# NIMS NOW International

World Materials Research Institute Forum
Participation in the 2nd Meeting, Berlin,13-15 June 2007

Special Issue on International Collaboration

2007.Vol.5 No.8 August

## NIMS Project

NIMS Projects and Recent Achievements

### Quantum Dot Research Center

■ Development of Quantum Dot Laser

## Research Highlights

- Aiming at Standardization of Atmospheric Corrosion Evaluation/Classification Methods in the Asian Region
- Discovery of Shape Memory Effect in Strain Glass Alloy

## FACE フェイス interview

### 'Always Aim High'

Ajayan Vinu, Senior Researcher

## SPECIAL Interview

**Prof. Václav Hampl**
Rector, Charles University

**Prof. Vladimir Matolin**
Department of Electronics and Vacuum Physics
Charles University

### International Joint Graduate School Program with Charles University of Czech Republic

World Materials Research Institute Forum 2007

# New Steps in Internationalization

– NIMS Lays Out Directions for Future International Collaboration –

# New Steps in Internationalization

## - NIMS Lays Out Directions for Future International Collaboration -

Internationalization is a key part of NIMS' commitment to becoming the world's core institute in materials research. As of July 2007, NIMS had already concluded more than 130 international collaboration agreements and ranked among the world's top ten in published research results. Nevertheless, NIMS does not enjoy a correspondingly high level of name recognition in the world scientific community. To learn more about the future direction of internationalization at NIMS, we asked Masaki Kitagawa, Vice President of NIMS, Toyohiro Chikyow, Managing Director of the Advanced Electronic Materials Center, and Masahiro Takemura, Deputy Director of the International Affairs Office to discuss the current condition of internationalization at NIMS and the challenges that the institute faces for the future.

### Strengthening NIMS' presence: Does the world know "NIMS" as a research institute?

**Kitagawa:** One first-stage target in internationalization is to increase recognition of NIMS' name based on our commitment to becoming a core institute in materials research and our proven record of achievements. Since you asked about the current condition of internationalization, we devote great effort to research exchanges, including joint research, and we're steadily increasing the number of collaborative relationships with other leading institutes each year [see the NIMS NEWS article "More than 130 International Collaboration Agreements Have Been Signed" on page 11]. This can be seen in the International Joint Graduate School Program and in the number of MOUs (memorandum of understanding) on international collaboration. In information-related activities, our Citation Index ranks 6th in the world in the field of materials science. We also publish "Materials Science Outlook" and the newsletter "NIMS NOW International." These are both periodical publications with an international readership. And we make considerable efforts to attract international researchers. We have a number of international Advisors, who are extremely distinguished scientists in their fields, and we receive many younger researchers from other countries, either in the ICYS program or as NIMS employees. Our ultimate goal is to have all of the Presidents of the world's top 100 materials research institutes visit NIMS at least once. That relates to future activities. But I think we should ask the other panelists about internationalization activities in their areas.

**Masahiro Takemura**
Deputy Director
International Affairs Office

**Chikyow:** One move that created important opportunities was the MOU with Germany's Max-Planck Institute for Metal Research. We began exchanges with them around 2003, and we now hold annual workshops alternately in Germany and Japan. These mutual visits give us a chance to do research together in the other country and have resulted in a number of papers. This is a win-win relationship. It's been quite successful, and we want to continue it in the future. As another example, under our MOU with the University of Washington in the U.S., students in their Ph.D. course come to NIMS and do research, and they receive university credits for their work here. The University of Washington appreciates this arrangement because it provides research opportunities and a research environment for their students, and because it produces results. One of these students is now a post-doc at the Max-Planck Institute for Metal Research. His work at NIMS led to this next position. We attach great importance to this intermediary role, and we are extremely pleased with the results.

**Takemura:** When we talk about international collaboration, I think that we need to consider whether it's the result of efforts by the researchers involved, like the kind Dr. Chikyow mentioned, or whether it's the result of our efforts as an institute. In a previous assignment, I was with the Nanotechnology Researchers Network Center of Japan (Nanonet) for about 3 years, and I worked in the area of international collaboration. I began by attending international conferences and getting to know my counterparts. I discovered that individual Japanese researchers are well known in the international scientific community, but there's almost no awareness of Japanese research institutes. The Japanese government invests more than 90 billion yen a year in nanotechnology and materials, but most people outside of Japan don't know much about our research institutes or the work we're doing. In other words, we aren't getting our message out. We're making a huge investment in research, but frankly, we aren't communicating effectively. And to return to my previous thought, we're making excellent progress in international collaboration when it's led by researchers, but we haven't reached the same level of collaboration at the institutional level.

**Toyohiro Chikyow**
Managing Director
Advanced Electronic Materials Center

**Kitagawa:** We've had technical exchanges in the past, but I think it's fair to say that these never really developed into the institutional activities.

**Chikyow:** Recently a foreign company invited me to give a talk. As part of my presentation, I gave an overview of NIMS and its research. When I mentioned that our Citation Index for papers in materials science ranks 6th in the world, they were astonished. So yes, we must do more to strengthen NIMS' presence and make sure that the world knows what we're doing here at NIMS.

### A relationship of trust and information are important for building human exchanges and institutional relationships.

**Kitagawa:** If I can follow up on that point, the World Materials Research Institute Forum (WMRIF) is a wonderful opportunity. When the Forum was held for the first time in Tsukuba 2 years ago, 15 institutes participated. We began by getting to know the other institutes and what kind of work they're doing. The 2nd Forum was held in Germany in June with 31 institutes participating [see the bottom of page 4 for details]. Of course, we're competitors, but we also face common problems, such as issues related to the operation of a research institute and globally common research topics. One concrete target is the creation of a research resources map. The Forum members also agreed that we should publish a survey of the state of the art and outlook for the near future in materials research, which we already published at NIMS as "Materials Science Outlook 2006". Other issues included the shrinking number of young people going into materials research, database sharing, and, from the viewpoint of research, cooperation in fields like materials for energy, reliability of materials, and simulation techniques. I should mention that our President Kishi was elected first President of the Forum, NIMS will be the Secretariat, and I will serve as the first Secretary General.

**Chikyow:** I really hope that this Forum will be a good chance for our human exchanges. Researchers in other countries would be able to create closer relationships with Japanese researchers when they both have the personal experience of working at NIMS and a larger framework such as this Forum. It's important for us to have human exchanges that build that kind of long-term relationship, along with efforts to maintain that and its framework.

**Kitagawa:** Attracting good people is important, but a resume doesn't tell you what kind of person you're hiring. However, activity in the WMRIF creates a relationship of trust between the heads of institutes, and this in turn can contribute to hiring good people from other member institutes. The WMRIF, which I mentioned a moment ago, certainly has a role to play here. To get out our message, we're asking our non-Japanese alumni to serve as "NIMS Ambassadors" in arranging MOU, expanding the International Joint Graduate School Program, and so on. The number of NIMS alumni is also expanding.

**Takemura:** I think we should make more efforts to introduce the whole scope of R&D activities in Japan and at NIMS when we have opportunities to make keynote lectures at international conferences. We also should use the internet in a more effective way. Of course, face-to-face communication would be the best, but the opportunities are limited. In holding international conferences, Japan has a geographical disadvantage. We should overcome this by strengthening information dissemination. Now we are trying to create an attractive website.

### Becoming a research center that will attract foreign researchers . . .

**Kitagawa:** What is most important, after all, is to have people come to NIMS. A second-stage goal is to become a research institute that makes researchers want to visit NIMS and do research here. NIMS is creating excellent facilities as an international core institute in materials research. Varieties of researchers are engaged in wide-ranging research and are expanding our fields in mutual interaction. I feel that activities such as the International Center for Young Scientists (ICYS) are also making an extremely large contribution. However, a problem is whether our location in Tsukuba is really an easy place for non-Japanese to live.

**Masaki Kitagawa**
Vice President

**Chikyow:** Where housing is concerned, the completion of the Ninomiya House [JST International Residence for Researchers operated by the Japan International Science and Technology Exchange Center] was a big step in the right direction. It's open to both short-term and long-term residents, and the leasing procedure is relatively simple. At least where housing is concerned, I don't think there's any problem.

**Kitagawa:** Another problem is language. We've created an English environment for researchers in NIMS, but people still have problems in their everyday lives, in town and elsewhere. Some of us also hesitate to invite foreigners to our homes because we're not sure how to entertain them, or don't have the space. And again, language is a problem. President Kishi has asked us to open a Japanese language school for all non-Japanese in NIMS, including researchers' families, so we can help them enjoy a more convenient and rewarding life in Japan. Personally, I hope our researchers' spouses and children, as well as the researchers themselves, will take an interest in the Japanese language and Japanese culture.

**Chikyow:** Several years ago, I visited a research institute at Grenoble in France with President Kishi. I was particularly impressed by the efforts that the local government, as a whole, had made to attract researchers. They'd devoted a lot of thought to appropriate facilities, and there were schools for each nationality using materials from the country concerned, beginning with a Japanese language school. They'd also hired teachers. In other words, Grenoble had created an environment in which researchers didn't have to worry about their children's education. Researchers could do their work without concern about everyday problems or their families, and there were excellent resorts nearby. . . . The local people had made Grenoble a thoroughly attractive town for researchers from other countries.

**Kitagawa:** In that sense, the ICYS has succeeded in internationalization. However, to be really successful, the everyday life that people experience while working here should make them want to come back again. That's the true measure of internationalization. Internationalization isn't something that can be achieved by the International Affairs Office alone. We have to create a system of cooperation that involves NIMS as a whole.

## Report on 2nd World Materials Research Institute Forum

The 1st World Materials Research Institute Forum (WMRIF) was held in Tsukuba in 2005, when it was hosted by NIMS, with the aim of achieving a higher level of materials research and promoting globalization in the field. A total of 15 of the world's leading public research institutes in materials research participated.

The 2nd WMRIF was held June 13-15 in Berlin and was hosted by Germany's Federal Institute for Materials Research and Testing (BAM). The number of participating research institutes increased to 31, representing 20 countries. (The cover shows a group photograph from the 2nd WMRIF.) President Kishi of NIMS was elected as the first President, NIMS was chosen as the Secretariat, and Vice President Kitagawa of NIMS was named Secretary General. Seven working group activities were also launched, including large-scale research facilities, outlook, human resources training, databases, energy-related materials, materials reliability, and simulation. The next round of the WMRIF is scheduled for 2009 in Washington, D.C., where it will be hosted by the United States' NIST.

### Participating Institutes

| | |
|---|---|
| Africa (1 organization) | **South Africa**: MINTEK |
| America (7 organizations) | **Brazil**: Inmetro<br>**USA**: Ames, EWI, LLNL, NIST, ORNL, (BNL) |
| Asia (11 organizations) | **China**: IMR **Japan**: AIST, NIMS **Korea**: KIMS, KIST<br>**Singapore**: IMRE **Taiwan**: ITRI **Thailand**: MTEC<br>**Vietnam**: VAST-IMS<br>**Russia**: RAS-Nikolaev, RAS-Grebentschikov |
| Europe (12 organizations) | **Finland**: VTT **France**: LNE<br>**Germany**: Fed. Min. of Eco. Tech, BAM, MPI-MF<br>**Hungary**: MFA **Poland**: Polish Min. Sci. Higher Edu.<br>**Spain**: CSIC-Madrid **Sweden**: SP-YKI<br>**Switzerland**: Empa **UK**: NPL, Univ. of Sheffield |

Note: Representative from the Brookhaven National Laboratory (BNL; U.S.A.) were scheduled to attend, but were absent due to a flight cancellation.

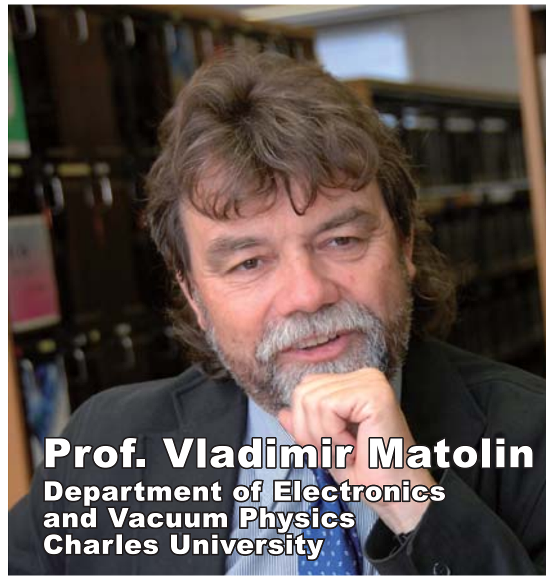
For more details: http://www.e-materials.net/network/WMRIF/modules/wordpress/



SPECIAL Interview

# International Joint Graduate School Program with Charles University of Czech Republic

**Prof. Václav Hampl**
Rector, Charles University



**Prof. Vladimir Matolin**
Department of Electronics and Vacuum Physics
Charles University

Since 2002, NIMS has been conducting the International Joint Graduate School Program, in which, every year, five doctoral students from Charles University in Prague come to Japan for a year to conduct thesis research with NIMS facilities and supervision.

For NIMS, the program is aimed at boosting name recognition, and forming relationships with excellent researchers from the top university in Eastern Europe. Charles University, for its part, welcomes the chance to boost its stature as an international university and provide overseas experience for students, especially at the graduate level.

The program so far has been an unqualified success. The 26 Czech students who have participated have nothing but praise for the program, for both the research opportunities and the chance to experience Japan. Several former participants have returned to Japan for post-doctoral studies. Joint programs with universities in Australia, Poland, India, and Russia are also in progress.

So the program is being extended. Prof. Hampl, Rector, and Prof. Matolin, Coordinator of the Program, of Charles University, were in Japan recently for the re-signing ceremony, and they met with the founders of the Program, Mr. Fujita, General Manager of the Integrated Strategy Office, and Dr. Mori, Vice Managing Director of the Fuel Cell Materials Center, of NIMS, to talk about the program's successes so far, and its future.

"In my opinion, the program has been very successful from a scientific point of view," Prof. Matolin said. "The students get opportunities to work with excellent NIMS researchers and use equipment not available in our labs, because the facilities at NIMS are top-notch. They also get a chance to discover Japanese culture. For us, Japan is a country very far away, with a very different culture, and people think life for Europeans is difficult. But of course everybody finds it very easy to adapt to Japanese life. Another motivation for the students is the growing presence of Japanese industry, especially automobile and electronics firms, in the Czech Republic."

Perhaps most importantly from the perspective of the students' academic careers and the institutions involved, the program has resulted in an impressive 60 jointly written academic papers published in high-level scientific journals.

"NIMS has expressed interest in accepting more of our students, and for longer than just one year," Prof. Hampl said. "We are of course open to this, especially if it means closer collaboration between the institutions."

Research topics have run the gamut of materials science, from metals to bio/nanotechnology. "The most important point was that the program fitted well with the studies of the students," Prof. Matolin pointed out. "We try to find NIMS supervisors who can ensure that research fits the student's thesis work. In all cases, we found appropriate supervisors here, and students were able to pursue exactly the fields they wanted."

Mr. Fujita noted, "One important point is that Charles University grants our supervisors adjunct professorships. Since the university is one of the oldest and most prestigious universities in the region, this is a powerful incentive for them."

To choose among the 48,000 students at Charles University, the program coordinators approached department heads and deans to propose candidates instead of simply advertising the program. "I think the selection process has worked well," Mr. Fujita said. "Our supervisors tell us that all the students are excellent – highly motivated, and very interested in Japan." These encouraging results will surely enhance the cooperation.

# Quantum Dot Research Center

## Basic Research Project on Fabrication and Control of Nanostructures

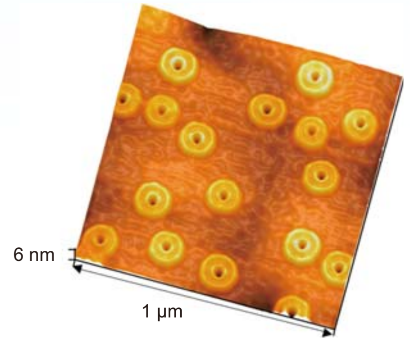
Semiconductors such as silicon (Si) and gallium arsenide (GaAs) are basic materials which support modern electronic society. High performance LSIs (large scale integrated circuits) are produced making full use of crystal growth and lithography techniques that enable high order elaboration, and are used as the heart of computers and other electronic devices. As semiconductors become progressively smaller and reach approximately the same size as the range of the wave function of an electron, the properties of the semiconductor change greatly. Semiconductor particles with diameters of several 10 nm are called quantum dots. Because the electron wave function is confined in such an extremely small volume, quantum dots behave in precisely the same manner as a single large atom.

The Quantum Dot Research Center is engaged in research focusing on semiconductor nanostructures of this type with the aim of achieving further development of infrastructure technologies for nanotechnology by realizing a higher level of sophistication in nanostructure fabrication techniques developed by NIMS and by a fusion of techniques. The Center is also devoting great energy to the development of theoretical research and evaluation techniques for nanostructures, as exemplified by micro laser spectroscopy and the characterization of physical properties in high magnetic fields, etc., and is strongly promoting research in the related fields of organic nanowires, plasmonics, and nanophotonics.

**Fig. 1** shows one representative example of a nanostructure developed by the Quantum Dot Research Center. This is a GaAs double quantum ring which was formed on a $Al_{0.3}Ga_{0.7}As$ film. When the emission capacities of individual double quantum rings were investigated using micro laser spectroscopy, the obtained results showed extremely good consistency with the electron wave function and energy obtained by theoretical calculations (**Fig. 2**). In order to investigate the electrical properties of quantum dots, the Center also developed a nanowire wiring technique using electron beam-induced vapor deposition (**Fig. 3**). In the future, we hope to discover new phenomena and link these to device applications through further elaboration of element technologies.

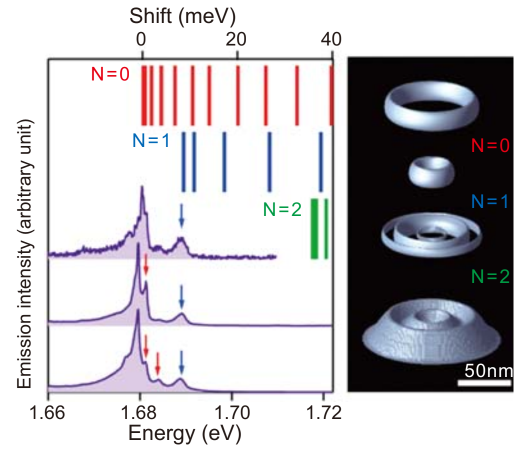
For more details: http://www.nims.go.jp/nanophoto/qdr/

Fig.1



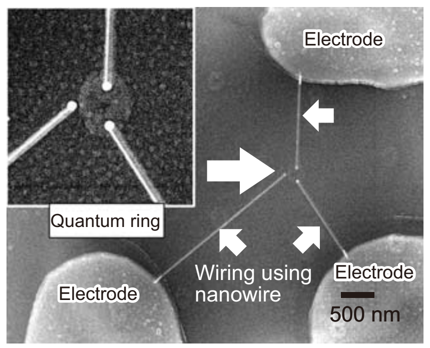

Atomic force microscope (AFM) image of GaAs double quantum rings.

Fig.2




The figure at the left shows the measured data for the emission spectra of a double quantum ring (in order from the top: weak, medium, and strong excitation power level) and the calculated values. (As calculated values, the emission energies from states having various angular momentums are shown for the principal quantum numbers N = 0~2 by the red, blue, and green lines, respectively.) The figure at the right shows a structural model of a double quantum ring (bottom) and the electron clouds of the electronic states when N = 0~2.

Fig.3




Electron microscope image of tungsten nanowires connecting a quantum ring and gold electrodes.



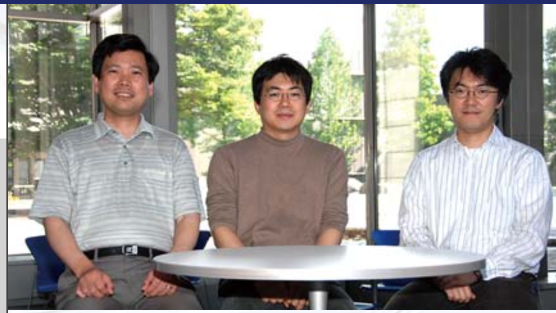


# Development of Quantum Dot Laser

## World's First Successful Laser Oscillation of GaAs Quantum Dots

Nano Photonics Group[*1]/Nano Growth Group[*2]
Quantum Dot Research Center

Managing Director
Group Leader[*1,*2]
Kazuaki Sakoda, Takaaki Mano[*2], Takashi Kuroda[*1]



The droplet epitaxy method, which is an original NIMS technology, is a method which is particularly well-suited to the fabrication of nanostructures by combining materials with mutually similar lattice constants (lattice-matched systems) such as GaAs quantum dots on an AlGaAs thin film. In the fabrication of GaAs nanostructures by the droplet epitaxy method, first, Ga droplets of nanometer size are deposited on the AlGaAs thin film by vapor deposition. Next, an As molecular beam is irradiated, causing the Ga and As to react and crystallize, forming a GaAs nanostructure having a crystallographic orientation aligned with the substrate. In research on the fabrication of quantum dots and quantum rings, we succeeded in fabricating GaAs-based specimens which have an excellent light emitting capacity and allow shape control by using this droplet epitaxy method.

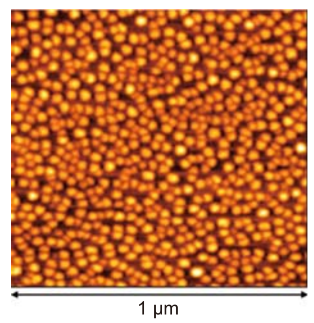
Furthermore, by applying ingenuity to the substrate surface and optimizing the crystallization conditions, it was possible to fabricate GaAs quantum dots with uniform particle diameters at a density approximately one order higher than with the conventional technique (**Fig. 1**). Based on this, strong light emission with a uniform wavelength could be expected. We therefore attempted laser oscillation by optical pumping in the temperature range from the temperature of liquid nitrogen to room temperature. As a result, significantly narrowed multiple emission lines and the threshold value for the light emission property were observed, confirming laser oscillation (**Fig. 2**). Laser oscillation was also possible at room temperature, although the photoexcitation intensity necessary for oscillation was high. This was the world's first laser oscillation with lattice-matched quantum dots.

Important results were also obtained in research on the bonding structures of photonic crystals and quantum dots. With photonic crystals, a micro optical resonator with good performance can be obtained by creating a periodic structure with a size on the order of the wavelength of light in a semiconductor or other appropriate material. A photonic crystal optical resonator with a structural period of approximately 200 nm enclosing GaAs quantum dots was fabricated jointly with the Center for Tsukuba Advanced Research Alliance (TARA) of the University of Tsukuba, which possesses the world's highest level of technology in the fabrication of photonic crystals. When the light emission performance of the GaAs quantum dots was investigated, a phenomenon called Purcell effect in which light emission occurred more rapidly than under ordinary conditions could be clearly observed. This is a type of quantum electrodynamics (QED) effect, and was achieved with GaAs quantum dots for the first time in the world in this research.

In the future, we plan to attempt laser oscillation by current injection and evaluate the performance of this potential device as a single photon light source which can be applied to quantum encrypted communications, among other topics.

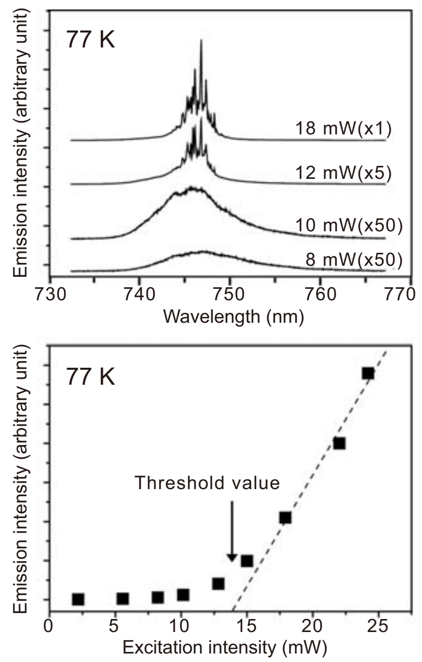
For more details: http://www.nims.go.jp/nanophoto/qdr/

Fig.1




Atomic force microscope (AFM) image of GaAs/AlGaAs quantum dots on the surface of a high index GaAs substrate. Density of quantum dots: 7 x $10^{10}$ /cm$^2$.

Fig.2




Sharpening of the emission spectra accompanying increased excitation intensity (top) and the threshold value dependence for emission intensity (bottom).

# Aiming at Standardization of Atmospheric Corrosion Evaluation/Classification Methods in the Asian Region

Corrosion Group, Materials Reliability Center

Group Leader
Tadashi Shinohara

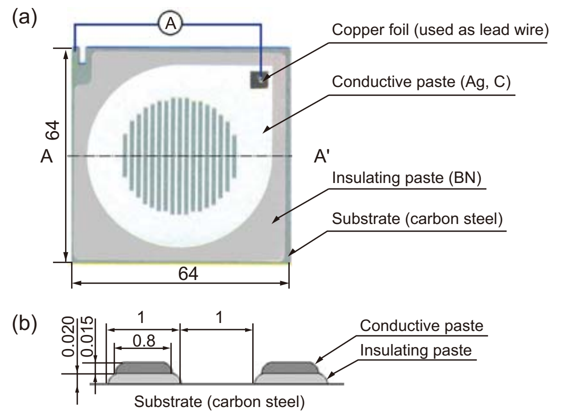
Because the climate in many parts of the Asian region is characterized by high temperature and high humidity, deterioration of metals as a result of corrosion is an extremely serious problem. In recent years, construction of bridges, buildings, railways, and other steel structures has been proceeding at a rapid pace throughout Asia, and consequently, countermeasures for corrosive deterioration of these structures have become an urgent matter. In order to implement appropriate measures, it is necessary to investigate the progress of corrosive deterioration in actual service environments by standardized methods.

At present, the mainstream method of classifying environmental corrosion is that specified in ISO 9223. This is a method in which the corrosion rates of various metals are classified in 6 levels based on the results of direct exposure tests (southerly, inclined, upward-facing exposure in a condition in which rain falls directly on the samples) conducted at 52 locations around the world. However, because the exposure sites are located mainly in the European region, standardization of an evaluation/classification method suited to the Asian region has been strongly desired. Therefore, in Japan, standardization of a corrosion classification method to complement ISO 9223 is being promoted. We are playing a central role in this effort.

We are also engaged in a project in which low alloy steels are being exposed at 3 locations in Japan (Tsukuba in Ibaraki Pref., Choshi in Chiba Pref., Miyakojima Island in Okinawa Pref.), and are publishing the results in Corrosion Data Sheets, and are promoting standardization of the shielded exposure test method in order to simulate environmental conditions such as the inner surfaces of girders in steel bridges and under the eaves of buildings where rainfall does not have a washing effect on deposits of sea salt, etc. In addition, we are evaluating atmospheric corrosiveness using the Atmospheric Corrosion Monitor (ACM) sensor shown in **Fig. 1**. In this sensor, an ammeter is connected between a base plate of carbon steel and an Ag electrode, and the current which passes between the two electrodes is measured as the sensor output. Because the sensor output increases as environmental corrosiveness becomes more severe, it is possible to estimate and evaluate factors related to environmental corrosiveness (wetting condition, deposition rate, etc.) by analyzing the magnitude and change over time in the sensor output. This sensor, which is being used to develop evaluation methods for environmental corrosiveness, centering on the Corrosion Group, is commercially available in products approved by the Corrosion Center of the Japan Society of Corrosion Engineering, and is widely used in a variety of fields.

Based on these results, NIMS is implementing environmental corrosion evaluation/classification in the Asian region in cooperation with universities and research institutes in other Asian countries. First, on the occasion of the signing of a Memorandum of Understanding (MOU) with the National Metal and Materials Technology Center (MTEC), Thailand, exposure tests using carbon steel and the ACM sensor were begun in the environs of Bangkok in June of this year by three organizations, including NIMS, MTEC, and the Thailand Institute of Scientific and Technological Research (TISTR) (**Fig. 2**). Exposure tests of this type are also scheduled to begin successively in China, India, Vietnam, and other Asian countries.

Fig.1




Composition of the ACM-type corrosion environment sensor (unit: mm). Fig. (b) is an enlargement of the cross section shown by A-A' in Fig. (a).

Fig.2

Preparations for the exposure test in Thailand (exposure site: Pattaya). Front: Direct exposure rack, rear: shielded exposure rack.

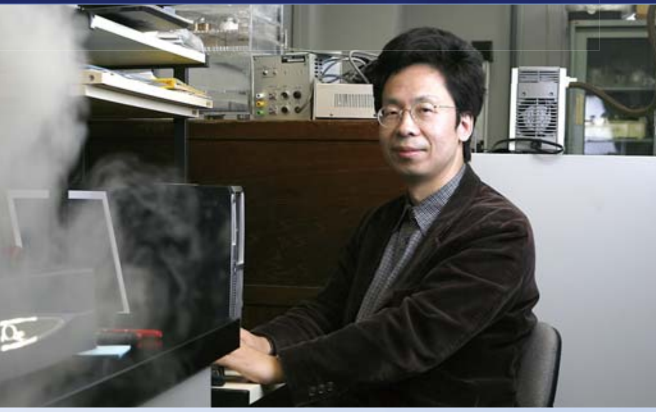




# Discovery of Shape Memory Effect in Strain Glass Alloy

## - Overturning the Common Sense about Shape Memory Alloys -

Ferroic Physics Group, Sensor Materials Center



Group Leader
Xiaobing Ren

The Ferroic Physics Group previously discovered the existence of a new state of substances, the strain glass state, appeared in certain alloys which do not undergo martensitic transformation. Strain glass is a distinct state which can be obtained by doping alloying elements/defects into a normal martensitic system to such an extent that the alloy no longer displays the martensitic transformation. As this state (**Fig. 2b**) is characterized by a "frozen" random distribution of local lattice distortions (or nano-strain-domains), it was named strain glass by analogy with spin glass. (Reference article: Yu Wang et al.: Physical Review Letters, 97, 225703 (2006))

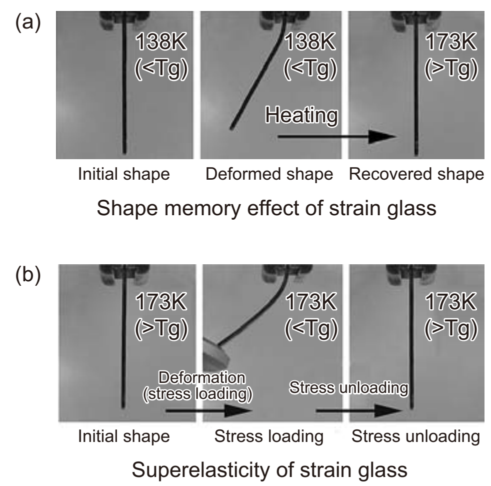
The Ti-51.5at%Ni alloy used in this research has long been known to exhibit no martensitic transformation; thus it has never been thought to demonstrate a shape memory effect or superelasticity. However, when such an alloy is plastically deformed at a temperature (138 K) below its strain glass transition temperature $T_g$ (160 K) and then is heated to above $T_g$ (173 K), it displays a shape memory effect – it recovers its original shape almost completely (**Fig. 1a**). Furthermore, it was also found that this alloy displays superelasticity with 7.5 % recoverable strain at a temperature (173 K) above $T_g$ (**Fig. 1b**).

Unlike conventional shape memory alloys, the mechanism of the newly-discovered shape memory effect and superelasticity involves a new mechanism of transformation from the strain glass state to a martensite phase under external stress. At temperatures below $T_g$, this alloy is characterized by a frozen random distribution of nano-strain-domains or "nanomartensite", although there is no change in average structure (**Fig. 2b**). When stress is applied to this alloy, long-range ordered strain (lattice distortion) occurs, causing the entire alloy to transform to the martensite phase, and the specimen deforms macroscopically (**Fig. 2c**). Then, when the alloy is heated, it returns to the strain glass state, in which the "nanomartensite" exists in a dynamic state, (**Fig. 2a**) and the macroscopic deformation also disappears. This is the shape memory effect. On the other hand, if stress is applied to an alloy at a temperature above $T_g$ in its dynamic "nanomartensite" state (**Fig. 2a**), the entire alloy changes to a martensite phase with a long-range distorted lattice (**Fig. 2d**), and then restores its original state and shape (**Fig. 2a**) when the stress is removed. This is the superelasticity effect.

This discovery overturns the long-standing view that the necessary condition for being a shape memory alloy is that the alloy must undergo a martensitic transformation during cooling. The discovery of shape memory effect in strain glass alloys is expected to greatly expand the conventional narrow composition range of shape memory alloys.

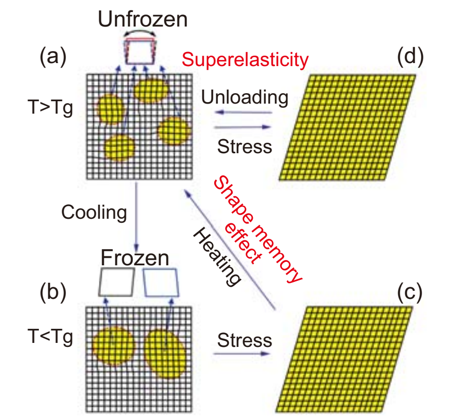
For more details: http://www.nims.go.jp/ferroic/

Fig.1




(a) Shape memory effect (recovery of shape by heating) and (b) superelasticity in Ti-51.5at%Ni strain glass alloy.

Fig.2

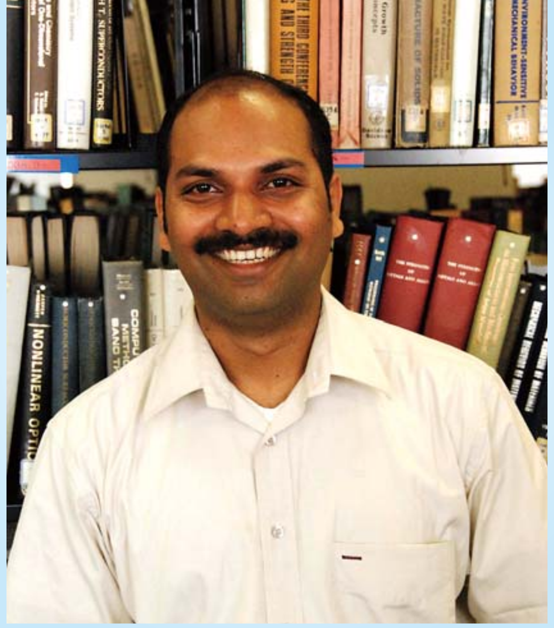



Mechanism of the shape memory effect and superelasticity in strain glass alloy. (a) unfrozen strain glass, (b) frozen strain glass, (c) stress-induced transformation of frozen strain glass to martensite. When this martensite is heated, the alloy changes to state (a) and recovers its original shape. (d) Forced transformation of the unfrozen strain glass to martensite by stress, and its recovery to (a) upon unloading; this process corresponds to a macroscopic superelasticity effect. ($T_g$: glass transition temperature)

F/A/C/E フェイス interview

This month's "FACE" features one of NIMS' young researchers, Dr. Ajayan Vinu, who recently won a project of the Special Coordination Funds for Promoting Science and Technology (SCFPST) with some other members of the Center. He spoke to NIMS NOW while busily preparing for the official kickoff of the program.

# 'Always Aim High'



**Dr. Ajayan Vinu, Senior Researcher**
Nano Ionics Materials Group, Fuel Cell Materials Center

Dr. Ajayan Vinu still seems a little amazed at all he's accomplished since he came to NIMS three years ago. At age 31, he is the author of over 100 papers and a recognized authority in the field of fuel cell materials. He is also one of the most successful researchers ever to work at NIMS.

A native of India, Dr. Vinu was born and raised in the city of Kanyakumari which is located at the southernmost tip of the Indian peninsula. He got his Ph.D. in November 2003 in India, at Anna University, though he carried out most of his research work at the University of Kaiserslautern, Germany, and worked there as a research scientist before coming to Japan in 2004 to work at the International Center for Young Scientists (ICYS) of NIMS as an ICYS Fellow.

Dr. Vinu has now turned his attention to boosting ties between Japan and his native India, heading up a "Development of Novel Nanostructured Catalytic Materials for Fuel Cell Applications Project" which was adopted by the "Asia S&T Strategic Cooperation Program" of SCFPST, MEXT. The main aim of the program is to develop highly efficient and low-cost fuel cells with high durability, using low-cost novel nanoporous catalytic supports with a huge surface area and pore volume. The project will see NIMS collaborating closely with two Indian research institutes, Anna University, Chennai, and the National Chemical Laboratory, Pune. Other than his research, he also serves as a bridge for both countries as a NIMS Ambassador to India.

"We're going to make novel low cost fuel cells, with the aim of increasing dispersion of platinum on nanoporous catalytic supports with high surface area, and thereby get higher efficiency and reduce cost. We'll develop novel catalytic supports with different functional groups and transition metal and metal oxides in them with the aim of reducing the platinum loading, and with the Indian side we will work on production and purification of hydrogen. We'll also use their theoretical expertise – they're well known for their ability to study the surface chemistry, especially the adsorption and the reactions over the catalysts supports in the fuel cells, and to calculate the reliability of fuel cells and how they will work for long periods of time."

He also hopes to use this project to enhance collaboration between NIMS and Indian research institutions. "Parallel to this project, we are planning to open a NIMS lab in Bangalore and actually started a dialogue with the Jawaharlal Nehru Center for Advanced Scientific Research (JNCASR), one of the top research institutes in India. We'll use the lab to link to neighboring countries like a hub and have scientists from all over the region do research."

"Then, at the end of the project, I hope to start a venture company to commercialize nanoporous catalysts and low-cost fuel cells, and also work toward standardization of the process and materials."

Dr. Vinu is delighted with his experience in Japan and at NIMS, both professionally and personally. "I like it here very much," he said. "The most important thing for me is the full freedom to do whatever research I want. Nobody tries to control me or get in the way of my ideas or creativity. NIMS is one of the top materials research institutes in the world, with a quite lot of world-class facilities which stimulate me to perform outstanding research. I got a position after only 2 years, and I've been able to write over 80 papers since I've been here, 30 this year alone. Honestly, to succeed in research here, all you need are intelligence, creativity, hard work and energy."

Certainly, there have been challenges, not least the language barrier. "I have to get some of the project proposals for getting a huge grant translated into Japanese. NIMS has an excellent English support system thanks to ICYS, but the person has to know my project in detail, the research area and the kind of work, in order to translate my ideas into Japanese. That's a weak point for researchers like me."

Like any parent, Dr. Vinu worries about his son's schooling, and he believes this could hinder people coming to Japan to do research. "This is quite puzzling, actually," he said. "Tsukuba contains 40% of the research institutes in Japan; it's an international research city, a science city, and about 7,000 foreign researchers live here. And yet there is only one small international school. If Tsukuba wants to attract foreign researchers, it will have to rectify this."

But mostly his experience in Japan has been positive. "I like the culture here very much, and the people – their silence, calm, discipline, hard work. And the nature, I love it. It's a very green place, very clean and pure."

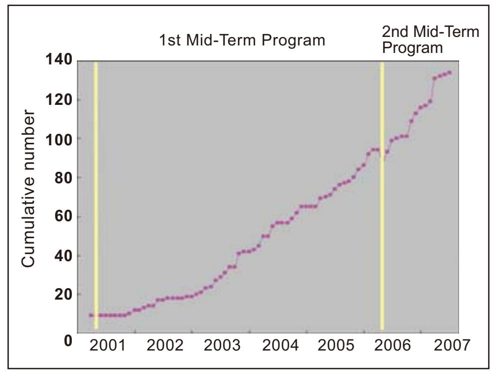
Most importantly, Japan, and NIMS, have allowed him to pursue his dreams. "My mentor said to me, 'Always dream big. If you dream small it is a sin you are committing in your life. Always aim high.'"

For more details: http://fuelcellmaterials.jp/en/modules/myinfo3/index.php?uid=25



# NIMS NEWS

## More than 130 International Collaboration Agreements Have Been Signed

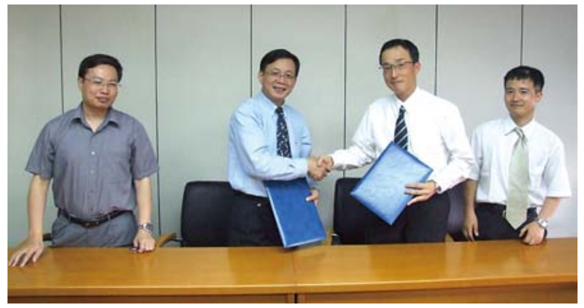



International collaboration and exchanges with the world's research institutes are indispensable for NIMS because NIMS aims to become the world's core institute in materials research. Since becoming an Independent Administrative Institute in 2001, NIMS has been able to establish collaborative relationships with research institutes in other countries on its own judgment, and the number of various types of collaboration agreements signed has been increasing year by year, as shown in the figure. Although NIMS had only 9 collaboration agreements when it was established in 2001, this number had grown to 134 institutes in 28 countries as of July 2007. By country, the largest number is with institutes in the US (21), followed by Japan's neighboring countries Korea (18) and China (14), and Germany (13).

In terms of the content of agreements, joint research with designated themes accounts for nearly 90%, and these agreements are signed by the researchers themselves. Other types of collaboration include "Comprehensive Research Cooperation," under which the parties conduct wide-ranging research exchanges, and the "International Joint Graduate School Program," under which NIMS receives outstanding students in graduate school Ph.D. courses for periods of several months to 1 year. These are signed by the President of NIMS and the head of the counterpart institute.

## NIMS Signs MOU with Hefei National Laboratory for Physical Sciences at the Microscale, University of Science and Technology of China

(June 7, China) — The NIMS Nano System Functionality Center and Advanced Nano Characterization Center (ANCC) concluded a memorandum of understanding (MOU) on joint research efforts with the Hefei National Laboratory for Physical Sciences at the Microscale (HFNL) of the University of Science and Technology of China (USTC).



From left, Prof. Dong (HFNL/USTC), Prof. Hou (HFNL/Vice President, USTC), Dr. Fujita (Managing Director, ANCC), and Dr. Guo (Post-doc Fellow, ANCC).

The aim of this MOU is to promote research efforts by NIMS and HFNL/USTC in connection with "Development of nanoprobe technology for single molecule science and advanced materials science." USTC is located in Hefei City, Anhui Province and is a university belonging to the Chinese Academy of Sciences (CAS). HFNL is an organization which is engaged in advanced research in materials science from the microscale to nanoscale, and in particular, has actively published pioneering research results in nanoscience and nanotechnology.

Taking advantage of the signing of this MOU, NIMS hopes to contribute to Chinese-Japanese research exchanges in nanomaterials science through close exchanges of research information, human exchanges of researchers, expansion of joint research, holding of joint symposiums, and other activities between NIMS and USTC.

## Joint Symposium of NIMS, KIMM and IMR on Superalloys and Advanced Processing

(May 29-31, NIMS) — The High Temperature Materials Center held the 3rd joint symposium of NIMS, Korea Institute of Machinery and Materials (KIMM), and Institute of Metal Research (IMR; China), on superalloys and advanced processing at the NIMS Sengen Site. A total of 13 researchers from KIMM and IMR participated.

Symposium participants.

This symposium is a trilateral symposium and takes turns for each two years in one of three institutes for exchanging their recent results on all fields concerning high temperature materials and for strengthening their further collaboration. After the symposium, the participants visited the Rolls-Royce Centre of Excellence for Aerospace Materials and other labs concerning high temperature materials, light metals, coating techniques and composites in the NIMS and National Institute of Advanced Science and Technology (AIST).

## Report on 5th RIST- NIMS Joint Workshop on Light Metal Processing

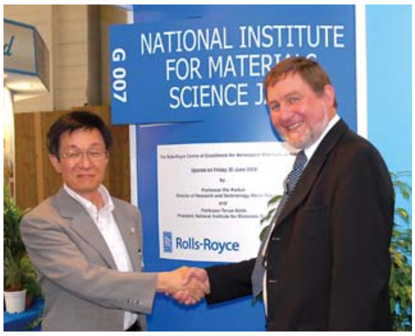
(May 25, Korea) — The 5th RIST-NIMS Joint Workshop on Light Metal Processing was held at the Research Institute of Industrial Science & Technology (RIST) in Korea. This joint workshop was organized based on an MOU between RIST and NIMS. Four researchers of NIMS belonging to Data Base Station, Structural Metals Center, and Composites and Coatings Center attended the workshop. Some researchers belonging to RIST, KIGAM (Korea), Inha University (Korea), and Hirosaki University (Japan) also attended the workshop. Research activities of each institute for titanium alloys, magnesium alloys, aluminum alloys, metal glasses, composite materials and database were introduced to each other to exchange knowledge.


Symposium participants.

## NIMS Exhibits at the International Paris Air Show

(June 18-24, France) — NIMS exhibited their advanced superalloy technologies (i.e. single crystal alloys, disc alloys and coating) developed by the High Temperature Materials Center (HTMC) at the 47th International Paris Air Show, Le Bourget, France. This Paris Air Show was one of the major international aerospace exhibitions; the event featured more than 2000 exhibitors, including airlines, aircraft manufacturers, engine markers, components suppliers, research institutes and universities, etc., there were also impressive flight show and important press announcements onsite.

Since the first day of the event, the NIMS booth had received large number of visitors and attracted interests from leading engine makers and aircraft manufacturers, such as Rolls-Royce, Pratt & Whitney, Snecma, Boeing and Airbus. This was a unique opportunity for NIMS to present their advanced superalloys on an international stage to promote a wider recognition for the continuing research and development efforts in the High Temperature Materials Center. By participating in this event, NIMS had gained the knowledge of the latest trends of aircraft and engine development, i.e. the future requirement for aerospace materials in particular, in addition, information exchange with other exhibitors and attending press announcement had also provided invaluable technical insight for NIMS.




Dr. Hiroshi Harada, Managing Director of HTMC (left), greeting Prof. Ric Parker, Rolls-Royce Director of Research & Technology, at NIMS booth.

## Hello from NIMS

Kevin Bell (University of Washington, U.S.A.)
ICYS Internship Student (June, 2007 - September, 2007)
Advanced Device Materials Group
Advanced Electric Materials Center
International Center for Young Scientists (ICYS)

My name is Kevin Bell, and I am from Seattle, Washington. I am still an undergraduate student, so I am very thrilled to have been presented with the opportunity to research at NIMS. Being a student of the Japanese language for over five years before I came to Japan, I was always eager to actually experience living and working in the country that I had studied and even visited so much already. Now that my wish has been realized through an internship at one of the foremost materials science institutes in the world, I have received a rare chance to expand my cultural and scientific knowledge in tandem.

This opportunity came to me by virtue of the long working relationship between my University of Washington materials science advisor, Prof. Fumio Ohuchi, and Dr. Toyohiro Chikyow of the Advanced Electronic Materials Center, who is now my mentor at NIMS. Prof. Ohuchi suggested early this year that I may benefit from an ICYS internship, and five months later I touched down at Narita.

[ Me, on the left, with other University of Washington materials science students in Shibuya, Tokyo ]

A year ago, I never would have dreamed that now I could be in Japan researching high-k dielectrics for next-generation computer chips. I am so lucky to be gaining first-rate research experience so early in my education, and the life experience of living in Japan will help me stronger in anything I do. My internship only lasts three months, but the memories will certainly last forever.

**National Institute for Materials Science**

Visit NIMS NOW International Online!
http://www.nims.go.jp/eng/news/nimsnow/



**To subscribe, contact:**
Mr. Tomoaki Hyodo, Publisher
Public Relations Office, NIMS
1-2-1 Sengen, Tsukuba, Ibaraki, 305-0047 JAPAN
Phone: +81-29-859-2026, Fax: +81-29-859-2017
Email: inquiry@nims.go.jp