringing their ends into contact caused the formation of physical connections,” report the team.

The microplates consisted of three parts for controlling the positions of the axon, dendrite, and cell body of neurons: two protruding rectangular parts for the axon and dendrite, connected to a small circular section from opposite sides, where the cell was located. This structure enabled the well-defined growth of neurons, with the neuron's cell body on the circle, and axon and dendrites growing along rectangular branches. The single neurons were connected using a micro-manipulator yielding functional synaptic actions between them. Visual imaging methods were used to confirm that the neurons communicated with each other via synapses.

Innovative cell-fiber technology for large scale expansion of iPS cells

Takeuchi and colleagues have developed a culture system based on core-shell microfiber technology [3]. This technology has recently applied to expand human iPS cells with the potential of scaling up for regenerative medicine applications [4]. This report is a major advance for the proliferation of regenerative medicine as the basis for cell expansion.

References

1. Yuya Morimoto et al., "*Bio-hybrid robot powered by an antagonistic pair of skeletal muscle tissues*",
Science Robotics (2018), doi: 10.1126/scirobotics.aat4440

2. Shotaro Yoshida et al., "*Assembly and Connection of Micropatterned Single Neurons for Neuronal Network Formation*",
Micromachines (2018), doi: 10.3390/mi9050235

3. Hiroaki Onoe et al., "*Metre-long cell-laden microfibres exhibit tissue morphologies and functions*",
Nature Materials (2013), doi: 10.1038/nmat3606

4. Kazuhiro Ikeda et al., "*Cell fiber-based three-dimensional culture system for highly efficient expansion of human induced pluripotent stem cells*",
Scientific Reports (2017), doi: 10.1038/s41598-017-03246-2

Further information

Takeuchi Laboratory http://www.hybrid.iis.u-tokyo.ac.jp/en/

Climate systems and hydrology

Data assimilation for constructing accurate models to predict the effects of climate change on the circulation of water around the Earth and implications for disaster mitigation and evolution of human civilizations

Water covers approximately 70% of the Earth's surface and the human body consists of about 55% water—it is indispensable for life on Earth. Too much water in the form of rain causes devastating floods. Too little water leads to droughts, wildfires, and destruction of human habitat. But what causes such extreme weather patterns and can they be predicted? What can we learn from weather patterns dating back hundreds or even thousands of years and how have they affected early civilizations?

Thes are some of the questions being addressed by Kei Yoshimura as part of his research on global water cycles and paleoclimate reconstructions. "In the early days as graduate student I set up a used mass spectrometer to analyze water isotopes for a project on atmospheric water cycles," says Yoshimura. "This was the beginning of my current research on hydrology. Evaporation and condensation during global water cycles leads to the formation of heavy and light water isotopes—this is referred to as isotropic fractionation. Determining how changes in weather patterns lead to isotopic fractionation is an important part of my research."

Examples of specific themes of research being undertaken by Yoshimura and his group include the coupling Earth system models with improved land-surface/hydrological models; hydrological cycles and paleoclimate using stable water isotopes and other proxy information; and regional climate projection using Regional Earth System Model.

Kei Yoshimura, Associate Professor

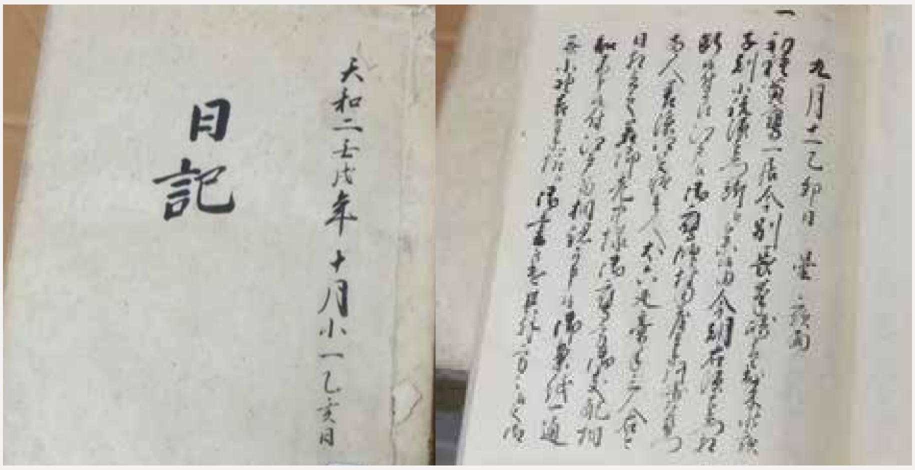
Recent research highlights

Tracking the movement of radioactive plumes

Radioactive matter from the Fukushima Daiichi nuclear plant accident in March 2011 travelled 200km through the atmosphere and reached the Tokyo metropolitan area. This was surprising considering initial alerts led to the evacuation of people living within 20–30km radius of the plant. So why did the radioactive plume reach such large distances?

To resolve these issues, Yoshimura and colleagues used a regional climate model to analyze the transport mechanisms governing the movement of radioactive plumes following the Fukushima Daiichi nuclear plant accident [1]. The major finding of this research is that the radiative plumes could travel long distances due to "nocturnal local winds" related to the northerly sea wind in the night. These results are expected to be important for planning evacuation procedures to prevent exposure to radiation plumes.

Reconstructing weather patterns from old Japanese diaries

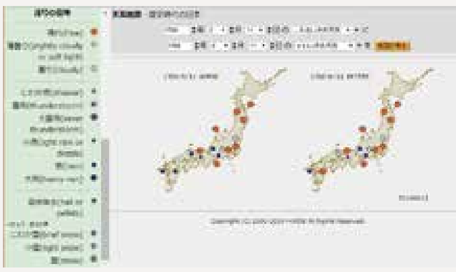


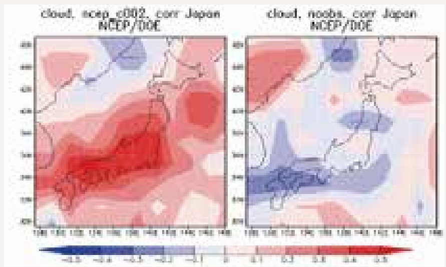
Scientists construct long term models for climate change based on historical data taken by instruments to measure factors such as rainfall, temperature, and atmospheric pressure. On the scale of the age of the Earth, reliable meteorological records have a relatively short history dating back to the beginning of the 19th century in Europe and 1870s in Japan. However, accurate models for predicting long term trends in global climate change require meteorological information dating back not tens of decades but centuries and millennia. Such paleoclimate research relies on 'climate proxies' including rocks, corals, tree rings, ice sheets, and other geo-biological based records of climate change.

"Accurate methods for data assimilation are critical for reconstructing reliable climate models," says Yoshimura. "Data from natural proxies is widely used but such information has low temporal resolution and offers limited variables, usually temperature. We decided to try a new approach by using non-instrumental historical documents from Japan that contain high resolution information on cloud cover."

Specifically, Yoshimura and colleagues used daily information about cloud cover contained in old Japanese diaries for 'historical weather reconstruction' based on high resolution 'total cloud cover' (TCC) [2]. Notably, this physics-based approach incorporates the general circulation model (GCM) and Local Ensemble Transform Kalman Filter (LETKF) and is expected to yield more information about atmospheric fields not only cloud information but also temperature.

The weather information was extracted from the Historical Weather Database on the Web (HWDB) that covers daily weather conditions recorded by 18 weathers stations in Japan between 1661 to 1892. Cloud cover records from Japanese diaries were classified into the three categories of 10% coverage for clear, 50% for partially cloudy, and 90% for cloudy. In summarizing their findings, the researchers state: "Compared with the simulation without assimilation of any observation, the results of the reanalysis data experiment show improvements, not only in TCC but also in other meteorological variables (e.g., humidity, precipitation, precipitable water, wind, and pressure)."





Climate change and evolution of human civilization

An intriguing trend in climate change research is investigating the effects of weather systems on well documented changes in the history of human civilization. Examples of reports include isotope analysis of a stalagmite that had grown continuously for nearly 2000 years in a cave in China that revealed links between the strength of the Asian Monsoon with popular unrest during several ruling dynasties in China over this period. In another paper, researchers found correlations between variations of the Indian summer monsoon for the past 5700 years with developments of civilizations in the Indus Valley.

"I am wondering if we can use our knowledge of weather patterns to find links with historical events in Japan," says Yoshimura. "For example, we may learn more about the rule of Queen Himiko in the Yayoi era."

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2. Kinya Toride et al., "*Feasibility Study of the Reconstruction of Historical Weather with Data Assimilation*", **Monthly Weather Review (2017), doi: 10.1175/WR-D-16-0288.1**

Further information

Yoshimura Laboratory http://isotope.iis.u-tokyo.ac.jp/

Historical Weather Database on the Web (HWDB) http://tk2-202-10627.vs.sakura.ne.jp/#english

TEAM KUROSHIO REACHES THE FINAL ROUND OF THE XPRIZE FOR DEEP SEA MAPPING

Autonomous underwater vehicles and imaging technology developed by IIS researchers passed rigorous technical assessment criteria to qualify for the final round of the prestigious $7M Shell Ocean Discovery XPRIZE for 3D mapping of 4000m-class seafloors.

Researchers at the Institute of Industrial Science (IIS) are playing a leading role as members of Team KUROSHIO that was formed to develop underwater vehicles and 3D imaging technology to visualize and uncover the mysteries of the Earth's deepest seafloors. Notably, Team KUROSHIO is the only group from Asia to qualify for the second and final round of the "Shell Ocean Discovery XPRIZE" competition with the goal of developing innovative approaches for rapidly mapping 4000m-class seafloors with high resolution.

Team KUROSHIO consists of members from academia, national research institutes, and industry. Associate Professor Thornton Blair, at the IIS is one of the founders of Team KUROSHIO. He has played a central role in devising technological strategies for deep sea mapping, in particular developing innovative lighting and highly sensitive sensors for color imaging from heights of 10 m above the seafloor. This technology enables autonomous underwater vehicles (AUVs) to rapidly collect data over large areas with sub-centimeter resolution for the construction of 3D maps of seafloors.
Team KUROSHIO consists of groups from the IIS at the University of Tokyo; Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Kyushu Institute of Technology; National Maritime Research Institute (NNRI), Nippon Marine Enterprises Ltd; Mitsui E&S Shipbuilding Co., Ltd; KDDI Research Inc; and Yamaha Motor Company Ltd

XPRIZE assesses the technical readiness of Team KUROSHIO's AUV

The XPRIZE was launched to encourage researchers to develop strategies for the rapid and unmanned exploration of the deep sea where no one had gone before. In the first round of the XPRIZE the potential of the AUV technology developed by Team KUROSHIO was examined by judges from the XPRIZE Foundation using dedicated underwater facilities at IIS.

The criteria for technical readiness cover 11 key areas to assess the capability of AUVs to explore large areas of seabed, rapidly and with high precision. Ultimately, in the final round, the AUVs are expected to be able to produce at least 10 images of specific targets located over 250km² of seafloor at depths of 4000m, within 24 hours.

The tests at IIS were conducted using the AE2000f AUV built by researchers at IIS in collaboration with members of Team KUROSHIO. Tests included demonstrations of the AUV's ability to capture images at the bottom a water tank, a six-hour cruise, and data recovery and processing. The judges were satisfied by the demonstrations and the technical readiness of Team KUROSHIO's AUV to meet the challenges of the XPRIZE.

The 2nd Round of the XPRIZE completion is scheduled for November/December 2018 when Team KUROSHIO will be one of the nine remaining teams selected from the original 19 contenders in the first round.

Further information
Team KUROSHIO
https://team-kuroshio.jp/en/
https://team-kuroshio.jp/en/technology/

Video of the Round One assessment
https://youtu.be/A4j84k_7Kco

Thornton Laboratory
http://ocean.iis.u-tokyo.ac.jp/research/3d.html

Investigation of collapse accident of Myaungmya bridge and safety survey of similar type bridges in Myanmar

Ruptured cable at the anchorage

On 1st April, 2018, Myaungmya bridge (suspension bridge with 180m span in Myanmar) was collapsed and two people were died. As requested by Ministry of Construction, Myanmar, Nagai laboratory conducted a site investigation of the collapse bridge together with related Japanese companies and Yangon Technological University. The main cause of the bridge collapse is rupture of the main cables due to corrosion induced by water accumulation at the anchorage. In addition, the team conducted safety survey of seven bridges in Myanmar whose construction age and structural type are similar to Myaungmya bridge. At present, severe damages were not observed, but some problems related to maintenance such as water accumulation at the main cable anchorages and damages of bearings were found.

Japan is now facing an aging problem of infrastructure. We hope this investigation result will be utilized to realize appropriate maintenance scheme for infrastructure in not only Myanmar but also the other countries including Japan.

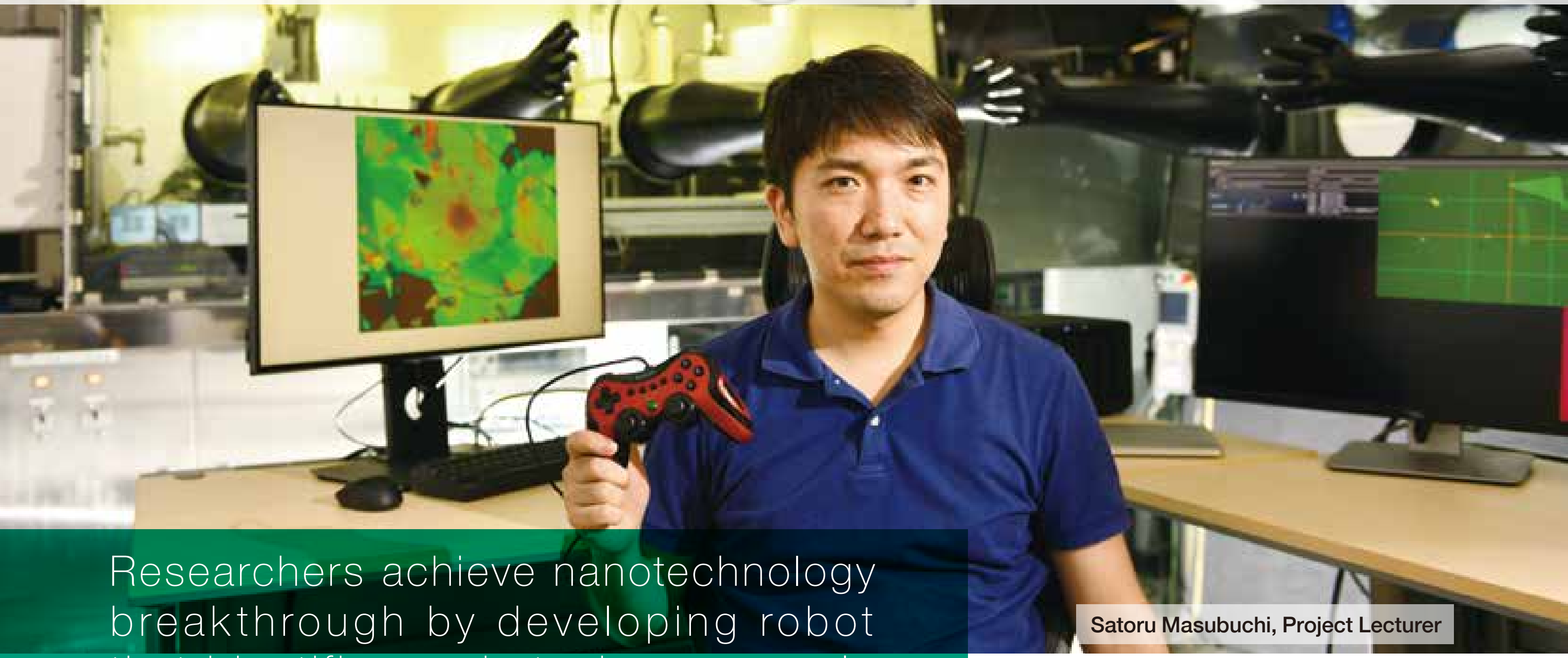
Taste of Japan

"Food event, Taste of Japan" was held at the University ground of Komaba Research Campus at lunch time on February 21st (Wednesday), sponsored by Yoshiyuki Kawazoe Laboratory. This event is an international exchange event aimed at creating campus new communication through traditional delicious food from Akita Odate.

On the day, the people of "Yo-ki na Ka-san no Mise (cheerful mother's restaurant)" in Odate city, Akita prefecture, served dishes to people in the campus, such as Kiritanpo pot, Soup, Miso rice balls, etc. Around 130 people including Japanese and international researchers, students, and university staff got to enjoy the food. Especially, the experience of making Kiritanpo fascinated many international students.

In addition, the table (produced by Gonda Metal Industry Co., Ltd.) designed by pursuing the possibility of magnesium alloy by Kawazoe Laboratory was also exhibited and used as a table for the meal during the event. The delicious traditional food has marked this event as successful.

Robot Developed for Automated Assembly of Designer Nanomaterials



Satoru Masubuchi, Project Lecturer

Researchers achieve nanotechnology breakthrough by developing robot that identifies and stacks nanoscale two-dimensional crystals.

A current area of intense interest in nanotechnology is van der Waals heterostructures, which are assemblies of atomically thin two-dimensional (2D) crystalline materials that display attractive conduction properties for use in advanced electronic devices.

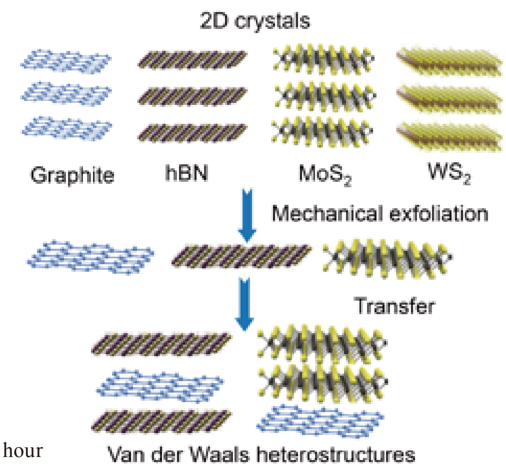
A representative 2D semiconductor is graphene, which consists of a honeycomb lattice of carbon atoms that is just one atom thick. The development of van der Waals heterostructures has been restricted by the complicated and time-consuming manual operations required to produce them. That is, the 2D crystals typically obtained by exfoliation of a bulk material need to be manually identified, collected, and then stacked by a researcher to form a van der Waals heterostructure. Such a manual process is clearly unsuitable for industrial production of electronic devices containing van der Waals heterostructures.

Now, a Japanese research team led by the Institute of Industrial Science at The University of Tokyo has solved this issue by developing an automated robot that greatly speeds up the collection of 2D crystals and their assembly to form van der Waals heterostructures. The robot consists of an automated high-speed optical microscope that detects crystals, the positions and parameters of which are then recorded in a computer database. Customized software is used to design heterostructures using the information in the database. The heterostructure is then assembled layer by layer by a robotic equipment directed by the designed computer algorithm. The findings were reported in Nature Communications.

“The robot can find, collect, and assemble 2D crystals in a glove box,” study first author Satoru Masubuchi says. “It can detect 400 graphene flakes an hour, which is much faster than the rate achieved by manual operations.”

When the robot was used to assemble graphene flakes into van der Waals heterostructures, it could stack up to four layers an hour with just a few minutes of human input required for each layer. The robot was used to produce a van der Waals heterostructure consisting of 29 alternating layers of graphene and hexagonal boron nitride (another common 2D semiconductor). The record layer number of a van der Waals heterostructure produced by manual operations is 13, so the robot has greatly increased our ability to access complex van der Waals heterostructures.

“A wide range of materials can be collected and assembled using our robot,” co-author Tomoki Machida explains. “This system provides the potential to fully explore van der Waals heterostructures.”



The development of this robot will greatly facilitate production of van der Waals heterostructures and their use in electronic devices, taking us a step closer to realizing devices containing atomic-level designer materials.

Reference

Satoru Masubuchi, Masataka Morimoto, Sei Morikawa, Momoko Onodera, Yuta Asakawa, Kenji Watanabe, Takashi Taniguchi & Tomoki Machida
“Autonomous robotic searching and assembly of two-dimensional crystals to build van der Waals superlattices”
Nature Communications (2018), doi: 10.1038/s41467-018-03723-w

Polarized Light: A Simple Route to Highly Chiral Materials

Researchers create chiral nanostructures using circularly polarized light as the sole source of chirality.

Chirality is at the heart of chemical research and much technology. For organic chemists, choosing between the left- and right-handed isomers of molecules is all part of a day's work. However, many solid materials also have enantiomeric forms, giving rise to a range of applications.

Organic chemists generally rely on an arsenal of laboratory reactions to control chiral purity. For materials, there is another, more elegant approach – circularly polarized light, which is readily made, and can be either left-circularly polarized (LCP) or right-circularly polarized (RCP). In material synthesis, the opposite twists of LCP and RCP light indirectly lead to structures that are mirror images of each other.

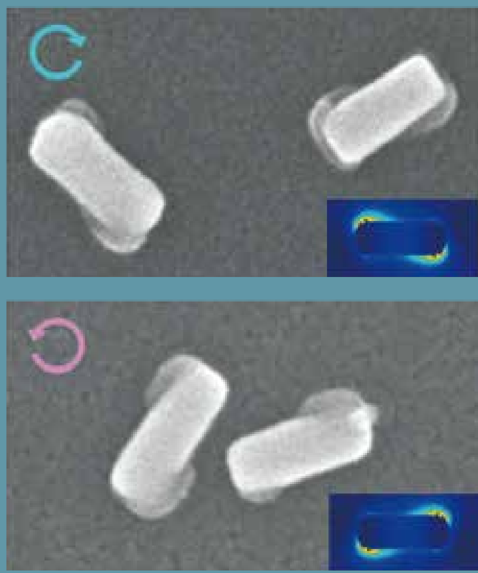
Previously, this strategy has been hampered in practice. Now, researchers at The University of Tokyo's Institute of Industrial Science have successfully created chiral nanostructures from particles of gold (Au). The trick was to use circularly polarized light to generate electric fields, which localize differently depending on LCP or RCP. This in turn drove the chiral deposition of a dielectric material.

As described in a study reported in Nano Letters, the researchers first deposited Au nanocuboids – essentially miniature rectangular gold bars – on a TiO_2 substrate.

As study co-author Koichiro Saito explains, "Under a beam of circularly polarized light, electric fields built up around the cuboids – but at one pair of corners for LCP rotation, and the opposite pair under RCP light. At this point, we had achieved chirality, but in electric rather than material form."

The chirality of the electric field was then transferred to the material itself by plasmon-induced charge separation, in which Pb^{2+} ions were oxidized through the chirally distributed electric fields. This deposited PbO_2, a dielectric material, at either one set of cuboid corners or the other, depending on the original light source. Electron microscopy showed the gold bars transformed into non-superimposable mirror images, the hallmark of chirality.

"This is the first time a chiral material has been made by exploiting plasmon resonance," co-author Tetsu Tatsuma says. "No other source of chirality is needed but light itself. Nanoscale chiral plasmonic materials are highly useful for sensing and asymmetric synthesis, and our process makes them much more efficient to produce. Plus, we don't think it's limited to one product – other chiral nanomaterials have an incredible range of functions in modern technology."



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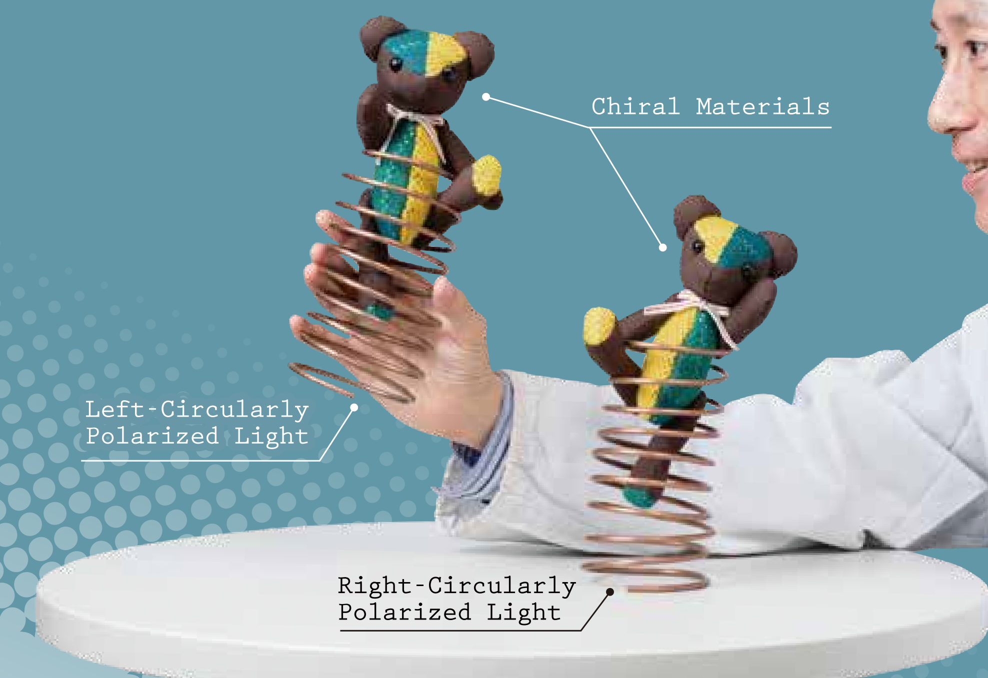
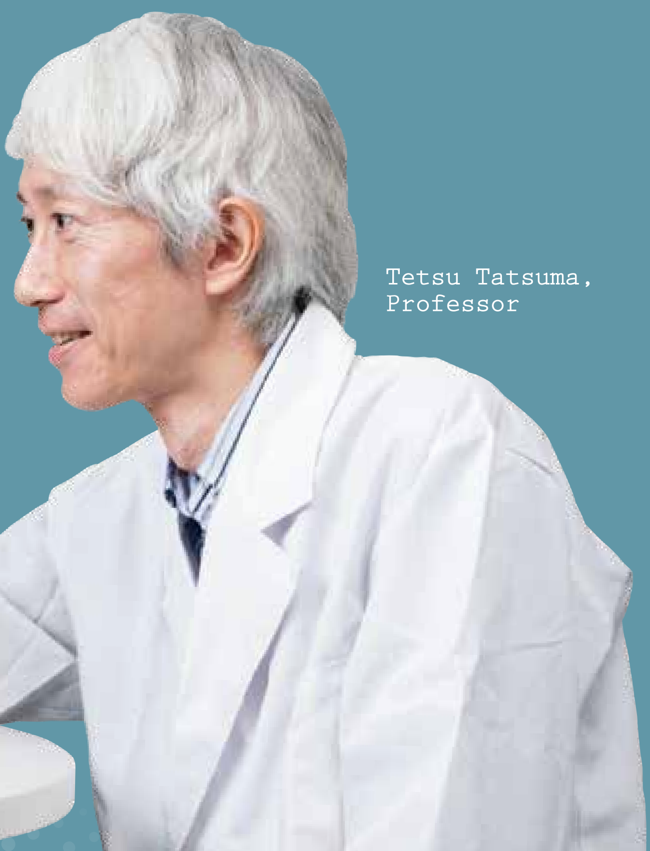
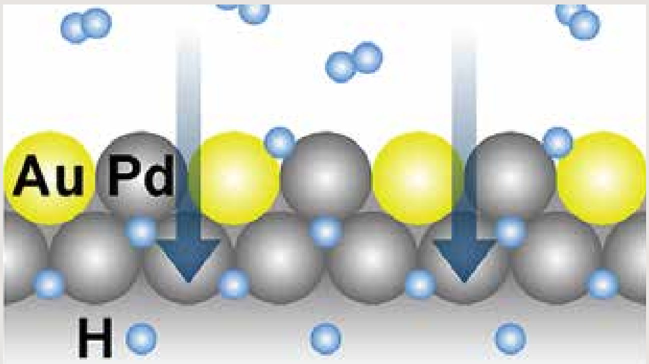
Koichiro Saito and Tetsu Tatsuma
"Chiral Plasmonic Nanostructures Fabricated by Circularly Polarized Light"
Nano Letters (2018), doi: 10.1021/acs.nanolett.8b00929





Tetsu Tatsuma, Professor

Why gold–palladium alloys are better than palladium for hydrogen storage

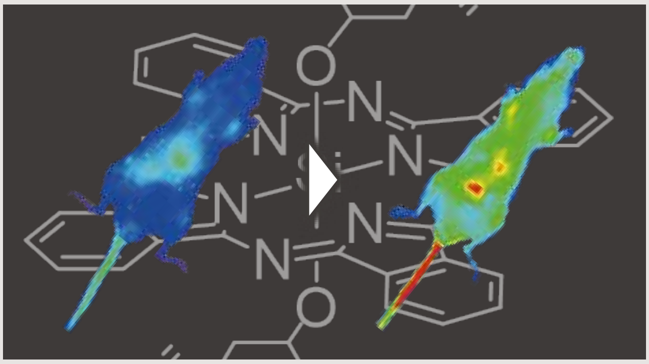


A research team led by Katsuyuki Fukutani investigated why alloying with gold improves hydrogen storage in palladium. The hydrogen concentration in sub-surface palladium was maximized when 0.4 monolayers of gold atoms were alloyed in the surface. Density functional theory calculations and photoemission spectroscopy showed that gold destabilized the surface-chemisorbed hydrogen atoms, hastening their diffusion from the surface into the interior. This will aid the design of hydrogen storage materials as energy carriers and catalysts.

PNAS (2018), doi: 10.1073/pnas.1800412115

Further information : https://www.iis.u-tokyo.ac.jp/en/news/2937/

Vitamin C in the body can be tracked by fluorescence



A research team led by Kazuyuki Ishii bio-imaged vitamin C in mice. A probe chemical emitted red fluorescent light after reacting with vitamin C in the mice's bloodstream. When a dose of exogenous vitamin C was injected, it accumulated in vital organs. This is the first bioimaging of vitamin C in living tissue, showing high sensitivity and good selectivity, paving the way toward the use of this vitamin to treat cancer.

Scientific Reports (2018), doi: 10.1038/s41598-018-19762-8

The Top 10 Scientific Reports Biochemistry and Molecular Biology papers in the first quarter of 2018

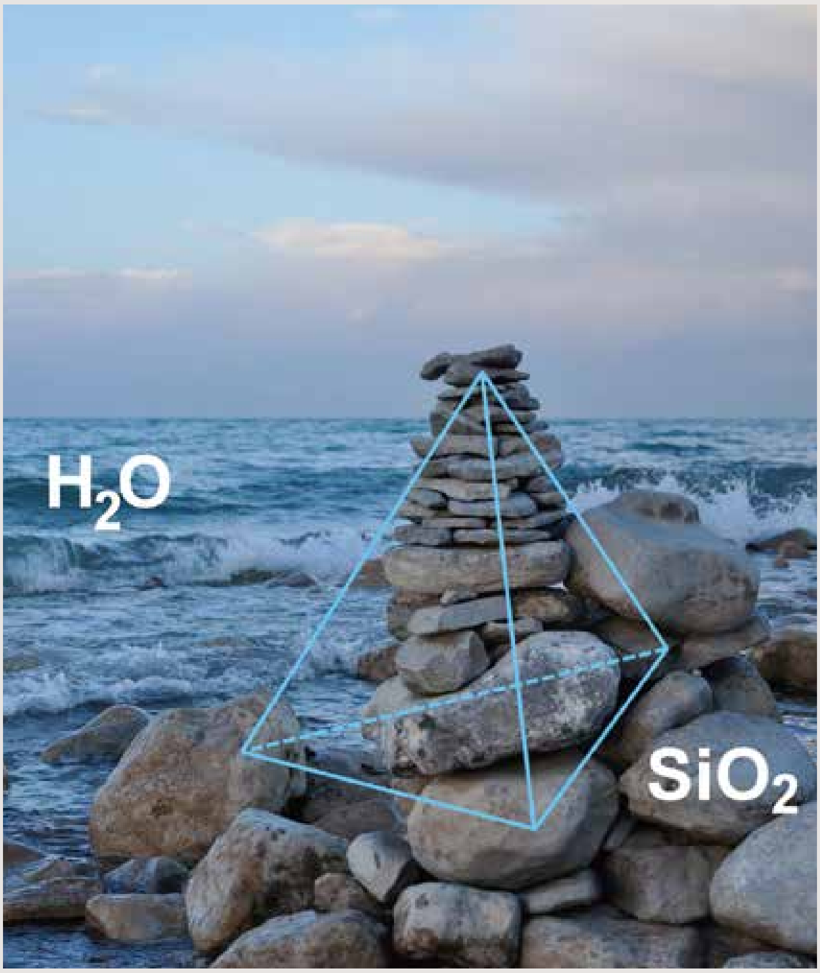
Further information : https://www.iis.u-tokyo.ac.jp/en/news/2849/

Breaking local symmetry: Why water freezes but silica forms a glass

IIS researchers Rui Shi and Hajime Tanaka simulated water and silica at low temperature. Despite structural similarities, the two liquids act differently when they are cooled: water freezes into ice, while silica continues to supercool, and eventually forms a glass. This arises from poor symmetry-breaking in silica; although atoms arrange properly in the first shell in both liquids, local rotational symmetry is harder to break in the second shell in silica, because of the less directional Si-O bonds.

PNAS (2018), doi:10.1073/pnas.1717233115

Further Information : https://www.iis.u-tokyo.ac.jp/en/news/2857/



Other recent publications by Hajime Tanaka's group

1. John Russo et al., "*Glass forming ability in systems with competing orderings*", Physical Review X (2018), doi: 10.1103/PhysRevX.8.021040
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2. John Russo et al., "*Water-like anomalies as a function of tetrahedrality*", Proceedings of the National Academy of Sciences of the United States of America (PNAS) (2018), doi: 10.1073/pnas.1722339115
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   https://www.iis.u-tokyo.ac.jp/en/news/2875/

3. Hua Tong and Hajime Tanaka, "*Revealing hidden structural order controlling both fast and slow glassy dynamics in supercooled liquids*", Physical Review X (2018), doi: 10.1103/PhysRevX.8.011041
   Further information
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UTokyo-IIS

Since its establishment in 1949, the Institute of Industrial Science at the University of Tokyo(UTokyo-IIS) is one of the largest university research institutions in Japan and its history reaches 70 years.

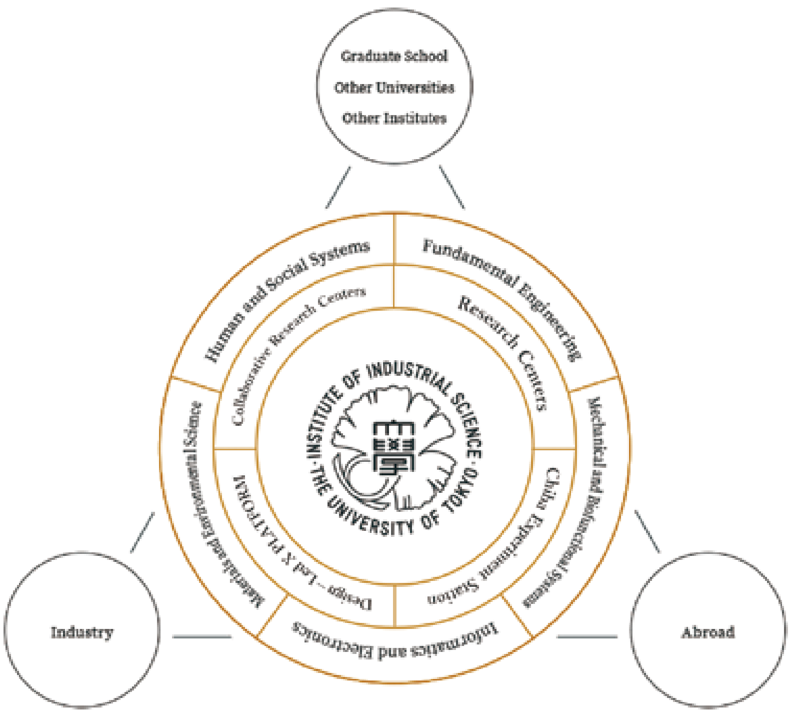
Our multidisciplinary research covers nearly all fields of engineering, and our professors, associate professors, and lecturers each lead dedicated laboratories, about 120 in total. More than 1,000 personnel, comprising approximately 300 faculty members including staffs and 750 graduate students, participate in educational and research activities that are responsible for producing excellent research outcomes and fostering outstanding talent. All our laboratories belong to one of five core research departments and some straddle multiple departments, providing the warp and weft for nine research centers, three collaborative research centers, and two international collaborative research centers. As well as promoting original research in each specialist field, we as an institution encourage cross-disciplinary and international activities. Last year saw the functions of the Chiba Experiment Station transferred from its original home in Nishi-Chiba to our Kashiwa campus, and the launch of the new Design-Led X Platform.

Since the foundation of the Institute, we have been acutely aware that the significance of academic research into engineering lies in its real-world implementation, and together with the seeding of new academic disciplines through enhanced specialization and cross-disciplinary collaboration, we have developed and deployed new technologies that contribute to solving problems in the real world. We have also made it our mission to nurture talented people to shoulder the responsibility of technological development and dissemination, especially in the industrial world. Such a philosophy and sense of mission has been programmed into our DNA since the foundation of the Institute, and we have taken a hands-on approach to address engineering challenges as a pioneer of advocacy for collaboration between industry and academia. We also take pride in the fact that our achievements and proactive stance are widely recognized together with the name *Seiken*.

Society is facing diverse problems today, and expectations are growing for the role that engineering plays in solving these problems. At the same time, the challenge for conventional engineering is that it is unable to make widely-accepted and compelling products with an approach that focuses only on technological development. For such situations that are difficult to address with engineering alone, we are seeking to build a new *Seiken* style—one that contributes to the creation of compelling value through innovation, founded on the pursuit of academic truth as a university research institute, and adding a multidisciplinary approach integrating humanities and sciences that incorporates exit strategies for real-world implementation, to the style that it is long known for: barrier-free, cross-disciplinary, practical industry–academia collaboration, and ambitious international collaboration.

Even though it is the largest of its kind in Japan, *Seiken* is perfectly sized to maintain a strong sense of organizational unity, and through our agility and collective strength as a world-class research institute in the field of engineering, we hope to continue helping to make everyone's dreams come true.

Director General　Professor　Toshiharu Kishi



Five Research Departments and Research Centers

Institute of Industrial Science, The University of Tokyo (UTokyo-IIS)
https://www.iis.u-tokyo.ac.jp/

Komaba Research Campus (Komaba II Campus)
4-6-1 Komaba Meguro-ku, TOKYO
153-8505, JAPAN
E-mail：koho@iis.u-tokyo.ac.jp

Chiba Experiment Station
5-1-5 Kashiwanoha Kashiwa-shi, CHIBA
277-8574, JAPAN
E-mail：chibajim@iis.u-tokyo.ac.jp

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The University of Tokyo

pro@iis.u-tokyo.ac.jp
https://www.iis.u-tokyo.ac.jp/