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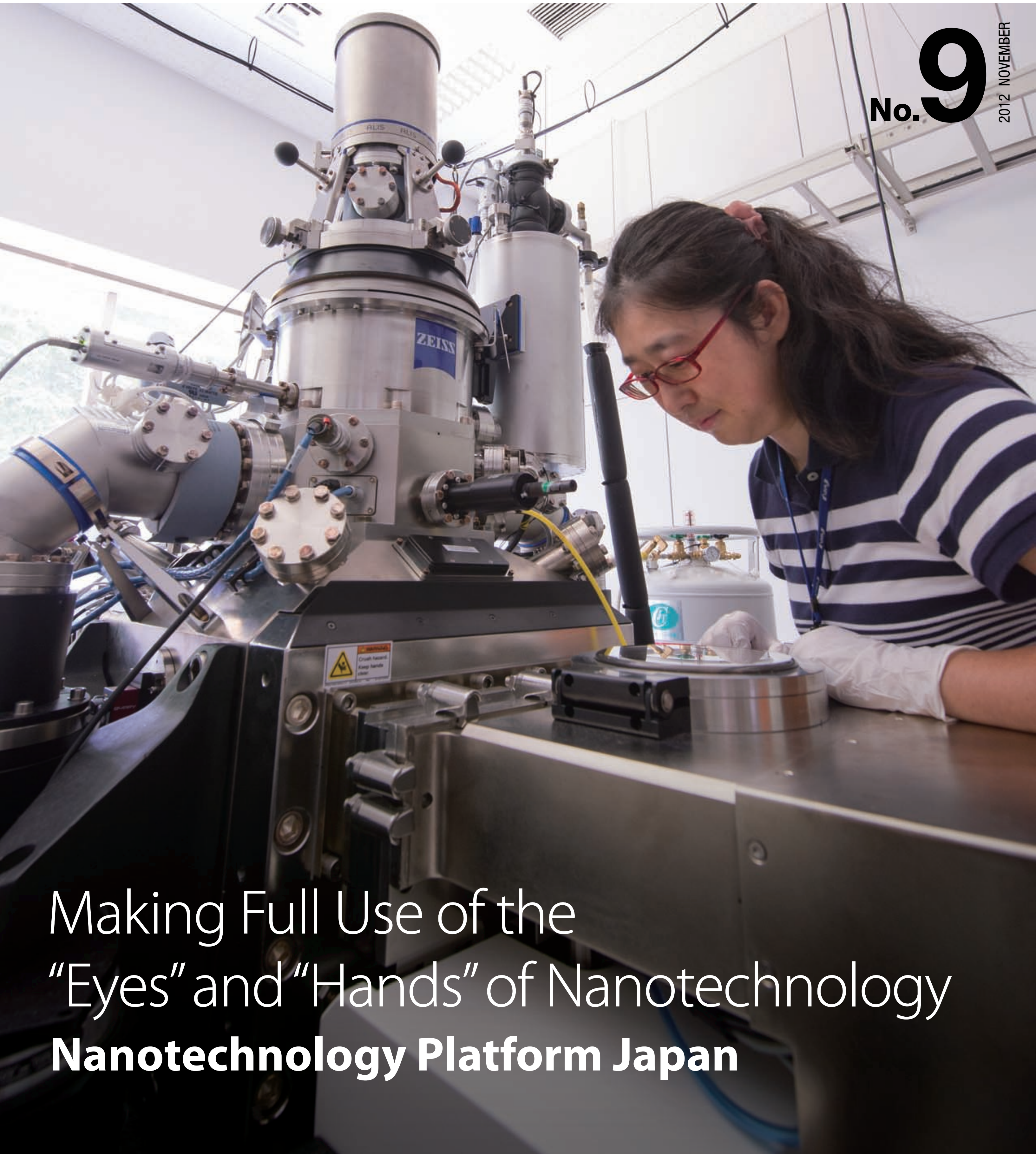


No.9 2012 NOVEMBER

Making Full Use of the “Eyes” and “Hands” of Nanotechnology

Nanotechnology Platform Japan

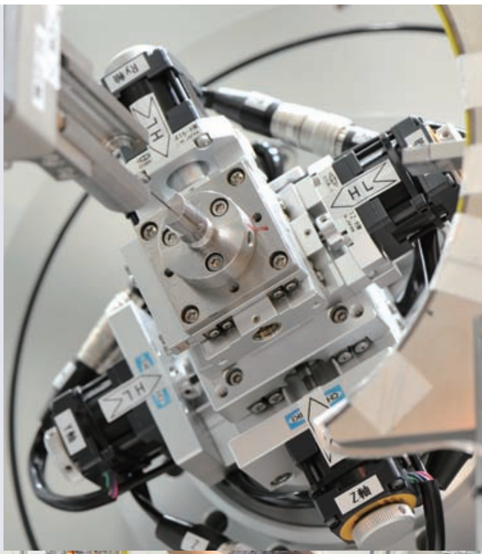
Making Full Use of the "Eyes" and "Hands" of Nanotechnology

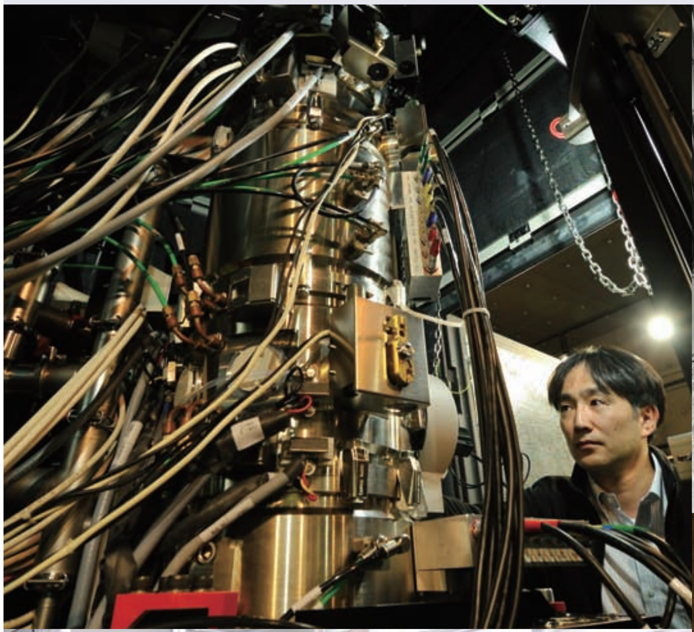
Nanotechnology Platform Japan

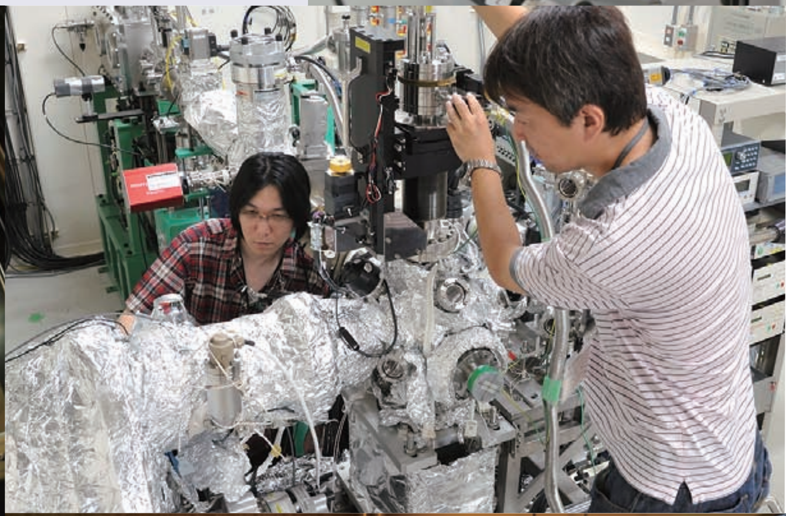
Nanotechnology requires special technologies. This is because the "eyes" used in nano-observation and the "hands" used in nanofabrication are far smaller than the human scale. Specific devices are also necessary in order to confirm nanostructures, and it's not rare that these devices are one-of-a-kind in Japan, or even one-of-a-kind in the world! However, such advanced technology has sometimes given a feeling of barrier in using the nanotechnology equipments to the outside researchers especially in industries.

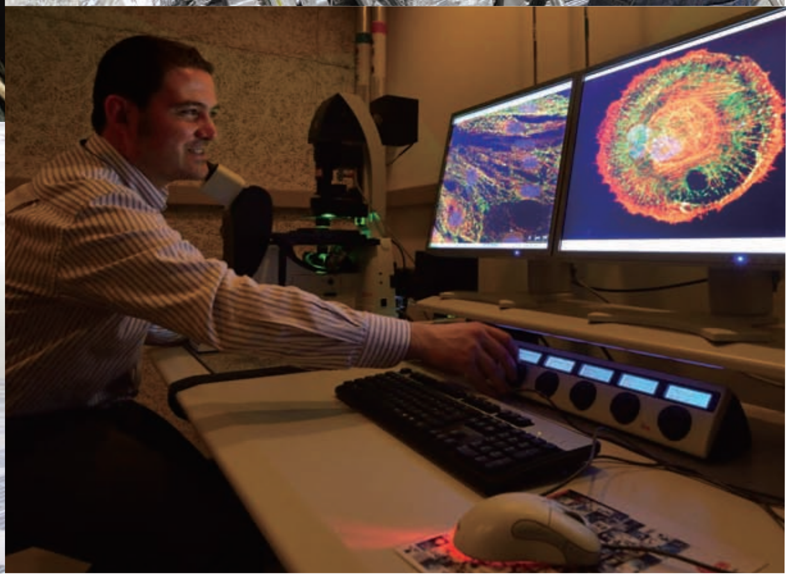
The "Nanotechnology Platform Japan" is a new project that have just launched in July 2012. The aim of this project is to create a system, in other words, a "platform," for shared use of the advanced nanotechnology-related equipment at universities and research institutes throughout Japan. This Platform will give all researchers in industry, academia, and government agencies an equal opportunity to use this essential equipment.

As a distinctive feature of the Nanotechnology Platform, 3 networks have been created in respective fields (Microstructural Characterization, Nanofabrication, and Molecule & Material Synthesis) so that users can take the shortest, most appropriate approach to advanced nanotechnology. This new project will enable more and better use of the "eyes" and "hands" that are necessary for the evolution of nanotechnology.









Institutes Participating in the Nanotechnology Platform (Total of 25 Nationwide)

Platform Center Institutes:

National Institute for Materials Science (NIMS)

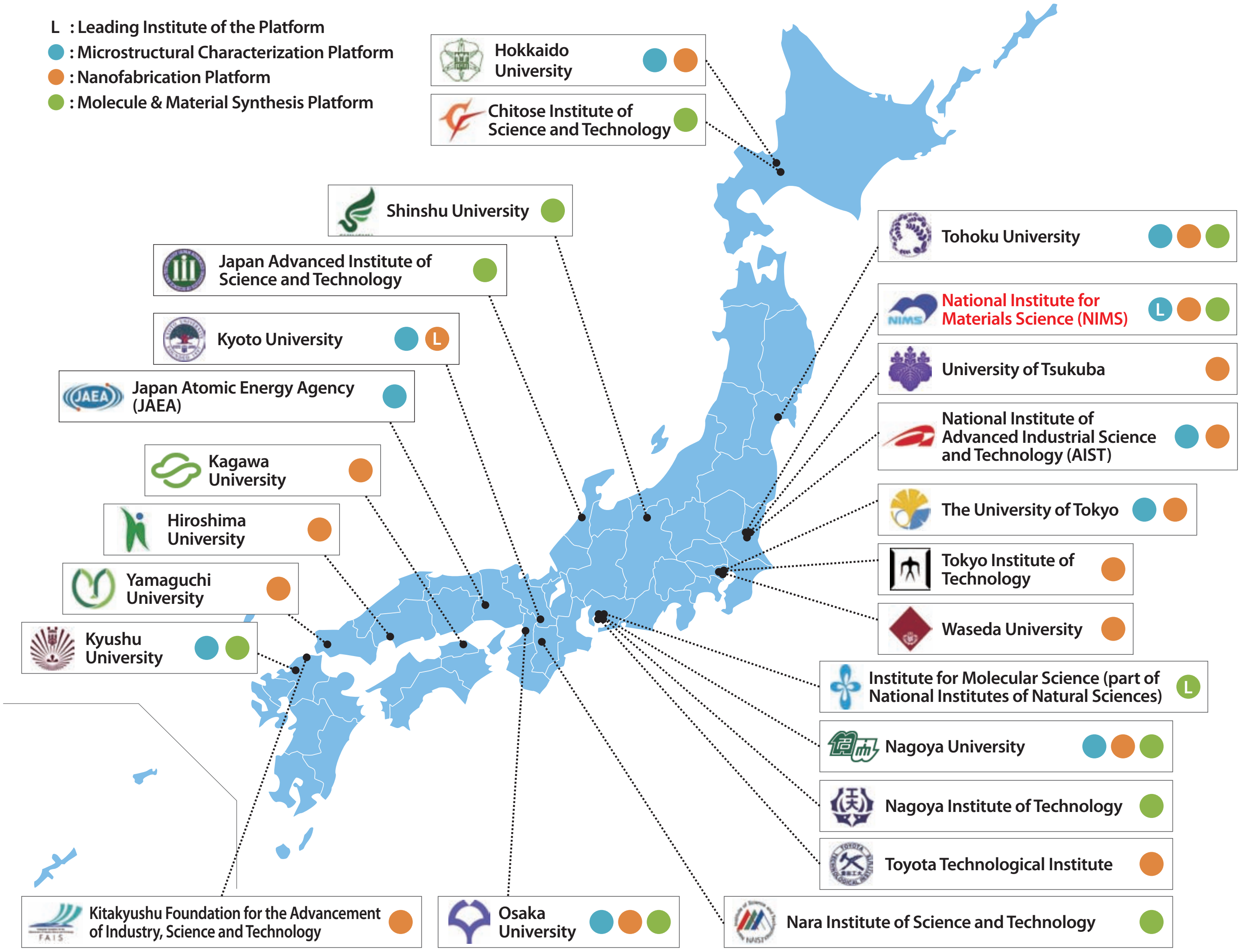
Japan Science and Technology Agency (JST)

L : Leading Institute of the Platform

● : Microstructural Characterization Platform (blue)

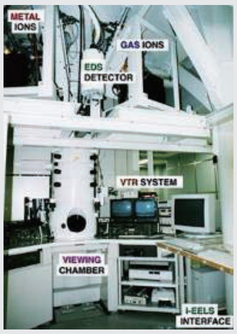
● : Nanofabrication Platform (orange)

● : Molecule & Material Synthesis Platform (green)



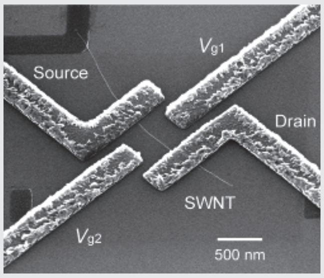
Microstructural Characterization Platform

Ultra-high voltage transmission electron microscopy, high performance electron microscopy (STEM), synchrotron radiation, etc.



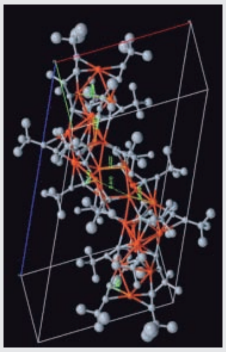
Nanofabrication Platform

Electron beam lithography, etching, ion beam processing, sputtering, etc.



Molecule & Material Synthesis Platform

Molecular synthesis, molecular design simulation system, mass spectroscopy, etc.



As Center for the Project

An Overview of the Nanotechnology Platform Project

Managing Director,
Center for Nanotechnology Platform
Tetsuji Noda

Aims of the Nanotechnology Platform Project

Nanotechnology/materials science and technology are the objects of priority R&D investment by countries around the world as fields which are not simply of scientific interest, but are expected to lead to technological innovations in a wide range of industries involved in energy, materials resources, reduction of environmental loads, life sciences, and others. On the other hand, to make efficient use of a research environment with limited human resources and facilities, research and development through close collaboration among industry, academia, and government is even more strongly required. In these circumstances, in July 2012, the Japanese government launched a new initiative called the Nanotechnology Platform Project. The aims of the project are to create a nationwide infrastructure for nanotechnology research and encourage close mutual cooperation by research institutions which possess advanced research facilities related to nanotechnology and know-how in their use, to promote joint research by industry, academia, and government, and to provide researchers the shortest approach to solve scientific and technological problems.

The specific targets of the Nanotechnology Platform Project are summarized in the following three aims.

1) To construct a system for shared use of advanced facilities in order to provide equal opportunities and a high degree of satisfaction in use of facilities to researchers in industry, academia, and governmental institutions.

2) To create a mechanism which makes it possible to provide the optimum combination of advanced research equipment and research support capabilities across research fields, and thereby contribute to solving the technological problems of industry.

3) To contribute to improving the research capabilities and expertise of technical support personnel through mutual exchanges of researchers and technical support staff and exchanges with overseas networks.

Structures of the Project : the Platform Center, Platforms in 3 Technology Fields, and 25 Institutes/39 Organizations as Implementing Institutes

The Nanotechnology Platform Project comprises the Platform Center (operated jointly by NIMS and JST), which coordinates and supports the activities of the project as a whole, and platforms in three technology fields (Microstructural Characterization Platform, Nanofabrication Platform, and Molecule and Materials Synthesis Platform). The Implementing Institutes of the project are 25 institutes and 39 organizations throughout Japan (Figure 1).

Each of the three platforms has a representative organization, or "Leading Institute," which is responsible for the overall operation of that Platform. The roles of the Leading Institute include determining the suitable equipment and its usage, establishing a charging system, training technical support staff, and promoting exchanges, for example, by holding symposiums, etc. Implementing Institutes establish the operating system based on the policy for shared use of facilities and conduct research support to outside users in their Platform.

NIMS, together with the Japan Science and Technology Agency (JST), is responsible for the operation of the Nanotechnology Platform Center and implementation of the Project as a whole. NIMS is also the Leading Institute of the Microstructural Characterization Platform and is participating in all 3 Platforms as an Implementing Institute.

Promoting the Platform Project and supporting users

Purpose of Nanotechnology Platform Project

To construct a system for shared use (platform) of advanced facilities in order to provide equal opportunities to use facilities to researchers in industry, academia, and government, and to support the creation of new research fields, new technological areas, and new industries, and human resources development.

Roles of the Center for the Nanotechnology Platform Project (NIMS, JST)

① **Overall coordination and promotion of the Nanotechnology Platform Project**
(Setting of project policy, planning/implementation of activities, general supervision of 3 platforms)

② **General contact with users and promotion of information exchanges**
(User services, holding result reporting meetings and symposiums)

③ **Collaboration with industry and promotion of interdisciplinary research**
(Cultivation of new users, promotion of problem-solving type joint research)

Interdisciplinary Collaboration Promotion Manager
Responsible for supervising promotion of industry, academia, and government collaboration. Also responsible for supporting use by young researchers in industry, academia, and government.

Industry-Academia-Government Collaboration Promotion Manager
Managers are assigned to 5 "blocks" throughout Japan for cultivation of new users and matching of industry, academic, and government needs in respective areas.
Identification of user needs, beginning with industrial users, promotion of industry, academia, and government collaboration and interdisciplinary research, promotion of platform use.

④ **Support for human resources training and promotion of international collaboration**
(Support for use by young researchers, etc.)

Human Resources Development Manager / International Collaboration Promotion Manager
Promotion of human resources development utilizing the Nanotechnology Platform, promotion of exchanges and collaboration with overseas networks.

Fig. 1 Purpose of Nanotechnology Platform Project and roles of Center and Managers.

The Nanotechnology Platform Center, which is operated jointly by NIMS and JST, takes the lead in coordinating the operation of the platform as a whole and for promoting information exchanges. Concretely, the roles of the Center are ①*Overall coordination and promotion of the project*, ②*Comprehensive contact with users and promotion of information exchanges*, ③*Collaboration with industry and promotion of interdisciplinary research*, and ④*Support for human resources training and promotion of international collaboration* (Figure 1).

1. Roles of the Platform Center

As one of roles, ①*Overall coordination and promotion of the project*, the Center holds meetings of Leading Institutes in order to coordinate the operating policies of the respective platforms, participates in meetings of the steering committees of each platform, and carries out activities such as visiting the other 24 Implementing Institutes to figure out the status of platform activities.

In ②*Comprehensive contact with users and promotion of information exchanges*, the Center is responsible, firstly, for creating the necessary web functions for overall nanotechnology user contact. (Figure 2). The website is used to introduce the project, provide contact for consultations, give information on methods of using the platform and lists of the available user facilities, provide links to participating institutes, present examples of research results using the platform, disseminate information on recent nanotechnology news and events, including those at each Implementing Institute, distribute a web magazine, etc. It is also used to distribute an email magazine to readers in Japan and other countries on a biweekly basis.

In promotion of information exchanges, the Platform Center plans general conferences to promote exchanges involving the Nanotechnology Platform Project as a whole, meetings to explain the project to potential users, symposiums to introduce the activities of the project at scientific societies, etc. It also holds international symposiums on nanotechnology and make presentations at international nanotechnology exhibitions and technical conferences, etc. (Figure 3).

2. Collaboration with industry and development of outstanding human resources

As distinctive features, the Nanotechnology Platform Project actively cultivates new users and promotes use of research facilities in order to solve scientific and technological problems arisen from interdisciplinary research and R&D in industry.

Therefore, to handle ③*Collaboration with industry and promotion of interdisciplinary research*, Interdisciplinary Collaboration Promotion Managers and Industry-Academia-Government Collaboration Promotion Managers (the latter dispatched from JST) are assigned to 5 "blocks" throughout Japan in order to expand joint research by industry, academia, and government through the shared-use platforms, with the cooperation of the institutes participating in the project (Figure 1). Where use by private companies is concerned, the Nanotechnology Business Creation Initiative (NBCI) and other organizations are cooperating with the project. The project will also implement a trial use system for research which is expected to yield results that contribute to problem-solving. In particular, the Center is actively working to develop new users in all parts of the country and carry out matching of industry, academia, and government by holding meetings to provide information on new technologies and facility use in regions throughout Japan, conducting surveys/visits and holding meetings to explain the facilities/equipment to universities and research institutes in various regions, and similar outreach activities.

In ④*Support for human resources training and promotion of international collaboration*, utilizing the Nanotechnology Platform Project, the Platform Center plans and implements interdisciplinary student training, facility use-type student training under the National Nanotechnology Infrastructure Network (NNIN) in the United States and other organizations, and training programs for project support staff. In cooperation with NNIN, the two sides mutually conducted summer training programs of about 10 weeks' duration. NIMS received 8 students from NNIN and the Nanotechnology Platform Project sent 2 students to NNIN in 2012 (Figure 3).

In addition, the Center will also organize workshops with the United States, Europe, Asia, etc. in order to foster young scientists. In the area of support for human resources development, the Center will support use of the platform by young researchers, particularly for those without equipment.

As outlined above, the Nanotechnology Platform Center aims to support the creation of new research fields, new technological fields, and new industries and to construct a system for human resources development by a network which enables shared use of facilities, through total efforts encompassing coordination, promotion, and support for human resources training in the Nanotechnology Platform as a whole.

Nanotechnology Platform Project
>> http://nanonet.go.jp

Fig. 2 Top page of the Nanotechnology Platform website (https://nanonet.go.jp/) Wide range of content, including an introduction of the project, profile of the Nanotechnology Platform, general contact, outlines of the participating institutes and user-facility equipment, web magazine, etc. (English website is currently in preparation)

- Summer student exchange (10 weeks) with NNIN in US
- Collaboration with Asia
- Young Scientist exchange with National Science Foundation (NSF) in US.

International Symposium on Nanotechnology Japan Nano and International Nanotechnology Exhibition & Conference.

(Photos are from Nanotech 2012 exhibition)

Fig. 3 (Top) Activties of human resources development and international promotion, and (bottom) scenes from the Japan Nano 2012 Symposium.

Tetsuji Noda Ph.D.(Engineering) Appointed Principal Researcher at NIMS in April 2001, and held the position of Vice President of NIMS from April 2005 to March 2011. He has been Director-General of the NIMS International Center for Nanotechnology Network since April 2008, and Managing Director of the Center for Nanotechnology Platform since July 2012. His specializations are materials processing and physicochemical properties.

Microstructural Characterization Platform as an Implementing Institute for Microstructural Characterization

Creating a User-Facility Infrastructure for Advanced Characterization and Accelerating Material Innovation

Operation Director,
Promotion Office for Microstructural Characterization Platform
Daisuke Fujita

Operation Manager,
Promotion Office for Microstructural Characterization Platform
Masaki Takeguchi

Microstructural Characterization Platform as infrastructure for nanotechnology

In nanotechnology, it is impossible to realize nano-creation and nano-fabrication without nano-scale observation and measurement, in other words nanocharacterization. For this reason, it can be said that *nanocharacterization techniques are the most fundamental of the key technologies that make up* the nanotechnology field. Beginning with the National Nanotechnology Initiative (NNI) in the United States in 2000, the advanced countries have promoted nanotechnology research and development as a national policy, and in particular, have steadily allocated budgets to improve nanotechnology infrastructure.

In Japan, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) launched the Nanotechnology Platform Project in July 2012 as a new measure for nanotechnology infrastructure improvement. Here, "platform" means "infrastructure for research and development." Platforms were created for microstructural analysis (nanocharacterization), microfabrication (nanofabrication), and molecule and material synthesis (nanomaterials creation), corresponding to the three main fields that form the basis for nanotechnology research. Each of these three platforms consists of a number of *Implementing Institutes*, which are responsible for shared use of facilities by outside researchers (user facilities), and a *Leading Institute* as the representative organization of the platform. As a distinctive feature of the Nanotechnology Platform Project, institutes that possess "advanced equipment for nanotechnology" construct a common nationwide user-facility system for shared use of such equipment, and provide wide-ranging opportunities for researchers in industry, academia, and government to use those facilities.

Target image of the Microstructural Characterization Platform as a Leading Institute for Platform

NIMS is participating in this project both as an Implementing Institute and as a Leading Institute with overall responsibility for management of the Microstructural Characterization Platform. As the Leading Institute, NIMS is responsible for setting project policies in microstructural characterization and constructing a sustainable operating model.

This Platform has two broad objectives. First, by "Concentration of knowledge" based on an optimum and interdisciplinary combination of Japan's advanced characterization technology groups, the Platform aims to establish a framework for shared use of user facilities at the national level in the field of microstructural characterization in the region from nanometer to micrometer scale, and thereby contribute to materials innovation by solving scientific and technological problems in advanced materials/device fields utilizing nanotechnology. At the same time, the Platform will also contribute to the ongoing progress of nanotechnology in Japan, improvement of Japan's competitiveness, and development of human resources.

To date, Japan's universities and Independent Administrative Institutions (IAI) have created a number of the world's leading advanced nanotechnology characterization technologies. By providing these technologies to support research matched to the needs of industrial, university, and government users, the Platform will make it possible to create a steady stream of top level research results that will lead the world in this field. We call this goal "Dramatic knowledge creation."

In cooperation with the Center organization, which is jointly managed by NIMS and the Japan Science and Technology Agency (JST), the Microstructural Characterization Platform also hopes to establish a sustainable advanced characterization infrastructure that will make it possible to provide research support responding to the needs of industry and actively promote "interdisciplinary research" between different fields. The target image of this Platform as a whole is outlined in the following points and Figure 1.

· Provide the optimum combination of advanced characterization equipment groups and high level research support capabilities.
· Respond to diverse needs of researchers and engineers in industry, government, and academia by offering a multi-dimensional characterization menu.
· Promote human resources exchanges among industry, government, and academia and effective human resources development based on "Concentration of knowledge" with the Platform's user facilities as a core.
· Strengthen technological competitiveness of the nanotechnology and materials fields by solving the technological problems of industry.
· Realize "Dramatic knowledge creation" in nano-

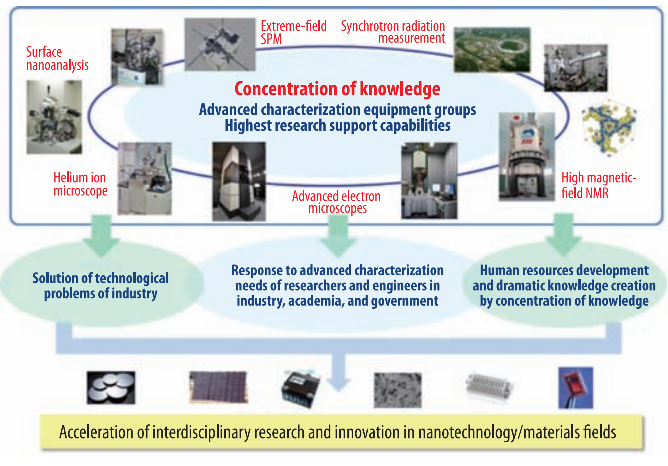


Fig. 1 Aims of the Microstructural Characterization Platform by "Concentration of knowledge" through construction of a complementary advanced characterization center network, and promotion of interdisciplinary research.

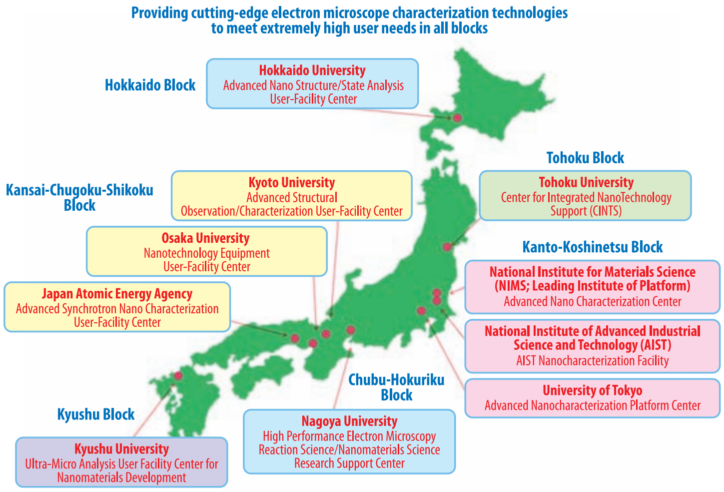


Fig. 2 Microstructural Characterization Platform comprises 10 research institutes covering 6 blocks throughout Japan.

science fields by solving scientific problems.
· Accelerate interdisciplinary research and materials innovation by "Concentration of knowledge."

Platform composition corresponding to the needs of researchers

An accurate understanding of the nanotechnology research support needs of researchers in industry, academia, and government is important for the overall design of the platform. For example, in 2011, the Nanotechnology Network Project conducted a "Next-Period User Facilities Network Awareness Survey" regarding equipment and instruments that industry, academic, and government R&D people hope to use through user-facility support. The No. 1 item in that survey was "Electron microscopes (TEM, STEM, HRTEM)." Nearly half of the respondents (45%) hoped to use these instruments, outstripping the No. 2 item, "Analytical devices for biotechnology use (ionization time-of-flight (TOF), etc.)" (31%) and other lower ranking items by a wide margin. Moreover, of the top 10 items, the top 9 were measurement and analysis (characterization) devices, and the top 7 were advanced nanocharacterization devices such as "High performance scanning electron microscopes," "Scanning probe microscopes," and "Characterization devices using synchrotron radiation."

The Microstructural Characterization Platform (see Fig. 2) was created by bringing together 10 National Universities and IAI that possess advanced characterization equipment such as synchrotron radiation characterization facilities, high magnetic-field NMR, advanced scanning probe microscopes, advanced surface characterization devices, and extreme-field characterization devices, while continuing to center on advanced electron microscopes, for which users expressed extremely high needs. The user facilities related to advanced characterization at these 10 institutions were installed in 6 blocks throughout Japan as "nanocharacterization centers." The aim of this block composition of nanocharacterization centers is to enable users anywhere in the country to enjoy microstructural characterization support by advanced electron microscopy. In addition to enabling users to take advantage of the advanced characterization fields which are the special expertise of each nanocharacterization center, the Platform also intends to implement a system for communications between centers, which will be complementary in terms of geography and support fields, in order to respond to needs for advanced and nano characterization throughout Japan.

Role as an Implementing Institute in the Microstructural Characterization Platform

The NIMS Microstructural Characterization Platform is an Implementing Institute for the Kanto-Koshinetsu Block of the Microstructural Characterization Platform. The platform organization at NIMS is named "Advanced Nanomaterial Characterization Center", which is particularly strong in research support by most advanced nanocharacterization technologies of advanced materials. NIMS has assigned personnel and the NIMS research facility to the 3 NIMS sites (Sakura, Sengen, and Namiki) in Tsukuba City and Nishi-Harima District (SPring-8 Synchrotron Radiation Facility) to support researchers and engineers from industry, academia, and government by a fusion of advanced nanocharacterization equipment groups and characterization know-how.

Although centering on the high performance transmission electron microscope (TEM) and scanning-transmission analytical electron microscope groups, the NIMS Microstructural Characterization Platform also provides research support by advanced nanocharacterization from the surface and surface layer to the interior of bulk materials by complementary use of advanced characterization technologies, including highly-advanced surface nanoanalysis by the scanning helium ion microscope (SHIM), low temperature and high magnetic field scanning tunneling microscope, time-of-flight secondary ion mass spectrometry (TOF-SIMS), etc., high resolution X-ray diffraction analysis by high brightness synchrotron radiation, hard X-ray photoemission spectroscopy, solid-state NRM with the world's highest magnetic field, and other advanced technologies (see Fig. 3).

In order to cultivate new users and promote interdisciplinary research, the Platform will also actively conduct outreach activities such as courses on equipment use, regional seminars, etc., and will implement human resources development for researchers and young support technicians with the aim of training personnel with a detailed knowledge of industry, academia, and government collaboration through its research support business.

To support Japan as a technology-oriented nation, the Microstructural Characterization Platform will actively promote exchanges and collaboration not only with academia, but also with industry. The Platform has already created user-friendly use arrangements and application procedures (http://www.nims.go.jp/acnp/). We welcome email inquiries about the use of facilities. Please feel free to contact us at our user-facility consultation address (acnp@nims.go.jp).

NIMS Microstructural Characterization Platform
>> http://www.nims.go.jp/acnp/

① Electronics materials, ② Environment and energy materials, ③ Magnetic device materials, ④ Nanomaterials, ⑤ Soft materials, ⑥ Development of new nanocharacterization technologies

	Equipment (type)	Main support fields
TEM	Single atom analytical electron microscope (FEI Titan Cubed)	①、②、③、④、⑤、⑥
	In-situ observation electron microscope group (JEM ARM200F & JEM-3000F)	①、②、④、⑤、⑥
	Atomic identification electron microscope (JEM-3100FEF)	①、②、④、⑥
	Cold electrode field emission type Lorentz microscope (HF-3000L)	①、②、③、④、⑥
	Cold electrode field emission type electron microscope (HF-3000S)	①、②、④、⑥
	200kV field emission type transmission electron microscope (JEM-2100F)	①、②、④、⑥
	3D multi-scale triple-beam analytical microscope (SMF-1000)	①、②、④、⑤、⑥
	Specimen preparation device group	①、②、③、④、⑤
	Ceramic specimen preparation group	①、②、③、④

	Equipment (type)	Main support fields
TEM	Damage-less TEM specimen milling apparatus	①、②、③、④
Synchrotron radiation	High brightness synchrotron radiation characterization device group (High brightness synchrotron hard X-ray spectroscopy system & high brightness synchrotron radiation high resolution X-ray diffraction device & high brightness synchrotron radiation thin film/nanostructure diffractometer)	①、②、③、④、⑤、⑥
NMR	930MHz solid-state NMR	①、②、③、④、⑤、⑥
	500MHz solid-state NMR	①、②、③、④、⑤、⑥
	400MHz solid-state NMR	①、②、③、④、⑤、⑥
SPM	Ultra-low temperature/high magnetic field scanning tunneling microscope	①、②、③、④、⑥
Ion microscope	Scanning helium ion microscope (ORION Plus)	①、②、③、④、⑤、⑥
Surface analysis	Time-of-flight secondary ion mass spectroscopy system (TOF-SIMS)	①、②、③、④、⑤、⑥

Fig. 3 Advanced characterization equipment and main support fields of NIMS Microstructural Characterization Platform.

Daisuke Fujita Ph.D. (Engineering) Completed the master's course at the School of Engineering, University of Tokyo in 1986 and then served as a research associate in the Institute of Industrial Science, University of Tokyo. Loaned to the National Research Institute for Metals (NRIM) of the Science and Technology Agency in 1991. (NRIM was reorganized as part of NIMS in 2001.) Appointed Associate Director in 2004 and Managing Director of the NIMS Advanced Nano Characterization Center (ANCC) in 2006, and also served as Coordinator of the Key Nano-technologies Field in 2010. Since 2011, he has been Division Director of the Advanced Key Nano-technologies Field, and was appointed concurrently to his current post in 2012. **/ Masaki Takeguchi** Ph.D. (Engineering) Completed the doctoral course at the Graduate School of Engineering, Osaka University in 1993 and joined JEOL Ltd. in the same year. Joined the National Research Institute for Metals (NRIM) of the Science and Technology Agency in 1998. Since 2011, he has been Station Director of the Transmission Electron Microscopy Station in the NIMS Research Network and Facility Services Division. He was appointed concurrently to his current post in 2012.

Nanofabrication Platform as an Implementing Institute for Nanofabrication

The NIMS Nanofabrication Platform Sets Sail!

Platform Director,
Nanofabrication Platform
Yasuo Koide

Supporting nano- and microfabrication

NIMS is an Implementing Institute for the Nanotechnology Platform's Nanofabrication Region. Our aims are to provide facilities, equipment, and high-order technical support for advanced nanotechnology "nanofabrication" to researchers at R&D type Independent Administrative Institutions (IAIs), universities, and private companies across Japan and create research results that lead to innovation.

The Nanofabrication Platform was originally launched in April 2007 as the Nano-Fabrication and Characterization Facility of the NIMS Nanotechnology Innovation Station. During the 4 and a half years since that time, it has functioned smoothly as a research support and user facility, providing nano- and microfabrication infrastructure for users both inside and outside of NIMS.

The key facility in the new NIMS Nanofabrication Platform is a clean room with an area of 450m^2, as shown in Figure 1. This facility is fully equipped with the world's highest level microfabrication processing devices and nanoscale observation, measurement, and characterization devices, totaling 40 units in all, and supports nano- and microfabrication of a wide variety of materials and fabrication of optical and electronic devices, with full technical support by an expert staff.

Figure 2 is a circle graph summarizing the fields of research support topics to date. Each year, the facility provides research support for around 80 topics. As a distinctive feature, the Platform provides research support for a wide range of diverse fields. By field, topics comprise electronic materials and devices, 35%, optical materials and devices, 24%, fabrication of nano- and microstructures, 22%, environment and energy, 13%, and medical engineering and bioengineering, 6%.

Aiming to establish a world nanotechnology center

Concretely, the research and technological support provided by the NIMS Nanofabrication Platform comprises the following capabilities:

(1) Requested microfabrication using a combination of electron beam lithography, laser lithography, electron beam deposition, and dry etching, and fabrication of nanobiochips, optical diffraction gratings, micromachine (MEMS) structures, field effect transistors (FET), light emitting and light receiving devices, nanowires and 1-dimensional electrical conductive structure chips, nanophotonic chips, as represented by photonic crystals, and microelectrode patterns for measurement of the electrical characteristics of organic and bioelectronics materials.

(2) Microsampling of electron microscope observation specimens and nanofabrication of various types of materials using a focused ion beam fabrication system.

(3) Scanning electron microscope (SEM) observation and Raman scattering spectroscopy imaging observation of various types of nanomaterials and nanofabricated structures.

To further strengthen interdisciplinary research and collaboration with industry and academia, in the future, the Nanofabrication Platform aims to strengthen its collaboration with other platforms and upgrade its equipment, making it possible to respond to the needs of private companies, and develop new scientific fields by mutual exchanges with engineers in other fields. As policies for future development, the Platform will select from the structures of use fee systems based on their track records and concentrate its efforts on those selected, establish interdisciplinary research support across fields based on nanotechnology, and provide international research support by collaboration with overseas networks. The ultimate goal of these efforts is to establish a world nanotechnology center and user system aiming at self-operation.

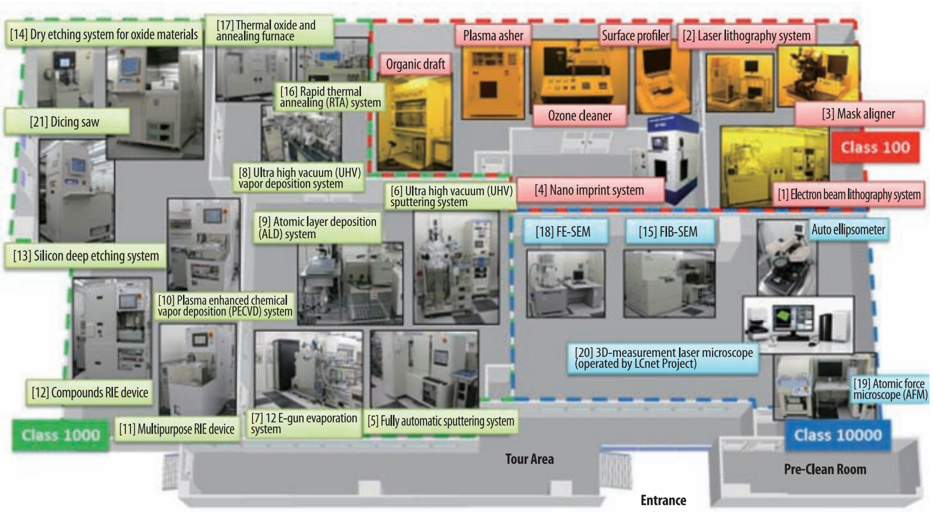


Fig. 1 Floor map of the Nanofabrication Platform's 450m^2 clean room and arrangement of its 40 nano- and microfabrication devices.

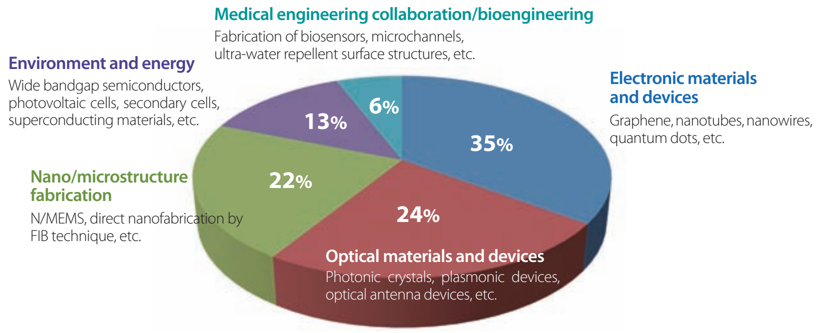


Fig. 2 Research support fields of Nanofabrication Platform.

Yasuo Koide Ph.D.(Engineering) Completed the doctoral course at the Nagoya University Graduate School in 1987. Prior to joining NIMS as a Chief Researcher in 2002, he was an assistant at Nagoya University and Associate Professor at Kyoto University. In addition to current position, he also holds a concurrent position as Group Leader of the Wide Bandgap Materials Group. His current research fields are development of diamond optical and electronic devices and investigation of the device physics.

As an Implementing Organization for the Molecule and Material Synthesis Region

Research Support by the Molecule and Material Synthesis Platform

Platform Director,
Molecule and Material Synthesis Platform
Nobutaka Hanagata

Supporting interdisciplinary research of nanotechnology and biotechnology

The Molecule and Material Synthesis Platform is a network organization comprising 10 institutions throughout Japan which provides a full spectrum of research support from synthesis and characterization of nanomaterials to application in the environment and energy field and biotechnology field. As one of the implementing organizations, NIMS is responsible for activities centering on support for interdisciplinary research involving nanotechnology and biotechnology. The main users are researchers in materials and nanotechnology-related fields and researchers in biotechnology and medical-related fields. For the former, the Platform provides support for biotechnology applications of nanomaterials. Support for the latter focuses on discovery genomics and realization of devices applying the resulting nanotechnologies.

Biotechnology applications of nanomaterials and discovery genomics

NIMS has constructed a system for integrated support spanning the processes from specimen preparation to data analysis by making the 14 devices and 12 device groups of the Bio-Organic Materials Facility of the NIMS Nanotechnology Innovation Station available for use in the Molecule and Material Synthesis Platform. In biotechnology applications of nanomaterials, we have created a system for proposing ideas for use of those nanomaterials as medical materials and biotechnology research materials based on nanostructured surfaces and nanoparticles designed and synthesized by the user, and providing support ranging from safety evaluations to applied research for practical applications.

For example, in research support for biotechnology applications of nanoparticles, we provided support for application of quantum dot particles synthesized by a user to bioimaging and intracellular drug delivery (Fig. 1).

On the other hand, in discovery genomics, it is possible to search for disease-related molecules by specimen preparation of biological samples provided by users using laser microdissection system, by global genome and proteome analysis utilizing DNA chips or a liquid chromatography/mass spectrometry system, and by bioinformatics analysis. We also provide support for realization of devices for trace amount detection of the molecules found by discovery genomics, and are expanding this technology to system development for diagnosis and postoperative management.

In addition to these types of support, the Platform supports synthesis of inorganic, organic, and polymer materials, fractionation/purification by various types of chromatography, structural analysis by NMR, and evaluation of the synthesized materials using various analytical devices such as confocal AFM, laser Raman microscopy, etc.

Some have voiced the opinion that there are initial high hurdles when nanotechnology and materials researchers attempt to extend their research into the biotechnology field, and when medical and biotechnology-related researchers develop their work into nanotechnology and materials. One mission of NIMS is to lower those hurdles and thereby contribute to promoting fusion research by users. The "Examples of use" at the following site presents interviews describing the process by which past users applied for support, how they received support, and what results they obtained. We hope that our readers will find this useful.

NIMS Molecule and Material Synthesis Platform
>> http://www.nims.go.jp/nice/sml/en/

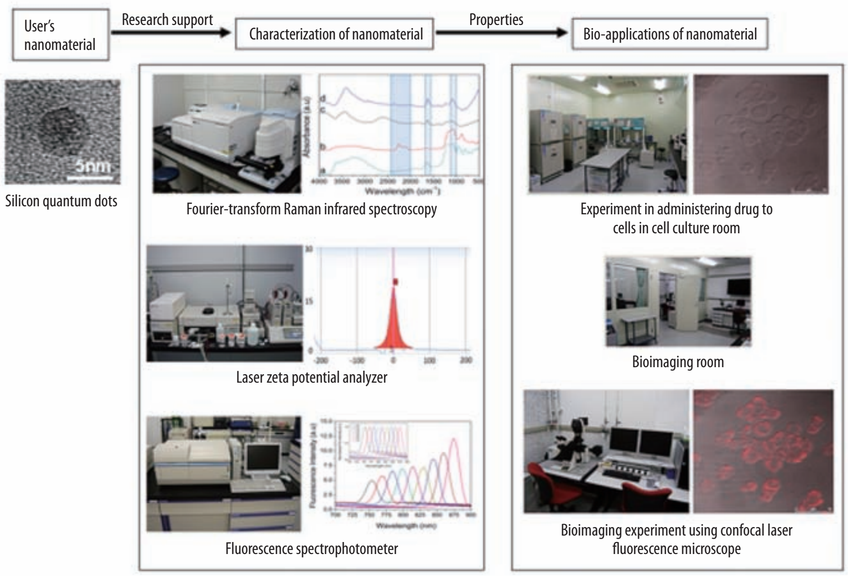


Figure Flow of support. Example of research support by the Molecule and Material Synthesis Platform, in which the properties of nanoparticles synthesized by a user were evaluated, and the material was applied to bioimaging and drug delivery in experiments in which nanoparticles were administered to cells.

Nobutaka Hanagata Ph.D. (Engineering) Prior to joining NIMS in 2005, he was employed at the Chiba Laboratory of Mitsui Engineering and Shipbuilding Co., Ltd. and held positions as Associate Professor at the Research Center for Advanced Science and Technology of the University of Tokyo and Professor at Tokyo University of Technology. He is currently Station Director of the NIMS Nanotechnology Innovation Station. He has held a concurrent position as Professor at the Graduate School of Life Science of Hokkaido University since 2008.

Development of Nonvolatile White Light-Emitting Liquids
– Coatable on Various Substrates; Facilely Creatable Full Color Luminescence –

Organic Materials Group,
Polymer Materials Unit, Advanced Key Technologies Division
Takashi Nakanishi

The need for light source materials for white light-emission that can be produced using simple processing technologies

Organic electronics devices, represented by organic EL and photovoltaic cells consisting of thin film structures of organic molecular materials, have been an object of active research and product developed in recent years as an alternative basic technology for inorganic (silicon, etc.) based electronic devices. It is because they are excellent in terms of light-weight and flexibility, and particularly they have the advantage of the possibility of production by printing and being inexpensive materials without using rare earth elements.

Because annual power consumption by lighting devices accounts for approximately 20% of all electric power consumption, technology for reduction of power consumption by lighting devices is important and indispensable for reducing discharge of greenhouse effect gases. In particular, high expectations are placed on white light-emitting organic materials as light source materials for next-generation lighting with the potential to replace conventional incandescent light bulbs and fluorescent lights. The organic materials developed up to now showed white light emission mainly when dispersed in a solution. However, these materials displayed poor dispersibility, as the molecules of the material tended to aggregate when the solution was coated on a substrate and the solvent was evaporated. As a result, these materials could not fully demonstrate their intrinsic white light-emitting performance. Moreover, organic molecular materials which make it possible to produce devices that emit white light with high luminescence by a simple method have been desired from the viewpoint of the manufacturing process.

Development of a liquid material that emits white color using a nonvolatile blue light-emitting liquid as its mother material

The organic molecular material we have developed is designed so that the core unit that control the optical and electronic functions is arranged with spacing to prevent aggregation among the neighboring core units. As shown in Fig. 1a, oligo(phenylenevinylene) (OPV) with a fluorescent function is used in the core, and the spacing to prevent aggregation between the OPV core parts is formed by introducing a branched, highly flexible alkyl side chains, as shown in the structural model in Fig. 1b. This material is nonvolatile and is a liquid at room temperature, and its viscosity is approximately 1 Pa•s, which is on the same order as typical lubricating oil. It emits blue color with an absolute fluorescent quantum yield of about 50%. The UV-visible absorption and fluorescent spectra of the liquid OPV compound (bulk state) substantially coincide with the spectra of a dilute solution in which the same compound is dispersed homogeneously in a solvent (Fig. 1c and 1d). It demonstrates that the intrinsic optical and electronic properties of the compound are basically the same as those in the room temperature liquid in the solvent-free bulk state.

Using this blue light-emitting liquid, a liquid material that can emit white light under UV irradiation was prepared, as shown in Fig. 2a, by adding solid light-emitting dyes (green color-emitting Alq3 and orange color-emitting rubrene) and blending them for only one minute. The prepared liquid material can be coated on a large area (Fig. 2b), and characters that emit white light can be drawn using a ballpoint pen that was prepared as a prototype product (Fig. 2c). This research also confirmed that white light emission with high brightness is possible when the material is applied by coating. As one example, a white light-emitting lighting device was fabricated by coating this liquid material on the surface of a UV-LED that emits basically blue light.

Full color luminescence can also be realized easily by selecting appropriate light-emitting dyes for addition to the developed blue light-emitting liquid material (Fig. 2e). In the future, further application is expected as it to be printable, flexible, lightweight, and also to be used for large area light-emitting devices such as lighting, panels, displays, etc. One particular goal for this liquid material is to be breakthrough as a continuous liquid light-emitting active layer for future-oriented device that can be folded, as this is not possible with solidified thin films.

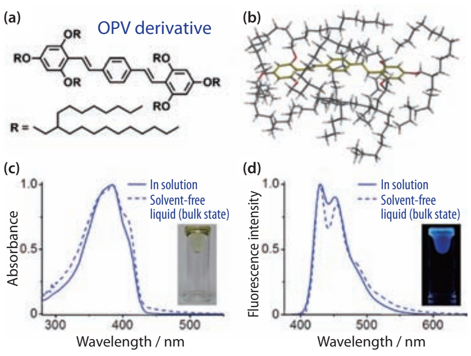


Fig. 1 **(a)** Molecular formula of the oligo(phenylenevinylene) (OPV) derivative used in this research. R indicates a branched, flexible alkyl chain. **(b)** Structural model of the OPV derivative, in which the OPV core part is substituted and isolated by the branched alkyl chains. Comparisons of **(c)** UV-visible absorption and **(d)** fluorescent spectra in a dilute solution and in the solvent-free liquid (bulk state). The insets are photographs of the OPV derivative (bulk state) taken **(c)** under visible light and **(d)** UV light with a wavelength of 365 nm.

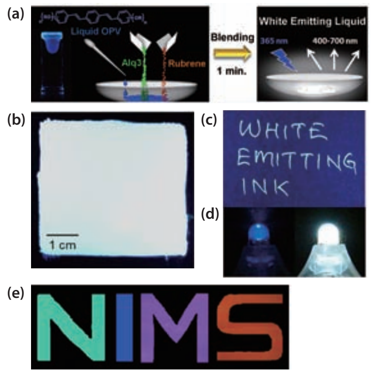
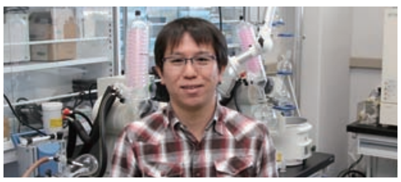


Fig. 2 **(a)** Preparation of white light-emitting liquid material by blending solid dyes of green color (Alq3) and orange color (rubrene) in a solvent-free OPV liquid. **(b)** Large area coating emits white light on area of 5 x 5 cm². **(c)** White light-emission of characters written with a ballpoint pen. **(d)** 375 nm UV-LED light-emitting photograph. Without coating the white light-emitting liquid (left) and with coating (right). **(e)** Full color luminescence achieved by blending of different solid dyes.



Takashi Nakanishi Ph.D. (Eng.) Completed the doctoral course in shorter period at Graduate School of Engineering, Nagasaki University in 2000. He was a JSPS doctoral research fellow at the University of Houston and the University of Oxford prior to joining NIMS. In 2004, he started his academic career at NIMS, as a researcher, in 2007 he became a senior researcher, and since 2010 he is the current position as a principal researcher. In 2007–2010, he was also a visiting group leader at MPI-NIMS International Joint Laboratory, Max Planck Institute of Colloids and Interfaces, Potsdam (Germany), and in 2007–2011, he was a researcher of PRESTO ("Structure Control and Function"), Japan Science and Technology Agency (JST). Since 2011 he is also a visiting Professor at Warsaw University of Technology, Warsaw (Poland).

Success in Manufacturing Tough, High-temperature Superconducting Whisker Crystals

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Jun Li

Electronics Group, Superconducting Properties Unit, Environment and Energy Materials Division
Jie Yuan

Electronics Group, Superconducting Properties Unit, Environment and Energy Materials Division
Huabing Wang

Strongly Correlated Materials Group, Superconducting Properties Unit, Environment and Energy Materials Division
Kazunari Yamaura

Iron-based superconductors,[1) which were developed in Japan by a group headed by Prof. Hideo Hosono at Tokyo Institute of Technology, contain iron and arsenic as essential elements and are known to achieve the highest superconducting transition temperature when they also contain two or more other additional elements. Because these iron-based superconductors have outstanding properties, including the highest superconducting transition temperature after copper oxide-based superconductors, growth of whisker crystals,[2) if possible, would open new horizons in nanotechnology, for example, in Josephson junction devices, sensor materials, etc. which have not existed heretofore. For this reason, the authors conducted a study/research on whisker growth methods, and as a result, finally succeeded in growing the desired iron-based superconducting whisker crystal. This achievement was a world's first. This iron-based superconducting whisker crystal displays a transition to the superconducting state at an absolute temperature of 33K (-240°C; see Fig. 1), and has a rod-like needle shape with an aspect ratio (diameter/length ratio) of 200 or more and a very small diameter of no more than 1µm, satisfying the conditions for superconducting whisker crystals (Fig. 2).

Considerable progress has already been achieved in research on copper-oxide based superconductors,[3) and copper-oxide whisker crystals with the same or higher superconducting transition temperatures have been grown. However, since ceramics are inherently brittle, their applications as materials are limited. Likewise, fullerene superconducting whisker crystals have been fabricated, but because their aspect ratio is 10 or less, their range of applications is also limited. In contrast, the superconducting whisker crystal grown in the present research displays properties closer to those of alloys than ceramics, and is strong and tough, reflecting the characteristic properties of iron-based superconductors (Fig. 2). Due to its large aspect ratio, an expanded range of applications is also considered possible. For example, application to Josephson junction devices and sensor materials is conceivable.

As advantages of the manufacturing method for the iron-based superconducting whisker crystal adopted in this research, manufacturing was performed in a closed condition. An additive that promotes crystal growth was mixed well with the raw material, which was then placed in a capsule-shaped metal reaction vessel. This facilitated control of the crystal composition and structure. This method was also simple and easy in comparison with the general whisker manufacturing method, in which elements are transported by the reaction gas or vaporization. Thus, as an additional feature, manufacturing was comparatively safe in comparison with the conventional method, even though the material contained highly toxic arsenic and other elements. Based on the results achieved thus far, it is thought that this high temperature superconducting whisker crystal and its manufacturing method will be useful in nanotechnology and other fields. At present, we are engaged in research on Josephson junctions using the newly-developed superconducting whisker crystal.

1) Iron-based superconductor: Compound which contains iron as an essential element and displays superconductivity. Iron-based superconductors have the second highest superconducting transition temperature after copper-based superconductors. Spurred by research by Prof. Hideo Hosono et al. of Tokyo Institute of Technology in 2008, research is now underway on a global scale.
2) Whisker shape: Whisker-shaped substances are substances with extremely large shape anisotropy. In general, they are also called nanowhiskers when their diameter is 0.1 micrometer or less.
3) Copper oxide-based superconductor: Oxide that contains copper as an essential element and displays superconductivity. This class of superconductors displays the highest superconducting transition temperature and is also a ceramic (sintered body produced by baking and hardening metal oxide).

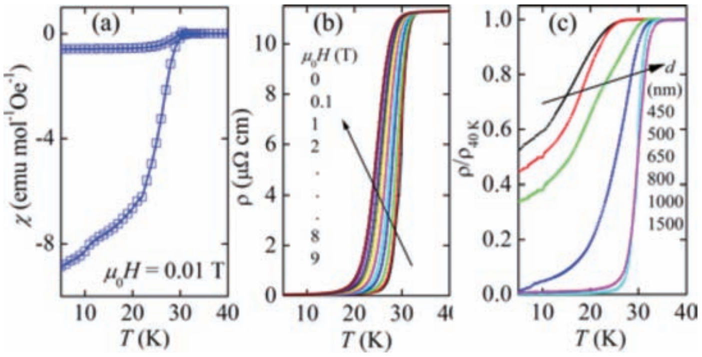


Fig. 1 Superconducting transition properties of the newly-developed superconducting whisker crystal. **(a)** Temperature dependence of magnetic susceptibility, showing the magnetic field cooling curve (top) and zero magnetic field cooling curve (bottom), **(b)** temperature and field dependences of electrical resistivity, and **(c)** crystal width dependence of electrical resistivity. In this figure, d is crystal width.

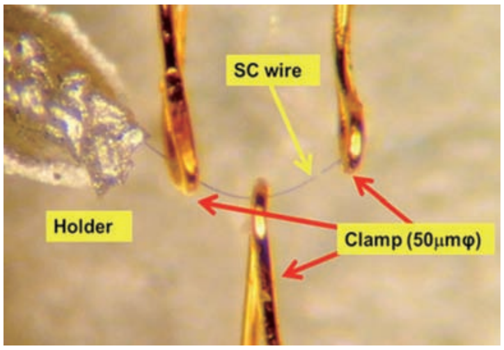
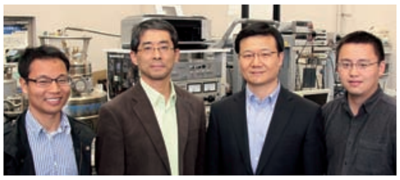


Fig. 2 State of superconducting whisker crystal when stress is applied.



Jun Li (right) Ph.D. (Science) Completed the doctoral course at the Graduate School of Science, Hokkaido University (NIMS Joint Graduate School Program) in 2012 and joined NIMS as a Postdoctoral Researcher in the same year. **/ Jie Yuan** (left) Ph.D. Completed the doctoral course at the Institute of Physics, Chinese Academy of Sciences and joined NIMS as a Special Researcher in 2007. Joined Wuhan University of Science and Technology as Associate Professor in 2009 and has held a concurrent position as NIMS Special Researcher since 2011. **/ Huabing Wang** (center right) Ph.D. Completed the doctoral course at the Department of Radio Physics, Nanjing University in 1995. Fellow of JST from 1997, Associate Professor at the Research Institute of Electrical Communication, Tohoku University from 2001 and Assistant Professor at Friedrich-Alexander University (Germany) from 2003. Joined NIMS in 2004 as a researcher in the International Center for Young Scientists (ICYS). He was appointed NIMS Principal Researcher in 2006. **/ Kazunari Yamaura** (center left) Ph.D. (Science) Completed the doctoral course at the Graduate School of Science, Kyoto University and moved to Princeton University (US) as a Postdoctoral Fellow in 1997. Postdoctoral Researcher at the National Institute for Research in Inorganic Materials (NIRIM; a predecessor of NIMS) in 2000. He joined NIMS as an external researcher in 2001, and was appointed Chief Researcher in 2004 and Principal Researcher in 2007.

NIMS NEWS

1 Report of 2nd NIMS-University of Rennes 1 Workshop

(Oct. 29-20, 2012) The "2nd NIMS-University of Rennes 1 Workshop" was held at the Namiki Site of NIMS. The participants included 13 researchers invited from France's University of Rennes 1 (UR1), with which NIMS concluded a comprehensive cooperation agreement as a sister institution in July 2010.

This workshop was held jointly with the 3rd NIMS Saint-Gobain COE (NIMS Saint-Gobain Center of Excellence for Advanced Materials) Workshop. The results of joint research and exchanges of researchers between the French and Japanese sides were presented. This event featured 34 lectures on nanomaterials, glass, ceramics, and organic materials and boasted approximately 60 participants.

UR1 and NIMS have enjoyed a number of mutual exchanges to date, and also conducted educational exchanges in the form of foreign student exchanges of graduate students at UR1 and the NIMS Joint Graduate School Program. Based on the comprehensive cooperation agreement, workshops will be held alternately at NIMS and UR1.

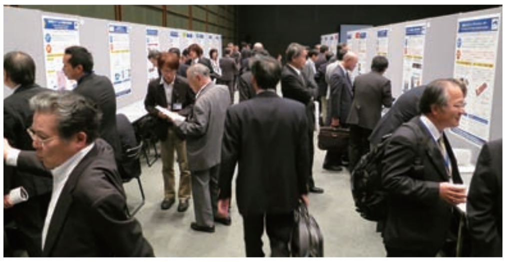

Participants of the workshop

2 Report of the 12th NIMS Forum

(Oct. 25, 2012) The 12th NIMS Forum was held at the Tokyo International Forum in Yurakucho, Tokyo. This event has been held annually since NIMS was established in order to publicize the advanced research results at NIMS, both internally and externally. This year's NIMS Forum, on the theme of "Toward Breakthroughs in Environmental, Resource, and Energy Problems," attracted 540 visitors and received high marks from those attending.

The oral session began with greetings from the President of NIMS, Prof. Sukekatsu Ushioda, which was followed by remarks on the roles and expectations placed on NIMS by Mr. Koichi Morimoto, Deputy Director-General of the Research Promotion Bureau of Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT). Directors of NIMS then introduced the present condition and future vision of their respective units. In the afternoon, researchers introduced four research topics particularly selected from recent research results, while the poster session provided a broad overview of recent achievements at NIMS. As a new feature in this year's Forum aimed at putting greater effort into development of the next generation of researchers, NIMS Postdoctoral Researchers gave poster presentations on 7 topics. These poster presentations were judged by the President and Executive Vice President of NIMS, and Postdoctoral Research Poster Awards were sent to three of the presenters.


Greeting from the President of NIMS, Prof. Ushioda


Researchers giving presentation at poster session

Hello from NIMS

Dear NIMS NOW readers,

I came to NIMS in August 2008. In last four years, I got my PhD degree from Joint Graduate School of NIMS and Hokkaido University and then continued to work at NIMS as a Post-Doctoral Researcher. I quite enjoyed my life in Tsukuba. In research, with the helpful advice from my supervisor and thorough support from NIMS, especially from the common facility department, my scientific exploration progressed smoothly.

In daily life, I also enjoyed the "exploration" in Tsukuba. By bicycle, my friends and I traveled to Tsukuba Mountain, Lake Kasumigaura, USHIKU-DAIBUTU (Huge Buddha), and so on. Sometimes, we just cycle to find some old Jinja (Japanese shrines) hided in woods. I also traveled to many cities in Japan, such as Kyoto, Nara, and Nikko. What impressed me most in Japan is the harmonious coexistence of humane society and nature.


Family trip in Kasumigaura Park


Jinja in Nara

Junyu Cao (China)
from 2008- present
Post-Doctoral Researcher
Environmental Remediation Materials Unit

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cover image: Scanning helium ion microscope

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