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NATIONAL INSTITUTE FOR MATERIALS SCIENCE

2017
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NIMS & UTokyo

New Strategies in the era of Human Resource Mobility

NIMS&U

New Strategies in the era of Huma

The technology-driven nation Japan is at the crossroads. A specialist in high-value-added products, Japan faces increasing international competition amid globalizing markets, diversifying client needs and advances in IT technology and technological advancement in developing nations, especially in Asia. Japan's high scientific and technological standards have enabled it to survive international competition despite its natural resource disadvantage. To remain competitive, Japan needs to put technological innovations into practice more rapidly than it has in the past.

The mobility of human resources across organizations in Japan is low by global standards, frustrating the appropriate allocation of people with desirable knowledge and skills. How can Japan increase the mobility of its human resources and continue to create new value? This question drove **NIMS** and **the University of Tokyo** to undertake a pioneering initiative. They established a cross-appointment system which will enable human resource mobility across multiple organizations, thereby allowing them to implement strategic research projects in a flexible manner.

The leaders of the two organizations and nine cross-appointed researchers will share their thoughts about this collaborative initiative.

Nine researchers who have been cross-appointed since April 2017

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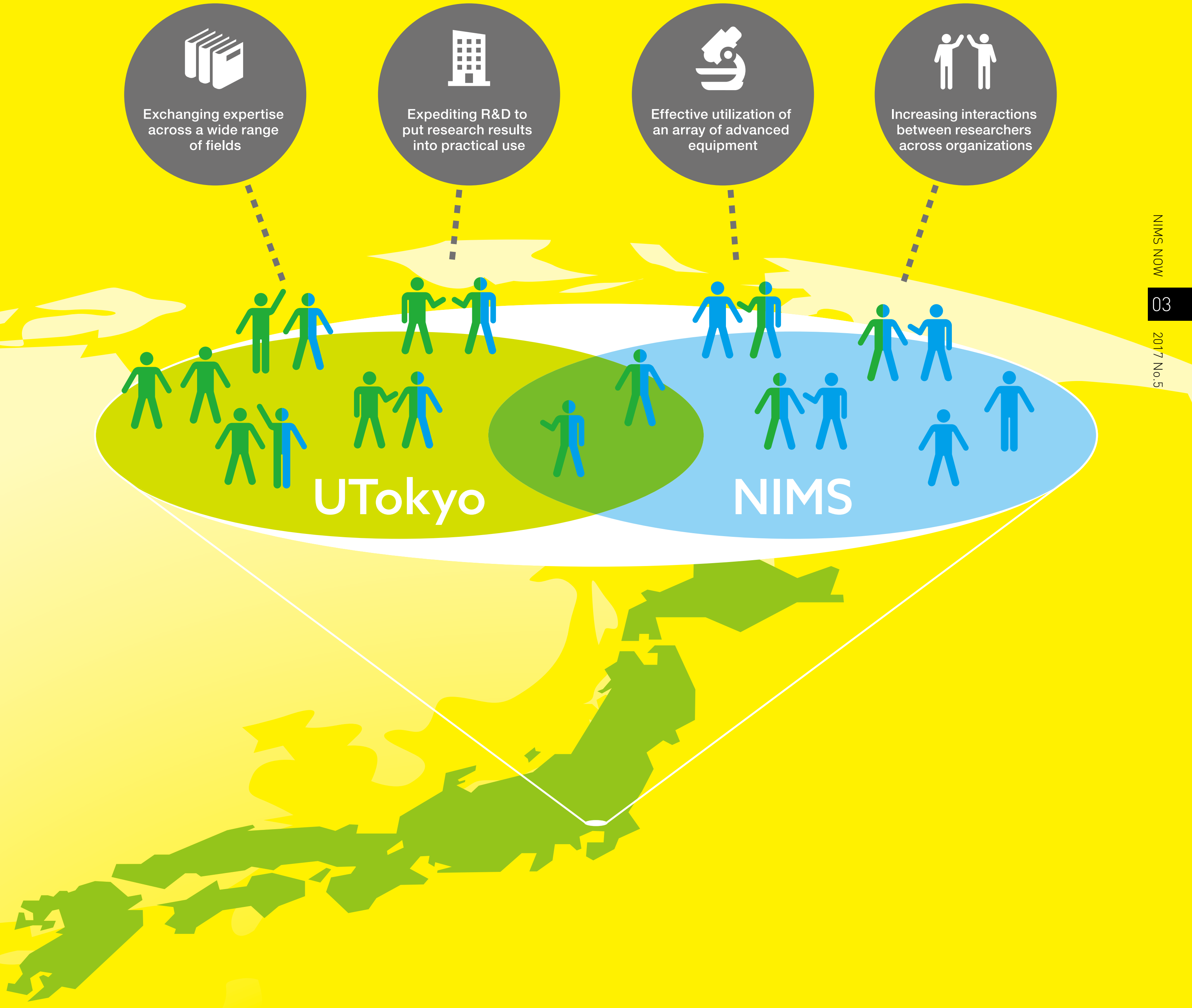
n Resource Mobility



Makoto Gonokami

President, The University of Tokyo

Organizational Cross-Appointments between NIMS and UTokyo Drive New Forms of Research

Cross-appointment systems, which enable researchers to work across multiple organizations, increase the mobility of researchers and provide greater opportunities for outstanding researchers to flourish. These systems could be pivotal in facilitating innovative research. NIMS and the University of Tokyo agreed to adopt a mutual cross-appointment system in April 2017. Nine researchers are already working on projects at the two organizations under this system. President of the University of Tokyo Makoto Gonokami and President of NIMS Kazuhito Hashimoto shared their hopes and goals for this collaborative effort.

Systems to facilitate innovative research

Hashimoto: The cross-appointment system between NIMS and the University of Tokyo has finally been launched. Four NIMS researchers and five University of Tokyo researchers have been cross-appointed so far. It all began when I brought the idea of cross-appointment to the University of Tokyo. The Japanese government strongly promotes systems of this type that enable employees of one organization to sign contracts with one or more other organizations. President Gonokami and I, among others, designed this cross-appointment system and prepared for its launch. I hope more organizations in Japan will adopt similar systems.

Gonokami: Rapid globalization is intensifying international research competition. To boost its overall research competitiveness, Japan needs to build employment systems that will give exceptionally talented researchers opportunities to fully utilize their talents in various fields, transcending boundaries. A cross-appointment system is one approach to this.

Hashimoto: There have been vigorous debates over how to promote Japan's innovation initiatives. Our cross-appointment system is a product of these debates. We are not only seeking to improve the performance of our two organizations. Rather, we should take into account the entire research community across Japan. It is crucial for us to build a system that will increase the mobility of researchers across multiple organizations, thereby strengthening Japan's international competitiveness.

Gonokami: Precisely. Some might say that one of the advantages of the cross-appointment system is the sharing of employees between organizations, which thereby reduces labor costs for each organization. However, this is completely different from what we aimed to achieve. We designed this new system to stimulate innovative research in Japan as a whole. The University of Tokyo and NIMS decided to jointly lead this effort by setting up a cross-appointment system to demonstrate the system's capacity to make outstanding researchers many times more productive.

Kazuhito Hashimoto

President, National Institute for Materials Science (NIMS)

Cross-appointment systems give more freedom to researchers

Hashimoto: I believe that the cross-appointment system is a very effective instrument for strategically strengthening specific research fields. We chose three fields this time: metals, chemistry and information science, selected nine researchers knowledgeable in these fields, and presented our proposal to the University of Tokyo.

NIMS aims to strengthen steel and polymer research capabilities via the Materials Open Platform (MOP) framework, which was launched in FY2017. MOP provides companies in the same industry opportunities to collaborate in basic research using researchers and facilities provided by NIMS. We visited many steel and chemical companies and explained the concept of MOP to them. As a result, major companies representing these industries have decided to join the MOP initiative. The key selling points we presented to these companies were that NIMS would provide our excellent researchers and cutting-edge facilities, and outstanding researchers from the University of Tokyo would join MOP using the cross-appointment system.

Gonokami: The globalization of capital markets is increasing the short-term profit expectations of Japanese companies. Consequently, it has become very difficult for these companies to continue to nurture talented personnel and carry out basic research independently. However, basic research is indispensable for their long-term prosperity, so they must maintain this function one way or another. Universities are generally expected to fill the role of meeting such basic research needs. On the other hand, some companies with specific objectives may feel that research interests at the University of Tokyo, for example, are a little too broad. When target research fields are clearly defined, as is the case here with steel and polymers, a research institution with expertise in these fields, in this case NIMS, should lead joint basic research efforts because it will be capable of coordinating the efforts efficiently and effectively. I think MOP is just the right framework for this purpose. Because public expectations for universities to apply their research results in society are increasing, frameworks such as MOP will be a good example for many other universities to strengthen their capability to meet these expectations.

Hashimoto: I appreciate your comments. I think we need to provide some sort of incentive to researchers who participate in these systems, so that they can feel the great advantages of the framework.

Gonokami: The most attractive incentive for researchers at the University of Tokyo is the fact that these systems give them greater research freedom. There are several stages in the research process. In the initial stage, it is important for researchers to take a bottom-up approach and freely undertake various research projects. Then, once promising projects are identified, progress on these projects should be accelerated by concentrating funding and human resources on them to encourage competitive research efforts. Cross-appointment of University of Tokyo researchers to other organizations may boost the number of researchers working on projects, thereby rapidly intensifying research activities. Another attractive feature is that NIMS possesses large-scale equipment that the University cannot necessarily provide on its own.

Meanwhile, we absolutely do not want cross-appointed researchers to feel that working at both organizations would restrict their freedom. Thus, we intend to provide positive support so that they feel that cross-appointments will, in fact, open up more opportunities to them.

Hashimoto: Our mission is to build a framework that will generate synergic interactions between the University of Tokyo and NIMS, bringing beneficial results to both of them. I deeply hope that this system becomes a model for other universities, national research institutes and companies.

(by Akiko Ikeda, Sci-Tech Communications)

Creating new value through collaboration on research from basic to applied

**Two researchers in different fields of study organic electronics and organic chemistry have initiated collaboration between their respective labs via a cross-appointment system.
We asked them about the current status of their collaboration and their future expectations.**

Junichi Takeya
Professor,
Department of Advanced Materials Science,
Graduate School of Frontier Sciences,
The University of Tokyo
Chief Invited Researcher,
Supermolecules Group,
WPI-International Center for Materials Nanoarchitectonics (MANA),
NIMS

Opportunity for researchers to widen their perspectives

—First, please tell us about the research projects the two of you are working on.

Takeya: My research is focused on the development of semiconductor devices, such as CMOSs (complementary metal–oxide–semiconductors), using organic materials. Unlike inorganic semiconductors, such as those made of silicon, organic semiconductors are compatible with low-cost manufacturing of large-area semiconductor devices using printing techniques. Semiconductors may be printed on light and flexible substrates to create foldable and portable displays. The two venture companies we have launched are developing IoT-compatible physical sensors that can be produced at low cost and large, lightweight digital signage displays.

Ariga: I am studying the self-assembly of organic molecules with unique functions, such as nanocars and nanomachines. In biological systems, organic molecules self-assemble into larger structures that perform various functions. My goal is to artificially reproduce naturally-occurring biological mechanisms.

In most joint research projects between the University of Tokyo and NIMS, the University performs basic research while NIMS handles applied research. However, our collaboration is very unusual reversal of this.

Takeya: Another unusual aspect of this collaboration is that Professor Ariga and I have completely different expertise, as his specialty is organic chemistry and mine is electronics, although we both work with organic materials.

—What do you think are the advantages of the cross-appointment system?

Takeya: I feel fortunate to have been cross-appointed to NIMS, with its many materials specialists. I think this type of collaboration will enhance our ability to gain a competitive edge both in research and in practical application of research achievements.

While many researchers studying organic chemical synthesis focus on the synthesis of only one type of organic molecule, Professor Ariga is trying to create so-called supramolecules by inducing multiple organic molecules to self-assemble. The organic semiconductor devices we are researching and developing are relatively large (approximately five microns); very comparable in size with the supramolecules Professor Ariga is working on.

Ariga: My cross-appointment to the University of Tokyo has given me the opportunity to interact with its students. I hope they will bring stimulating new perspectives to NIMS. Students sometimes come up with completely unexpected ideas and take surprising directions. I expect NIMS researchers to be inspired by the visiting students. This offers a great opportunity for NIMS researchers—myself included—to widen our perspectives.

Joint research initiated

—You have been cross-appointed for about five months. What has been your

Katsuhiko Ariga

Principal Investigator and a Leader of the Supermolecules Group,
WPI-International Center for Materials Nanoarchitectonics (MANA),
NIMS

Professor,
Department of Advanced Materials Science,
Graduate School of Frontier Sciences,
The University of Tokyo

experience at the two organizations?

Ariga: We are already engaged in joint research with Professor Takeya's students. We recently held a joint seminar with the Takeya Laboratory at which a student explained his research to me. I gave him some advice. I was surprised that he managed to produce promising results only one week later.

Thin film deposition at room temperature is a technique currently available to fabricate organic semiconductor devices. However, the student told me that the technique does not allow the formation of clean thin films because organic molecules bind together into clusters at room temperature. I thought this issue could be resolved if thin-film deposition techniques could be applied at 100°C or higher or at extremely low temperatures. My idea was that organic molecules would be completely separated at high temperatures. The molecules should then be properly cooled to allow them to form a clean, thin film with no molecular clustering. The student immediately experimented with this idea and succeeded in forming clean thin films. I was amazed by the potential of the students at the Takeya Laboratory and began engaging in collaborative research with them.

Takeya: My students were very fortunate to have access to Professor Ariga's advice due to his wealth of knowledge on and experience with organic materials. Professor Ariga treats the students like professional scientists, and the students actively engage in scientific discussions with him. This kind of interaction may stimulate the development of a sense of professionalism in students early in their research careers. I frequently noticed these professor-student interactions in the last five months. In a manner analogous to the self-assembly of organic molecules, I am observing the spontaneous growth of a research group between NIMS and the University of Tokyo.

—What research direction are you planning to pursue by leveraging the advantages of the affiliation between the two organizations?

Takeya: My lab and venture companies are mainly focused on R&D related to physical sensors, such as temperature and vibration sensors. Because of the close relationship we have established with Professor Ariga, we would like to take the opportunity to launch a new R&D project related to chemical sensors with NIMS as our research base. In addition we hope to have the chance to collaborate with the major corporations NIMS actively engages in joint research with to expand and advance our project to develop organic semiconductor devices.

Ariga: I intend to devote myself to intriguing, immediate research projects. Accordingly, I enjoy the inspiration I receive both at NIMS and the University of Tokyo, as I did while working with students at the Takeya Lab. It will be exciting if we can produce research results that fascinate the world. It's very thrilling for me to think about the many potential directions in which our collaboration may evolve.

(by Kumi Yamada)

Soft materials

Development of new polymers for our society

Masanobu Naito and Kazuaki Kato are developing novel adhesives which enable to joint different materials, including metals, composites, and resins. Since cross-appointment between NIMS and the University of Tokyo signed, they started a joint laboratory at the University of Tokyo.
Naito and Kato discussed their perspectives on research and education.

Kazuaki Kato

Lecturer,
Department of Advanced Materials Science
Graduate School of Frontier Sciences,
The University of Tokyo

Senior Invited Researcher,
Adhesive Materials Group
Research Center for Structural Materials,
NIMS

Practical application of novel structural materials; that is our goal

—First, please tell us about the research projects the two of you are working on.

Naito: Aiming to improve the fuel efficiency of transport vehicles, such as aircraft or automobile, it is critical to reduce their structural weight. For this reason, new manufactural concept "multimaterials" becomes important. It is to use various structural materials with appropriate combination to express best performance in specific parts of the transport vehicles or infrastructures. Manufacturing with multimaterials requires novel adhesives which enable us to connect various materials with any combination. My research background is polymer and supramolecular chemistry, and I try to apply knowledge learned from these research to practical applications of adhesive materials to various materials such as metals, polymer materials and composite materials together. We are currently studying novel adhesive materials—which were inspired from natural materials. Now, I'm developing application product in collaboration with chemical companies.

Kato: My initial research focus was supramolecular science as it applies to crystals. After completing a postdoctoral program overseas, I started working as a researcher under the guidance of Professor Kohzo Ito at the University of Tokyo. I decided to pursue this career because I was impressed by Professor Ito's research on "slide-ring gels."

A slide-ring gel is a material composed of necklace-like polymers called polyrotaxanes that are connected to each other (crosslinked). Because the crosslinking points between polymers slide along the backbone polymers freely, the material is capable of dispersing stress applied to it.

I was intrigued by the physical properties of polyrotaxanes. Some parts of a polyrotaxane are innately capable of moving freely to a certain extent. Because of this property, the polymer can avoid receiving excessive stress by utilizing stress-generated energy for movement. We recently succeeded in strengthening a hard material composed of non-crosslinked polyrotaxanes by taking advantage of the polymeric properties.

In addition, our lab and collaborating companies jointly discovered that the strength of polymeric materials can be increased by adding only a small amount of polyrotaxanes to them. We are currently investigating the strengthening mechanism and developing polymeric structural materials.

Cultivation of students with innovative mind

—You have been cross-appointed for about five months. What has been your experience at the two organizations, and what are your future expectations?

Kato: I joined the Adhesive Materials Group led by Dr. Naito at NIMS this April. I am preparing to launch a research project with support from NIMS staff and researchers.

In addition, the Naito-Kato Laboratory was inaugurated at the University of Tokyo Kashiwa Campus. We are preparing new research projects for prospective students enrolling in FY2018.

Masanobu Naito

Group Leader,
Adhesive Materials Group
Research Center for Structural Materials,
NIMS

Associate Professor,
Department of Advanced Materials Science
Graduate School of Frontier Sciences,
The University of Tokyo

Naito: I manage laboratory at NIMS and at the university in a different way. We, NIMS researchers, usually conduct both organizational and our own project. By comparison, university researchers basically can decide the direction of research based on their freewheeling thinking. However, they always have to keep in mind the educational aspects. I look forward to working with the students in the University of Tokyo. I also expect synergic effects in research and education through collaboration between NIMS researchers and the students.

Kato: NIMS facilities recently became available for our use. Both my students and I are very thrilled about this opportunity.

The structural materials we study can fulfill their purposes only if they are put into practical use. From this viewpoint, collaboration with NIMS is a big advantage for us because NIMS carries out basic research while envisioning the subsequent applied research step, conducts applied research while envisioning practical application of the research products, and is actively engaged in joint research with companies. I want the students to feel the guiding principle of NIMS researchers first hand: the true value of materials is in their use.

Naito: I am carrying out a number of research projects in collaboration with chemical manufacturers. So, the students will have opportunities to gain firsthand experience in R&D efforts that assume practical application of research products.

I want to see the students conducting research while thinking flexibly and creatively and without being constrained within the frames of basic or applied research. I hope that this type of collaboration will encourage many students with innovative minds as possible. I think it is my task at the University of Tokyo, to create those environments for students.

—What research direction are you planning to pursue?

Naito: Most research projects conducted at NIMS assume practical application of research products in five to seven years. At the University of Tokyo, I would like to conduct research that will contribute to the development of an ideal society in 20 to 30 years, as envisioned in the Society 5.0* concept. I look forward to taking on challenging research projects—which I want to call "intellectual adventures"—while encouraging the students to bring fresh ideas.

Kato: When I participated in the NIMS WEEK event last October, in which the latest NIMS research accomplishments were presented, I felt that NIMS has an excellent system to support its researchers in publicizing their research results to the world. I was particularly impressed by the fact that NIMS effectively presents its selling points to companies. It is uncommon for university researchers to take this kind of action. Since I am now cross-appointed with NIMS, I would like to actively publicize my research accomplishments and thereby accelerate our R&D efforts that assume practical application of research products.

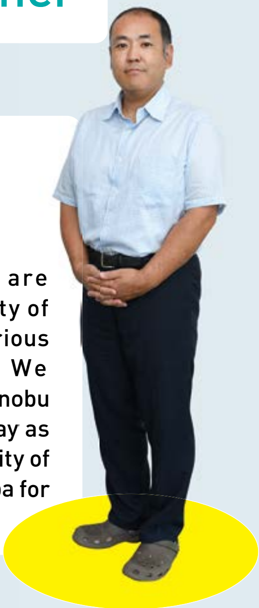
(by Kumi Yamada)

* Society 5.0 is a series of initiatives to put the "super-smart society" concept into practice. The aim of the concept is to bring abundant life to people in Japan by integrating cyberspace into physical space (the real world).

A day in the life of a cross-appointed researcher

Masanobu Naito's day

Cross-appointed researchers are affiliated with both the University of Tokyo and NIMS. You might be curious about their daily schedules. We shadowed NIMS group leader Masanobu Naito (associate professor) for a day as he commuted between the University of Tokyo Kashiwa Campus and Tsukuba for his research.



At the University of Tokyo

8:00

Starting the day by checking email

Starts his day by checking his email at his University of Tokyo office. He communicates with the companies with which he is conducting joint research and gives instructions to researchers in his group at NIMS.

10:30

Meeting with an equipment manufacturer

He carefully examined documents to determine the specifications and sizes of new equipment to be placed in his lab.

12:00

Lunch

Usually has a quick meal in his lab, but sometimes eats in the cafeteria when time allows.

Commuting to NIMS

13:00

Discussion with Dr. Kato

Discusses future directions for their joint research on polymer materials with Dr. Kato. The informal discussion unexpectedly turned into a heated debate!

16:30

Meeting with a postdoctoral researcher

Confirming the progress of the development of an adhesive that is removable as needed with an additional new function. Upon reviewing the research results, he gave the postdoc advice.

20:00

NIMS summer night festival

After many meetings, he joined the annual NIMS summer night festival. Enjoyed informal conversation with NIMS staff in a relaxed atmosphere.

Metals

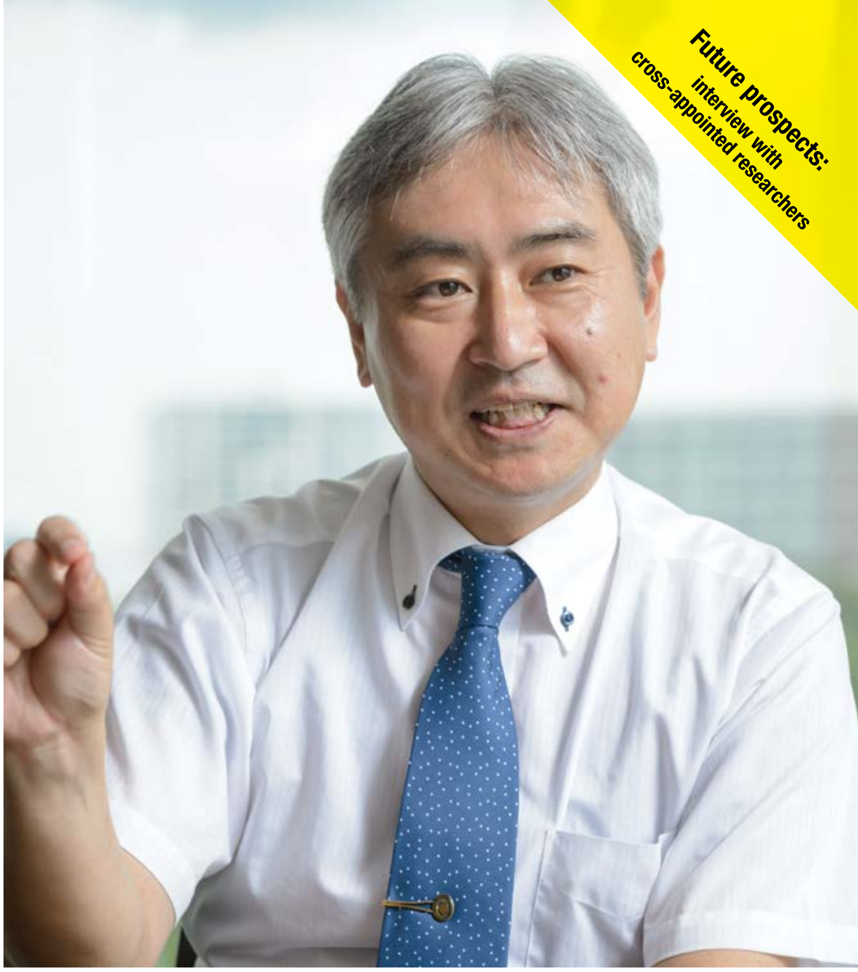
Application of light and strong magnesium alloys in domestic aircraft

Eiji Abe, the Professor of the University of Tokyo, is developing magnesium alloys suitable for use in automobile and airplane bodies. He signed a cross-appointment contract with NIMS, his previous workplace, in order to accelerate his research by leveraging the advantages of the two institutions. We asked him about the future prospects of the project.

Eiji Abe

Professor,
Department of Materials Engineering,
The University of Tokyo

Chief Invited Researcher,
Computational Structural Materials Design Group,
Research Center for Structural Materials,
NIMS



Investigating methods of strengthening alloys by leveraging the assist of computational science

—First, please tell us about your research project.

My specialty is analyzing the structure of metal materials at the atomic level using a state-of-the-art electron microscope (EM). When I analyzed the structure of magnesium alloys using an EM several years ago, I discovered a crystalline structure that made the alloy stronger. This structure—since named the long period stacking ordered (LPSO) structure—is now drawing global attention.

Current aircraft bodies are composed of lightweight, high-strength aluminum alloys. If aluminum alloys can be replaced with even lighter magnesium alloys, aircraft weights could be reduced by approximately one-third. This is why magnesium alloys are currently the subject of active research and development around the world.

The development of metal materials has long relied on the intuition and experience of veteran engineers. It is critical, however, to understand the mechanisms involved in strengthening these materials in order to expedite their development amid intensifying competition to develop new metal materials.

Thus, I am striving to identify the roles of the constituent elements in a magnesium alloy in the alloy's strength. I am using three approaches in this investigation: advanced measurement using an EM, crystalline structure analysis at vast research facilities, such as SPring-8 and numerical simulations using computers.

I have recently become very interested in materials informatics (MI). When running a numerical simulation that uses first-principles calculations, computational complexity rapidly increases as the number of chemical elements composing the crystal under analysis increases. The full utilization of machine learning and data mining in MI will be a promising technique to efficiently search for new or alternative materials.

—You have been cross-appointed for about five months. What has been your experience at the two organizations?

I was affiliated with NIMS for about 10 years before joining the faculty of the University of Tokyo in 2004. Even during my time there, NIMS was undertaking a full-scale initiative to incorporate computational science into materials research. I seconded a graduate student to the Computational Structural Materials Design Group at NIMS last year. She has been carrying out computational science studies there.

She has already produced some interesting results. She recently studied a thermally stable magnesium alloy to which zinc and yttrium had been added. She found from her computational science studies that the interaction between zinc and yttrium was particularly important to the thermal stability of the alloy. This is a significant discovery in understanding the relationship between the crystalline structures and thermodynamic properties of alloys.

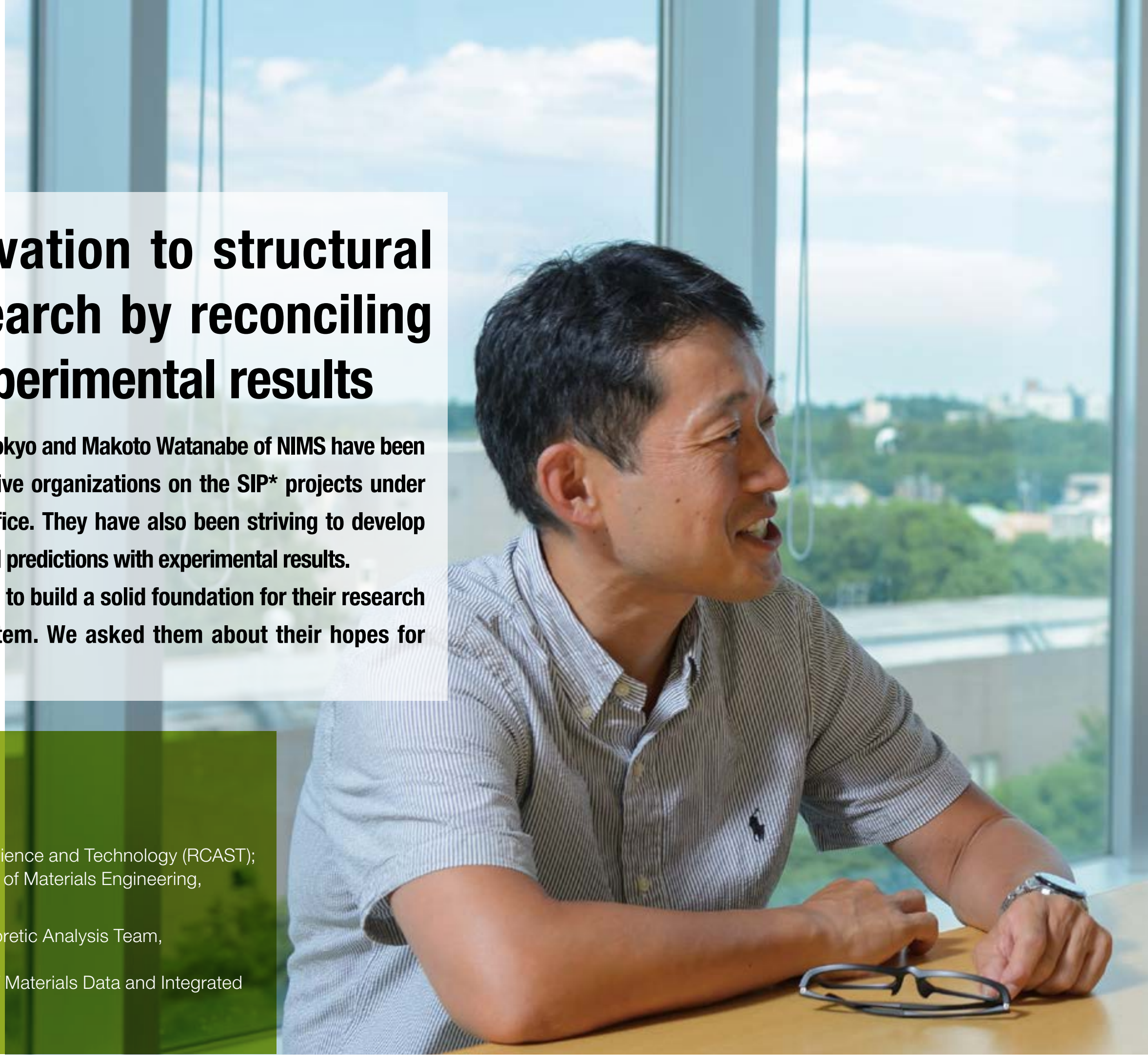
—What research direction are you planning to pursue by leveraging the advantages of the affiliation between the two organizations?

We will try to accelerate our development of magnesium alloys by fully utilizing both the University of Tokyo and NIMS facilities and collaborating with companies. My dream is the actual future use in domestic aircraft of alloy products we develop.

I would also like to repay NIMS for allowing me the freedom to conduct independent research when I was young. I had a lot of fun during my 10 years there. I intend to invite many students to NIMS to introduce them to the joy of research.
(by Kumi Yamada)

Metals

Bringing innovation to structural materials research by reconciling theory with experimental results



Junya Inoue of the University of Tokyo and Makoto Watanabe of NIMS have been closely integrating their respective organizations on the SIP* projects under the leadership of the Cabinet Office. They have also been striving to develop techniques to reconcile theoretical predictions with experimental results.
Both researchers have been able to build a solid foundation for their research via the cross-appointment system. We asked them about their hopes for future activities.

Junya Inoue
Associate Professor,
Research Center for Advanced Science and Technology (RCAST);
also affiliated with the Department of Materials Engineering,
The University of Tokyo

Leader, Practical Information-Theoretic Analysis Team,
SIP-MI Laboratory
Research and Services Division of Materials Data and Integrated System (MaDIS), NIMS

Accelerating the development of metal materials through MI*

—First, please tell us about the research projects the two of you are working on.

Watanabe: My area of expertise is materials manufacturing processes involving the use of metal powders and non-destructive inspection of materials. A non-destructive inspection usually means detection of defects in completed material products using ultrasound or X-rays without destruction. However, inspection techniques are not limited to these. I am trying to reduce defects in metal materials by monitoring material manufacturing processes and thereby understand how crystalline structures in materials are formed.

For example, I am currently studying metal product manufacturing processes, such as thermal spraying and additive fabrication, in which metal particles are repeatedly sprayed and heated to form metal layers. High-quality materials may be developed by monitoring various parameters, such as the speed at which particles are sprayed, the temperature to which they are heated and the temperature of the equipment.

Inoue: The initial focus of my research was structural materials for use in infrastructure projects. My main approaches were to use theoretical calculations and computer simulations. However, my interest in actually creating structural materials grew over time, and I began working with a variety of metals, including steel, aluminum and magnesium. I have been researching metal materials ever since.

The deformability of steel is one of my research interests. Demand is high today for steel materials that are strong yet formable. If steel plate can be shaped into desirable forms using a press, manufacturing costs can be reduced. The capability of steel materials to deform without breaking in response to impact is also important from a safety perspective. The development of high-strength steel requires the use of martensite, a very hard form of steel crystalline structure. I am currently studying the mechanisms involved in martensitic transformation through direct observation and other means.

The large discrepancies between theoretical calculations and experimental results were striking to me in these studies. While I was considering how to resolve the discrepancies, the SIP program was launched and the SIP-MI Lab opened. I saw this as a great opportunity and joined the lab. I thought the lab would be helpful in resolving the discrepancies between theory and results.

Watanabe: MI is a new concept that integrates theory, experiment, calculation and data as they apply to materials science. MI enables researchers to choose appropriate materials and processes, predict the performance of materials and develop them in a rational manner.

In principle, materials should be designed from the perspective of the manufacturing processes in which they are to be used. If MI could enable me to identify metal materials that could be efficiently produced at a high level of quality for a given manufacturing process, it would be very useful in my research.

Inoue: After joining the SIP-MI Laboratory, I initiated joint research with NIMS

Makoto Watanabe

Leader,
Integrated Smart Materials Group,
Research Center for Structural Materials;
also a Director of the SIP-MI Laboratory,
MaDIS, NIMS

Associate Professor, RCAST;
also affiliated with the Department of Materials Engineering,
The University of Tokyo

researchers, including lab director Watanabe. We are currently developing tools for constructing an MI system.

Diverse expertise and student participation are stimulating research activities.

—What do you think are the advantages of the cross-appointment system?

Inoue: Dr. Watanabe and I have been jointly engaged in an SIP project. Even after completing the project, our cross-appointments will continue. I hope that we will develop a solid, long-term collaborative relationship.

It has also been a great advantage for me to have greater access to the world-class experimental and measuring equipment at NIMS. The University of Tokyo also has various equipment, but most is dedicated to use by specific faculty members and not available for shared use; I cannot use it whenever I want to. Readily accessible equipment reduces the restrictions on my research and can expedite my research efforts.

Watanabe: The greatest advantage of the cross-appointment system for me is that I have become a University of Tokyo faculty member with the privilege to confer degrees on graduates. This is the big difference from the conventional collaboration with Universities. I think this arrangement will make it easier for students to carry out research under my supervision and may therefore attract more students to our lab. NIMS would also welcome increased student involvement as it may bring stimulating new perspectives.

—What research direction are you planning to pursue by leveraging the advantages of the affiliation between the two organizations?

Watanabe: I am affiliated with RCAST at the University of Tokyo, which brings professors from a wide range of disciplines together, including social technology and artificial intelligence. This provides a very stimulating working environment. I want to widen my research perspectives by interacting with professors in fields unrelated to materials.

Inoue: My research is currently focused on metal materials, but structural materials also include many other types of materials. NIMS has researchers specializing in all kinds of materials. I want to broaden my network with NIMS researchers and eventually expand my research to include non-metal materials.

It is difficult for University of Tokyo researchers to find companies to conduct joint research with and to incorporate the needs of companies into their research plans if they remain within the university environment. By comparison, NIMS is actively engaged in joint research with companies. I hope to strengthen collaboration with companies via NIMS and thereby put our research results into practice.

(by Kumi Yamada)

*SIP stands for “Cross-ministerial Strategic Innovation Promotion Program” led by the Cabinet Office. A total of 11 national project categories—including the “innovative structural materials” projects in which Inoue and Watanabe have been involved—were set under the SIP.

*MI is an abbreviation for “materials integration” within the context of the SIP. MI also refers to “materials informatics” within the context of the MI^{2}I (see p. 15) projects.

Information science

Expediting development of materials through full use of information science

Koji Tsuda of the University of Tokyo and Ryo Tamura of NIMS are experts in information science and materials science, respectively. Each is delving deeply into the other's field in a joint effort to formulate materials informatics (MI*) techniques.
Tsuda and Tamura are now seconded to one another's groups via a cross-appointment system. We asked them about their ambitions.

Koji Tsuda

Professor,
Department of Computational Biology and Medical Sciences, Graduate School of Frontier Sciences, The University of Tokyo

Chief Invited Researcher,
Data Science Group Center for Materials Research by Information Integration (CMI[2]),
Research and Services Division of Materials Data and Integrated System (MaDIS),
NIMS

Leveraging information science in materials development

—First, please tell us about the research projects the two of you are working on.

Tsuda: My specialty is bioinformatics. I have been researching and developing computational techniques for analyzing large quantities of biological data, such as genetics and protein data. I was invited to join the NIMS-led MI[2]I* in July 2015. I have been engaged in a novel research challenge ever since: the application of information science to the materials field or MI. One benefit of integrating MI into materials science is that the approach can reduce research costs. For example, if an MI approach can reduce the number of experiments required for a research project from 100 to 10, the cost and duration of the project can be reduced, and the money and time saved can be allocated to other research.

Among the various information science approaches available, I have focused my efforts mainly on machine learning-based prediction. In one recent MI[2]I project accomplishment, I was able to predict maximum and minimum thermal resistance for a given nanostructure using a new computational technique I developed. These results may be applicable to the development of technologies to control heat transport within materials. Such technologies may, for example, increase the heat radiation of electronic devices and the efficiency of thermoelectric conversion elements, thereby making them more energy efficient.

Tamura: I was initially conducting a theoretical study of magnetic materials at the NIMS International Center for Young Scientists (ICYS). When MI[2]I opened two years ago, I joined it to learn about MI. I have been studying computational techniques in information science ever since.

While working at MI[2]I, I participated in NIMS-led collaborative R&D involving industry, national research institutes and academia to develop an odor sensor called a Membrane-type Surface stress Sensor (MSS). We succeeded in determining the alcohol content of odor samples using a combination of an MSS and machine learning. We first collected a large amount of data correlating electrical signal patterns with odor samples and the alcohol content of the samples. We then created the machine learning model by the collected data, which enabled it to estimate the alcohol content of unknown odor samples. This technique is applicable to odor detection in a variety of settings, such as environmental monitoring and measuring the maturity and freshness of food products.

—You have been cross-appointed for about five months. What has been your experience at the two organizations?

Tsuda: I am an information science expert but a novice in materials science. I need advice from materials scientists on the application of machine learning to materials science. Fortunately, I have been able to learn about various aspects of materials from NIMS. Dr. Tamura, who is now affiliated with my lab, has introduced me to other NIMS researchers and my cross-appointment to NIMS has also been educational.

On the other hand, I have also been told that materials science is a very complex disci-

Ryo Tamura

Researcher,
Data Science Group CMI^2, MaDIS, NIMS

Lecturer,
Department of Computational Biology and Medical Sciences, Graduate School of Frontier Sciences, The University of Tokyo

pline and that it is more challenging for information science experts to familiarize themselves with materials science than vice versa. If this is the case, I hope that Dr. Tamura will be able to effectively apply information science to materials research.

Tamura: I am really excited to have the opportunity to fully study information science at the Tsuda Laboratory. The lab's researchers, including Professor Tsuda, are currently teaching me the various techniques used in information science. Every day is stimulating. A stream of new ideas has been coming to me, including the potential application of information science to certain materials development processes. However, I am focusing only on learning at this point and hope to be ready to actually put these ideas into practice in the near future.

Facilitating the advancement of MI by effectively utilizing the cross-appointment system

—What research direction are you planning to pursue by leveraging the advantages of the affiliation between the two organizations?

Tsuda: I believe that a deeper understanding of materials science will assist me in creating groundbreaking materials using MI.

In addition, I would like to actively engage in joint research with materials scientists at NIMS. This interaction may provide NIMS researchers with opportunities to master information science and become skillful in the use of computational techniques. If some acquire such knowledge and skills, they should be able to perform MI research without my support. I intend to assist them in reaching that goal.

Tamura: We need more researchers at NIMS capable of applying information science techniques so that NIMS can truly serve as an MI research center. It is also very important for NIMS researchers to recognize the benefits of MI. For these reasons, I want to gain at least an adequate level of information science knowledge and establish an MI research center at NIMS as a venue for application of the "fourth scientific method." I hope that Professor Tsuda and other University of Tokyo information science researchers will teach NIMS researchers about the computational techniques they use. I also plan to demonstrate the usefulness of MI in the development of new materials using as many real-world examples as possible.

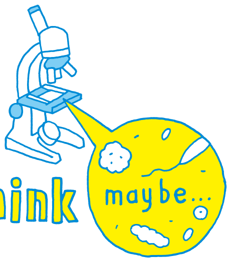
Tsuda: The MI field is still developing and has not yet fully matured. However, I have no doubt that MI will establish itself as a distinctive field of study within the next several years, as bioinformatics did in the past. MI research has been greatly accelerating in the United States and China, and Japan must not be left behind. I hope to contribute to the advancement of MI by effectively utilizing the cross-appointment system.

(by Kumi Yamada)

*MI stands for "materials informatics" within the context of the MI^{2}I projects. MI also refers to "materials integration" within the context of the SIP program led by the Cabinet Office (see p. 13).

*MI^{2}I stands for the "Materials Research by Information Integration Initiative," a project launched to fulfill the requirements of the "Support Program for Starting up Innovation Hubs" led by the Japan Science and Technology Agency (JST). The objective of MI^{2}I is to facilitate the design of novel materials by bringing people engaged in materials science, information science and mathematical science in the private sector, academia and at national research institutes together to build databases and apply data science in an integrated manner, and to encourage participation by a wide range of companies.

Science is even more amazing than you think



Dr. Yoshio Nishina

Text by Akio Etori
Illustration by Joe Okada (vision track)

Long ago, researchers were expected to focus on their own research subjects to the exclusion of virtually everything else.

However, science and technology have become increasingly advanced and complex. Scientific researchers are now not only required to take an interdisciplinary approach; they also need to be knowledgeable about seemingly unrelated topics, such as economics and politics. In other words, they are required to be versatile and have a broad range of expertise. Thus, researchers capable of multitasking have been assigned to influential projects and have led Japan's progress in science and industrial technology.

When I think of multitalented researchers, Dr. Yoshio Nishina (1890-1951) comes to mind immediately.

Dr. Nishina studied under Professor Niels Bohr in Copenhagen, Denmark, which led him to become an outstanding physicist. He became famous internationally when he and Professor Oskar Klein published the Klein-Nishina formula, which gives a differential cross section of photons scattered from an electron when it is subjected to X-rays or gamma rays.

After returning Japan, Dr. Nishina devoted himself to fostering the careers of young researchers, many of whom became world-class physicists. He also engaged in a wide range of research projects, including research on cosmic rays and the measurement of the mass of mesons. His most famous achievement was the construction of cyclotrons in Japan.

A cyclotron was a vital instrument for physics research which was enormously expensive to construct. To raise funds for its construction, Dr. Nishina frequently gave lectures, wrote articles for magazines and appeared on the radio to raise public awareness of the importance of science.

In addition to physics, the cyclotrons were used by a variety of other disciplines, such as medicine and biology. The military also planned to use cyclotrons to develop atomic bombs.

Dr. Nishina assumed leadership of the nuclear research program in order to attract substantial funding for his scientific research from the military and bring Japan's many talented young physicists together. His actions prevented these researchers from being forced into military service, saving many of their lives. Two of Dr. Nishina's students, Professors Hideki Yukawa and Shinichiro Tomonaga, later became the first and second Japanese Nobel Prize winners, respectively.

The US occupation authorities ordered Dr. Nishina's cyclotrons to be disassembled and disposed of in Tokyo Bay after the end of World War II. This was heartbreaking for Dr. Nishina and was criticized by scientists around the world.

Dr. Nishina remained very active after World War II, working to restore Japan's scientific capabilities.

He led RIKEN in an effort to promote science, becoming its director of RIKEN after it was converted into a private company. Financially challenged, he sought ways of translating research results into commercial products. Dr. Nishina's lab (the director's office) has been preserved as he left it, with his last writings on the blackboard: a list of commercial product ideas.

Rutin, B12, ACTH*1 and athlete's foot (medicine)

These ideas later developed into a group of companies called the RIKEN Group, including RIKEN Vitamin.

When Dr. Nishina passed away at the age of 60, Professor Tomonaga lamented the loss of one of the giants of physics. A scientist associated with Nishina described him as, "a man of a broad research perspectives and of exemplary character." "He energetically pursued theoretical and experimental approaches to physics and worked on the administrative aspects of scientific endeavors. He is truly the father of atomic physics in Japan and a leader in the global scientific community."*2

*1 ACTH: adrenocorticotropic hormone
*2 Ryohei Nakane et al. (eds.) "Yoshio Nishina ōfukushokanshū" (Collection of correspondence with Yoshio Nishina), Misuzu Shobo Publishing Co.

Akio Etori: Born in 1934. Science journalist. After graduating from College of Arts and Sciences, the University of Tokyo, he produced mainly science programs as a television producer and director at Nihon Educational Television (current TV Asahi) and TV Tokyo, after which he became the editor in chief of the science magazine Nikkei Science. Successively he held posts including director of Nikkei Science Inc., executive director of Mita Press Inc., visiting professor of the Research Center for Advanced Science and Technology, the University of Tokyo, and director of the Japan Science Foundation.

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To subscribe, contact:
Dr. Yasufumi Nakamichi, Publisher
Public Relations Office, NIMS
1-2-1 Sengen, Tsukuba, Ibaraki, 305-0047 JAPAN
Phone: +81-29-859-2026, Fax: +81-29-859-2017
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