NIMS NOW International

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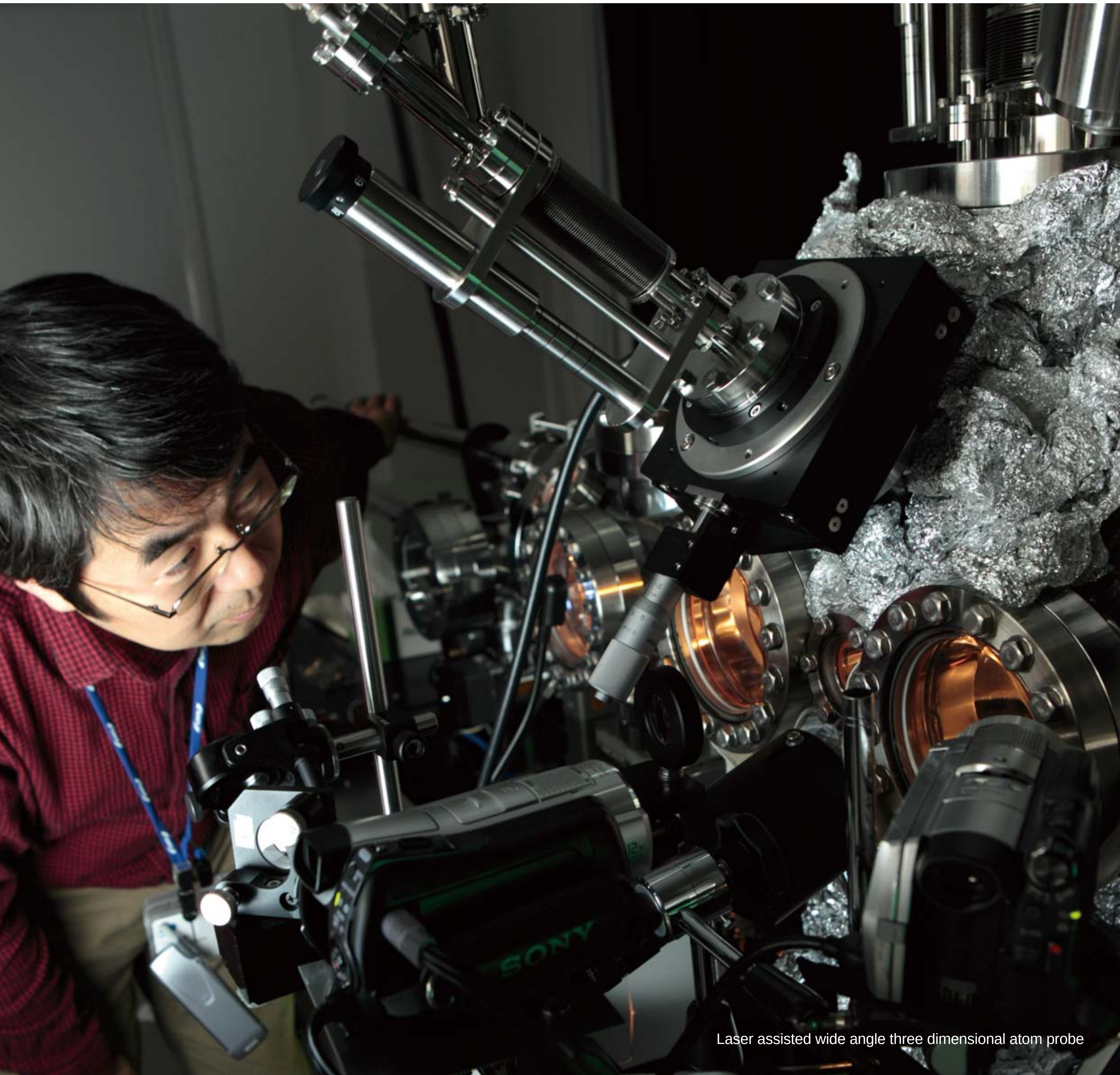
Achievements of International Research Collaboration

Expanding the Research Network with Memorandums of Understanding (MOU)



Laser assisted wide angle three dimensional atom probe

Achievements of International Research Collaboration

Expanding the Research Network with Memorandums of Understanding (MOU)

Memorandums of understanding (MOU) are agreements which are concluded in research group units, specifying particular research topics, with the aim of activating international exchanges of researchers and research information. By joining the small bonds which exist between individual researchers with deep friendships to cooperation with the research groups to which those researchers belong, and developing collaboration between research institutes, these agreements create the foundation for building a larger research network.

MOUs allow the partner organizations to share benefits in various ways. For example, MOUs facilitate holding of workshops and dispatches of researchers to counterpart institutions, thereby encouraging exchanges of researchers and information. These agreements also enable a division of labor in research projects, and allow the partners to take advantage of their counterpart's complementary technical strengths when carrying out research.

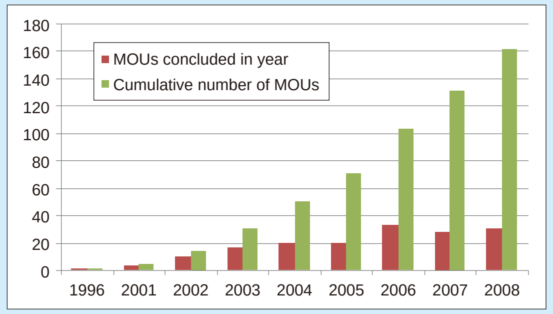
In addition to these merits, MOUs are also important for the development of human resources. At NIMS, agreements with universities account for approximately 60% of all MOUs. This allows talented young scientists to do research work at NIMS while they are still students. These human resources are then employed at NIMS or at other leading research institutes around the world. From this viewpoint, MOUs are also an extremely significant activity for the training of technical personnel and researchers, which is one part of our mission at NIMS.

As shown in the following figure, since NIMS became an Independent Administrative Institution (IAI) in 2001, we have put great effort into the creation of research networks. As of the end of 2008, we had concluded a total of 161 MOUs. By research region, this included 193 items. Of these MOUs, 22 have developed into "sister institute agreements" with other research institutions, and we have concluded a total of 15 joint international graduate school agreements, further strengthening cooperation.

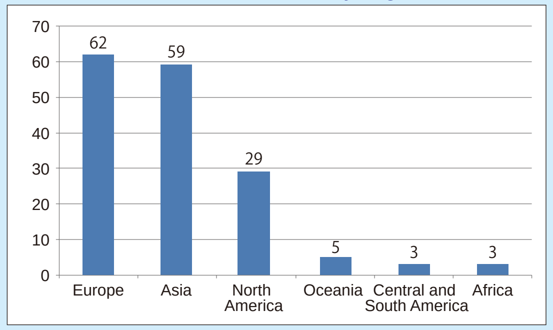
In this feature, we will introduce the achievements of 3 of our 161 MOUs.

Fig.

Transition of number of MOUs

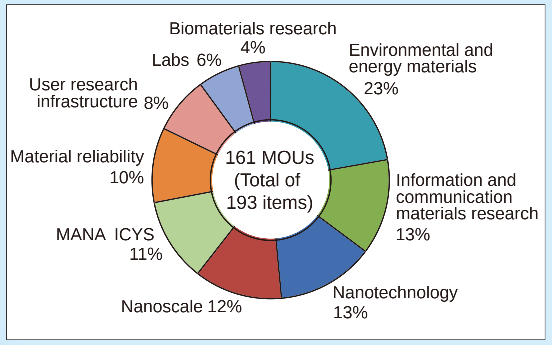


Number of MOUs by region



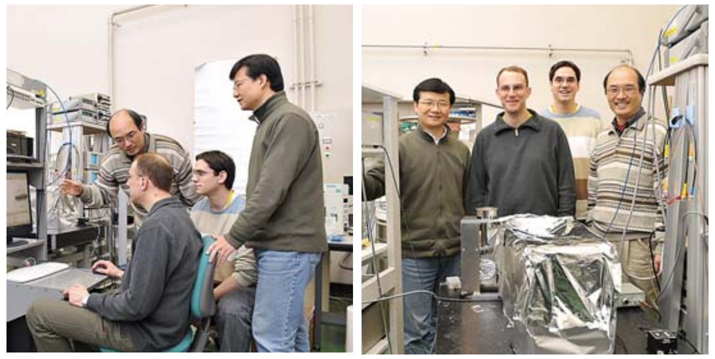
*Europe included NIS countries

Number of MOUs by research region



ICYS: International Center for Young Scientists
MANA: International Center for Materials Nanoarchitectonics

Researchers from partner institute



Joint research on "Nano superconductor electronics" by University of Tubingen (Germany) and NIMS Advanced Nano Materials Laboratory

NIMS researcher at partner institute

Joint research on "Superconducting strands for future accelerator magnet" by the NIMS Superconducting Materials Center and the Fermi National Accelerator Laboratory (USA)

Pacific-Rim Joint International Research on Fuel Cell Materials

- Searching for the Unknown Possibilities Concealed in Fuel Cell Materials -

NIMS Fuel Cell Materials Center × University of Queensland, Centre for Microscopy and Microanalysis (Australia)
Alfred University, Kazuo Inamori School of Engineering (USA)

Period of MOUs: 2001-2006, 2006-2011

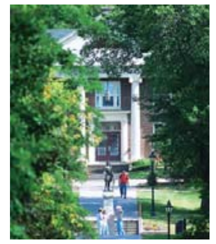
In 2001, NIMS Fuel Cell Materials Center signed an MOU on "Analysis and Simulation of Nanostructures in Solid Electrolytes for Fuel Cells" with the Centre for Microscopy and Microanalysis, University of Queensland and the Kazuo Inamori School of Engineering, Alfred University. This was the first MOU for joint international research concluded by NIMS with the aim of promoting research on environmental and energy materials, and was signed in the first fiscal year when NIMS began activities as an Independent Administrative Institution (IAI).

The objectives of this joint research were to accurately evaluate and analyze microscopic structures with the potential to have a large effect on the macroscopic physical properties of structures which exist in fuel cell materials but are so small that they are difficult to perceive, and to provide a theoretical elucidation of the effect of these nano-level structures on macro physical properties. In the educational aspect, in 2003, NIMS also concluded MOUs in connection with joint international graduate school programs with five Australian universities, beginning with the University of Queensland, in order to increase the effectiveness of this collaboration in the training of young human resources.

Because the Centre for Microscopy and Microanalysis at the University of Queensland and the School of Engineering at Alfred University were not engaged in research on fuel cell materials at the time, for these institutions, this relationship had the merit of opening the way for active involvement in the field by conducting research with NIMS. For NIMS, it had the merit of enabling rapid development of high quality research, integrated from the basic level to applied research, by promoting research on detailed nano-level structural analysis and simulations based on the results of that work, using the materials handled by NIMS.

Following the signing of this MOU, the results of this research were published under joint authorship in peer-reviewed international journals, beginning with Physical Review B and Applied Physics Letters, in a total of 27 articles and 3 reviews. The published results of joint research on simulation techniques were also highly evaluated and received a commendation from the International Congress on Physics of Solid State Ionics.

University of Queensland



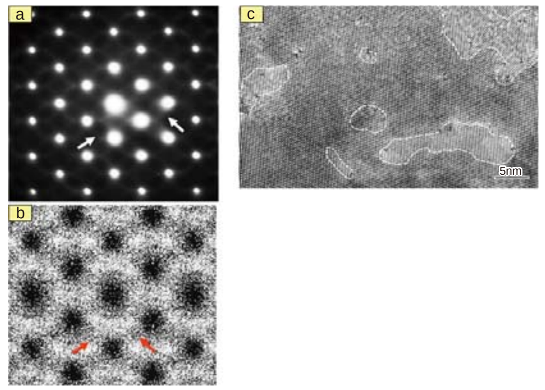
Alfred University

The accompanying **figure** shows an example of the results of this joint research. Doped ceria is a solid oxide electrolyte for fuel cells. The **figure** shows the results of transmission electron microscope (TEM) observation of a microdomain structure that extends through this doped ceria and is considered to greatly reduce performance, and the results of the calculation of an electron diffraction pattern based on a model which was established for that structure. The calculated results show good correspondence with the observed electron diffraction pattern, demonstrating the appropriateness of the model in this research.

This series of joint research achievements and educational results was highly regarded. As a result, in 2004, President Teruo Kishi of NIMS received the title of Honorary Professor from the President of the University of Queensland, which was a first for a Japanese national in Australia, and in 2007, Dr. Toshiyuki Mori, who is Deputy-Managing Director of the NIMS Fuel Materials Center and is in charge of this research, was selected as adjunct Professor by the Centre for Microscopy and Microanalysis of the University of Queensland. Thus, the results of this mutual cooperation have steadily borne fruit which has appeared in diverse forms. At present, NIMS has secured a NIMS Office at the University of Queensland and is creating the conditions for even more active joint research.

Because this trilateral Pacific Rim joint international research by organizations in Japan, Australia, and the United States is an effort by fellow researchers who are geographically separated, there have also been various difficulties, but conversely, it is also an advantage that researchers with different ideas and ways of thinking are able to promote research while giving each other mutual stimulation in a positive sense. Involvement in this joint international research is also an extremely valuable experience for the students and young scientists who will be responsible for the next generation of research. It is our strong hope that students and young scientists will actively participate in this joint international research, and they will use this as an opportunity for achieving substantial professional and personal growth.

Fig.



(a) Electron diffraction pattern observed from a sintered body of doped ceria, (b) calculated electron diffraction pattern, and (c) high resolution transmission electron microscope (TEM) image. The areas indicated by the arrows in (a) and (b) show a phenomenon called "diffuse scattering" and seem to suggest the existence of the short-range ordered structure called microdomains. In (c), the regions surrounded by the wavy lines are microdomains. It this research, it was found that the part inside these small regions has a different structure and composition from that outside the microdomains.

Development of New Materials and Nanotechnology including Thermoelectric Materials

NIMS Advanced Electronic Materials Center
NIMS Organic Nanomaterials Center
× University of Washington, College of Engineering (USA)

Period of MOUs: 2002-2007, 2007-2012

In 1994, Dr. Toyohiro Chikyo, Managing Director of the NIMS Advanced Electronic Materials Center, visited the University of Washington (UW), where he gave a lecture and UW sounded him out the possibility of cooperation. The idea was shelved, as NIMS's predecessor organization, the National Research Institute for Metals, had no freedom in the use of its budget at the time. However, after that institute became part of NIMS as a newly-established Independent Administrative Institution (IAI), it became possible for research group units to receive students, and Ph.D. course students at UW studied at NIMS. Occasioned by a post-doctoral fellow who planned to continue research at NIMS after completing his doctorate, the UW College of Engineering and the NIMS Nanomaterials Laboratory (of the time) concluded an MOU on "Discovery of Innovative Multifunctional Nanosubstances toward Future Applications," leading to the development of a wider range of cooperation.

The aims of this MOU were to discover new functional materials through cooperation between UW and NIMS, which possessed diverse materials development technologies, to introduce Japanese research to UW through education and research by UW graduate students by participation in research using the advanced apparatus at NIMS, and furthermore, to promote research by acquiring competitive funds in Japan and the United States through this research.

The merits of this agreement for NIMS are the construction of a relationship with professors at UW, who enjoy an excellent reputation in the United States, and the ability to conduct joint research with outstanding graduate students. In fact, up to the present, NIMS has received a total of 10 doctoral course students, including long- and short-term students, and has also participated in the examinations of the doctoral dissertations of two of these students.

On the other hand, the merit for UW is that it can perform quick screenings of materials using the combinatorial materials synthesis devices and high throughput material characterization technologies which NIMS developed for oxides and metal materials. These devices make it possible to evaluate the structure and electrical conductivity of oxide thermoelectric materials. In addition, both NIMS and UW have acquired external budgets through this research.

The following results have been achieved through this research.

(1) Development of oxide thermoelectric materials

The aims of this work are to enhance the thermoelectric properties of thermoelectric materials by introducing a magnetic effect, and at the same time, to realize thermoelectric devices with only n-type semiconductors. NIMS and UW acquired a budget for joint international research, which is a project of Japan's New Energy and Industrial Technology Development

At the signing of the MOU in 2004 by the NIMS Nanomaterials Laboratory (of the time) and the College of Engineering, UW.

During a meeting to discuss the NEDO international research project in 2006 (at UW).

Organization (NEDO), and in cooperation with the National Institute of Advanced Industrial Science and Technology in Japan and the Pacific Northwest National Laboratory in the United States, produced a large number of results over the period 2005-2007. During this work, UW also obtained funding from the National Science Foundation in the US.

(2) Development of high dielectric oxides

Using combinatorial techniques, NIMS and UW conducted a search for high dielectric gate insulation film (high-k) materials for direct bonding on silicon. One of the achievements in this research was published in Advanced Materials in 2008, and due to its unique content, it was also introduced in the web version of Nature. Doctoral students who received guidance in this research also participated in research as post-doctoral fellows and later were employed by the Max Planck Institute, which has a close relationship with NIMS. Thus, this international collaboration also functions as a career path for human resources.

UW, together with the American company MICRON, is engaged in searching for new high dielectric materials by the combinatorial material synthesis techniques which it acquired in joint research with NIMS, and has established the "MICRON-Lab" at UW for this purpose. This is an example in which the results of international cooperation led to collaboration with one of the world's top companies.

Last year, a NIMS Overseas Office was established at UW, and a system for permanent stationing of NIMS researchers in this office has been created. This will expand a diverse range of possibilities, such as cooperation with multiple faculty members at UW, collaboration with companies located around Seattle, and the like. In the midst of increasingly international research, the relationship between NIMS and UW is a good example of what international cooperation should be.

Elucidation of Mechanism for Improving the Corrosion Resistance of Rare Metal-Free Weathering Steel Developed by NIMS

NIMS Structural Metals Center × University of Virginia, Department of Materials Science and Engineering (USA)

Period of MOU: 2006-2011

The NIMS Steel Research Center and the Department of Materials Science and Engineering at the University of Virginia (UVa) in the United States signed an MOU on "Structural Metals for High Performance in Severe Environments" in 2006. Following changes in the research organization at NIMS, the Structural Metals Center took over this activity in April of the same year.

UVa is famous as the university that was founded by Thomas Jefferson, the author of the Declaration of Independence and the third president of the United States. Today, it is an important center of materials research in the eastern United States and is involved in a large number of very interesting studies, including industry-government-university cooperation, in a wide range of research fields such as physics and chemistry. Since the university is highly focused on metal materials with more than half of its professors and staff involved in research in this field, NIMS considered that the university was the ideal partner for research on structural metal materials.

The signing of this MOU paved the way for personnel exchanges and joint workshops for sharing information on the mechanisms of corrosion and destructive damage. On the other hand, preventing the leakage of technology has been an issue in projects related to materials development, and collaborative research and the writing of papers remain difficult. However, research activities that presuppose the writing of papers are known to be effective for deepening debate and mutual knowledge, and thus analysis and evaluation, which are separate from materials research, have been accepted in this cooperation.

The present research examines severe environments in which materials are exposed to corrosion, high temperature, and the force of impact. To overcome environmental and energy problems, plants such as thermal power plants need to be made more efficient, and the lifespan of infrastructure such as bridges needs to be extended. For example, operating at a higher temperature boosts the efficiency of power plants, and so

University of Virginia

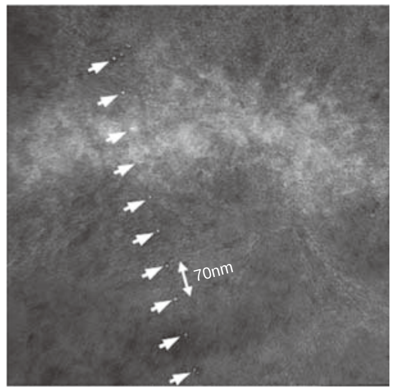
materials which can withstand higher temperatures need to be developed and the mechanism of deterioration of such materials must be clarified. Similarly, to extend the useful life of bridges and plants in coastal areas, where corrosion is severe due to high concentrations of salt, it is important to develop materials with excellent corrosion resistance and to clarify the mechanism of corrosion.

Rare metals such as nickel and copper are usually added to high corrosion resistant steels (coastal weathering steels). Meanwhile, NIMS has been conducting research to develop a coastal weathering steel which does not contain any rare metals and has proposed a carbon steel containing approximately 2mass% of added silicon and aluminum, which are abundant elements. The development and patent application have already been completed; however, the relationship between the corrosion resistance of the developed steel and the nanostructure of the rust that forms on its surface remains unclear. NIMS is now examining the relationship between corrosion resistance and the rust nanostructure with researchers at UVa, who are particularly strong in surface/interface microstructural analysis.

The photograph on the left is a transmission electron microscope (TEM) image of a rust layer which was formed on the surface of the developed steel. In this research, NIMS prepared the alloy samples and performed the corrosion testing, while UVa carried out the TEM observation and composition analysis. Both parties have been trying to improve the corrosion resistance. An analysis of the chemical composition of regions 1 nm in diameter located at intervals of 70 nm, as shown in the photo, revealed the formation of nanometer-sized microscopic silicon oxide particles, which exist densely in the rust layer, and prevent the penetration of harmful ions such as chlorine ions, thus improving the corrosion resistance.

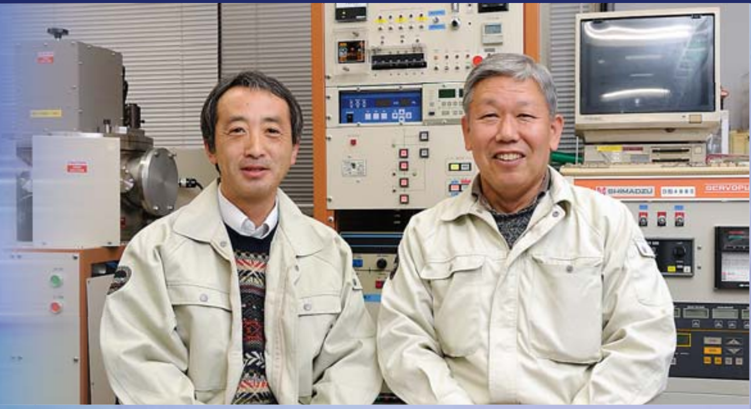
The rare metal-free weathering steel proposed by NIMS is an attractive material that was developed at a time when natural resources are dwindling. However, the practical application of structural materials usually takes an extremely long time, often exceeding 10 years, due to the need to evaluate reliability. Based on this MOU, we are working to elucidate the mechanism through joint research and are carrying out research aiming for practical application in both Japan and the United States.

Fig.



Transmission electron microscope (TEM) image of a rust layer on 2mass% Si-added carbon steel. The white points at the tips of the arrows are points where the chemical composition was analyzed. Corrosion Science, Vol. 50 (2008), 2159-2165

Development of a Simple Polyimide/Shape-Memory Alloy Thin-Film Actuator



Actuator Functions Group, Sensor Materials Center

Group Leader
Akira Ishida

Morio Sato

As products become more compact and portable, the development of actuators*[1] which are capable of moving microscopic parts is an increasingly important challenge. In previous work, we developed a shape-memory alloy (SMA) thin-film actuator with force and displacement extremely larger than those of the conventional micro-actuators such as piezoelectric devices, etc. (NIMS NOW 2005, No. 7). However, with the thin films developed to date, after deposition on a Si wafer, heat treatment at 500°C or higher is required for crystallization of the films, and it is also necessary to perform micro-processing on the formed thin film by the same technique as that used in the semiconductor process. This type of process is extremely effective in mass production, but conversely, the difficulty to achieve practical application due to the high cost of the manufacturing facilities has been a problem.

Therefore, in this research, we developed a novel SMA thin-film actuator by deposition on a polyimide substrate with the aim of manufacturing simpler, more general-purpose actuators. This invention was realized based on the finding that a crystal film can be obtained even at low temperature if 15-25 at. % Cu is added to the conventional Ti-Ni alloy. The fabrication method is simple, requiring only sputter deposition of the Ti-Ni-Cu film with a thickness of several µm on a polyimide substrate heated at approximately 300°C. Heat treatment after fabrication is not necessary. The thin film can be used as an actuator by simply cutting out an appropriately shaped piece with scissors or punch and then connecting its two edges to a battery (**Fig. 1**). When the temperature of the thin film due to Joule heating exceeds the phase transformation*[2] temperature of the SMA (approximately 50°C), the shape of the actuator changes, making it possible to move an object.

The conventional shape-memory alloy, Ti-Ni, is a material which by nature cannot be soldered. However, deposition of a copper film approximately 1µm in thickness on the Ti-Ni-Cu film enabled direct soldering (**Fig. 2**). **Fig. 3** shows the movement of the wings of a toy dragonfly using the developed polyimide/SMA actuator. In this example, the weight of the wings was approximately 0.18g. However, it was also possible to lift a weight of more than 10g simply by changing the thickness of the polyimide film (**Fig. 4**). A large reduction in power consumption to 0.2W was also achieved in the case shown in **Fig. 2** by leaving the copper film on parts other than the actuator, thereby bypassing the current to the copper film.

Electroactive polymers,*[3] which are similar actuators, require strict sealing to keep moisture in them. In contrast to this, because the polyimide/SMA actuator can be cut out any arbitrary shape for use, application as a simple actuator for small parts is expected.

*1 Actuator: A machine or device which moves an object.

*2 Phase transformation: A phenomenon in which the crystal structure or magnetic properties of a substance change. Shape- memory alloys undergo a large change in shape when the crystal structure changes.

*3 Electroactive polymer: Also known as "artificial muscles"; when a voltage is applied across the two sides of a special polymer film, the ions in the film undergo displacement, causing the film to bend.

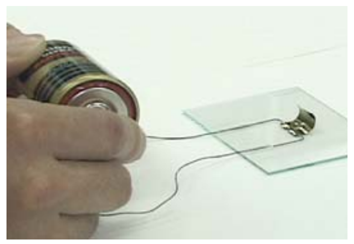


Fig.1 Operation of the developed polyimide/SMA actuator using an ordinary dry battery.

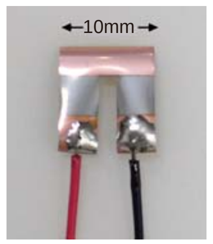


Fig.2 A device in which leads were soldered to a Cu thin film formed on an SMA thin film.

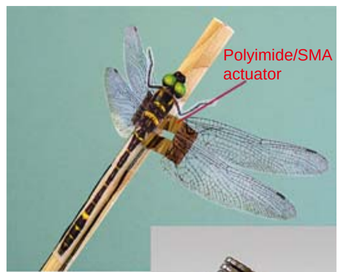


Fig.3 A toy dragonfly with wings moved by the polyimide/SMA actuator.

Fig.4 The polyimide/SMA actuator lifting three coins weighing 4.5g each.

Polymer Nanowire Fabricated with Laser Processing

Micro-nano Materials Engineering Group, Materials Reliability Center

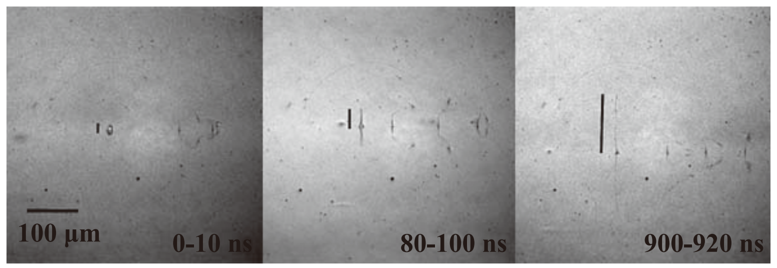
Group Leader
Masahiro Goto, Akira Kasahara, Masahiro Tosa

With progress in nanotechnology, it has now become possible to fabricate nanowires using various types of materials, including semiconductors, metals, ceramics, and others, resulting in heightened interest in the creation of devices that take advantage of their unique properties. Recently, it has also become possible to form polymer nanowires consisting of multiple polymer chains, which are organic materials, and application of these materials to gas sensors, laser elements, and organic transistors is underway. As the main methods for fabricating polymer nanowires, the methods using a mold with numerous microscopic holes, applying a high voltage to a pipette in which a polymer solution has been injected, followed by extrusion and others are well known. We discovered a completely new technique for fabricating polymer nanowires utilizing laser processing, and also succeeded in observing the growth process of the nanowires. The outstanding points of this method include the fact that the fabrication process is extremely simple, it is possible to grow a single polymer nanowire at the location where the laser is irradiated, and if the necessary materials are mixed in advance in the polymer film used as the raw material, doping of those materials in the wire is simple. As an additional advantage of the developed method, although the conventional technique has the drawback that the wires may be damaged by exposure to the etching solution or the effects of the high electrical field, damage to the polymer nanowires during growth is minimal with the new method.

The polymer nanowire fabrication method is as follows. First, the polymer film which serves as the base material is fabricated on a glass substrate by the spin coating method*[1]. When this is irradiated with visible pulse laser light (e.g., wavelength: 440nm, pulse width: 900ps) focused by an objective lens, the light is absorbed and a polymer nanowire grows. One point which is extremely important here is optimization of the intensity of the laser light. A nanowire will not grow if the intensity of the laser is too strong or too weak. With polymer materials having low laser light absorption, a trace amount of a dye molecule (on the order of 4wt%) is dispersed in the material. When it is desirable to impart a different functionality to the polymer, the material which is the source of that function is added simultaneously. We installed an optical microscope in the processing system and succeeded in photographing the growth process of nanowires using a CCD camera with an extremely high speed shutter function (**Fig. 1**). The results revealed that the growth time is approximately 1µs. This wire stands upright from the substrate for several minutes, and thereafter falls due to disturbances in the air. **Fig. 2** shows an example of a scanning electron microscope image of a fabricated polymer nanowire (polystyrene, length: 100µm, diameter: 150nm). Up to the present, we have attempted fabrication with four kinds of polymers, and it was possible to form nanowires with all of these substances. As it is thought that this novel technique will make it possible to fabricate polymer nanowires with various functions in the future, this work has undoubtedly opened the road for the manufacture of new functional devices.

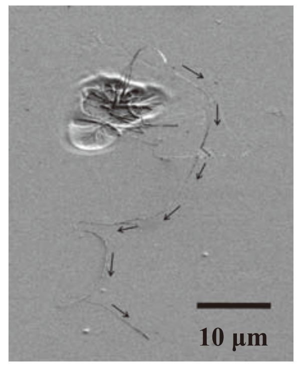
*1 Spin coating method: A method of fabricating a homogeneous thin film on a substrate by rotating the substrate at high speed and dripping a polymer solution on it.

Fig.1



Example of time-resolved photographs of a polymer nanowire grown by irradiation with pulse laser light. A phenomenon which begins with swelling of a wide region, followed by growth of a single thin, long wire can be observed (polymer: polybutylmethacrylate).

Fig.2



Example of scanning electron microscope observation of a polymer nanowire. (polymer: polystyrene).

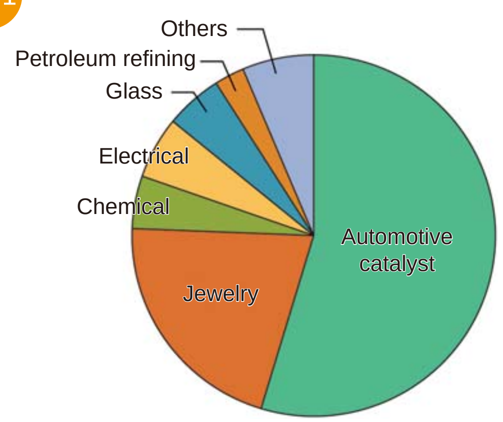
Efficient Use of Platinum Group Metals

Platinum Group Metals Task Force in the Strategic Use of Elements Cluster launched in 2007 is made up of researchers from the NIMS Innovative Materials Engineering Laboratory, Composites and Coatings Center, Advanced Electronic Materials Center, Fuel Cell Materials Center, Computational Materials Science Center, and Advanced Nano Characterization Center. The objective of this Cluster is to establish guidelines for the efficient use of platinum group metals by the multidisciplinary knowledge and experiences in NIMS.

"Platinum group metals (PGM)" refers to 6 metals, namely, platinum, palladium, rhodium, iridium, ruthenium, and osmium. Although these are extremely expensive rare metals with small reserves and production, they play key roles in various industrial fields. For example, **Fig. 1** shows the ratio of demand for platinum. Its main industrial application is as a catalyst. In particular, catalysts for purification of automotive exhaust gas account for more than half of demand. Taking advantage of the high melting point and excellent resistance to oxidation and corrosion of the PGMs, these metals are also used as heat-resistant materials for melting furnaces producing glass for liquid crystal displays, coatings for turbine blades in jet engines, spark plugs for automobile engines, and other applications. Due to increasing production of automobiles and stricter requirements for environmental improvement, demand for PGMs as automotive catalysts has increased rapidly. Similarly, production of liquid crystal displays has also grown substantially in recent years. Accordingly, technical development is needed to ensure efficient use of the limited PGM resources.

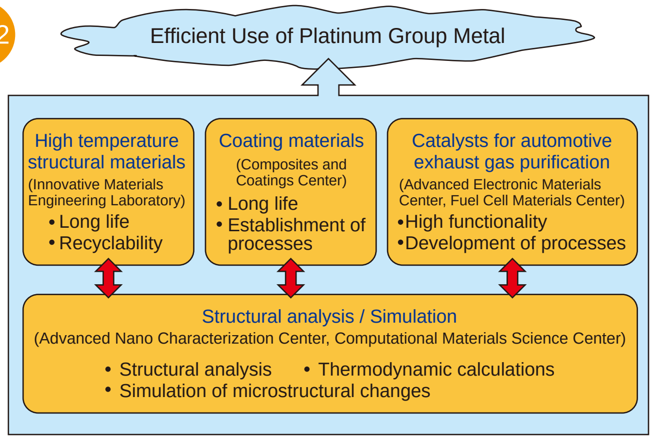
In responding to this mission, we have selected three targets, high temperature structural materials, coating materials, and catalysts for automotive exhaust gas purification, and are developing technologies for efficiently use of PGMs from the viewpoint of reducing the amount used, improving material performance, and securing recyclability. The system of collaboration in this Cluster is shown in **Fig. 2**. Three teams are responsible for production and assessment of iridium-based oxide dispersion strengthening alloys with high recyclability, high performance PGM-based coatings, and platinum-based intermetallic compound catalysts, respectively. The mechanisms by which properties are manifested will be clarified in cooperation with another team, which will analyze the microstructures and crystal structures of the materials using advanced electron microscopy, evaluate phase diagrams based on thermodynamic calculations, and predict microstructural changes by computer simulations. The Cluster often holds seminars to share information and thereby establish the knowledge-base for the efficient use of the rare elements of PGMs.

Fig.1



Demand for platinum (source: Platinum 2006).

Fig.2



Collaboration of teams in the Cluster aiming at establishment of technologies for efficient use of platinum group metals.

The Magnetic Materials Center conducts fundamental research on magnetic materials for next-generation high-density recording systems, spintronics devices, and energy saving. Recently, there has been much research on the development of high coercivity permanent magnets for hybrid and electric vehicles. The Managing Director of the Magnetic Materials Center, Professor Kazuhiro Hono, was selected as one of the recipients of the Honda Frontier Award for 2009 for his contribution on the structure–property relationships of magnetic materials.

Structure–property relationships of magnetic materials

Kazuhiro Hono
NIMS Fellow
Managing Director, Magnetic Materials Center

How did you start the research on permanent magnets?

I was very interested in permanent magnets when I was a junior and I wanted to join a magnetic materials laboratory for a senior project, but there were too many applicants. There was a ballot to get into the lab, but I was not confident about winning so I ended up choosing a metal physics lab, where I started research on aluminum alloys using atom probe field ion microscopy. I have been working with the atom probe technique ever since. When I moved to NIMS in 1995, I immediately set up an atom probe and began working on nanocrystalline soft and hard magnetic materials. The reason was simple: the microstructures of these materials are perfect for the atom probe technique. But at that time, I never thought I would be able to start working on the development of magnetic materials by myself.

How did you change directions from analytical research to materials development?

When I started publishing papers on the atom probe results of nanocomposite magnets, those who had worked on the processing of permanent magnets started applying to my group to do their post docs. This became a turning point to get into the processing of magnetic materials by ourselves, because I let them continue working on such processing in my group. Also, I was appointed as associate professor of the graduate school at the University of Tsukuba through the collaborative graduate program system, so it became possible to expand my research field to other than the atom probe technique. I think my group would have remained as an analytical group if I had not joined the graduate program.

Research has expanded to processing, hasn't it?

Almost at the same time, Dr. Yukiko Takahashi, who received her degree in the processing of magnetic thin films, joined my group as a post-doctoral fellow, saying that she wanted to characterize the microstructure of her own samples by transmission electron microscopy (TEM). I advised her not only to work on the characterization of thin films but also to continue working on thin film processing. So we began our research on high magnetocrystalline anisotropy films for magnetic recording media. Because materials with high magnetic anisotropy can also be used as permanent magnets, we expanded our work to the fabrication of nanocomposite permanent magnets as well, and we were able to obtain top data on $SmCo_5$/FeCo anisotropic nanocomposite magnetic thin films.

Nanocomposite magnets are scientifically interesting, but their practical application is still a long way off. While I was thinking about starting more practical research, I met Dr. Masato Sagawa, who had invented the Nd-Fe-B magnet, at an international conference. We discussed the possibility of developing Dy-free high coercivity magnets. At that time, people were beginning to recognize the importance of "element strategy", which means that rare elements must be substituted with more abundant elements, so we submitted research proposals on Dy-free Nd-Fe-B magnets. Recently, the need for substituting rare metals has become clear, so research on the development of Dy-free magnets has gained momentum. In the short term, we should try to improve the coercivity of sintered magnets, but in the long term, nanocomposite magnets also have potential as higher-performance magnets. Scientifically, this is very interesting and challenging, even if practical application is not possible immediately. Currently, we just have launched research on both next-generation high-performance sintered magnets and next-next-generation nanocomposite magnets.

What other kinds of research are you doing?

One topic is searching for half-metallic Heusler alloys and their application to giant magnetic resistance devices. We are attempting to achieve large magnetic resistance in multilayer films using Heusler alloy ferromagnetic electrodes with high spin polarization, in which a current flows perpendicularly to the film plane. To achieve this goal, we need to control the interfacial structures of the multilayers at the atomic scale by optimizing the processing conditions, and that requires evaluating the structures using TEM and atom probe techniques. Without close collaboration among various areas of expertise in thin film processing, microfabrication, nanocharacterization, physics and materials science, it would be impossible to obtain cutting-edge results.

What are your hopes for young scientists? Do you have a message?

Instead of continuing to do what you are told by your superiors, I encourage researchers to tackle areas that really interest them, in their own way. Experimental results are often unpredictable. Even if the results are not successful, you will only learn by trying. Learning from failure is the next step in development.

The NIMS Advisory Board meetings

A scene at the Advisory Board meeting.

Meetings of the NIMS Advisory Board were held on January 19-20 and February 12, 2009, attended by NIMS Advisors who are active in the forefront of materials research. The participants at the meeting in January included nine professors from universities in Japan. At the meeting in February, five top corporate leaders and other knowledgeable persons attended.

The Advisors offered frank opinions on a variety of issues and points for improvement, including the NIMS research organization and its operation, international/industry-academic-government collaboration, human resources development, use of user facilities, research results and their dissemination, and efforts as one of the world's core research institutions, as well as industry's requests for NIMS.

The Advisors recommended that NIMS should strive for greater external visibility with regard to the use of facilities by outside researchers, put more effort into publicity to encourage an interest in materials in private companies and middle and high school students, and give priority to basic research and research that contributes to improving the competitiveness of industry. NIMS should recognize that corporate investment in R&D will be difficult for the foreseeable future due to the current economic downturn. These critiques and recommendations will be incorporated in the future direction of NIMS, and will be positively utilized in both organizational operation and research work.

Joint Workshops with South Africa and New Zealand

The New Zealand-Japan Workshop

(Jan. 19-20, 2009) NIMS and members of South Africa's "COE for High Strength Materials" held a joint workshop at NIMS. The keywords of this workshop were high strength alloys, ceramics, superhard materials, nanocarbon materials, diamonds, etc. South Africa is blessed with an abundance of rare metal resources, for example, accounting for approximately 75% of the world's total production of platinum. The workshop was a part of ongoing exchanges with that country on research and development in connection with high temperature alloys and other applications using those resources. In the future, mutual exchanges in a wider range of material fields are expected.

(Jan 28-29, 2009) NIMS also held a joint workshop with nanomaterials researchers from New Zealand, who were visiting Japan with the support of the country's Ministry of Research, Science & Technology (MoRST). The workshop was held following a preparatory period of about one year after a mission from New Zealand visited Japan in December 2007. Each side introduced 10 topics, spanning a wide range of research including electronics, environment/energy, biotechnology, etc. Continuing joint research and exchanges of researchers in the future were also discussed.

Thailand-Japan Workshop in Bangkok

All participants of the WS

(Feb. 6, 2009) The "Thailand-Japan Workshop on Advanced Materials for Environmental Sustainability" was held on February 6 at Chulalongkorn University (CU) in Bangkok. This workshop brought together four organizations, the Advanced Ceramics Unit of Department of Material Science, Faculty of Science at CU, the Thailand Institute of Scientific and Technological. Research (TISTR), Thailand's National Metal and Material Technology Center (MTEC), and NIMS. The workshop was open to the general public, had more than 100 persons participated. The event featured a total of 17 lectures (CU: 3, TISTR: 2, MTEC: 4, NIMS: 8) as well as enthusiastic discussions. This bilateral workshop was realized by great efforts of Prof. Shigetaka Wada of CU's Department of Material Science, Faculty of Science, who was invited to NIMS in February 2008 to present a lecture on producing a ceramic (silica: SiO_2) powder from Thai rice husks, and took one year to materialize.

We, all expect another meeting opportunities in future, and deepen cooperation among those organizations participating in this Thailand-Japan workshop.

Results of the 7th International Symposium on Nanotechnology (JAPAN NANO 2009)

Lecture scene of JAPAN NANO 2009

(Feb. 18, 2009) The 7th International Symposium on Nanotechnology (JAPAN NANO 2009) was held at the Tokyo Big Sight International Exhibition Center as part of "nano week 2009," which brought together a large number of exhibitions and international conferences. The Symposium was sponsored by NIMS, and cosponsored by the institutions participating the Nanotechnology Network Project for Innovation (Nanonet Japan) of Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT). The theme of this year's Symposium was "Nanotechnology for Energy and the Environment."

Following greetings by Mr. Fumio Isoda, Director-General of the MEXT Research Promotion Bureau and Prof. Teruo Kishi, President of NIMS, Dr. Yoichi Kaya, Vice President and Director-General of the Research Institute of Innovative Technology for the Earth (RITE), delivered the Keynote Address, entitled "Technology for Preventing Global Warming," in which he presented an overview of the key challenges in energy problems related to the environment and the expectations placed on nanotechnology in meeting those challenges. A total of 11 Japanese and foreign researchers who are active in the forefront of nanotechnology research were also invited, and discussed the status of advanced research and development in the fields of energy creation and use, energy transportation and storage, and the environment/energy conservation.

Q & A session

More than 700 persons visited the Symposium, including both Japanese and international participants, and gained a better understanding of the condition of R&D that challenges the energy and global environmental problems facing humankind by utilizing nanotechnology.

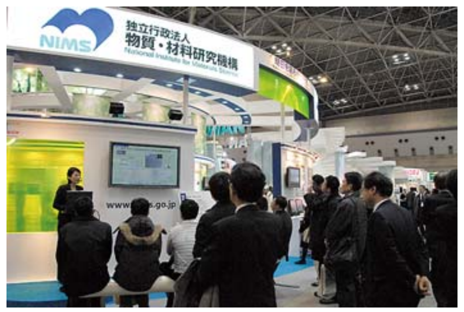
NIMS Participated in nano tech 2009 – International Nanotechnology Exhibition and Conference

Explanation of the NIMS nanoparticle production device.

(Feb. 18-20, 2009) The nano tech 2009 – International Nanotechnology Exhibition and Conference was held at the Tokyo Big Sight International Exhibition Center.

Nano tech 2009 is the world's largest-scale international nanotech exhibition and conference, with participation by many institutions including those from outside of Japan. The event serves as a platform for introducing the world's advanced technologies and recent product information in connection with nanotech, and for generating new projects by matching "seeds" and "needs." Based on the theme "The Future of Green Nanotechnology R&D has Begun," which was the common topic of 7 simultaneous exhibitions, this year's event made it clear that nanotechnology has advanced from basic research to applications, and delivered the message that nanotechnology will play an important role in environmental and energy problems.

As a research center which is a driving force for nanotechnology in the field of materials, NIMS presented a total of 17 exhibits on research/technology seeds with the potential for collaboration, including topics related to the environment and energy and others, and its large-scale scientific instruments such as the NMR magnets, nanoparticle production device, etc. The diverse exhibitions by NIMS also included a nanotechnology education DVD and outline of priority project research at NIMS. Mr. Fumio Isoda, Director-General of the MEXT Research Promotion Bureau also viewed these NIMS exhibits. In a Special Symposium held in the event venue, Dr. Kyoko Kawagishi, a Senior Researcher in the NIMS High Temperature Materials Center, presented a lecture on "Superalloys and Energy Saving" which attracted strong interest among visitors.



NIMS booth on Feb. 20

The number of visitors at all exhibition areas during the 3 day event totaled 47,272, demonstrating the high interest in nanotechnology.

WMRIF Asia-Oceania Workshop

(Feb. 15-17, 2009) The 3rd Meeting of the World Materials Research Institute Forum (WMRIF) is scheduled in June 2009, for extensive discussions of the contribution of materials research to environmental and energy problems. The forum will be hosted by the National Institute of Standards and Technology in the United States (NIST).

Preceding this event, the 1st WMRIF Asia-Oceania Workshop was held at NIMS on February 15-17 in order to deepen mutual recognition in the Asia-Oceania region. At the workshop, representatives of 13 research institutes from China, India, Korea, Singapore, Taiwan, Thailand, and Japan gathered and introduced their respective efforts in responding to environmental and energy problems. The deeply-interesting topics were discussed at this workshop included the importance of water purification, biomass research, and proposals for joint research on materials for bicycles and motorcycles, which have high demand in Asia. The participants also agreed to hold the 2nd workshop, centering on an introduction of the results of joint research.

WMRIF: http://www.ematerials.net/network/WMRIF/

Ecomaterials Forum WG 5th Symposium "Materials Development Utilizing Computational Science"

(Feb. 12, 2009) The working group "Exploration of the potential development of alternative materials maximizing use of advanced nano physical properties" of the Ecomaterials Forum and NIMS Strategic Use of Elements Cluster jointly hosted the 5th symposium at NIMS under the title "Materials Development Utilizing Computational Science."

The focus of this event was a discussion of the possibility of substituting the excellent physical properties shown by rare elements with common elements by utilizing nanotechnology, which has achieved such remarkable development in recent years.

The further active efforts are planned with the aim of presenting proposals for element substitution strategy from the viewpoint of the physical properties of materials.

The lecture by Prof. Yoshiyuki Kawazoe of Tohoku University, entitled "The Reality of Physical Properties Revealed by Real First-Principles Calculations."

Hello from NIMS

My name is Karolina Statkiewicz. I work in the Administrative Office of MANA (WPI International Center for Materials Nanoarchitectonics). I had already been at NIMS in 2007 as an internship student. This time I will stay here for one year. In Poland, I graduated from the course in Japanese Studies at the University of Warsaw, so I know about the Japanese language and culture. However, I still encounter many surprising things in daily life. I think this is one of the reasons why Japan is so interesting and exciting for foreigners. I really enjoy working at NIMS. I have made many friends from all over the world and I'm enjoying a very nice working environment at my office. On weekends I travel around Kanto with my friends. I'm also going to visit Kansai and Hokkaido. I'm looking forward to having some bike trips too, because I love motorcycles. Actually, I can't wait! I'm sure that I will come back to Japan many times in my life.

[With my lovely friends at a MANA Symposium]

Karolina Statkiewicz (Poland)
Administrative staff
October 2008 - present
MANA

[With Sumo wrestlers, Tokyo]

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