NIMS NOW International

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DIALOGUE

Continuing to Grow and Evolve as a Research Institute

– The Importance of Systemic Reforms and Evaluation as an "Independent R&D Institution" –

As part of the larger process of administrative reform in Japan, a review of Independent Administrative Institutions, or IAI*, is now underway. In this issue of NIMS NOW International, we welcome a very special guest, Nobel Laureate Ryoji Noyori, who is President of RIKEN, a world-class research institute that is responsible for scientific and technical research in Japan. Here, NIMS's President Kishi asks Prof. Noyori to discuss his vision of the IAIs, the problems that he has recognized through the operation of RIKEN, and his future image of these institutes.

* IAIs are independent legal entities which assumed the operational functions of certain government organizations, such as national laboratories, as part of Japan's policy of administrative reform. The IAIs are under Ministry supervision and receive operating subsidies from the government, but employ private-sector management methods and have considerable budget autonomy.

Ryoji Noyori President of RIKEN

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Teruo Kishi President of NIMS

Profile

Ryoji Noyori

Named first President of RIKEN in 2003. University Professor, Nagoya University; member of the Japan Academy and the Pontifical Academy of Sciences; foreign member of the National Academy of Sciences (NAS; USA) and the Royal Society (UK), and other distinguished organizations. President of the Chemical Society of Japan for FY2002. Prof. Noyori's specialty is organic chemistry. He was awarded the Nobel Prize in Chemistry for 2001 for his research on chirally catalyzed hydrogenation reactions with ruthenium complex catalysts.

Profile

Teruo Kishi

Named first President of NIMS in 2001. Director-General of the NIMS Nanotechnology Support Network. Vice President of the Science Council of Japan from 2003 to 2005 and President of the Japan Federation of Engineering Societies since 2007. Prof. Kishi's specialty is nondestructive evaluation of materials and their strength.

The mission of public research institutes and reform of the system of utilizing the human resources that support them.

Kishi: I'd like to start by asking you to discuss the mission of RIKEN.

Noyori: RIKEN has four missions as a public research institute. The first is to conduct research of the highest quality in the natural sciences. Our purpose is not limited to ordinary individual research, but also includes strategic integration of such research and pioneering new research fields. Secondly, we develop and construct research infrastructure for the scientific community inside and outside of Japan, and we provide ample opportunities for use of that infrastructure. Work that falls under this category includes the SPring-8 synchrotron radiation facility and the RIKEN BioResource Center (BRC), and the development of the Next-Generation Supercomputer and the XFEL (X-ray free electron laser), which are national critical technology projects that we began last year. Thirdly, we promote scientific research in these areas and play a leadership role in creating new research systems for the development of young human resources. As an example of this, RIKEN was the first institute in Japan to introduce a fixed-term employment system. Our fourth mission is to return the results obtained in our research to society. This is not limited to the purely economic aspect of industrializing the results of research at RIKEN, but also includes contributing broadly to cultural and educational improvement.

Kishi: You're talking about research in the natural sciences, but if we simply substitute materials science for natural science, NIMS's mission is quite similar to RIKEN's. First, there are basic research and infrastructural and generic technology research. When we talk about infrastructural and generic technology research, we mean the intellectual infrastructure, for example, the research infrastructure and standards. In addition, this area of our mission also includes popularization of research results, shared use of facilities and equipment with researchers outside NIMS, and improvement in the quality of researchers and research engineers. Creation of new materials is a general task for NIMS, but in addition to this, "the true value of materials is in their use" and "nanotechnology-driven materials science for sustainability" describe the major pillars of our research. However, I'd like to ask about RIKEN's third mission, human resources, which you mentioned. Concretely, what are you doing in the area of human resources development?

Noyori: In order to fulfill its mission, an IAI that's involved in research and development has to develop outstanding human resources with a diverse range of expertise, and it has to make full use of those capabilities. Fluid human resources are indispensable for this. This means it's necessary to create a flexible personnel system for training and using human resources, beginning with hiring, but also including "graduating" people back into society, and follow-up after they leave RIKEN. As I mentioned earlier, RIKEN introduced the fixed-term employment system before other institutes, and at present, 85% of all our researchers are fixed-term. In the future, we will also strengthen our efforts to support their career paths, considering the life cycle of fixed-term employees. For this, we'll have to strengthen cooperation outside of RIKEN, for example by creating a network for researchers who've changed jobs. We think this will be a valuable asset for RIKEN.

We've also created an International Associate Program as a system for hiring and training outstanding young researchers from around the world, and we're expanding our Joint Graduate School Program, which educates top students worldwide, beginning with the Asian region. If you go overseas, you'll find an extremely large number of students who want to do research at RIKEN, but because we don't currently award academic degrees, top foreign students use our Joint Graduate School Program with universities to come to RIKEN. In particular, if we consider the relationship between Japan and the Asian nations, opening the way for human resources in Asia is going to be increasingly important in the future. Anticipating this system, in 2001 RIKEN established an Asian Joint Graduate School Program, under which we're building cooperative relationships with six universities in Asia. Based on these relationships, we're making "securing and training diverse human resources for creation of outstanding results and training and turning out the human resources required by society" one pillar of our next Mid-Term Plan, which begins in our next fiscal year next April.

Advice for reviewing IAIs: An absolute evaluation is necessary for "only one" activities. From "Independent Administrative Institution" to "Independent R&D Institution".

Kishi: Both RIKEN and NIMS aim to become the world's top research institute in their respective fields. Could you comment on this?

Noyori: RIKEN researchers publish around 2000 scientific papers each year, and this number is increasing every year. The number of papers in the top 10% of the Citation Index, particularly in the top 1%, has increased rapidly over the last ten years. This has now reached a level similar to that of the leading universities in the United States. If we assume that the level of research can be measured by the Citation Index, I think we have achieved an extremely high level.

We also have the operation of RIKEN as a whole evaluated once every two to three years by the RIKEN Advisory Council (RAC). The members of this council are eminent researchers and outside experts with a proven record in the administration of representative universities and research institutes. The RAC has about 20 members, half of whom are Japanese. The other half are non-Japanese, and include Nobel laureates. We held a meeting of the RAC in June of last year and received an assessment from an international perspective. At the time, I spoke on the topic "RIKEN: Where did we come from? What are we? Where are we going?" Happily, the title of the report which answered those questions was "RIKEN: Leading Japanese Science to Global Preeminence." The report stated that "RIKEN has reached national eminence and, in terms of scientific quality, has taken its place among the most prestigious international research organizations, including the National Institutes of Health in the United States, the Weizmann Institute in Israel, the Max-Planck Society in Germany, the British Medical Research Council, or the French National Research Organizations, CNRS and INSERM." In this, I think we've received an extremely high evaluation, not merely as a formal evaluation, but also for the substance of our work. Likewise, the evaluation found that we've made considerable advances in the operation of RIKEN.

Kishi: When NIMS became an IAI, we received clear policy guidelines from an international Advisory Board. One point that was strongly emphasized was the fact that we were publishing a lot of papers in Japanese, but the number of English-language papers appearing in top journals was inadequate. We made strenuous efforts to remedy this situation, and as a result, our citation rank in the field of materials science has risen from 31st to 6th, comparing the total for the five years since we became an IAI against the previous five years. To be sure, our number of published papers and patents, Impact Factor, Citation Index, and the like are steadily increasing. However, I feel that it's extremely difficult to define what makes a "good research institute" and then to measure research institutes based on that definition. I think it's important to become the kind of institute that's open to information from the international community and attracts numbers of people even if it doesn't publicize itself.

Noyori: As evaluation standards, those responsible for evaluations, beginning with MEXT [Ministry of Education, Culture, Sports, Science and Technology], insist on formal quantitative evaluations, like the number of published papers or Impact Factor. That represents a certain kind of evaluation, but it's not the whole story. For example, if we look at this question in the light of RIKEN's mission, how does one assign a numerical score to SPring-8, or to the creation of the Next-Generation Supercomputer or the XFEL? Of course, a relative evaluation would be possible if there were a large number of similar projects, but a relative evaluation simply isn't possible for "only one" activities. These projects are the only ones of their kinds in the world, so they have to be evaluated in absolute terms. If they aren't, the whole effort becomes problematic.

A similar problem arises when we talk about training and turning out top-class researchers. In this case, what index do you use to show that you're a good research institute? Similarly, what do we mean by a "COE" [Center of Excellence]? Ultimately, we have to actively assert ourselves. If we passively accept evaluations, we won't be able to do the work that we should essentially be doing.

Kishi: I agree that a passive stance is no good. We have to argue that "this is our role," as we see it, and not let others define it for us.

Noyori: At the outset, I explained the four missions of RIKEN. However, what's really key here is to ensure that the world understands that science and technology are crucially important to modern society and civilized society, and we achieve this understanding by doing excellent research. However, this isn't the job of the individual researcher. It is important to make this case as a research institute. This, I think, is our job as the top management of our respective organizations.

Kishi: You're absolutely right. Considering the fact that fundamental and basic research account for 70% of our activities at NIMS, it's critical that the public understand the importance of this type of research.

Noyori: The work we do doesn't have a fixed form. Since the government is talking about reviewing the IAIs, I think this is fine, and I hope they'll make a careful review and evaluate the proper form of the IAIs. However, because the IAIs are legal entities that are evaluated by the world for specialized work in research and development, I think it would be appropriate if we were evaluated as "Independent R&D Institutes," and not as Independent Administrative Institutes.

Kishi: Japan's science and technology budget has been reduced substantially during the last four years. However, we must ensure that those concerned fully understand that "research costs" are in fact "personnel costs." If we don't do this, independent R&D institutions that can play a central role in the life of the nation will no longer be possible.

Noyori: I'd like to see the creation of a system in which ambitious, aggressive independent R&D institutions can compete at the world level.

Kishi: In this, we have to make it very clear how our institutes are substantially different from other IAIs.

Noyori: However, just saying we're different doesn't get us anywhere. We have to emphasize precisely what kind of work we're actually doing. We have to win the understanding and support of the Japanese people by effectively communicating our vision and direction for the future.

Accelerating the return of research results to society.
A new paradigm: Adopting a parallel model of collaboration with industry.

Kishi: Let me ask about the role of IAIs in promoting innovation. What are your thoughts on this?

Noyori: It's also an issue in the government's 3rd Science and Technology Basic Plan (FY2006-FY2010), which was begun with a 25 trillion yen development investment target, and "innovation" has become a keyword. We have to have a direction for achieving this. Although Japan is making an enormous investment in fundamental research, it's difficult to translate the results of fundamental research directly into social or economic benefits. Of course, this isn't limited to Japan; it's a fact of life everywhere. Under these circumstances, I think the IAIs have an extremely large role to play in innovation in the middle-to-long term.

Up to the present, RIKEN has made some genuinely impressive achievements in fundamental science. In the future, we want to make sure that these achievements contribute to innovation in industry, medicine, foods, the environment, energy, and other fields as quickly as possible. For this, if I can compare it to a relay race, we need a "baton zone" where we pass the baton to industry. Staying with the same simile, in this race, RIKEN isn't the anchor man who crosses the finish line. This means other sectors also have to take the baton and run with it.

Kishi: The "baton" being research results . . .

Noyori: That's right. In the conventional linear model of fundamental research, applied research, and development, the baton rarely gets passed. You feel like the next runner is waiting 500 meters down the track. This suggests the need for a new paradigm. We need to revise this linear model into a parallel model, and create a mechanism in which the transfer and receiving of research results can occur in parallel. And we need to return research results to society efficiently. In cooperation with industry, RIKEN wants to build a system for promoting use which has the real ability to put results into practice. Foreign institutes give RIKEN high marks for its capabilities and results, and propose cooperation with us. Unfortunately, however, few Japanese companies seem interested. This tendency is particularly strong in the life sciences. Firstly, we are obliged to compete and cooperate with domestic institutes, but if we can't find partners in this country, we must inevitably cooperate with foreign institutes. However, I'm beginning to think that perhaps the global interest that results from this kind of cooperation ultimately comes back to us and benefits Japan's national interest as well.

Having said that, RIKEN remains committed to identifying intellectual property and producing innovations jointly with domestic companies. To this end, in the present fiscal year, we started a program for Collaboration Centers whose names include private-sector companies. This was begun as part of a "baton zone" policy for transferring research results from RIKEN to industry. For example, in May we set up a joint Collaboration Center with Olympus.

Kishi: Without a doubt, the principle of self-sufficiency is deeply ingrained in Japanese companies. We created the Rolls-Royce Centre of Excellence for Aerospace Materials in NIMS. In 2010 or so, planes will be flying using superalloy engine materials developed at NIMS. In some cases, these are fields where Japanese companies aren't particularly strong, but in other fields as well, foreign companies have always been more interested in cooperating with us. Of course, we exercises due care to avoid losing Japanese technologies and intellectual property. In any case, this is all a delicate issue, because your research may end up being left on the shelf if you're too particular about your partners.

Science and technology: A source of national strength. Becoming an irreplaceable research institute for the society of tomorrow and a research institute that continues to grow.

Kishi: Now let me ask you about the problems you've noticed through the operation of an IAI.

Noyori: It's now been four years since I became the first President of RIKEN as an IAI. Our research is progressing smoothly, but various problems related to the IAI system have becoming apparent, and these affect RIKEN's ability to demonstrate its full potential. The activities of an independent R&D institution are not some kind of standardized administrative work. Among the 21 research IAIs, I think that RIKEN is a central or core presence, and we're proud to think that we're playing a key role in the priority fields in strategic areas of technology identified by the national Science and Technology Basic Plan, as well as in creating innovations for these national critical technologies. I believe that an excellent research institute, like a strong economy, is characterized by the ability to grow and continue evolving. However, in attempting to realize this, we are faced with certain systemic problems. A solution to these problems is urgently needed if RIKEN is to be an institute that truly contributes to society.

The first point is the problem of evaluations and allocation of resources. Domestically, evaluations are made at various levels, but these frequently tend to be formal evaluations. As we carry out our daily activities, we're always mindful of the true essence of a research institute, which includes taking on the challenge of advanced research topics, making discoveries and inventions that astonish the world, playing a useful role in constructing a research infrastructure of the highest level, and so on. Socially, these activities are highly evaluated, but where the allocation of research resources is concerned, there are serious questions as to whether action is appropriate.

The second point is restrictions on hiring personnel. Under a Cabinet resolution in 2006, implementation of proportionate efforts to reduce total personnel costs for national government employees was applied across the board, including also the IAIs. We fully understand the difficult condition of the nation's finances, but for the IAIs which are responsible for research and development, being unable to secure suitable human resources due to personnel cost reductions is a matter of life and death. Even assuming we attempt to carry out joint research with funding from the private sector, we cannot hire researchers, so if we introduce funding from the private sector, we can't accept joint research unless we restrict hiring using our operating subsidy. Furthermore, even if we're commissioned to do research and development which is indispensable for Japan such as national critical technologies using commissioning fees from the national government, hiring of personnel for this purpose is not excluded from the scope of personnel cost reductions. This means the IAI has to pay for personnel out of its own pocket in order to take on the project.

A third problem is the lack of incentives for management efforts. Essentially, the IAI system is based on the principle of post-evaluation, and the independence and autonomy of the IAIs in accomplishing their work should have been respected as fully as possible. However, this hasn't been the case. If the IAIs are required to make management efforts, implementation of a system that rewards those efforts is necessary. Whether this has actually been realized now is extremely questionable.

Because international competition in research and development is so intense, we must have the competitiveness to compete effectively with other countries. The United States and China are rapidly increasing their investment in science and technology in a way that's truly dynamic. Management rationalization is necessary, but if the point of the discussion is trivialized as a purely domestic problem, we won't be able to compete internationally.

Kishi: In an era when personnel expenditures are rising in other countries, personnel budgets in Japan will shrink without a review of the total framework for personnel expenditures and the Laspeyres index [index comparing the compensation system for public employees].

Noyori: Because research is done by people, you have to hire good people and compensate them appropriately. It's natural to pay high salaries to people with high abilities. The main cost of research is personnel costs. I'd like to see the research and development work that we're doing evaluated properly, and the creation of a system with international competitiveness, based on the recognition that science and technology are the source of a nation's strength.

Kishi: What's your dream for the future of RIKEN and the IAIs?

Noyori: RIKEN recently celebrated its 90th anniversary. Ten years from now, we'll reach the century mark. I'd like to double our level of activity by then. By double, I don't necessarily mean 2.0 times. It's not something you can quantify, but rather, I'd hope that everyone will have an image of RIKEN as a research institute that's grown dramatically in 10 years. The image of RIKEN which is our aim is an "irreplaceable research institute for the society of tomorrow." I hope RIKEN will be a presence which is always respected and appreciated by society. However, we can't achieve this alone, so we want to investigate the possibility of all types of collaboration with others.

It is important to actively undertake strategic collaboration in order to construct win-win relationships with other organizations of all kinds, including industry, universities, the educational world, and cultural groups, in which we can share the benefits. Independent R&D institutions must continue their research for the prosperity of this country, and for the continuing life of humankind. From this viewpoint, I hope that NIMS will also enter into powerful and beneficial collaborative relationships.

Kishi: NIMS also hopes to be a research institute that will continue to grow. I would like to thank you for all of your instructive comments today. Including the current collaboration, I hope that both you and RIKEN will continue to honor NIMS with your support and friendship.

(Translated by the NIMS Public Relations Office)

SPECIAL Interview

Winner of the NIMS Award for Recent Breakthroughs in Materials Science and Technology

Prof. William Butler
Director, Center for Materials for Information Technology (MINT)
University of Alabama, U.S.A.

Dr. William Butler, Professor at the Center for Materials for Information Technology (MINT), at the University of Alabama, visited NIMS in July to receive the first NIMS Award* for "Theoretical prediction of giant tunnel magnetoresistance in Fe/MgO/Fe junction" at the NIMS Conference 2007.

The discovery, in 2001, that led to Dr. Butler's NIMS Award has already resulted in breakthroughs in extending our ability to read and write to magnetic media. This is a welcome development, since the new materials give greater sensitivity and resolution, and demand for ever greater storage capacity and speed is intense and growing in the data storage industry.

Dr. Butler's work on calculating tunneling transport through MgO single-crystal thin films led to him predicting giant tunneling magnetoresistance in a three-layer Fe/MgO/Fe junction, and a resulting enormous increase in coherent tunneling transport through the middle magnesium oxide layer. Later experimentation bore this prediction out, and the resulting rapid improvement in conductance in these two layers (as much as 500% has been achieved) will allow much higher functionality for spintronics devices and lead to new applications.

Dr. Butler and his former team at the Oak Ridge National Laboratory were working on calculations to see how the current changed when you changed the orientation of the magnetic moments in a thin film. "What we found, to our surprise as much as anyone else's," Dr. Butler said, "was that this change could be very large, that when the moments were parallel there was a relatively large current, and when they were antiparallel there was a small current."

The discovery was, in a sense, the result of serendipity – "The results were very strange, very different from what we expected, so we had to convince ourselves that the physics was correct. It was a matter of seeing the results, understanding them, and also believing them."

Excited, they set about understanding what was going on, and found what turned out to be a simple physical principle that explained the effect. "You always have to be careful that you're not reporting some garbage that's coming out of the calculations," he said. "But now we understand the physics in rather simple terms."

"The exciting thing is that it is quickly being employed commercially," he went on. "The next hard disk drive you buy will probably have giant TMR technology in it. It's also possible that this effect will be used for a new kind of solid-state memory called magnetic random access memory (MRAM). This is rather like flash memory, but solves some of flash's problems, such as limits on the number of time it can be written."

For the near future, Dr. Butler's research will probably focus on a strange set of substances called half-metals, which exhibit the properties of metals for one set of spins, and insulators for another. "It turns out that NIMS is doing some of the world's best work in this area, which I was impressed to discover," Dr. Butler said.

He said he hadn't been aware of NIMS before hearing about the award, but he said he's been impressed by what he has seen during his visit. "You're doing some really exciting work here, from what I've learned from the presentations I've seen here. There have been some huge investments, and they're clearly paying off."

"Another thing about NIMS is the number of foreign researchers. I think that's good for Japanese science, to have scientific exchanges. We need more of that in the U.S., especially in our field."

Dr. Butler is careful to emphasize that the discoveries he has made have all been the result of teamwork. We asked him the secret of making a great team. "That's a really good question, and I wish I knew the answer. I think if everyone is sincerely interested in the science, and you're working together to understand it, and are driven by the joy of discovery and intellectual curiosity, the rest of it usually works out pretty well. You just have to get the right people together who have those objectives."

*For more details of the NIMS Award, see page 14 and www.nims.go.jp/nimsconf07/01f.html

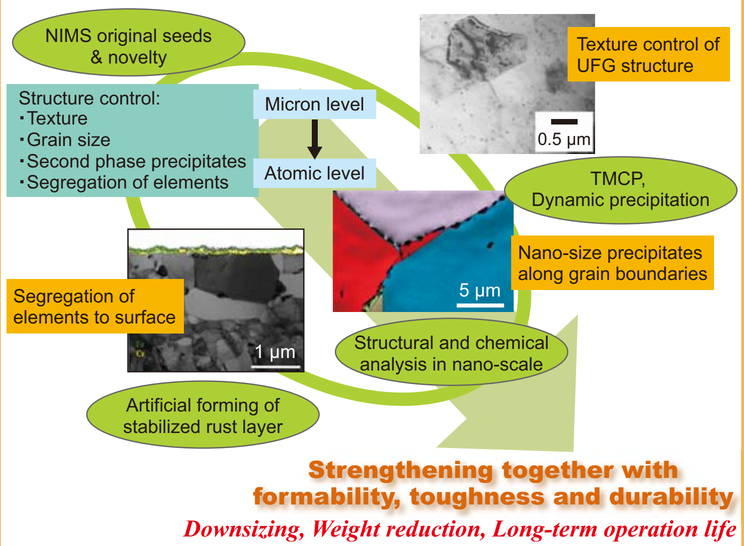
Structural Metals Center

Development of High Performance Structural Materials through Multi-Scale Structural Control

Structural materials are the basic materials for automobiles, machinery, and shipbuilding, which are key industries for Japan as a nation that depends on trade in processed manufacturing products. They are also important for the construction of infrastructure such as power plants, buildings, and bridges, which is essential for a safe and secure nation. On the other hand, significant reductions in the availability and quality of ore resources are expected in the near future. In particular, critical shortages of many alloying elements are predicted. To ensure Japan's sustained growth, we thus need to develop metallic structural materials that does not depend on alloying elements. This will require new kinds of materials, for example, "alloy-less materials" which display high functional performance without addition of scarce alloying elements, and "impurity-tolerant materials" with excellent performance even when contaminated with impurities originating in raw materials or the service environment.

Microstructural control provides a powerful tool for realizing these kinds of new materials. Virtually all metallic structural materials have polycrystalline structures and consist of two or more phases. The materials form a wide variety of metallic microstructures, depending on the size, shape, orientation, and condition of distribution of crystal grains, and their microstructure is deeply related to the properties of the metallic material.

The Structural Metals Center is engaged in fundamental research with the aim of achieving high performance (high formability, high toughness, high durability) in metallic structural materials such as steels, magnesium alloys, aluminum alloys, titanium alloys, and others, and in joints of those materials, without depending on alloying elements. The key to this effort is control of the metallic microstructure from the nanometer level.



Project Motto

The motto of the Structural Metals Center is "Creation of new-type structural materials with a gaze fixed firmly on the near future." Our basic philosophy is to break through the barriers of existing material properties and process technologies by developing radically new technologies which are not simply an extension of conventional technologies. In addition to inventing and proposing new materials and process technologies, we intend to elucidate the ideal microstructures corresponding to property requirements and provide theoretical backing for those microstructures.

Material Development Targets of the Project

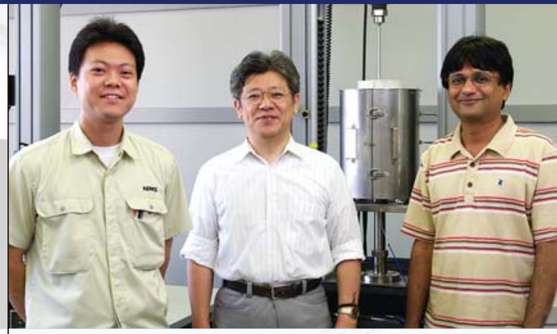
In order to achieve the following five targets, we are engaged in collaborative research on common fundamental technologies such as analysis techniques, while clearly defining the division of work among the Center's 5 groups. The research is being carried out with the cooperation of universities and private companies.

- Magnesium alloys which possess formability and toughness comparable to aluminum alloys (Lightweight Alloys Group)
- High temperature titanium alloys with reduction of the use of the scarce element niobium (Nb) by more than half (Titanium Group)
- High temperature alloys which realize a 50 °C increase in steam temperature in thermal power plants (Heat Resistant Design Group)
- High strength steels which dramatically increases impact absorbed energy (Welding Metallurgy Group and Physical Metallurgy Group)
- Cu- and Ni-less corrosion resistant steels with corrosion rates reduced to 1/10 (Physical Metallurgy Group)

For more details: http://www.nims.go.jp/smc-5/indexe.html

Design of High Strength, High Ductility, High Toughness Magnesium Alloys

Lightweight Alloys Group, Structural Metals Center



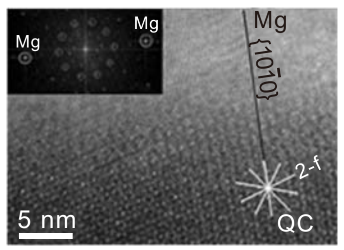
Group Leader
Hidetoshi Somekawa, Toshiji Mukai, Alok Singh

As the threat of global warming becomes increasingly apparent, reduction of CO_2 emissions has become an urgent social issue. Weight reduction in automobiles and other means of transportation is being actively pursued as a part of the solution to this problem. Among the structural metallic materials, magnesium is the lightest in weight and is therefore a promising candidate for weight reduction. Specifically, in comparison with the conventional structural materials, the density of magnesium is 1/4 that of steel and 2/3 that of aluminum. In order to apply magnesium alloys to lightweight automotive structural components, the essential challenges for research are to overcome brittleness, which originates from the crystallographic structure, simultaneously with realization of high strength (in other words, improving toughness), and to eliminate differences in strength which depend on the direction of deformation, which can be seen in differences in tensile deformation and compressive deformation. We are engaged in research to optimize the material microstructure in order to realize high strength and high toughness in magnesium alloys without sacrificing high ductility (easy formability) by improving the microstructure of the material at the micro- as well as nano-meter orders sizes.

An effective approach to overcoming brittleness is to impart properties that secure uniform deformation in all directions. We found that securing a comparatively random distribution of crystal orientations is effective for this. On the other hand, in realizing high strength, refinement of the grain size of the alloy and uniform dispersion of nano-sized spherical precipitates is effective. Therefore, we attempted to achieve high strength and improve the distribution of crystal orientations by using quasicrystal particles as strengthening particles, as these are expected to form an interface with strong bonding with the matrix (magnesium). For example, in an Mg-Zn-Ho alloy, we discovered that the crystal orientation of the matrix is randomized simultaneously with uniform dispersion of nano-size quasicrystal particles in the grain refining process when severe plastic deformation is applied at a temperature of around 200°C. As shown in **Fig. 1**, high resolution TEM observation revealed that an interface in which the crystal lattice has good match (shown by the black and white lines in **Fig. 1**) is formed between the uniformly dispersed quasicrystal particles and the matrix.

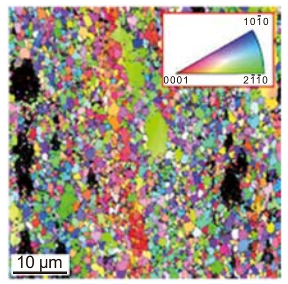
From the basal plane orientation distribution (**Fig. 2**) observed using SEM/EBSD (Electron Back-Scattered Diffraction), it can be understood that the crystallographic orientations have been randomized in comparison with conventional wrought magnesium alloys. The yield strength of the obtained material in tension and compression are approximately 300 MPa in both the cases, indicating that the problem of anisotropy in yield strength under different conditions has been solved. In our work with an Mg-Zn-Y alloy having a similar microstructure, the strength-toughness balance was improved in comparison with the conventional wrought magnesium alloys (see **Fig. 3**). This research demonstrated that it is possible to create magnesium alloys with mechanical properties comparable to those of high strength aluminum alloys.

Fig.1



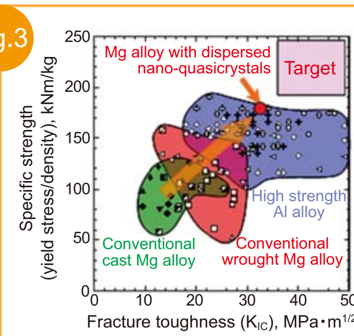
Formation of a coherent interface between quasicrystal particles and the matrix in an Mg-Zn-Ho alloy. (The inset shows a Fast Fourier Transform (FFT) spectrum image at the interface; QC: quasicrystal, 2-f: two-fold symmetry plane).

Fig.2



Distribution of crystallographic orientations of grains in the Mg-Zn-Ho alloy with dispersed quasicrystal particles.

Fig.3



Example of the improved balance of specific yield strength (yield stress/density) and fracture toughness in a Mg-Zn-Y alloy with dispersed quasicrystal particles.

Probing Electronic States in the Vicinity of a Single Dopant Atom on a Silicon Surface

Advanced Scanning Probe Microscopy Group,
Advanced Nano Characterization Center

Managing Director
Daisuke Fujita, Keisuke Sagisaka

Semiconductor large-scale integrated circuits (LSIs) are produced by processing a very large number of devices on a silicon surface. Higher performance is realized in LSIs by reducing the dimensions of the individual devices and increasing the degree of integration. However, when the device dimensions are reduced to several nanometers (nm), the physical phenomena that occur in this micro-region influence device performance, and in particular, have a large effect on the electronic state, which controls the motion of electrons.

In recent research, we measured the electronic state in the vicinity of doped atoms dispersed on a silicon surface (Si(001) surface) using the scanning tunneling spectroscopy (STS) technique. By nature, silicon which contains absolutely no impurities displays large electrical resistance at room temperature. However, when doped with trace amounts of phosphorous (P), boron, or other elements, the nature of silicon changes, allowing an electrical current to pass easily. This occurs because the doped atoms discharge holes or electrons which carry the current. However, because the distribution of the doped atoms is random, the possibility of deviations in the performance of individual transistors increases as the dimensions of the devices become smaller. For this reason, a characterization technology for observing the atoms doped in silicon and investigating their effects becomes necessary.

Fig. 1 shows the results of imaging of the electronic state of a silicon surface, which was measured with atomic resolution by STS. The honeycomb structure which extends over the entire image originates from the electronic states of the silicon atoms which are arrayed in the surface, and the spot which is clearly visible near the center of the image corresponds to a doped phosphorus atom (more precisely, a dimer consisting of P and Si). Electron waves scattered by the P atom and neighboring Si atoms were confirmed in the vicinity of the P atom (**Fig. 2**). Furthermore, an electronic state image different from other images could be observed in a limited region with a radius of approximately 3 nm centering on the P atom (**Fig. 3**). These results revealed that P atoms on the extreme surface are charged and also have an effect on the electronic states of neighboring Si atoms. It can be assumed that similar electron scattering and changes in electronic state will also occur in the vicinities of impurity atoms in actual LSIs. Thus, high expectations are placed on the development of the scanning tunneling spectroscopy technique which we used in this research as an advanced nano-characterization technology which will provide useful fundamental data for development/design guidelines for semiconductor LSIs of the future.

For more information: http://www.nims.go.jp/nanophys6/eindex.htm

Fig.1

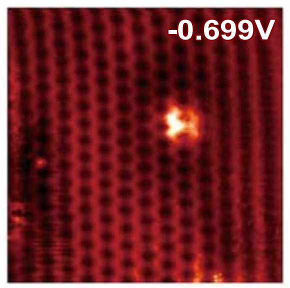


Fig.2

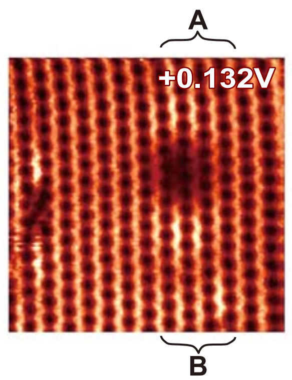
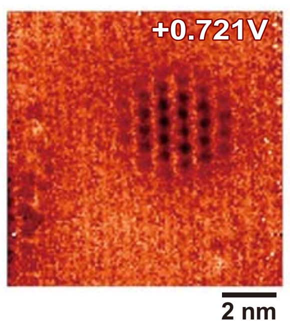


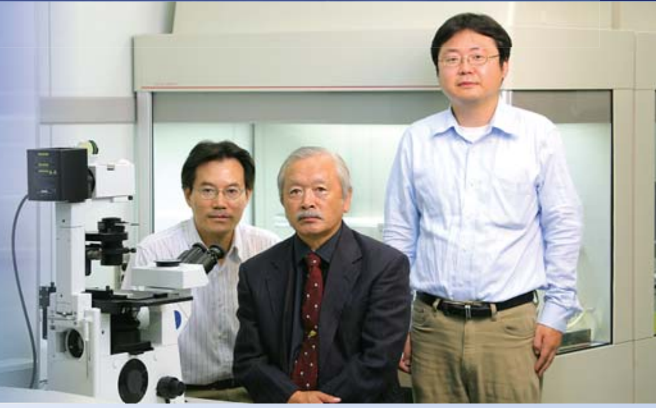
Fig.3



Results of measurement of electronic state in the vicinity of a doped substance (phosphorus) on an Si(001) surface. The three images are local density of states images measured in the same region of a clean Si(001) surface. When the voltage used in imaging is changed, the electronic state can be observed at a different energy level. The contrast in the image which can be seen in the region along the A-B direction in Fig. 2 represents electron waves scattered by the P atom and neighboring Si atoms. The observation temperature was -194°C.

Development of Porous Scaffolds for Organoid Engineering

Organoid Group, Biomaterials Center (BMC)



Group Leader Managing Director
Guoping Chen, Tetsuya Tateishi, Naoki Kawazoe

Organoid engineering is a technology for regeneration of organ-like complex structures (organoids) by seeding living cells in a porous scaffold and culturing them with supplement of growth factors. The organoids are then transplanted to patients to treat tissue or organ damage and diseases. Regenerative medicine through applying organoid engineering may provide patients with a new treatment to solve the problems that confront the conventional treatments of artificial implants and organ transplantation.

The requirements for porous scaffolds used in organoid engineering include biocompatibility, biodegradability, adequate mechanical strength, high porosity and high pore interconnectivity. When used for organoid engineering, porous scaffolds should be processed to have their external shapes and internal micro-structures be precisely controlled. We have developed a few kinds of such porous scaffolds described below by using biodegradable synthetic polymers made from lactic acid and glycolic acid, and collagen that is a kind of naturally derived polymers.

A hybrid porous scaffold (**Fig. 1**) was developed by covering all the outside surfaces of a collagen sponge except its upside with a lactic acid/glycolic acid copolymer mesh. As a feature of this porous scaffold, it possesses both excellent biocompatibility and high mechanical strength. It was found that the mesh has the effect to protect the leakage of the seeded cells, and thus can hold cells in the scaffolds with a high efficiency. The porous scaffold was then used for chondrogenic differentiation culture of human bone marrow-derived mesenchymal stem cells. The cells distributed homogeneously in the porous scaffold and cartilage-like tissue was regenerated.

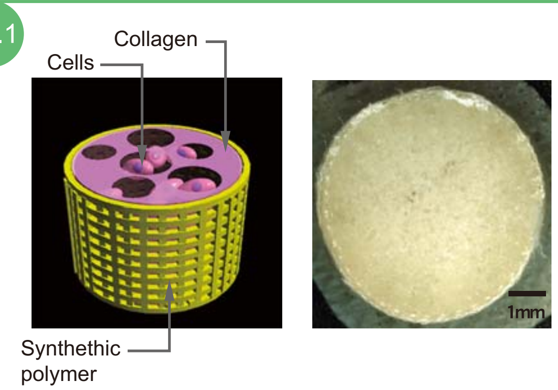
Living tissues and organs consist of numerous kinds of cells arranged in a determined order. To simultaneously regenerate two adjacent tissues in a connected mode, we developed a biphasic scaffold with a stratified two-layer structure (**Fig. 2**, left). The upper layer of the scaffold is a collagen sponge, and the lower layer is a hybrid sponge of lactic acid/glycolic acid copolymer and collagen. The biphasic scaffold enabled simultaneous regeneration of osteochodral tissue.

To precisely control the pore structure, we also developed a method using a biodegradable polymer template for the preparation of interconnected porous scaffolds. The collagen sponge fabricated by this method has high porosity and pore interconnectivity (**Fig. 2**, right). This interconnected collagen scaffold promotes adhesion and proliferation of human dermal fibroblasts. In comparison with the conventional scaffold, control of cellular interaction was easier, and the scaffold was effective in regeneration of skin tissue.

The above mentioned porous scaffolds will be useful for the regeneration of ligament, bladder, blood vessel, trachea, esophagus and muscle as well as bone, cartilage and skin.

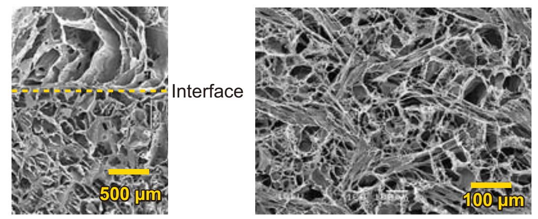
For more details: http://www.nims.go.jp/bmc/index_e.html

Fig.1



Collagen sponge covered with synthetic polymer mesh. The right shows a photograph of this top surface. The mesh has the effects of stabilizing the sponge shape and protecting cell leakage.

Fig.2



Biphasic porous scaffold consisting of collagen sponge (top) and synthetic polymer-collagen hybrid sponge (bottom).

Interconnected collagen sponge fabricated by the template method.

FACE フェイス interview

With the aim of creating an appropriate working environment for employees of both genders, NIMS launched a Gender Equality Committee in October 2005. A Gender Equality Team was established in February of 2007 to implement actual measures. In the current fiscal year 2007 (beginning April), the project "Support for female researchers utilizing hidden human resources" was adopted as a NIMS project under a Grant in Aid of Special Coordination Funds for Promoting Science and Technology commissioned by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). This was proposed as "Supporting Activities for Female Researchers" and will be a 3-year activity.
In this article, we discuss the issues involved with two of the three members of the Gender Equality Team who are currently raising children themselves, Team Leader Yoko Yamabe-Mitarai and Committee Member Shinjiro Yagyu. Unfortunately, Committee Member Akiko Nakamura-Itakura was overseas on business and was unavailable for this interview.

Yoko Yamabe-Mitarai
Group Leader, Platinum Group Metals Group, Innovative Materials Engineering Laboratory
Team Leader, Gender Equality Team, Human Resources Development Office

Shinjiro Yagyu
Senior Researcher, Advanced Device Materials Group, Advanced Electronic Materials Center
Gender Equality Team, Human Resources Development Office

Akiko Nakamura-Itakura
Senior Researcher, Advanced Scanning Probe Microscopy Group, Advanced Nano Characterization Center
Gender Equality Team, Human Resources Development Office

Compatibility between Research and Child Care: Gender Equality Activities at NIMS

A change in consciousness is key.

First, could you describe the events that led to the creation of the Gender Equality Team?

Yagyu: In the summer of 2006, the Gender Equality Committee created a "grand design" which was to be the basic policy for achieving gender equality at NIMS. This plan mentioned four pillars, which were positive hiring of women, review of work practices, support for childrearing, and reform of consciousness. However, there wasn't a team with responsibility for implementing these policies. In February of this year, three researchers who are actually raising children were asked to form a Gender Equality Team.

Yamabe-Mitarai: In particular, because researchers are expected to produce results and competition is so intense, we have to use virtually all of our free time for research. Given these conditions, the burden of housework and childcare inevitably falls on female researchers, and in some cases it's difficult for women to continue working in research. If men were also involved in childcare, I think it would be possible for women to devote themselves more fully to their research. Because gender equality is also important in research institutes, we have to create an environment in which diverse human resources can work effectively. This means that it's necessary to determine what problems we have at NIMS, study how these problems can be addressed, and propose support methods based on the results.

Can you give some actual examples of support?

Yagyu: In actually promoting a policy of gender equality, a change in consciousness is absolutely key. Once you recognize this, you have to consider measures that will change people's thinking. The first such measure is certification under Japan's Law for Measures to Support the Development of the Next Generation. To obtain certification, an organization – like NIMS – has to create a concrete support system that lets people take childcare leave without penalizing them in the workplace or in their careers. By making this one objective, we hope to change the consciousness in NIMS as a whole.

Another example is identifying and recognizing hidden human resources. Assuming that a male researcher's spouse is a hidden human resource, his consciousness is going to change if his wife works outside the home. This was also true in my family. When the wife works, you have to divide the family responsibilities, which include housework, child-raising in general, and of course, care for sick children. I think an awareness of this is the result of mutual discussion in the family and mutual cooperation.

Yamabe-Mitarai: A great deal of any researcher's work is experimental in nature. If you expect to make progress in your research, you have to come to the laboratory, operate equipment, and produce data. For this reason, NIMS has created a support system for researcher's work, under which a technical staff member is assigned to support researchers during early childcare. Although the period of this support is limited, and the system is currently only available to full-time female researchers, we think that this kind of support should be extended to include male researchers who are helping with childcare, and also post-docs.

Because NIMS researchers are involved in large projects, many group leaders think it will interfere with research work if female researchers take maternity and childcare leave, or if they frequently take time off because children are ill or go home on time to pick up children from child care facilities. In some cases, female researchers hesitate to have children, thinking they may be distracted by childrearing responsibilities, and this might cause problems for their colleagues. However, I think we have to recognize that these problems are temporary in nature, and of course, they're problems that we all have at one time or another. From the long-term perspective, if we all work together in creating an environment that supports a higher level of activity by researchers, our work will become easier. In short, even if we construct a system, after all, what's most important is changing how we think.

Publicizing options and information for problem-solving.

What do younger people think about these issues?

Yagyu: To describe my own consciousness of this, I'm a second-generation baby boomer, so I'm used to being around women, and I was brought up with women as competitors in certain situations, for example, in university entrance exams. So I feel that it's also natural that women work.

Yamabe-Mitarai: For working couple, I think, it is quite natural to share in their housework. If more men would help out with the housework, maybe it would lead to larger changes in attitude. As long as housework is considered "woman's work," the system we're talking about today will be seen as a "system for women," and there won't be any real change in consciousness. This is one reason why it's so important that women also work and men share in the responsibility for the home.

Where do we go from here?

Yamabe-Mitarai: Because everybody has different problems, I hope that we can create a system that will gradually reduce these respective problems. I also hope that we can provide a sufficiently wide range of options to solve problems no matter what they may be. We shouldn't accept the kind of thinking that isolates people who have children and stigmatizes them because they go home on time. To provide easy-to-understand information on what kinds of support systems are available and parents can use, we plan to provide a homepage that places priority on childcare support. We also hope to create a social networking service (SNS) which will provide opportunities to exchange information that can satisfy both childcare and research needs, and this will include both male and female researchers. This kind of network will let people talk to each other and exchange opinions and thoughts, so people can learn from others with the same, or similar, experiences. If this is possible, it won't have to be limited to NIMS. It could be expanded in Tsukuba City, for instance, and eventually nationwide, as a system for mutual encouragement and support.

This problem also concerns post-docs, doesn't it?

Yamabe-Mitarai: Full-time employees have a comparatively good system for time off, and their jobs are secure. Where vacation and other time off are concerned, the position of post-docs is quite different, in that they have to produce results quickly, and they have to think about their next positions. This affects researchers of both genders. Among younger researchers, there are cases where both the researcher herself and her husband are post-docs.

Yagyu: The method of providing technical staff is one type of support for female post-docs who are caring for young children. Another possible proposal, which may or may not be accepted, is a system for extending the post-doc's contract period in case of maternity or childcare leave. Of course, these are reforms in the system itself, and will require the agreement of the NIMS Board of Executives and labor union.

Yamabe-Mitarai: Since post-docs inevitably tend to be isolated, we hope they'll make good use of the homepage and SNS that I mentioned before. Looking further into the future, we also hope that they'll also use other newly-created systems, and this will help them do their research work and raise their children with greater peace of mind as they aim at the next steps in their careers. Ultimately, we hope they will think of NIMS as a supportive working environment for dedicated researchers.

Report on "NIMS Conference 2007"

(July 11 - 13, Tsukuba) — NIMS Conference 2007 was held at the Tsukuba International Congress Center Epochal. For this Conference, the content was completely updated on the occasion of the NIMS 2nd Mid-Term Program, which began in FY2006. As an international conference focusing on "Recent Breakthroughs in Materials Science and Technology," three fields were taken up as subjects for the present fiscal year, "Recent Progress in Spintronics and Magnetic Materials," "Spherical Aberration Correction in the Electron Microscope," and "Novel Organic Materials with High Functionality."

Speakers and participants (front row, center: Prof. Butler, recipient of the NIMS Award).

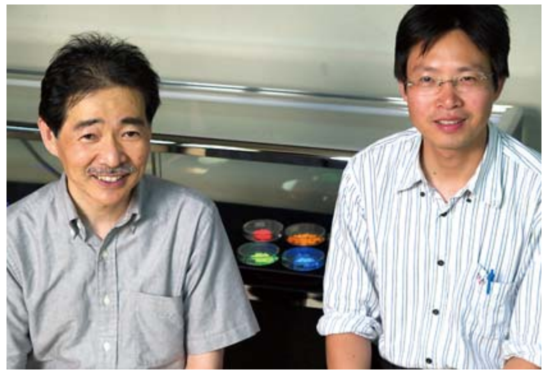
The largest feature of the "newly-reborn" NIMS Conference is the award of the "NIMS Award for Recent Breakthroughs in Materials Science and Technology." As a result of selection by an impartial committee of experts from among candidates recommended by top scientists, the NIMS Award for 2007 was given to Prof. William Butler of the University of Alabama (US) for his achievement in "Theoretical Prediction of Giant Tunnel Magneto-resistance in Fe/MgO/Fe Junction." (An interview with Prof. Butler appears on p. 7). The Conference included 21 invited lectures by front-line researchers and 57 research presentations (posters submitted in response to open invitation), as well as lively debate among the 241 participants. NIMS plans to hold the "new NIMS Conference" annually, and hopes to contribute positively to the promotion of materials research at the world level and the construction of an international network through this program.

For more details: http://www.nims.go.jp/nimsconf07/

17th Tsukuba Encouragement Prize Awarded to NIMS Researchers

(July 24, Tsukuba) — The Tsukuba Encouragement Prize (Practical Application Research Category) was awarded to Naoto Hirosaki, Group Leader, Nitride Particle Group, Nano Ceramics Center, and Rong-Jun Xie, a Senior Researcher in the same Group, for their work on "Development of SiAlON-based phosphors for use in white-light LED applications." The Prize recognizes researchers for their remarkable achievements in research on technologies in Ibaraki Prefecture and is intended to encourage original research activities by researchers.

This award is given by the Science and Technology Promotion Foundation of Ibaraki Prefecture (Chairman: Leo Esaki) as a research and development encouragement project. The award ceremony was held at the Tsukuba International Congress Center on September 28.



Dr. Hirosaki (left) and Dr. Xie.

For more information on the research achievements of the Nitride Particle Group, Nano Ceramics Center, readers are invited to see the Special Features section on the Nano Ceramics Center in NIMS NOW International Vol. 5 No. 3 and the Research Highlights in Vol. 5 No. 7.

Cooperation Agreement with Metals Bank, Korea Institute of Materials Science

(May 10, Korea) — The NIMS Database Station signed a Memorandum of Understanding (MOU) on collaborative research in the field of materials databases with the Metals Bank, a database in the Korea Institute of Materials Science (KIMS; former Korea Institute of Machinery and Materials).

The creation of materials databases is a national project in Korea, and aims at the development of the Metals Bank, as well as a Ceramics Bank and Polymer Bank. KIMS is in charge of the Metals Bank, and is working toward the construction of a light metals database. NIMS and KIMS will cooperate in the mutual linkage of material databases, international conferences on material databases, and standardization activities related to material databases.

Dr. Byoung-Kee Kim (left; Director General, KIMS) and Dr. Masayoshi Yamazaki (Station Leader, Database Station).

NIMS Signs MOU with the University of Central Florida, U.S.A.

(March 2, U.S.A.) — The NIMS Composites and Coatings Center and Computational Materials Science Center signed a Memorandum of Understanding (MOU) on "Development of novel coating system and its characterization" with the Advanced Materials Processing Analysis Center Faculty (AMPAC Faculty) of the University of Central Florida (UCF) in the United States. This agreement has already produced substantial results, as Dr. Machiko Ode, a Senior Researcher at NIMS, received the Outstanding Young Scientist Award at the 3rd International Conference on Diffusion in Solids and Liquids held in July 2007 for her joint research with Prof. Yongho Sohn of UCF. Plans call for a deepening of exchanges in the future, with the aim of joint Japanese-US development of coating systems.

From left: Prof. Sudipta Seal, Prof. James Pearson (Director, AMPAC Faculty), Dr. Hideyuki Murakami (Chief Researcher, Composites and Coatings Center), Dr. Machiko Ode (Computational Materials Science Center), and Prof. Yongho Sohn (Associate Professor, AMPAC Faculty). (As of March 2)

NIMS Signs MOU with the U.K.'s University of Hull

(March 30, U.K.) — A Memorandum of Understanding (MOU) and a Confidentiality Agreement were signed between the Department of Chemistry of the University of Hull (U.K.) and the NIMS Nano Ceramics Center.

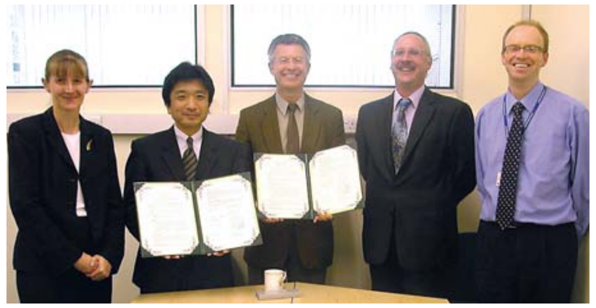
The Hull Department of Chemistry and NIMS Nano Ceramics Center started collaborations in the areas of microfluidic chemistry and high magnetic fields in 2006, and conducted preliminary experiments together in Tsukuba in November 2006. The MOU forms the basis for further strengthening of this collaboration and exchanges of researchers in the coming years.

From right: Dr. Alexander Iles (University of Hull, former ICYS Fellow), Dr. Nicole Pamme (University of Hull, former ICYS Fellow), Prof. Yoshio Sakka (Managing Director, NIMS) and Dr. Noriyuki Hirota (NIMS).

NIMS Signs MOU with Loughborough University, U.K.

(June 28, U.K.) — The NIMS Composites and Coatings Center and Innovative Materials Engineering Laboratory signed a Memorandum of Understanding (MOU) on "Microstructural characterization of high temperature structural materials and their coatings" with the Materials Research School at Loughborough University (LU) in the UK.

The Research School in Materials is one of five interdisciplinary research units within Loughborough University and brings together the significant strengths in materials research across the University involving over 60 academics in 9 different departments (including Mechanical and Manufacturing Engineering, Physics, Chemistry, Mathematics, Materials etc). There are a wide range of research projects carried out in collaboration with UK and international academic institutions, research organisations and companies. The School facilitates research at the discipline boundaries and encourages initiatives in important emerging areas. It is supported by an excellent range of state of the art experimental facilities for materials research. There is particular emphasis on providing solutions to real industrial problems, from life extension to the development of novel materials. The recent signing of this MOU with the Materials Research School is expected to promote joint research on high temperature structural materials and their coatings.



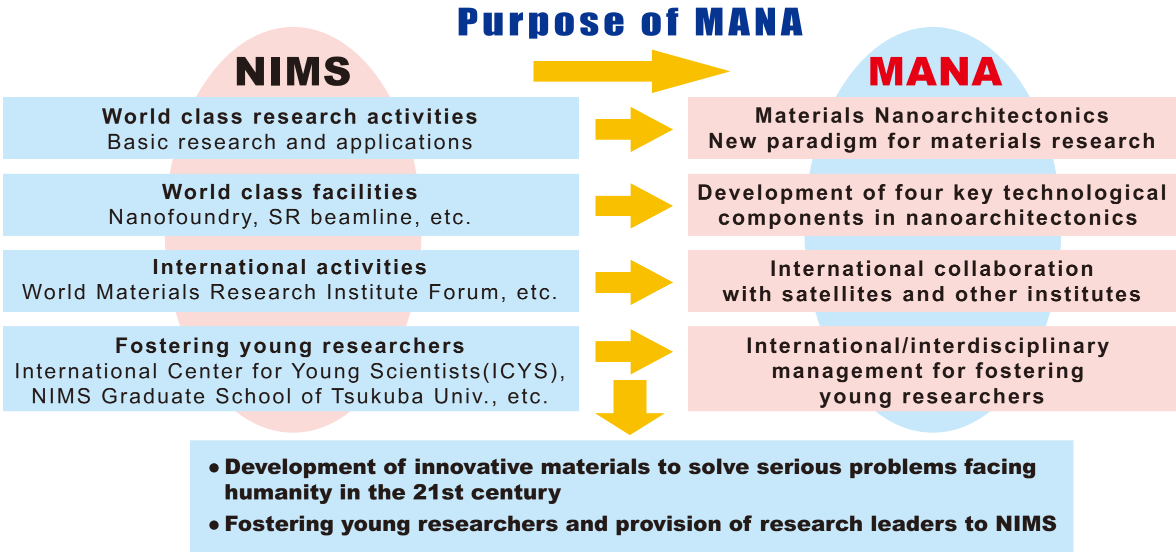
From left: Prof. Rachel Thomson (Director of the Materials Research School, LU), Dr. Hideyuki Murakami (Chief Researcher, Composites and Coatings Center and concurrently Innovative Materials Engineering Laboratory), Prof. Peter Golding (Pro Vice Chancellor for Research, LU), Prof. Jon Binner (Head of Department, Institute of Polymer Technology and Materials Engineering, LU), and Dr. Ray Kent (Research Office, LU).

NIMS Takes Large Stride toward Becoming 'World Premier International' Research Center

(September 12, NIMS) — NIMS has been selected as one of the five institutes eligible to receive research grants under the "World Premier International Research Center Initiative," a program sponsored by Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT). In a fierce sevenfold competition, NIMS and four universities, the University of Tokyo, Kyoto University, Osaka University, and Tohoku University, were selected.

NIMS was selected for its proposed "International Center for Materials Nanoarchitectonics" (MANA), which will capitalize on one of Japan's particular strengths – materials development – to contribute to the solution of serious problems faced by 21st century society, including challenges in such areas as the environment, energy, and resources. Utilizing the know-how and expertise cultivated at the International Center for Young Scientists (ICYS), NIMS will establish MANA as a center for generating talented researchers, attracting preeminent scientists and engineers from all over the world, and producing solid, outstanding results.

Over the next ten years, NIMS will endeavor to develop MANA into a world-class hub for research in nanotechnology and nanomaterials, with this project leading the way for NIMS' evolution into one of the world's top-level materials research centers.



The ICYS-ICMR Summer School on Nanomaterials 2007

(July 23-28, NIMS) — The ICYS-ICMR Summer School on Nanomaterials 2007 was held successfully with 15 prominent scientists (invited lecturers), 58 students and young researchers from 14 countries (Japan: 26, USA: 15, other countries: 17). Since last year, this School has been co-hosted by NIMS' International Center for Young Scientists (ICYS) and the International Center for Materials Research (ICMR) of the University of California, Santa Barbara.

The objective of this school was to expose participants to interdisciplinary concepts in nanomaterials research. This school helps participants enhance their research perspectives through lectures and mutually-stimulating oral and poster presentations by the students themselves. The organizers also offered a Japanese cultural program to make the school more enjoyable and well-rounded, with not only scientific but also various cultural experiences. The establishment of an international network among the participants was another important purpose of this school. This year's school concluded with numerous fruitful achievements.

Summer School lecturers and participants.

For more details: http://www.nims.go.jp/icys/event/summerschool2007/

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