NIMS NOW International

2008.Vol.6 No.4 April

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The NIMS Nanotechnology Support Network

A Nanotechnology Network Supporting Shared Use of Cutting-Edge Equipment

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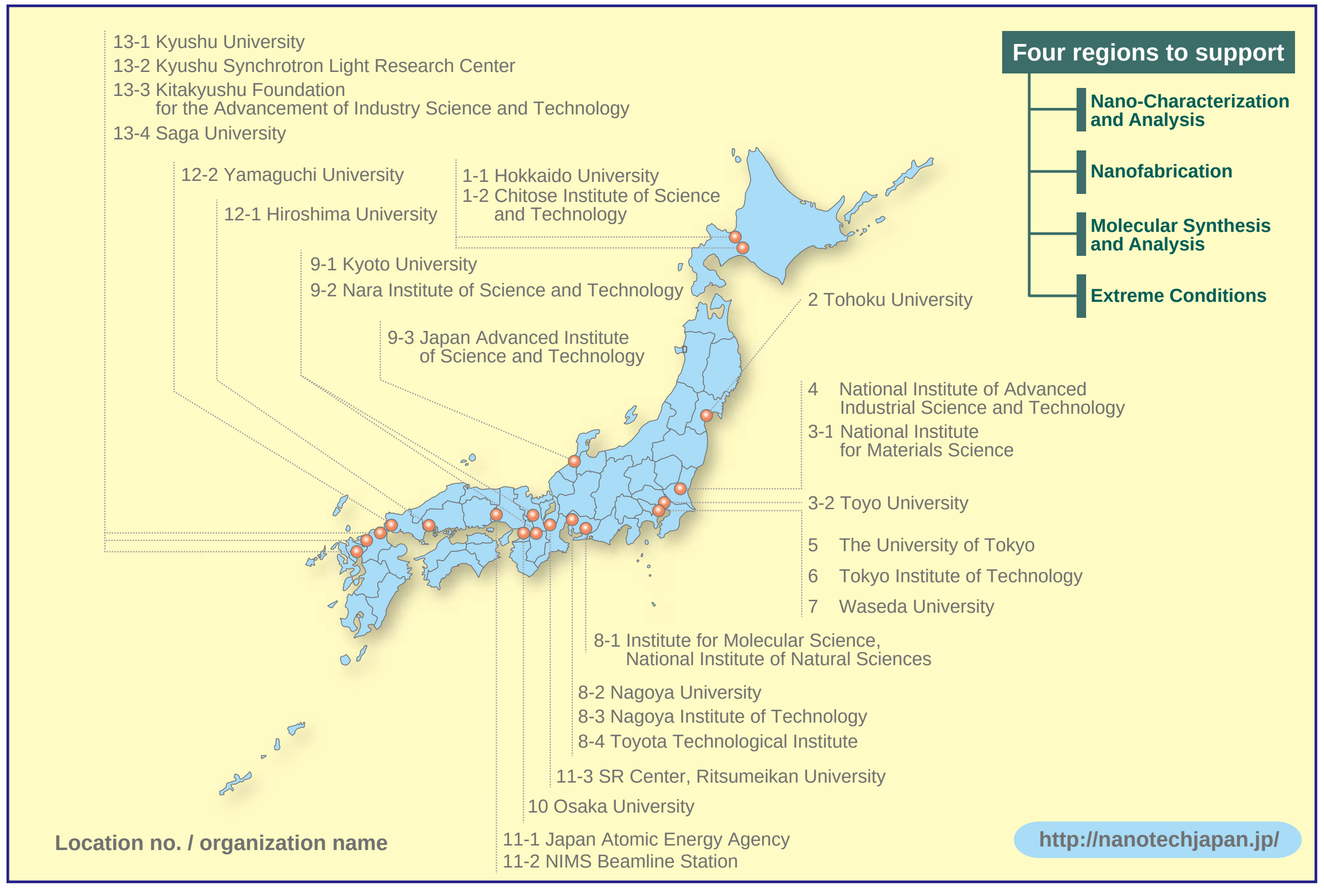
A Nanotechnology Network Supporting Shared Use of Cutting-Edge Equipment

The “Nanotechnology Network” is a project sponsored by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) which aims at generating research results that will lead to innovation. In this project, 13 research centers in Japan that possess offer opportunities for nanotechnology researchers throughout the country to use their cutting-edge nanotechnology facilities and equipment. The NIMS Nanotechnology Support Network, which was established in NIMS, arranges equipment for comprehensively conducting “Fabrication” (nanofabrication and materials synthesis), “Observation” (characterization), and “Measurement” (ultimate analysis) in order to provide technical support services in three of the four areas designated by MEXT as objects of this project, “Nano-Characterization and Analysis,” “Nanofabrication,” and “Extreme Conditions.” (Support by NIMS excludes only the area of “Molecular Synthesis and Analysis.”) In this roundtable, four key members of the NIMS Nanotechnology Support Network discuss the origins, objectives, and issues in this project.

Overview of Nanotechnology Network Japan



Norio Ojima
Former Manager, Coordination Office,
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Station Leader,
High Voltage Electron Microscopy Station

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Nano Technology Innovation Center

Tadashi Shimizu
Group Leader, High Field NMR Group,
High Magnetic Field Station

First, could you tell us how this project was launched?

Ojima: The NIMS Nanotechnology Support Network is a continuation of a predecessor project called the “Nanotechnology Support Project.” The predecessor project, which began in 2002, provided large-scale facilities in the areas of “Nano Foundries,” “Molecular Synthesis and Analysis,” “Ultra High Voltage Electron Microscopy,” and “Synchrotron Radiation,” which are necessary for many researchers involved in nanotechnology research and development, but were not accessable to use easily. In that project, support was provided by 3-5 central institutes organized by central institutes in each of the respective fields. “Nanotechnology Researchers Network Center of Japan,” was also established to provide wide region of information to nanotechnology researchers, to promote exchanges of researchers, to develop of human resources. This program included various popularization and educational activities related to nanotechnology, such as holding general symposiums on nanotechnology, with eminent researchers invited from abroad, creation of DVDs for children. Because international ties were a priority, considerable effort was put into exchanges with other countries by sending young researchers to the US, France, Sweden, England, and other countries.

In the current project, MEXT has designated to establish the regional centers which cover several functions out of four areas, which are “Nano-characterization and Analysis,” “Nanofabrication,” “Molecular Synthesis and Analysis,” and “Extreme Conditions,” to accomplish the activities of “Fabrication,” “Observation,” and “Measurement.” The NIMS Nanotechnology Support Network provides technical support services for “Nano-characterization and Analysis,” “Nanofabrication,” and “Extreme Conditions.” In addition, taking advantage of our experience of the “Nanotechnology Researchers Network Center of Japan”, NIMS has also assumed the responsibility for overall coordination of the 26 institutes in the 13 centers nationwide.

Furuya: The previous project included only two groups, our High Voltage Electron Microscopy Station and the synchrotron radiation facility at SPring-8. During that 5 year project, large-scale, expensive equipment at national research institutes and universities was opened to a wide range of users in order to expand researchers’ knowledge of nanotechnology, and every possible effort was made to respond to a large number of individual subjects spanning diverse fields and levels of research. There was some anxiety about such activities because no such project was coordinated by government before that, but ultimately, the project was evaluated as successful, and this led to the current project. The current project is not limited to electron microscopy, but also includes high magnetic fields as extreme conditions, as well as a function that provides interdisciplinary support, including also nano-fabrication. The objective of the project is to generate research results which lead to innovation by creating a research center in a form that encompasses all of these functions and promoting shared use of the facilities.

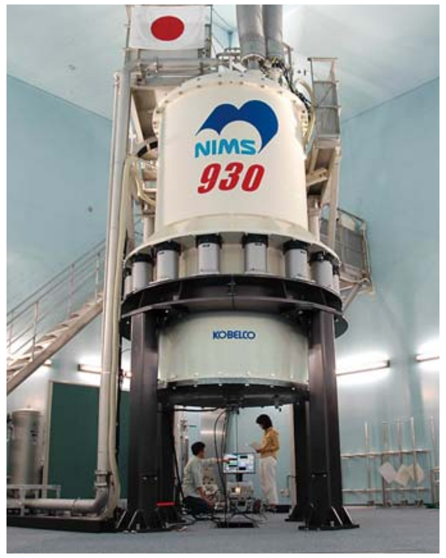
Shimizu: Long before the word “nanotechnology” became notable, the High Magnetic Field Station developed extremely advanced, large-scale high field facilities. This type of facility was only available here in Japan. Therefore, we voluntarily operated this equipment as “user facilities,” meaning it could be used by outside researchers. This point has a similar aspect as the NIMS Nanotechnology Support Network, and approximately 80 institutes throughout Japan used these facilities under the shared-use policy. Research conducted at high field facilities is not necessarily 100% nano-related. However, where NMR is concerned, many users from industry take advantage of this equipment in order to analyze molecular structures with atomic level resolution. For this reason, the High Magnetic Field Station is participating in the project particularly in the area of NMR.

The NIMS high field NMR devices are the largest in Japan, and are also among the world’s leading high field devices. However, new contributions are not possible if these facilities are not different from the electron microscopes and X-ray devices that have been used conventionally to analyze nanomaterials. Because NMR is an extremely low sensitivity device, measurement time is at least one order longer than with other analytical devices, so NMR has the drawback of poor efficiency. On the other hand, because this technology has a complete atomic identification capability, even with amorphous substances, for example, with amorphous materials and glass, precise identification of the atomic structure is possible. Because research to date has centered on X-ray and electron microscope technologies, great progress has been achieved with crystalline materials. However, with materials in which important functions are concealed by the fact that they are amorphous, development efficiency is extremely poor, and development can only proceed by trial and error. It is important to note that glass, catalysts, and rubber are all typical examples of amorphous materials, but even today, the structures of these very basic materials are not well understood. In explaining why there has been no research on these materials using NMR until now, for a very long time, dissemination of NMR had been limited to existing devices with fields of around 10 Tesla. With a 10T field, it is only possible to measure the nuclei of hydrogen, carbon, and similar elements with precision, which means these devices are virtually useless in analyzing inorganic substances. NIMS has had an infrastructure for the development of superconductor materials since the time of its predecessor institute, the National Research Institute for Metals, and carried out development that extended as far as final magnet products using its own proprietary superconductors and wire materials. For this reason, we were able to achieve extremely high magnetic fields which were not possible with existing devices. It only becomes possible to apply NMR to elements such as aluminum, boron, and titanium when a magnetic field of 20T or higher is used. We believe that the role of the NMR devices at NIMS is to clarify the total nature of various kinds of materials by playing a complementary role to X-ray and electron microscope characterization technologies, focusing on elements that could not be analyzed with the conventional NMR.

Hanagata: The Nano Technology Innovation Center is a newest center that was launched in April 2007, timed. “Interdisciplinary research,” which is the mission of this center, means technical integration of research in other fields, such as information technology, the environment, and biotechnology, with nanotechnology. Although research in nanotechnology has been underway for a fairly long time now, one reason why there have been so few socially useful research results with visible form is thought to be due to the lack of integration with other fields. A second part of our mission as an interdisciplinary center involves people. This means realizing various kinds of technical exchanges by bringing together here researchers from different backgrounds, for example, researchers from universities, researchers from national research institutes, and researchers from private companies. Disseminating results that will lead to innovations that can be returned to society based on these two types of integration is one mission of this center.

The center has three lines which are included in the NIMS Nanotechnology Support Center. The 2-D Nano-Patterning Foundry line is a previously-existing facility that we inherited. The Bio-Organic Materials Facility was opened in October of last year and is already accepting requests for support. The 3-D Nano-Integration Foundry has just started full operation in this April. The 3-D Nano-Integration Line and the Bio-Organic Materials Facility are all newly-constructed facilities. Because these lines also have the mission of “Shared Use of Facilities and Equipment” under the NIMS 2nd Mid-Term Program, the equipment layout and other features were decided from the beginning on this basis. Until now, the “support function” of the nano-fabrication has been largely limited to a temporal use, but in the new lines, the devices and layout were decided based on the concept of creating lines that will make it possible for the users who come to us with ideas to carry out the full range of work from nano-fabrication to evaluation in an integrated manner, based on those ideas.


Focus Ion Beam System


930MHz high resolution solid-state NMR magnet

Objectives of the NIMS Nanotechnology Support Center

Furuya: In shared use of facilities, outside researchers carry out research using the equipment at NIMS. As a result, linking their work efficiently to results is not easy. Support is not possible without an understanding of the counterpart’s research at roughly the same level as one’s own research. In particular, nanotechnology not only includes a wide range of fields, but also many difficult technologies. How to produce new research results based on a total understanding of this extremely complex field is our most difficult challenge. In the case of accepting research themes using electron microscopy from outside researchers, after acceptance is determined by an examination, three professionals are always allocated into one topic, the researcher from our side, the technician who will prepare specimens for use in electron microscopy, and the researcher who will actually operate the electron microscope, and all work from specimen preparation and operation of the electron microscope to compilation of the data is performed as a single integrated process. Our goal is to provide support which enables users to produce results in a precise, systematic, and effective manner.

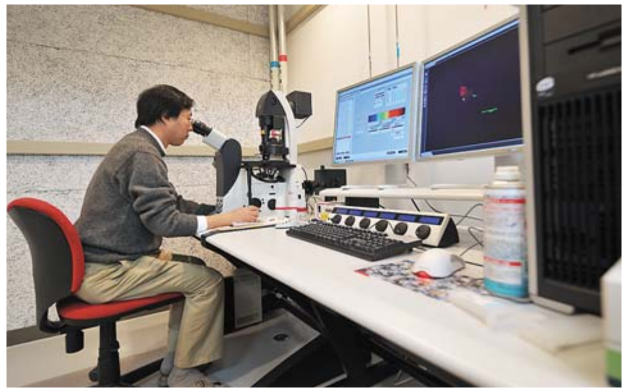
High voltage electron microscopy is not limited simply to observing atoms and molecules; it is also possible to observe the movement of atoms and structural changes. This is called in-situ observation, which is important and very difficult step in technique at the same time. In electron beam tomography, in order to perform 3-dimensional analysis, a 3-D image is obtained by rotating the specimen in the electron microscope. Aside from NIMS, there is hardly anywhere where this kind of research is being done. Moreover, because this is a high voltage electron microscope, it is possible to observe large specimens with high resolution.

Shimizu: The goal of NMR, as discussed previously, is to enable the kind of new research on materials with NMR which becomes possible with fields of 20T and higher, and thereby to contribute to the material manufacturing, which is one of Japan’s fortes. In this context, “manufacturing” means monodzukuri, that is, a distinctively Japanese style of manufacturing. In truly advanced materials development, if the equipment is not also advanced, the results will simply be a rehash of earlier work. From this viewpoint, we intend to contribute to the development of new materials with global competitiveness by developing cutting-edge NMR devices using purely Japanese technology.

Hanagata: There are two kinds of results which we are considering: One is producing research outputs that will lead to innovation, and the other, because we are extremely aware of interdisciplinary fields, is establishing a new scientific region which will be an integrated field encompassing nanotechnology and biology. The NIMS-Leica Microsystems Bio-Imaging Laboratory should be mentioned in this connection. Although the field is bio-imaging, there were almost no researchers in nanobiology at NIMS. Therefore, in order to achieve an early startup, we borrowed the strength of a private sector company. Personnel from Leica are assigned full-time to this project and perform all operations. Bio-imaging has not yet reached the stage of application, but it is like to discover cancers at a very early stage by isolating the carcinoma during diagnosis. In bio-imaging at the cellular level, we are developing a system which will make it possible to analyze how one biomolecule in a given cell is distributed in the cell. We also want to propose methods of using devices in this new field to potential users. In addition to support items, we believe that it may be possible to disseminate and popularize the NIMS results produced in this work.

Furuya: The problem of charges arises in this kind of activity. How far do you go in asking the user to pay for using the equipment? Do the results belong exclusively to the user, or are they disclosed and returned to the public? It has been argued that the division of charges can be definitely different on each cases, and each conditions.

Hanagata: In the case of the Nano Technology Innovation Center, because we started from zero, we cooperated with the private sector, considering how to obtain the maximum effect with the minimum investment, in order to provide to a complete range of equipment.


Confocal laser scanning fluorescence microscope
(NIMS-Leica Bio-Imaging Lab.)


Dual-ion beam interfaced high-voltage TEM

Ojima: Charges are a major issue in this project. Because national support will not continue forever, the 13 centers are attempting, by trial and error, to determine what kind of system is sustainable when various researchers conduct research that leads to innovation using this kind of support. In this, the largest issue is charges. On a different subject, the 13 centers are presenting ideas to enable effective use of this network. Assistance in searching for the proper directions for this is an important role of the Coordination Office. We are also attempting to develop a paradigm for a system after the project is concluded and support from the national government ends, including studying examples from other countries. In particular, it is necessary to establish a support system which is clearly demarcated from the private sector, so that we don’t compete unfairly with private sector companies.

Furuya: How much these centers will be used, and what kind of results they will produce, are of course open questions. The discussion tends to end simply with that, but that isn’t the end of the story.

Shimizu: One of the distinctive features of *monodzukuri* and materials development is the fact that it is completely impossible to predict when, by whom, where, and how inventions and discoveries will be made. As this suggests, the only way to succeed is for everyone to do their own work. Considering the fact that expensive, large-scale, specialized equipment exists at only a small number of research centers, we must create an environment where everyone can use this equipment.

Furuya: And because professional capabilities are necessary in order to provide the support that makes it possible for anyone to use the kind of large, advanced equipment which nobody can buy, research centers that fulfill this function are also necessary.

(Translated by the NIMS Public Relations Office)

cover picture : Cleanroom, 3D Nano-Integration Foundry

Advanced Nano Materials Laboratory

Promoting exploratory research in search of the seeds of innovation

The Advanced Nano Materials Laboratory is engaged in exploratory research in search of the seeds of innovation, centering on nano-related materials. The concepts which we consider important for research are “interdisciplinary research” and “serendipity.” We believe that the serendipity, which means “something found unexpectedly (discovery),” is generated precisely as a result of the interdisciplinary research. Therefore, our aim is to conduct advanced materials research in each of the 8 research groups outlined below, and at the same time, to promote fundamental research with a wide vision through mutual cooperation/fusion of fields.

Materials Exploration Group

This group is exploring and developing novel functional materials using a variety of synthesis techniques such as ultra-high pressure synthesis, ultra-high oxygen pressure synthesis, soft chemistry.

Boride Group

The object of research in this group is refractory (high melting point) borides consisting of a boron network and metal. Work includes production of high quality specimens and characterization of their physical properties, discovery of new properties and phenomena, and development of materials.

Interconnect Design Group

This group designs and realizes next-generation interconnect interfaces (adhesion, bonding interfaces) for application to integration of semiconductors and MEMS devices, high density packaging, etc. using low energy, reversible, environment-friendly techniques and biomimetics technologies that imitate nature.

Supermolecules Group

The objective of this group is to develop novel organic nanomaterials through various supramolecular interactions based on organic synthesis. The group is also engaged in fabrication of nanostructures using these supramolecular structures as templates.

Special Subjects Group

In order to carry out research which leads mainly exploratory research or cooperation with external organizations, this group promotes work on multiple themes based on the concepts of individual researchers in the form of independent research.

High Pressure Group

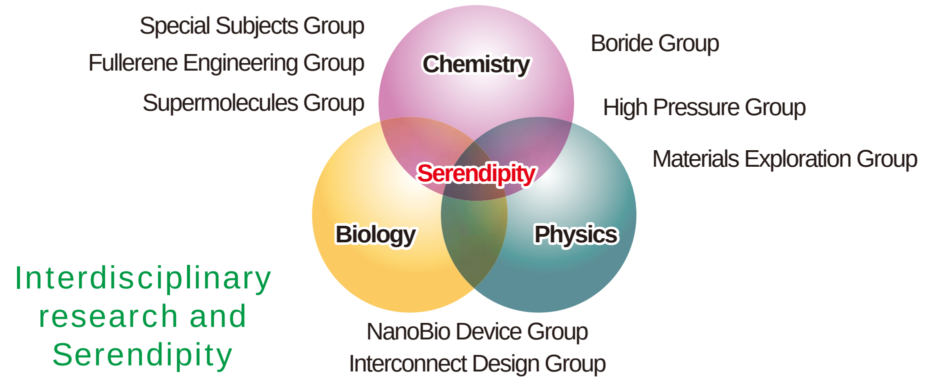
The aim of this group is to develop an ultra-high pressure research system for exploring new high density materials, high functionality materials, etc. through research on ultra-high pressure material synthesis technologies and the states of substances in ultra-high pressure environments.

NanoBio Device Group

This group is engaged in the development of pain-free injection systems (painless needles), various types of diagnostic devices, photoresponsive culture substrates, etc. based on the principles of nanofabrication techniques, self-organization, interfacial chemical modification, and others.

Fullerene Engineering Group

The activities of this group include synthesis of diverse advanced nanomaterials such as nanowhiskers, nanotubes, and nanosheets from fullerenes, elucidation of their properties, development of applications, and standardization and safety assessment.



Searching for Ferroelectric Materials Utilizing Ultra-High Pressure Environments

Eiji Muromachi* Alexei Belik*

High density structures become stable under high pressure. For example, closepacked structures such as spinel (AB_2X_4), Perovskite (ABX_3), and corundum (A_2X_3) are high density structures. It can generally be said that electron orbit overlap is large in high density structures, and as a result, the correlation between electrons acts in a more remarkable form. It is not difficult to imagine that this will have an important effect on the conductivity and magnetism of substances. In our experience, there is a higher probability of interesting properties in substances produced under high pressure than in those produced under normal pressure. For this reason, our group was among the first to focus on the utility of high pressure synthesis techniques in exploratory research on new materials. Using one of the world’s leading high pressure devices (**Fig. 1**), which is part of the NIMS research infrastructure, we are engaged in the development of new substances including superconductors, magnetic bodies, ferroelectrics, etc. In this article, we would like to introduce part of our work.

Ferroelectrics are important practical materials which are used in memories and other applications. Recently, “multiferroic materials,” which have a combination of two or more ferroic properties, including a combination of ferroelectric and ferromagnetic or ferroelastic properties, have attracted attention not only in basic research but also from the viewpoint of possible applications. At present, however, only a limited number of compounds show these properties. One effective method in the search for ferroelectrics and multiferroics is to focus on Perovskite substances, in which an element with unpaired electrons, such as Pb or Bi, that tends to induce strain in the crystal structure, occupies the A site in the aforementioned chemical formula (ABX_3). From this viewpoint, we are conducting a systematic search under high pressure conditions, including solid solutions, centering the Perovskite substances.

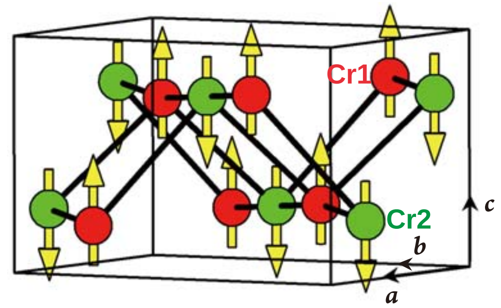
$PbVO_3$ and $BiCoO_3$ are both ferroelectrics, but recently, we discovered that $PbVO_3$–$BiCoO_3$, which is a solid solution of these substances, shows extremely large spontaneous polarization, and in a certain composition range, displays antiferromagnetism, proving that this is a new multiferroic material. We also succeeded in synthesis of good quality $BiCrO_3$, which is well-known as a multiferroic substance, and clarified its magnetic structure in a neutron diffraction experiment (**Fig. 2**). These studies are important, as they provide guidelines for the search for new multiferroics. We discovered that $BiAlO_3$ is a Pb-free ferroelectyric with high Curie temperature and indicates a polarity-electric field hysteresis loop nearly rectangle in shape, thus clarifying the fact that this is a promising material for memory applications.

In the future, we will continue to explore novel functional materials, making the fullest possible use of the unique features of high pressure environments.

Fig.1

NIMS’s 30,000t high pressure synthesis device. This device enables large capacity high pressure synthesis experiments at pressures in the range up to 10GPa.

Fig.2



Antiferromagnetic structure of $BiCrO_3$, as determined by powder neutron diffraction. The arrows show the direction of magnetic moment.

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*Both Dr. E. Muromachi and Dr. .A. Belik are currently a member of the newly- established International Center for Materials Nanoarchitectonics (MANA) at NIMS.

Discovery of a Nanohalf-Metal

- Exploratory Research on Novel Substances -

- New Materials Group,
  Superconducting Materials Center
- First Principles Simulation Group (2),
  Computational Materials Science Center[†]
- Materials Analysis Station,
  Department of Materials Infrastructure[††]
- Department of Physics, Louisiana State University (LSU)
- Los Alamos National Laboratory (LANL)
- Oak Ridge National Laboratory (ORNL)

Kazunari Yamaura　Akira Sato,[††]
Masao Arai[†]　Eiji Muromachi

Others: A. B. Karki (LSU), D. P. Young (LSU),
R. Movshovich (LANL), S. Okamoto (ORNL), D. Mandrus (ORNL)

The New Materials Group is endeavoring to develop new materials which will be important in the middle to long term through advanced material synthesis, precise structural analysis, and characterization of physical properties. For example, focusing on unconventional superconduction, gigantic magnetoresistance, anomalous quantum magnetism, dielectric properties, multiferroic properties, half-metal properties, the group is exploring new materials with potential applications and new substances which are expected to have a high scientific impact.

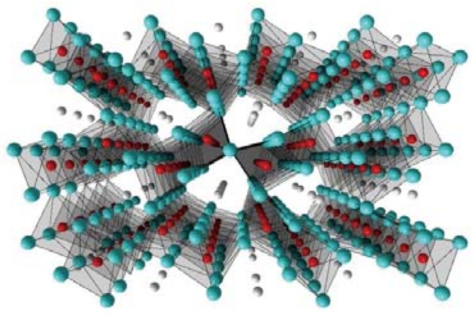
In particular, we are engaged in research focusing on the half-metals.* Half-metal substances are expected to see application in the field of spintronics, taking advantage of their unique electronic states. For example, it is thought that these substances will be useful in the development of magnetic heads for high performance hard disk drives, non-volatile magnetic memories, and spin transistors.

As one result of our research to date, we recently synthesized a half-metal substance with unprecedented features. This new crystal has a crystal structure (**Fig. 1**) that appears to consist of bundles of long, fine chains. It is thought that each of these chain-like structural units is a half-metal and is aligned in antiparallel* to the adjacent half-metal chains (**Fig. 2**). Because this state of an alternating arrangement of half-metals and antiparallel half-metals at the nanoscale is new, and phenomenologically, also displays properties different from those of the half-metals known to date, we named this new crystal a “nanohalf-metal.”

In the past, computer experiments had shown the possibility of this nanohalf-metal state, but this is the first time such a substance has actually been synthesized. The paper reporting this new crystal was carried in the American Physical Society’s Physical Review Letters (PRL), which is highly regarded in the international scientific community, and was selected as the headline paper representing that issue.

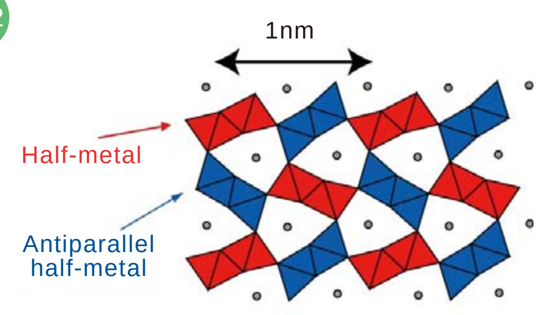
In the future, we plan to carry out spintronics research using this new crystal. However, the new crystal does not achieve the nanohalf-metal state unless cooled to at least -130°C. Therefore, in order to facilitate application, improvement of the new crystal to enable operation at room temperature is necessary. Moreover, because this crystal is the only nanohalf-metal which was been confirmed to date, it is also important to discover second and third nanohalf-metal crystals.

Fig.1



Crystal structure of the nanohalf-metal. The red spheres show the element vanadium (V), light-blue spheres, oxygen (O), and gray spheres, sodium (Na). The chemical formula of the crystal is NaV_2O_4. The chain-like structural units consisting of V and O extend from in front of the surface of the page into the distance. Figure 2 shows a schematic diagram of the nanohalf-metal.

Fig.2



Schematic diagram of the nanohalf-metal. Each of the chain-shaped units extending in the direction perpendicular to the surface of the page is a half-metal. These units are arranged alternately with antiparallel half-metals (up-spin chain - down-spin chain) at the nano scale.

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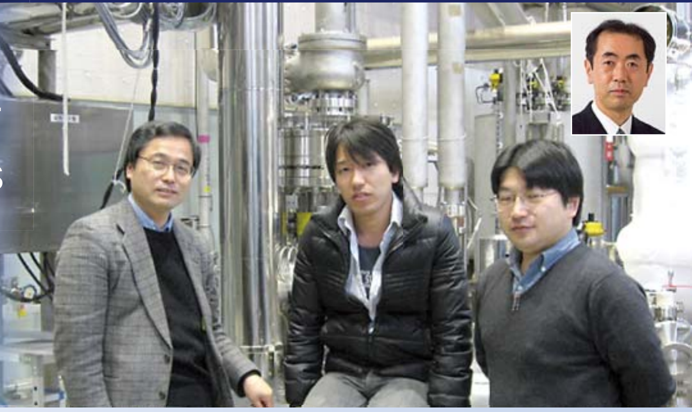
*The spin in the electrons of an element takes a state of either “up-spin” or “down-spin,” depending on quantization. A physical substance that acts as a conductor only to up-spin electrons is termed a “half-metal.” On the other hand, a substance that conducts only electrons in a down-spin state is termed an “antiparallel half-metal.”

K. Yamaura, M. Arai, A. Sato, A.B. Karki, D.P. Young, R. Movshovich, S. Okamoto, D. Mandrus and E. Takayama-Muromachi, Phys. Rev. Lett. 2007, 99, 196601.

Perpendicular Orientation of Mesochannels Realized in 30T Class Ultra-High Field Process

- Magnetic Effect on Diamagnetic Molecules in High Magnetic Field -

International Center for Materials Nanoarchitectonics (MANA)
Faculty of Science and Engineering, Waseda University[†]



Deputy Director-General
Yoshio Sakka, Yusuke Yamauchi, Noriyuki Hirota, Prof. Kazuyuki Kuroda[†]

Mesoporous silica, which contains mesoscale (2-50nm) pores, is a porous ceramic consisting of silicon dioxide (silica) and can be synthesized simply by using a surfactant micelle template. Mesopores of uniform size can be formed by fixing the periphery of a regularly-arranged surfactant with the silica component, and then removing the surfactant in the interior of the pores by calcination, leaving only the silica network. Mesoporous silica having this regular pore structure is a promising material for applications such as adsorbents, catalyst carriers. As a distinctive feature, the macroscopic morphology is easily controlled to various shapes, including fibrous, thin film, spherical, and others. Among these, because mesoporous thin films have extremely high transparency, application to optical materials and electronic materials is expected. Moreover, various mesoporous structures can be produced in these thin films by controlling the surfactant used, synthesis conditions, etc.

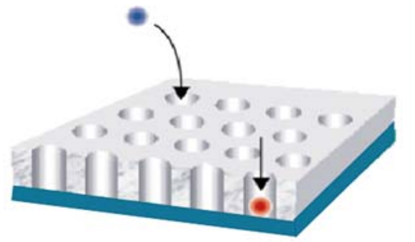
Generally, in thin films with tube-shaped mesopores, the direction of the mesochannels is parallel to the substrate. However, if it were possible to orient these mesochannels perpendicular to the substrate (normal direction), it should be possible to produce a next-generation ultra-high density magnetic recording medium by embedding magnetic particles in the substrate at the nanoscale (**Fig. 1**). Furthermore, this structure would provide easy access into the thin film for a variety of substances, opening the way to other applications such as high activity catalysts and high sensitivity sensors, among others.

To realize this kind of structure, we proposed an ultra-high magnetic field process using a hybrid magnet (**Fig. 2a**). Utilizing the force of the magnetic field, we manipulated the arrangement of the surfactant molecules which function as the template for the mesopores. Because the surfactant consists of organic molecules and thus is not a magnetic material like iron, it is not oriented in a magnetic field of ordinary intensity. However, in an ultra-high field of 30T class, the surfactant also behaves like a magnetic material and can be oriented in the direction of the magnetic field (**Fig. 2b**). Therefore, a high field was applied during the process of self-assembly of the surfactant molecules, thereby aligning the surfactant template perpendicular to the substrate in advance, and the periphery of the surfactant was then fixed with silica (**Fig. 2c**). Because this technique can be applied to various surfactants with different sizes, precise control of the pore diameter is also possible.

Although orientation of the mesochannels in the perpendicular direction is still imperfect, we are currently refining the synthesis conditions with the aim of producing thin films with higher orientation, and are shifting our work toward applied research using this thin film. For details regarding this research, please see the following paper:

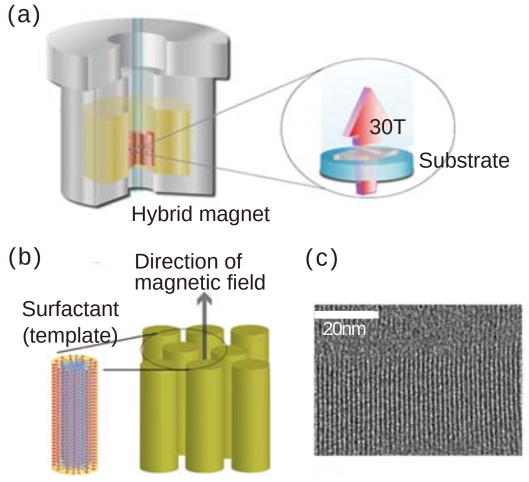
Y. Yamauchi, N. Hirota, Y. Sakka, K. Kuroda *et al.*, Chemistry - An Asian Journal 2007, 2, 1505-1512 .

Fig.1



Mesoporous thin film with perpendicular orientation. Because the mesochannels are oriented perpendicular with respect to the substrate, various substances can be introduced easily from outside the film.

Fig.2



(a) Synthesis method in hybrid magnet. The substrate is placed in the center of the field, and a thin film is synthesized. (b) Orientation model of the assembly of the surfactant (template) in the high field. The rod-like template is oriented in the same direction as the field. (c) Cross-sectional TEM image of a slice of the substrate in the normal direction, showing the mesochannels oriented perpendicular to the substrate surface.

F/A/C/E フェイス interview

Since his appointment as Managing Director of the Nano System Functionality Center in October of last year, one of the Dr. Tomonobu Nakayama's aims has been to engage a variety of people in everyday conversation. Dr. Nakayama believes that communication is particularly important for producing new ideas. In this Face Interview, he discusses the research in which he has been involved to date and the research themes which are his goals at present.

Tomonobu Nakayama
Managing Director, Nano System Functionality Center

The Challenge of a Brain-type Computer Based on a New Concept

Could you describe the research you have done up to now?

In my university days, I was engaged in basic research investigating the structure of the surfaces of semiconductors using the electron microscope. After that, I studied the growth of compound semiconductors with the aim of application to devices in the research center of a material maker. At the time, it was the peak period of corporate diversification. High temperature superconductors were in the limelight, and I also participated in a national project to measure the magnetic fields of the human brain as part of an applied research team working on superconductors. Another researcher who was in that project was Dr. Masakazu Aono, who was a Chief Scientist at RIKEN at the time and is now a NIMS Fellow. As a result of that relationship, I participated in Dr. Aono's Atomcraft Project and later moved to RIKEN. In 1992, we introduced an STM (scanning tunneling microscope), and I began research on ion scattering spectroscopy and the multi-probe technique. I started my research at NIMS in 2002, at the same time as Dr. Aono.

What are your thoughts on becoming Managing Director of the Nano System Functionality Center?

This center is made up of five groups. Dr. Aono, who was the previous Managing Director, frequently said that this is a really interesting combination, and he was right. The Nano Functionality Integration Group is working with the probe microscope, nano-fabrication, and also nanobio-measurements. The Atomic Electronics Group focuses on nanotechnology based on atomic and molecular dynamics, beginning with atomic switches. The other three groups, the Nano Quantum Transport Group, Nano Quantum Electronics Group, and Nano Frontier Materials Group, are basically working with superconductors. High temperature superconductors manifest superconducting properties in a complex crystal structure which is formed by self-assembly, and this is understood to be a material function which is integrated using nanoscale units. We generally talk about the macroscopic aspects of superconductivity, but in reality, "nano" is important. It is extremely interesting to consider substances and materials from this viewpoint. At present, I'm studying this and searching for directions for using this concept.

What kind of research is your group doing?

We are engaged in development and applied research on the multiple-scanning-probe microscope (MPSPM), which is one of the cutting-edge technologies in which NIMS is the leader. We are also pursuing fabrications of interesting structures at the nano to atomic scales, and research on measurement of the properties of those structures. Recently, we have put particular effort into nanobiotechnology. Our aim is a brain-type computer based on a new concept. Because neural network theory and algorithms already exist, brain-like processing seems to be possible – at least to a certain extent – if software is implemented in a silicon-based computer. However, the brain realizes such processes by creating extremely complex materials such cells and their networks. A systematic understanding of the materials science that makes this possible would be a first step toward a brain computer, I believe.

In this sense, we are extremely interested in cells, and are developing fundamental technologies for investigating the functions of a cell, taking advantage of one of our strong points. One such effort is the development of new types of nanoprobes. It is possible to observe the morphology of cells using the AFM (atomic force microscope), but cellular functions could not be observed. Therefore, we are engaged in research with the aim of realizing a brain-type computer using a combination of our multiprobe and nanoprobe technologies.

What is your dream, Dr. Nakayama?

I have been engaged in the development of MPSPM since the earliest stage, and I would like to make this technology more widely available to researchers worldwide. Although there is no question that this is an extremely useful technology, there is also an impression that, as a device, it is somewhat difficult to use. It is possible to measure the functions of structures so small that electrodes cannot be connected with the conventional technology. Moreover, all of the functions of the scanning probe microscope can be used in MPSPM, which means, for example, that it is possible to create structures by manipulating atoms. However, it is not possible to create LSIs or a brain-type computer only by this technique. If it were possible to use this probe at the level of a hundred, thousand, or tens of thousands, such problems could be solved, and the multiprobe technique would become a basic infrastructure technology for nanotechnology, both as a nano-fabrication technique and as a nano-characterization technique. We take pride in the fact that our multiprobe technology is on a level unmatched by any other research institute in the world, and for this reason, I want to popularize and expand the use of this novel technology.

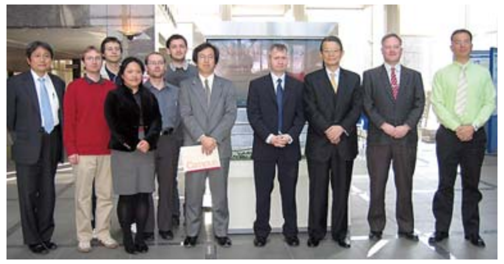
NIMS NEWS

NIMS President Receives the award of an honorary doctorate

Prof. Teruo Kishi in his speech after receiving the award of honorary doctorate from Charles University

(Apr. 7, 2008) Prof. Teruo Kishi, President of NIMS, received the award of an honorary doctorate from Charles University in Prague, the Czech Republic. Charles University has a prestigious history and tradition of 660 years since being founded in 1348, and is the oldest university in central Europe. On April 7, 2002, NIMS concluded an International Joint Graduate School agreement with Charles University, becoming the first Independent Administrative Institution (IAI) in Japan to establish such a relationship with a university overseas. NIMS has been accepting 5 Ph.D. students from Charles University for research guidance each year, and hired a Charles University graduate as a tenured researcher last year. The recent award to Prof. Kishi shows the high evaluation placed on these results. The honorary degree was bestowed on Prof. Kishi with the full tradition and formality in front of the Prime Minister and Ministers of the Czech Republic and the entire Faculty of the Charles University at the awarding ceremony. NIMS hopes that this kind of international collaborative activity will contribute to the further development of science and technology in Japan and central Europe in the future.

Mr. František Trojáček, Commercial and Economic Section at the Embassy of the Czech Republic, visits NIMS



Prof. Teruo Kishi (third from right), Mr. František Trojáček (fourth from right) with other staff including researchers from the Czech Republic working at NIMS

(Feb. 27, 2008) Mr. František Trojáček, Counsellor, Commercial and Economic Section at the Embassy of the Czech Republic, visited NIMS. After touring the laboratories in the Namiki and Sengen sites, he met Professor Teruo Kishi, President of NIMS. At the meeting, he exchanged information on new trends in science and technology policies and met researchers and students from the Czech Republic.

Prof. Shi Erwei, Vice President of Chinese Academy of Science, visits NIMS

From left: Prof. Teruo Kishi, Prof. Cui Ping, and Prof. Shi Erwei

(Feb. 19, 2008) Prof. Shi Erwei, Vice President of the Chinese Academy of Science and his 8 members, visited NIMS and met Dr. Masaki Kitagawa and Dr. Tetsuji Noda, the Vice Presidents of NIMS, and toured the Nanotechnology Innovation Center. After the tour, Prof. Cui Ping, Director of the Ningbo Institute of Material Technology and Engineering (NIMTE) and Prof. Teruo Kishi, President of NIMS, signed a cooperation agreement on a joint graduate school program. Based on this agreement, NIMS is going to accept several doctor course students from the Institute.

A MOU with Kent State University

From left: Prof. Mietek Jaroniec (Professor, KSU), Prof. Roger Gregory (Professor and Chair of Department of Chemistry, KSU) and Dr. Ajayan Vinu (Senior Researcher, NIMS)

(Jan. 10, 2008) The International Center for Materials Nanoarchitectonics (MANA) and Fuel Cell Materials Center jointly signed a Memorandum of Understanding (MOU) for research collaboration on the design of novel nanoporous materials with Kent State University (KSU), Ohio, USA. The two institutions agreed to promote exchanges of researchers and research information, conduct research seminars, write joint research proposal, and execute collaborative research on the development and structural analysis of nanoporous materials. KSU is regarded as one of the top universities in the field of materials science and chemistry in the USA, and is home to a large number of excellent researchers. Numerous outstanding researches are expected to come from remarkable agreement.

MANA International Symposium 2008 & ICYS Final Workshop 2008 Report

The International Center for Young Scientists (ICYS) and the International Center for Materials Nanoarchitectonics (MANA) jointly held a 4 day workshop and symposium from March 10 through 13, 2008. The ICYS Workshop was held to demonstrate the outstanding research results obtained at the ICYS since its establishment in September 2003 through completion at the end of March 2008. At the MANA Symposium, achievements during the half-year period beginning in October 2007 and research plans for the future were presented. As a guest at the ICYS Workshop, Mr. Hiroshi Ikukawa, Director of the Strategic Programs Division, Science and Technology Policy Bureau, Ministry of Education, Culture, Sports, Science and Technology (MEXT) addressed the opening remarks. Since the ICYS was launched in September 2003, it accepted 81 researchers from 27 countries, 52 new NIMS researchers and researchers working under exploratory research grants joined the ICYS. At the MANA Symposium, 4 Principal Investigators from MANA's satellite research centers gave lectures. The entire 4 day period was characterized by spirited discussions. These events succeeded in impressing the many participants with the accomplishments of the two projects.

Period:
March 10 (Monday) – 13 (Thursday), 2008
Location:
No. 1 and No. 2 Conference Rooms, NIMS Sengen Site

Total number of participants: 191

•ICYS Workshop presenters:	Invited lectures	3
	Oral presentations	34
	Poster presentations	87

Among persons giving presentations, 31 were ICYS alumni invited from 15 countries.

•MANA Symposium presenters: (Oral presentations)	Principal Investigators	18
	Young Scientists	10

Hello from NIMS

"What is your research background?" This was the usual question asked when we arrived in NIMS two years ago, and everyone was a bit amused to learn of our backgrounds in geosciences. I joined the Nanostructure Control Research Group (Photocatalytic Materials Center) headed by Dr. Hirohisa Yamada in April 2006 as a postdoctoral researcher after finishing my doctorate research in Environmental Mineralogy and Geochemistry at Kanazawa University (Ishikawa, Japan). My wife, Dr. Cherry L. Ringor, who previously studied U-Th geochronology in corals as a key to understanding climate change, later joined the Fullerene Engineering Group (Advanced Nanomaterials Laboratory) headed by Dr. Kuni`chi Miyazawa. We were overwhelmed by the shift of research focus at first, but later enjoyed such a change after several weeks. Materials science research is relatively fast-paced when one notes that geologic time considers 10,000 years very short.

[Kenroku-en in Kanazawa, Ishikawa is one of the three most beautiful gardens in Japan]

Our stay in NIMS (Namiki) is analogous to a visit to Tokyo Disneyland (or DisneySea if you would prefer). The excitement one feels in the variety of research topics studied here makes one strive more in one's work. Interestingly, most of the materials studied in NIMS have natural analogues, from synthetic layered transition metal silicates to fullerene nanotubes. Geonics – a term Yamada-san and I coined recently – refers to such similarities where natural analogues studied in the geosciences can be adapted in the preparation of novel functional nanomaterials.

Of course, not all things in NIMS or Japan are related to research. In fact, it is in Japan that we became fond of photography (including looking at TEM/SEM images of nanomaterials). There are so many beautiful places in Japan that beg to be photographed, from the gardens of Kanazawa and Mito up to the heights of Tsukuba, Nantai and Fuji-san. Most important of all, our many years of stay in Japan are made most memorable by close friendships with its people; be it a scientist or the neighborhood obaa-chan (grandma) and ojii-chan (grandpa).

Chelo S. Pascua (Philippine)
Postdoctoral Researcher
(April 2006 to March 2008)
Nano-structure control research Group, Photocatalytic Materials C
Present(from April 2008)
National Institute for Geological Sciences (NIGS)
University of the Philippines, Diliman, Quezon City, Philippines

[Cherry, Diego and Chelo in Ishigaki Island, Okinawa]

National Institute for Materials Science
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