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International Center for Materials Nanoarchitectonics (MANA)

Leader's Voice

Breakthroughs Are What Make The Future

Leo Esaki

Asking the Researcher

Guoping Chen

Taking on the Challenge of Regenerative Medicine with a Nano Approach

MANA Principal Investigator (PI)
Coordinator of Nano-Life Field,
Unit Director of Tissue Regeneration Materials Unit and Biomaterials Unit

Guoping Chen

PROFILE

Ph.D. Engineering. Came to Japan in 1993 and studied at the Kyoto University Graduate School of Engineering, Department of Material Chemistry, where he received his Ph.D. Previous positions include Postdoctoral Researcher, Nara Institute of Science and Technology, Graduate School of Materials Science (1997), Postdoctoral Researcher, National Institute for Advanced Interdisciplinary Research (1998), Researcher (2000) and Senior Researcher (2003), National Institute of Advanced Industrial Science and Technology, Senior Researcher, NIMS (2004) and Group Leader (2007). Dr. Chen has been a MANA Principal Investigator and Unit Director since 2011, and has held his current position since 2015.

Asking the Researcher

Taking on the Challenge of Regenerative Medicine with a Nano Approach

Regenerative medicine is a cutting-edge field of medicine which is expected to be realized in the near future. However, many points in connection with the mechanism of tissue and organ regeneration remain to be elucidated. For example, what is the path to regeneration of tissues and organs by appropriate differentiation of stem cells ? MANA's Dr. Guoping Chen is taking on the challenge posed by these questions by an approach based on nanomaterials.

Interviewer: Akio Etori, Science Journalist

Why is regenerative medicine needed?

What kind of medical treatment is conceivable in cases where a patient has lost part of his or her body tissue or organs, or has lost physiological functions due to an illness or accident?

Conventioanl treatment takes the form of an organ transplant or an artificial organ. However, in organ transplantation, there is a chronic shortage of donor organs, and even assuming the necessary organ is available, the medical risks associated with organ transplants are hardly negligible. For example, immunorejection and medical complications caused by the use of immunosuppressant drugs are potential problems. On the other hand, artificial organs such as artificial joints can partially replace lost functions, but problems such as the maintenance necessary in long-term use still remain.

Regenerative medicine, which has attracted much interest in recent years, was proposed in order to overcome these problems. Regenerative medicine asks whether it might be possible to create new organs and tissue from cells. Although originally regarded as a nonsensical idea, regenerative medicine has been an area of active research gradually since the 1970s, and has now advanced to the stage of clinical trials in some cases.

Dr. Guoping Chen says that he also began research on regenerative medicine based on a desire to help patients with critical conditions. “When I came to Japan in 1993, the Organ Transplantation Law had still not been established in this country, so we had to ask what treatment was possible for patients with heart disease, kidney disease and other very serious conditions. At the time, the concept of regenerative medicine and tissue engineering had appeared in the United States, and the development of therapeutic methods which did not depend on donors began. I was extremely interested in this.”

The nano-sized microenvironment is deeply related to cell differentiation.

As Dr. Chen explains, “Three elements are necessary in regenerative medicine, namely, cells, cell growth factors and scaffolds. First, the cells used in regenerative medicine include stem cells such as embryonic stem cells (ES cells), induced pluripotent stem cells (iPS cells) and somatic stem cells, and somatic cells of tissues which have differentiated from stem cells. The cell growth factors control and promote proliferation and differentiation of these cells to make it possible to induce regeneration of large tissues from a small number of cells. The scaffolds are the materials where cells adhere, and also play the role of securing the space for regeneration. It is important to use these three elements individually or in appropriate combinations.”

The main type of cells which Dr. Chen uses is mesenchymal stem cells (MSC). These stem cells, which are taken from bone marrow, etc., are cultured and used clinically. Dr. Chen notes that the most difficult problem in using stem cells is control of differentiation. “The most difficult point is inducing differentiation of stem cells. The problem is how to guide the stem cells to be committed in the direction of the target tissue cell. Ideally, we would know the factor involved, but that’s also the most difficult issue. That’s a problem that researchers around the world are studying.”

As a distinctive feature of Dr. Chen’s research, he says that he attaches particular importance to the chemical and physical cues which act in stem cell differentiation, and for this reason, he focuses on nano-sized structures. “Medical and biological researchers generally attach importance to how biological factors which inherently exist in the body, for example, cytokines and other biological factors, influence cell differentiation. On the other hand, we are trying to find chemical and physical cues from the viewpoint of materials science rather than biological factors.” “The cells of tissue and organs are surrounded by a nano-sized extracellular microenvironment, and cells maintain homeostasis while interacting and exchanging information with surrounding cells via this extracellular microenvironment. If biological tissue is damaged, the extracellular microenvironment is lost together with the cells, but we are attempting to replicate the same microenvironment by supplying the proper nanostructured materials.”

Cartilage and bone are macro-sized tissues, and it can be said that the cells which make up such tissues are micro-scale. However, the even smaller, nano-sized microenvironment holds the key to the differentiation of cells.

What is a nanostructured porous scaffold?

Dr. Chen has investigated the differentiation function of stem cells in the various stages of the creation of regenerated tissue by this materials science-based approach. One representative example is a nanostructured porous scaffold which promotes regeneration of bone. As a scaffold to promote osteogenic differentiaon of stem cells for bone regenration, Dr. Chen developed a hybrid scaffold that combines microsponges of naturally derived collagen and a mesh of a synthetic copolymer (PLGA) of lactic acid and glycolic acid. This is a combination that utilizes the strong points of the two types of materials while mutually compensating for their weaknesses, in that natural polymers are biocompatible but are soft and low in strength, whereas synthetic polymers have high strength, but are inferior to natural polymers from the viewpoint of biocompatibility (see figure 1).

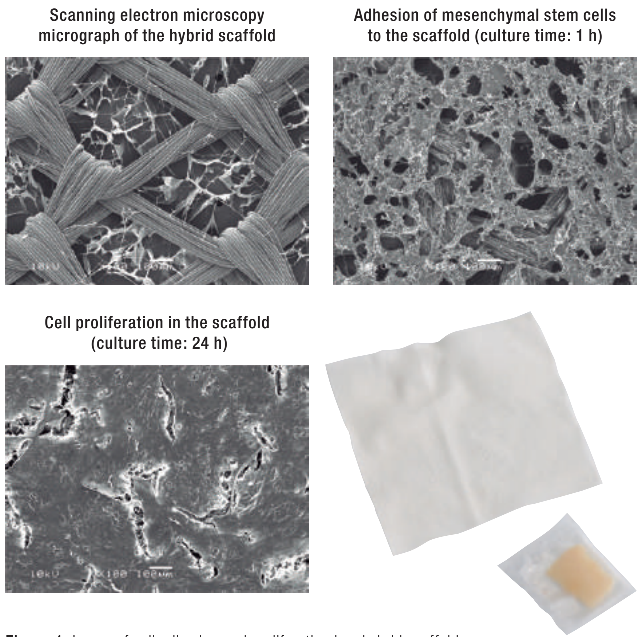


Figure 1: Image of cell adhesion and proliferation in a hybrid scaffold.

Dr. Chen also succeeded in enhancing the osteoinduction capacity of the hybrid scaffold by immobilizing the bioactive factor BMP4 (bone morphogenetic protein 4), which is known to promote osteogenic differentiation to bone, on the collagen microsponges (see figure 2). This structure mimics the in vivo nanostructured cellular microenvironment, and has been found to maintain its effect of inducing bone formation when transplanted into mice. This is a novel hybrid nanostructured porous scaffold which is a composite of a synthetic polymer and natural polymer, with the further addition of a bioactive factor.

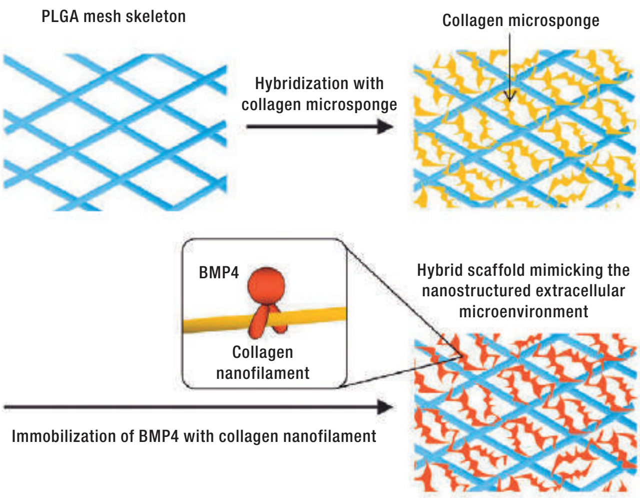


Figure 2: Illustration of the collagen/PLGA/BMP4 hybrid scaffold

Research on cell differentiation using Au nanoparticles

Dr. Chen is also engaged in research using gold (Au) nanoparticles to mimic the nanostructures of scaffolds, in which he investigates how the scaffold nanostructure itself influences cell differentiation. Although all the compositions will be replaced with naturally derived collagen in practical in vivo application, Dr. Chen prepares and studies sample structures using gold nanoparticles in order to investigate the optimal structure, geometry, surface functional group for controlling stem cell differentiation.

"One of the reasons why I use gold nanoparticles is because surface modification is easy. It's easy to introduce functional groups and bioactive molecules on the surface of gold nanoparticles. Glod nanoparticles also have good biocompatibilty." Last year, in a paper published in April 2015, Dr. Chen modified the surface of gold nanoparticles with different functional groups and disclosed the influence of functional groups on osteogenic differentiation of mesenchymal stem cells (see figure 3).

"For final usage, the functional groups can be structurally contained or artificially introduced in collagen. Based on the results, we can design the structure and prepare the scaffold by choosing optimal functional groups or molecules for a desirable differentiation."

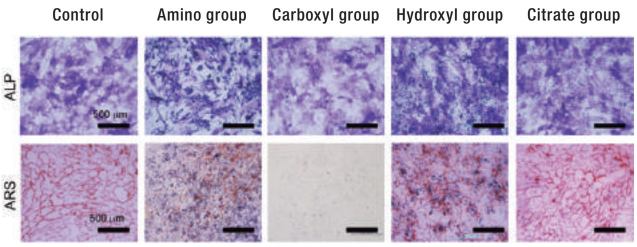
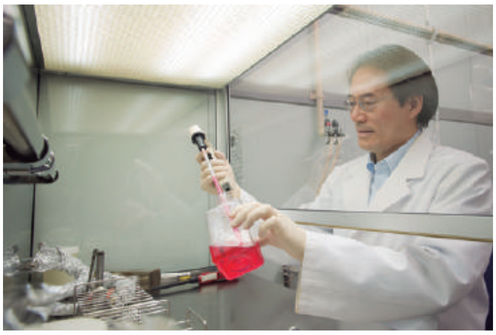


Figure 3: Influence of surface modified Au nanoparticles on osteogenic differentiation of human mesenchymal stem cells. In the photos in the upper row, the parts which are stained purple are regions where ALP exists. In the lower row, the red stained areas indicate deposited calcium phosphate that is stained with Alizarin Red S. Both results show the different influence of functional groups on osteogenic differentiation of stem cells.

Another very interesting point is that the size and shape of nonaparticles can also influence stem cell differentiation. Dr. Chen's research revealed that whether the size of Au nanoparticles is 40 nm, or 70 nm or 110 nm, and whether the shape is spherical, or rod-shaped or star-shaped, that kind of nano-level microenvironment is deeply related to stem cell differentiation. This is the world's first attempt to investigate how nano-scale microenvironments which are controlled with this kind of precision influence the differentiation of stem cells.

This series of studies by Dr. Chen challenges for controlling stem cell functions by using the approaches of nanomaterials and nanotechnology. He is striving to continue the research, aiming at biomedical applications of his achievements through collaborations with companies and medical doctors.



Admission as Fellow of the Royal Society of Chemistry

Last year, Dr. Chen was admitted as a Fellow of the Royal Society of Chemistry. Dr. Chen commented that, "While being recognized with my research achievements, I am also serving as an Associate Editor of the scientific journal 'Journal of Materials Chemistry B.' I think my selection as a Fellow also recognizes that contribution. I handle the peer review of around 300 papers a year. That's roughly 1 paper every day!"

Dr. Chen holds a concurrent position as Professor in the Doctoral Program in Materials Science and Engineering in the NIMS-Tsukuba University Joint Graduate School Program and is extremely enthusiastic in advising students. "I always work with students with the feeling that they're my own children. My stance is that I'm a strict but warmhearted advisor where research is concerned, and outside of the research setting, we're friends. I always think about communication."

The vitality of this serious, genial Dr. Chen may be the result of physical training. "In my daily life, I like sports, and I play often. I play ping-pong, badminton and sometimes basketball too. Since I'm busy, I think about how I can train efficiently in a short time. Now, running every day is indispensable for that. I go running around 10 pm every day," Dr. Chen laughs.

Finally, we asked Dr. Chen about his dream as a researcher. "I have a short-term dream and a long-term dream. In the short term, my dream is of course practical application of my present results; I want to continue to the clinical level. For example, in skin transplantation and regeneration of articular cartilage for patients with osteoarthritis (degenerative joint diseases), fields like that. However, my long-term dream, and goal, is after all treatment of cancer. In particular, I want to give patients with terminal cancers some kind of hope. Unlike early stage cancers, no effective therapeutic methods have been established for terminal cancers yet. If I can be useful, even in some small way, in improving recovery and prognosis quality-of-life by applying new materials, that is my dream for this lifetime."

The Universe of Atoms and Molecules in Batteries Explained with Supercomputer Simulations

Yoshitaka Tateyama
Group Leader
Nano Power Field

For development of a more efficient battery and solar cell

Transformation of energy management systems via success of efficient utilization of renewable energy and CO_2 zero emission is an urgent challenge facing our society. To step toward its realization, development of larger batteries and next-generation solar cells has been extensively addressed. However, neither is the establishment of high-efficiency techniques nor high reliability yet satisfactory for practical implementation. Crucial issues in the field of batteries such as lithium ion (LIB) include safer electrolyte and high-performance film at the electrolyte-electrode interface to prevent thermal runaway, and higher energy density. The recently emerging perovskite solar cell (PSC) still faces problems, such as poor durability, which limit its practical use. Due to the difficulty in experimental observations, these atomistic mechanisms remain unresolved issues.

Program development making highly-efficient use of K computer

Quantum mechanics-based first-principles calculation techniques are necessary to examine chemical reactions in electrolyte, solid electrolyte interphase film (SEI film), and material degradation. However, such calculations are computationally quite demanding, and handling of complex structures and phenomena involving vast numbers of atoms and molecules is still prohibitive. Performing further functionalization, parallelization, and acceleration of our first-principles calculation code, we succeeded in high-performance computing of the complex behavior of atoms and molecules at the battery's operational temperature on the K computer (Fig. 1).

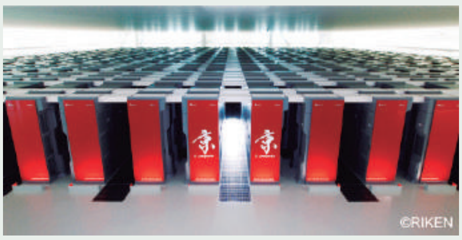


Figure 1: K computer

Atomic & molecular behaviors in batteries and solar cells revealed via supercomputer

In studies of LIBs, we demonstrated the reductive decomposition mechanism of electrolyte molecules and the subsequent processes of the decomposed products for SEI films formation, which overturned conventional understanding. (Fig. 2a) [1, 2]. Furthermore, we theoretically elucidated the electrochemical stability of highly-concentrated lithium salt electrolyte solution and the origin of its excellent transport characteristics[3]. In studies of PSC, the stability of the surface and interface of the perovskite material and the probable cation diffusion in addition to the anion were theoretically demonstrated for the first time. Then, the possible degradation mechanism and how to control it was proposed as well (Fig. 2b) [4]. We are still maintaining intensive collaborations with the experimenters as well as the industry, and solving crucial issues for fundamental science and industrial application on the atomic scale. In the near future, our computational research may play a decisive role in the transformation of energy management in our society.

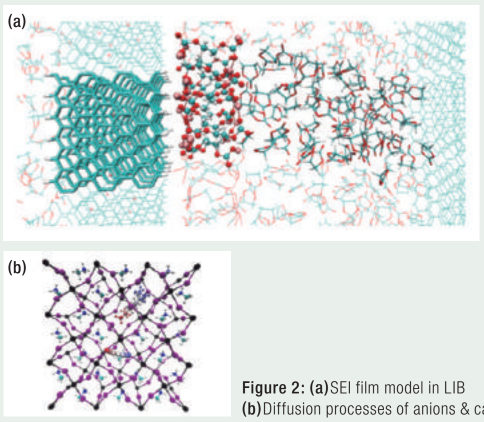


Figure 2: **(a)**SEI film model in LIB
(b) Diffusion processes of anions & cations in PSC

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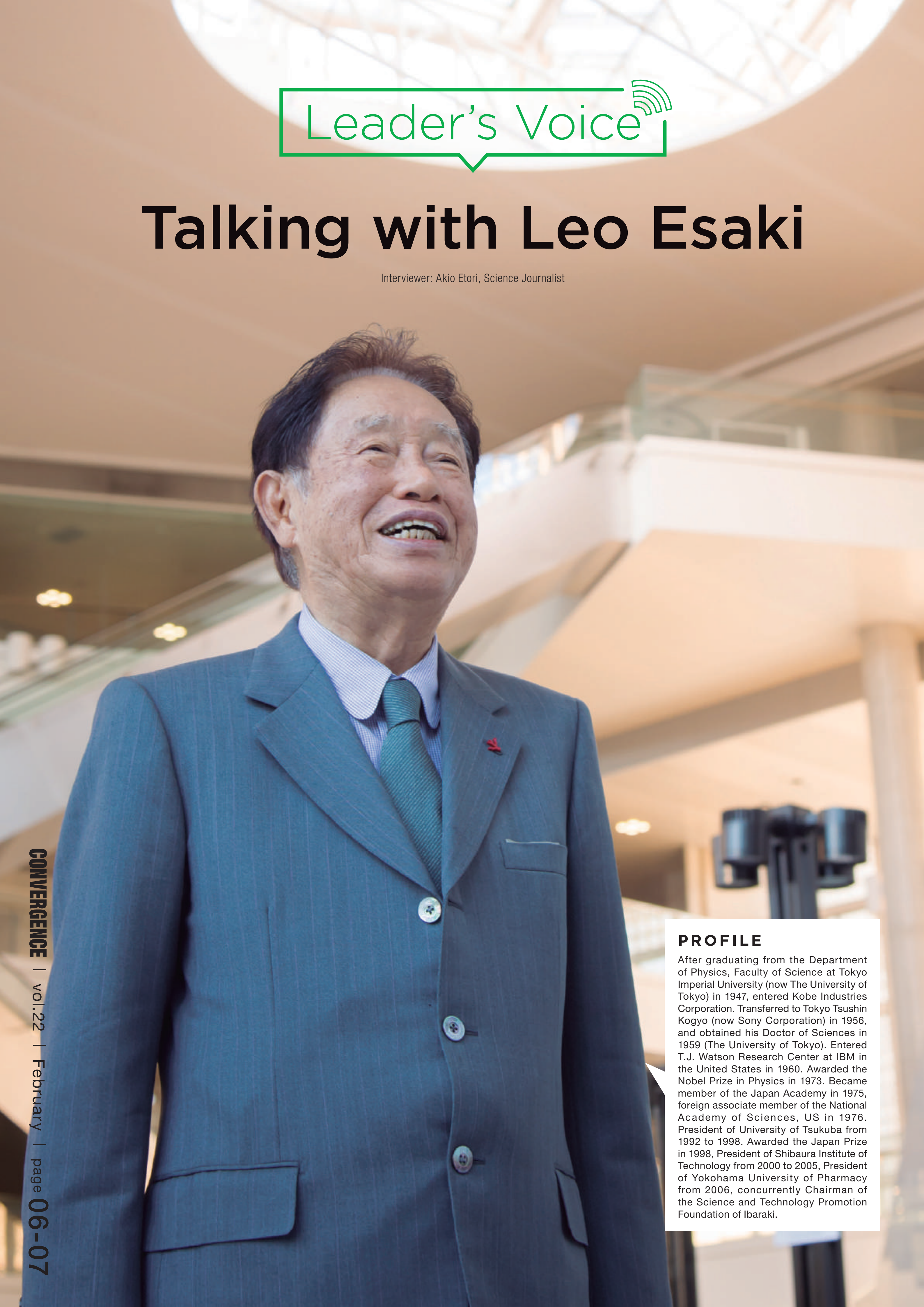
Leader's Voice

Talking with Leo Esaki

Interviewer: Akio Etori, Science Journalist



PROFILE

After graduating from the Department of Physics, Faculty of Science at Tokyo Imperial University (now The University of Tokyo) in 1947, entered Kobe Industries Corporation. Transferred to Tokyo Tsushin Kogyo (now Sony Corporation) in 1956, and obtained his Doctor of Sciences in 1959 (The University of Tokyo). Entered T.J. Watson Research Center at IBM in the United States in 1960. Awarded the Nobel Prize in Physics in 1973. Became member of the Japan Academy in 1975, foreign associate member of the National Academy of Sciences, US in 1976. President of University of Tsukuba from 1992 to 1998. Awarded the Japan Prize in 1998, President of Shibaura Institute of Technology from 2000 to 2005, President of Yokohama University of Pharmacy from 2006, concurrently Chairman of the Science and Technology Promotion Foundation of Ibaraki.

Captivated by the truth during wartime

—What was your definitive awakening to the world of science?

There is a history behind that. My first failure was the entrance exams for Kyoto Prefectural Junior High School at age 12. It was extremely discouraging, but at 13 I got into Doshisha Junior High School. That was in 1938. It was there that I was exposed to a new world of Christian-based American culture, and for me it proved beneficial to expanding my horizons. It's at the age of 13 that you begin to question authority and you can pursue things yourself. The awakening of the self. Since then, I began to think that scientific research, with its value for all humankind, was the job that I was supposed to do. I feel that being at Doshisha created the foundation for me to flourish in scientific research internationally.

—That was during the Second Sino-Japanese War.

Correct. Constant war throughout my teen years. The year after the Pearl Harbor attack, I was able to enter the Third High School ("Daisan", or "Sanko" under the Meiji-established old system, now ↗ part of Kyoto University). At the time, American B29 planes would come for reconnaissance, flying with exceeding stability high in the stratosphere where Japanese fighters simply couldn't come close. I considered this a victory not for the Americans, but for science.

Again, this was during the war but at the time there were few things I could believe in. I was searching for knowledge that anyone could put faith in, knowledge that was timeless and could be deemed absolute. I believed that the knowledge of science, having expanded humanity's limitless possibilities, and physics' argument of universal laws linking the cosmos, were to become what was most valuable.

Here's a memory from the days of war. I enrolled in the Tokyo Imperial University's Department of Physics, but the air raids had gotten worse and worse. From around midnight on March 9, 1945 until the dawn of the 10th, the Tokyo Air Raids claimed 100,000 lives among its million victims in a single night. At the time, I lived in an apartment 50 meters from Tokyo University's Red Gate, so I was able to go back home to retrieve books and such. Dawn broke on the 10th, and my Physics 1 professor Tsutomu Tanaka held his lecture at 8 A.M. as usual, and ignoring the war damage we immersed ourselves in the world of physics and desperately took notes. Professor Tanaka said nothing about the war and held class as usual. He taught us to place value on studying as top priority, no matter what happens. ↙

Breakthroughs Are What Make The Future

It was a time I felt the true existence of Tokyo Imperial University's academism.

The Frontier Spirit is to do what no one has done

—The lectures at the time were dealing with quantum theory, right?

Correct. I found lectures on quantum mechanics, which went beyond classical mechanics, to be extremely interesting, and I was deeply impressed by them. The war had ended, and I graduated in 1947 wanting to utilize my knowledge of quantum mechanics in the industry. No one in the industry knew about quantum mechanics. I intended to do what no one else had done before.

A new transistor, the point-contact transistor, came out in 1947. This was an incredible breakthrough. Until then, vacuum tubes had been used for signal amplification. I had also done research on vacuum tubes. An important point here is that had the transistor not come about, my vacuum tube research would have continued. In a stable society, people tend to think of the future as a straight continuation of the present, but breakthroughs are not the same ↗ as constantly-evolving research results. Breakthroughs lead to innovations that create the future.

Inspired by the creation of the transistor, I started research on the physics of the semiconductor, completely new in the industry at the time. Semiconductors, at the time an unexplored frontier, operated with germanium and silicon. Research in unexplored territory, with plenty of topics to study, brought great numbers of results. By researching these frontier fields, we witnessed the implementation of breakthroughs. The Esaki tunnel diode was work in such unexplored territory.

—What troubles did you face with the Esaki diode?

The challenge of the limits of thinness. I made the electron barriers of p-n junctions as thin as possible, a width of 10 nanometers. It was research from scratch. I made lab equipment by myself through trial and error. Finally in 1957, I was able to survey quantum-mechanical tunneling of electric current. Then at the same time, there was also the surprise of negative resistance. This gave diodes ground-breaking characteristics, an unexpected discovery. My hardships up until then were rewarded. Surprises like this are the true essence of science.

The following year, in June 1958, the Esaki diode attracted →

Leader's Voice

Talking with Leo Esaki

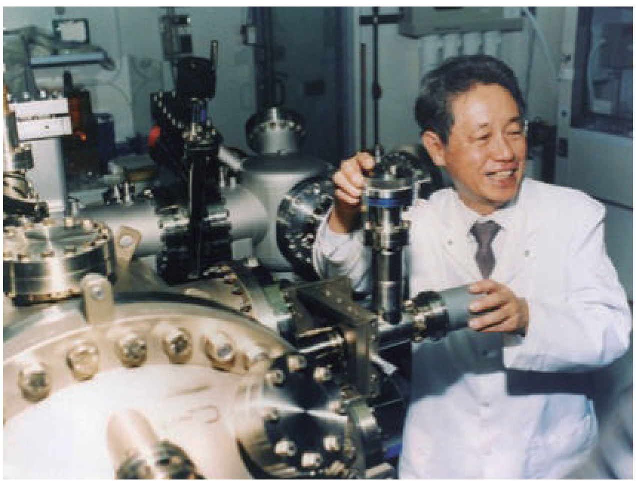
attention at the International Conference on Solid State Physics in Electronics and Telecommunications in Brussels. William Shockley, winner of the 1956 Nobel Prize in physics, praised my research results on the tunnel effect, saying "Leo Esaki will show you the most beautiful research achievement on the tunnel effect we had ever seen." Thanks to him, the lecture was packed to capacity. I was 33 at the time.

── After that, research on the Esaki diode in the U.S. really began to pick up steam.

Yes. I was called upon, invited to give lectures in many places across the states. When I went to Bell Laboratories for a lecture, there was a bust of Alexander Graham Bell accompanied by his words. I still remember them now. "Leave the beaten track occasionally and dive into the woods. You will be certain to find something you have never seen before." Moved by this, I thought, "Alright then, I'll leave the beaten track of Japan, dive into the woods of America, and test my strength." The frontier spirit.

──Then you entered the Thomas J. Watson Research Center at IBM.

In 1960, their central research facilities were still midway through construction. There, lab chief Lloyd Hunter told me to freely research whatever I thought to be of value. There are two ways of going about research - you can tackle a challenge on your own, taking a "do it my way" approach, or you can go after a hot topic many are concerned with, surrounded by competition. The latter is easier to receive funding for, while the former has the risk of receiving no appreciation until you have results to show. However, if you're lucky to have the opportunity, a breakthrough may be possible. And Dr. Hunter understood that. At the time, I was working with man-made superlattices, which of course falls into the former category of research. Thanks to that, molecular beam epitaxy research progressed greatly, and we were able to use it in creating the structure for semiconductor superlattices. With these results, I was awarded the 1998 Japan Prize. But long before that, in 1973, I was awarded the Nobel prize for my discovery of the quantum-mechanial tunnel effect. I was 48 at the time. ↗



Prof. Leo Esaki operating Molecular Beam Epitaxy at IBM Thomas J. Watson Research Center around 1988.

You play the lead in the human drama

── What expectations do you have of nanoscience from here on?

What's interesting about science is that you can't clearly predict the future of science. The future of technology we can, and why is that? It's because technology is the practical use of current science.

Fields close to the practical application of science, such as the biomedical field, will make great advancements, and gravitational wave observation using KAGRA is one I have high hopes for. Nanoscience will contribute to understanding of life through DNA. Generally speaking, interdisciplinary nanoscience is a field that we can expect groundbreaking results from in the frontier of new research.

── Anything you can share with MANA's youth?

I believe scientific research is the most valuable work that humans can do. Science precisely internalizes progress, and limitlessly magnifies the capacities of humans. Literature, music, the arts, and sports change shape along with the times, but will never progress like science will.

When I graduated from Tokyo Imperial University, I developed my own life script. I constructed a grand life plan of attempting to do things no one could do, to apply new ideas in quantum mechanics and build quantum devices. Human life is a drama where you perform the lead role, and that script is put to the test. If you can create a scenario where you harness the best of your abilities, then all you have to do is wait for the opportunity. Pasteur said, "In the fields of observation chance favors only the prepared mind."

Architectonics of Functional Molecular Liquids

Takashi Nakanishi
Independent Scientist

The Third Generation of Molecular Liquid

Matter generally has three phases: solid, liquid, and gas. Above all, when we turn our attention to molecular "liquids", small molecule-based solvents such as water, alcohol, and benzene are most common. Liquid refers to a fluctuating, fluid state where the molecules lack a definite direction and are not in fixed orientation. Since the start of the 21st century, topics in the spotlight have included the development of ionic liquids by controlling the electrostatic force of positive (cation) and negative (anion) charges of room-temperature liquid salt, and the use of electrolytes and low environmental impact reaction solvents. As for general purpose solvents and ionic liquids as new divergent third liquids (room-temperature, solvent-free), we have succeeded in the development of "functional molecular liquids", specifically liquid luminous dye[1], and using the nanocarbon substance fullerene (C_{60}) as material for liquid C_{60}.[2] The development of flexible electronic devices has been thriving in recent years, and we expect that developed functional molecular liquids will be useful as materials and ink for durable, foldable devices in the near future.

Features of Functional Molecular Liquids

The molecular design of the functional molecular liquids we have developed employs "alkyl-π engineering"[3] technology. Here, the intermolecular interaction among π-conjugated units can be regulated in-part or completely by introduced branched alkyl chains. With this molecular design, it yields various benefits as molecular materials. For example, in organic dye that typically photo-oxidizes/decomposes easily, the pigment core is protected by the alkyl chains, and stability against UV degradation increased tenfold or more. Liquid viscosity can be controlled depending on the type of introduced alkyl chain (like honey's viscosity, 10^{-2}~10^{3} Pa·s), displaying a wide range of thermal stability from -50 up to 350˚C. In addition, it can be applied to various shapes and geometric substrates without use of volatile solvents, and can be placed on microfabricated points in high density liquid materials by utilizing capillary action.

Practical Use as Photoelectric Ink

Let's look at two types of novel liquid material which make full use of the solvent function, another characteristic of functional molecular liquids (see Figure). First is the example of anthracene, a liquified blue light-emitting dye molecule. We had success in constructing single wavelength exited full-color luminescent ink material by directly mixing liquid anthracene, with its electron donor character, together with another color of electron acceptor one, such as red or green. [1]

Another type is a liquid that uses C_{60}, which also can be applied to organic thin film solar cells, as material. By adding pristine C_{60} or the alkyl chain component alkane molecule (hexane, etc) to amorphous liquid C_{60}, the C_{60} units tended to order and spherical micelles, fibrous gel, or nanosheet structures were formed. From one portion of these organized structures, C_{60}-derived photoconductivity was expressed, which demonstrates the possibility of further functionalization of liquid materials. [2]

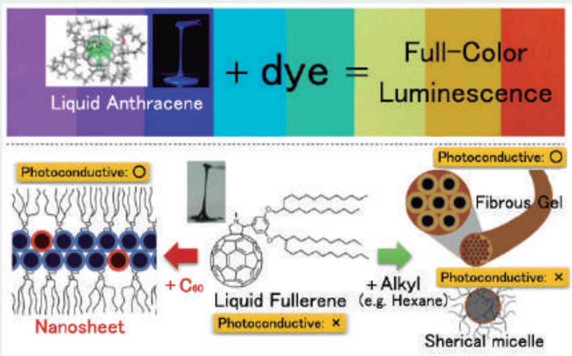


Figure: Blue light-emitting anthracene (top). Full-color luminescence tuning of ink by adding trace amount of acceptor dye. Liquid fullerene (bottom). While forming a nanosheet-like aggregate with the addition of C_{60}, the addition of alkyl components (such as hexane) forms spherical micelles or fibrous gel.

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MANA×COMPANIES

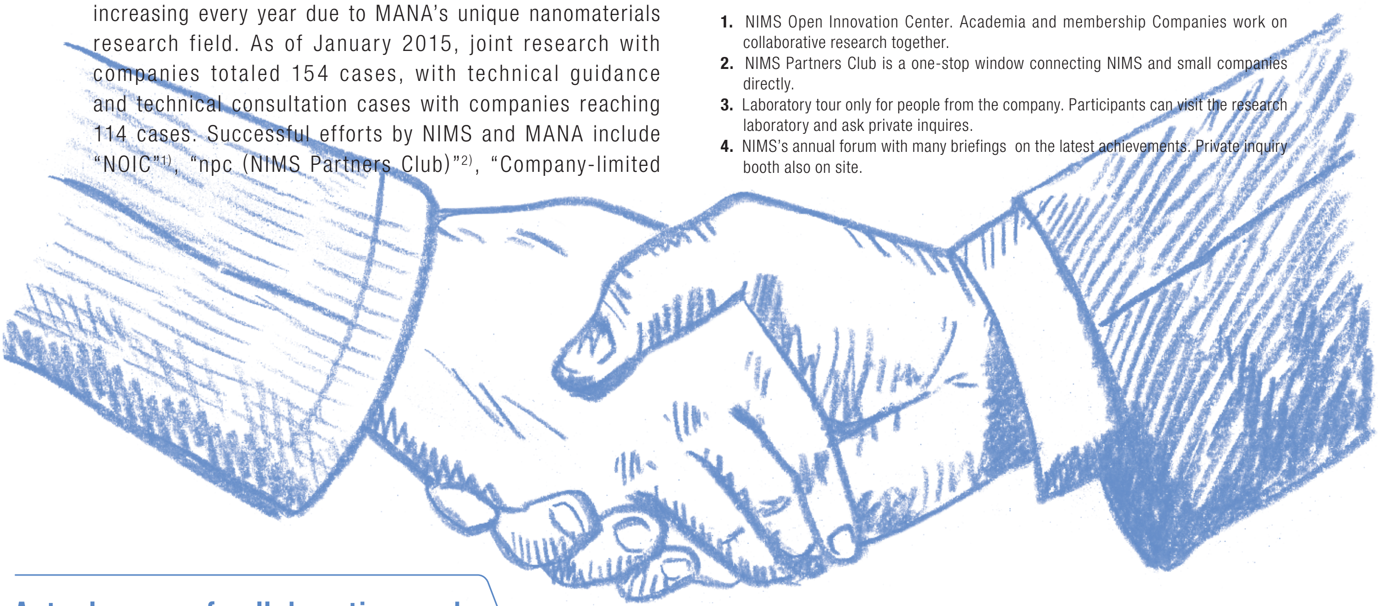
Reaching society via collaborations with companies

One of the most effective means of making use of MANA’s research in society is productization of developed materials for daily life. Sharing MANA’s knowledge and technology with companies in need can be a great contribution to society as well.

Collaboration between MANA and companies has been increasing every year due to MANA’s unique nanomaterials research field. As of January 2015, joint research with companies totaled 154 cases, with technical guidance and technical consultation cases with companies reaching 114 cases. Successful efforts by NIMS and MANA include “NOIC”[1], “npc (NIMS Partners Club)”[2], “Company-limited laboratory tour”[3] and “NIMS Forum”[4]. MANA’s research achievements have been attracted a great deal of public attention as a result.

Notes

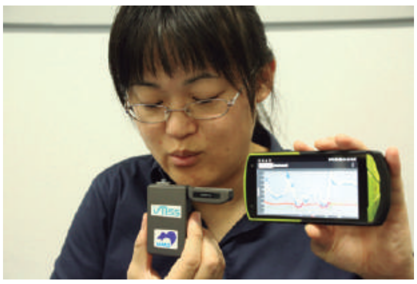
1. NIMS Open Innovation Center. Academia and membership Companies work on collaborative research together.
2. NIMS Partners Club is a one-stop window connecting NIMS and small companies directly.
3. Laboratory tour only for people from the company. Participants can visit the research laboratory and ask private inquires.
4. NIMS's annual forum with many briefings on the latest achievements. Private inquiry booth also on site.



Actual cases of collaborative work

1 MSS Alliance launched to set De Facto Standard for Odor-Sensing Systems

MSS is a sensor element jointly developed by independent scientist Genki Yoshikawa, the late Dr. Heinrich Rohrer, and Ecole Poly Technique Federale de Lausanne (EPFL). MSS has among its features an ultra-small size and ultra-high sensitivity and can be used as a breath analyzer, food evaluation system, environment measurement system, and much more. NIMS, Kyocera, Osaka University, NEC, Sumitomo Seika and NanoWorld launched the MSS Alliance with the purpose of establishing a de facto standard for odor analysis and sensor systems. This initiative is intended to accelerate practical use and popularization of this system.



Dr. Yoshikawa demonstrating mobile MSS system

2 Improving HEV with new electronic materials

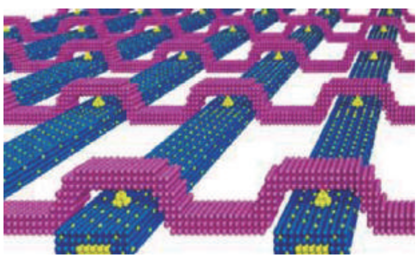
HONDA-NIMS Center of Excellence for Advanced Functionality Materials, led by group leader Kazuya Terabe, is conducting joint research with Honda Motor Co., Ltd. Upgrades of motors, power control units (PCU), and batteries are needed for improved performance of Hybrid Electric Vehicles (HEV). Novel electronic materials from the collaborative research between MANA and HONDA support HONDA’s catchphrase, “The POWER of DREAMS”.

HONDA Accord HYBRID

3 The atomic switch is being put to practical use

The atomic switch has been developed at MANA for several years. Recently, NEC Corp. has successfully used the atomic switch to innovate FPGA (Field Programmable Gate Array), the most advanced IC chip. The novel FPGA is vastly improved in functionality and production cost. It is about 1/4 in both size and power consumption, and is unaffected by interference from strong electric noises or cosmic rays when used in a robot or an artificial satellite.

This novel FPGA will play an important role for developing AI (Artificial Intelligence), Iot (Internet of Things), and much more.



Schematic figure of the original atomic switches

NEWS & TOPICS

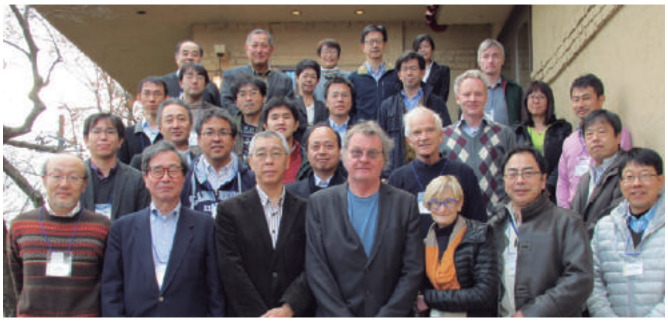
EVENT REPORTS

Tsukuba Science Festival 2015

From October 31 to November 1, 2015, MANA participated in the “Tsukuba Science Festival 2015” held at Tsukuba Capio and exhibited “Smart Polymer” at their booth. “Smart Polymer” is a material that can be used for the diagnosis and medical treatment of diseases. The Smart Polymer Rangers science show was also shown. Members of the Namiki Junior High School science club and University of Tsukuba students lended a hand as well.

ISSP-MANA Grand Challenge Meeting

From November 27 to 28, 2015, the ISSP-MANA Grand Challenge Meeting was held in Nasu, Tochigi. Both young and experienced scientists from MANA, as well as successful researchers from The Institute for Solid State Physics (The University of Tokyo) joined the event. Lively discussions about important research themes for the future were held.



MANA-RSC Symposium

From October 15 to 16, 2015, MANA and the Royal Society of Chemistry held the MANA-RSC Symposium with assistance from the University of Tsukuba and the National Institute of Advanced Industrial Science and Technology (AIST). At the event, 14 presentations by researchers involved with energy research including Prof. Fraser Armstrong (University of Oxford), and 38 poster presentations from young scientists were shown. Participants totaled more than 130 people, and one third of them were from outside of NIMS.

NEWS

Thomson Reuters’ “Highly Cited Researchers 2015” lists 5 researchers from MANA

“Highly Cited Researchers” from Thomson Reuters is an annual list recognizing leading researchers in the sciences and social sciences from around the world. They are selected from authors among the top 1% of cited scientific papers in their research field. In 2015, 5 researchers from MANA were selected as Highly Cited Researchers.

Katsuhiko Ariga
(Principal Investigator)
[Materials Science]

Yoshio Bando
(Chief Operation Officer)
[Materials Science]

Dmitri Golberg
(Principal Investigator)
[Materials Science]

Zhong Lin Wang
(Principal Investigator)
[Materials Science]
[Chemistry]
[Physics]

Omar Yaghi
(Principal Investigator)
[Chemistry]

AWARDS

Yukio Nagasaki, Satellite PI
“The Japan Society of Drug Delivery System: 15th Nagai Award”(2015.7)

Francoise Winnik, Satellite PI
“Urgel-Archambault Award 2015”(2015.10)

Mitsuhiro Ebara, MANA Scientist
“Japanese Society for Biomaterials: 37th Science Incentive Award”(2015.11)

Mahito Yamamoto, NIMS Postdoctoral Researcher
“The Japan Society of Applied Physics: 39th Young Scientist Presentation Award”(2015.11)

Christian Joachim, Satellite PI
“Europe’s Rising Stars 2015” (2015.12)

Kohei Uosaki, PI
“The Chemical Society of Japan (CSJ) Fellow” (2016.1)

Takao Mori, Group Leader
“nano tech 2016: Research Project Award”(2016.1)

EVENT NOTICES

MANA International Symposium 2016

From March 9 to 11, 2016, the MANA International Symposium 2016 will be held at the Tsukuba International Congress Center. Lectures from prominent researchers from both overseas and Japan, and orations and poster presentations by researchers from MANA regarding their latest achievements will be held. (Admission Free)

http://www.nims.go.jp/mana/2016/

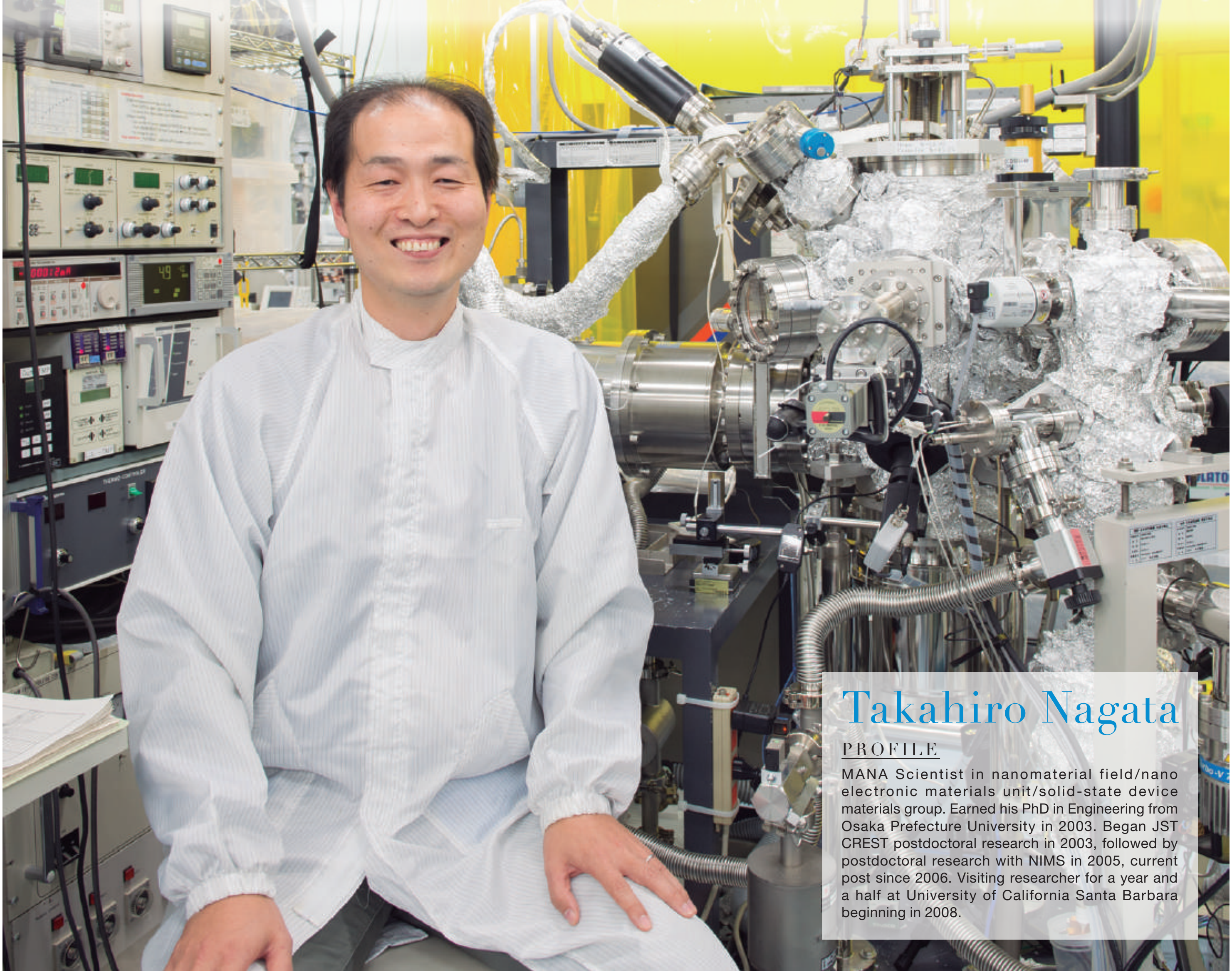
Emerging MANA Researcher

"I always liked making things; as a child I would build motors and such and play with them," says Nagata with an air of nostalgia. Deeply impressed with the success of atomic-level patterning using an IBM STM (Scanning Tunneling Microscope) while he was in high school, he took the materials system course in university and is now working in Research & Development at MANA, with high expectations for electronic application of thin film materials. Specifically, most of his research pertains to MOS (Metal Oxide Semiconductors), which enables high integration of transistor elements, and high dielectric constant materials that can be used in high temperature environment for application of power devices that implement high voltage and high current.

He is currently receiving aid from the JST (Japan Science and Technology Agency) "Sakigake" (PRESTO) program, and working on projects including development of fluoride high dielectric ultra-thin film material that can be applied to MOS structures using germanium, a next-generation alternative to silicon. Originally utilized as a bulk material, fluoride has newly discovered characteristics with possible use as electronic device material, a revolutionary proposal.

In Nagata's words, nanoarchitectonics is "how to precisely control nanostructures that we call thin film materials to meet our objectives". His greatest motivation in his research, he says, is the joy of having the initially imagined implementation of functions with self-designed materials.

He is now the father of 2 children, and says with a smile, "I treasure my days off spent with my children. Having kids makes me realize how many things I miss out on." However, we can assume his powers of observation and flexibility are used well at both home and in his research work.



Takahiro Nagata

PROFILE

MANA Scientist in nanomaterial field/nano electronic materials unit/solid-state device materials group. Earned his PhD in Engineering from Osaka Prefecture University in 2003. Began JST CREST postdoctoral research in 2003, followed by postdoctoral research with NIMS in 2005, current post since 2006. Visiting researcher for a year and a half at University of California Santa Barbara beginning in 2008.

MANA NEWS LETTER

CONVERGENCE

No.22, Eng. Ed., Issued in February, 2016

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"CONVERGENCE"
is the keyword used to symbolically describe the entire project of MANA, where outstanding researchers from around the world assemble and converge in the "melting pot" research environment to bring together key technologies into nanoarchitectonics for the creation and innovation of new functional materials.

COVER: MANA Principal Investigator
Guoping Chen and young researchers

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