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NIMS Project

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NIMS Launches the International Center for Materials Nanoarchitectonics (MANA)

– A Giant Step toward becoming the World's Leading Research Center –

MANA Launch Interview

Teruo Kishi	Chief Entire-Project Officer
Masakazu Aono	Director-General
Takahiro Fujita	Administrative Director

International Center for Materials Nanoarchitectonics
– World Premier International (WPI) Research Center –

NIMS Launches the International Center for Materials Nanoarchitectonics (MANA)

– A Giant Step toward becoming the World's Leading Research Center –

NIMS has been selected as one of the institutes to be funded under the "World Premier International (WPI) Research Center Initiative" established by Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT). The program began in 2007 with the goal of creating in Japan research centers with "global visibility," which will boast extremely high research standards and a research environment that will attract many of the world's top researchers. Following a review of documents and interviews on a total of 33 proposals, five institutes, NIMS, the University of Tokyo, Kyoto University, Tohoku University, and Osaka University, were selected in September to receive funding under the program beginning in fiscal year 2007. NIMS was the only Independent Administrative Institution (IAI) among them.

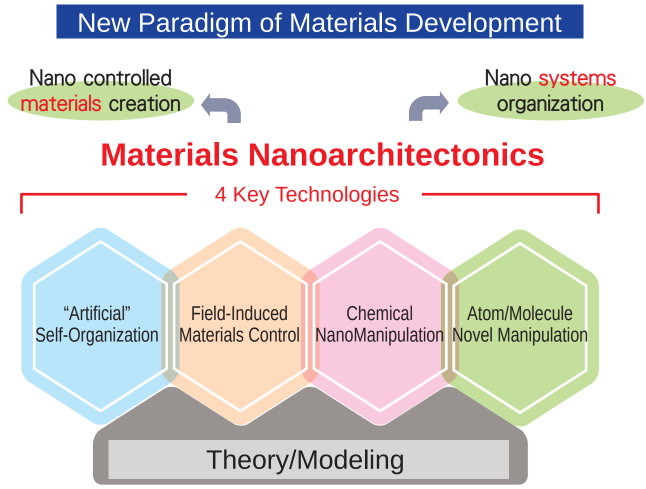
International Center for Materials Nanoarchitectonics (MANA)

The International Center for Materials Nanoarchitectonics (MANA), which was established in NIMS, was launched on October 1 with NIMS President Prof.Teruo Kishi as the Chief Entire-Project Officer and Dr Masakazu Aono as Director-General with responsibility for the overall management of the project. The official English name of the center is abbreviated MANA (Materials Nanoarchitectonics). The Center's logo has also been decided, and consists of a four circles, which represent the four key technologies in materials nanoarchitectonics. The design as a whole also resembles the structure of an atom, expressing the goal of creating diverse substances and materials with MANA as a nucleus.

What is Materials Nanoarchitectonics?

The ultimate research goal of MANA is to develop novel materials that support "sustainable development." MANA will contribute to solving various serious problems confronting humankind in the 21st century concerning environment, energy, resources and others, from the direction of materials, which is one of Japan's greatest strengths. As specific targets, MANA will focus on superconducting materials, materials for devices, biomaterials, and others. As a key feature of MANA, the new Center will place the new materials development concept of materials nanoarchitectonics[*1] at the center of its research as it strives to achieve this objective.

Materials nanoarchitectonics is not limited to creating single nanostructures and elucidating their functions. It is an innovative research concept that aims to extract and utilize the ultimate functions of materials by understanding the mutual interactions of individual nanostructures and intentionally controlling the arrangement of those nanostructures.



Organization of MANA

For realization of the concept of MANA, more than 20 of the world's most outstanding researchers will be invited to MANA as Principal Investigators. These researchers will come from NIMS and six other institutes, such as the University of Cambridge, UCLA (University of California, Los Angeles), CNRS (Centre National de la Recherche Scientifique, France), Georgia Institute of Technology, University of Tsukuba and Tokyo University of Science. In addition, approximately 40 young scientists from NIMS, about 60 post-doc researchers and 40 graduate students from around the world will be selected. A total of 200 staff will work in the project, including engineers and administrative personnel. The six institutions as MANA satellites will create a powerful alignment for promoting research and human resources development within the MANA framework. NIMS will provide ample space for research activities, and research will be concentrated in a single location as far as possible.

High Evaluation of NIMS's Achievements

The reason for the selection of NIMS as the only IAI in the new program in spite of intense competition was the high overall evaluation of NIMS itself as the host institute, as well as MANA's unique research concept of "materials nanoarchitectonics." The following were considered as remarkable achievements to ensure our support for realizing the MANA concept.

01 Excellent research results in nanotechnology and nanomaterials

02 World's top-class large-scale research infrastructure, including high magnetic field facilities, ultra-high resolution/ultra-high voltage electron microscopes, NIMS dedicated beamline for synchrotron research, etc.

03 Program for developing outstanding human resources for research, centering on the International Center for Young Scientists (ICYS)

04 Wide variety of international collaboration projects, including the World Materials Research Institute Forum and the International Joint Graduate School Program, etc.

Continuing Systemic Reform

In spite of its impressive achievements to date, NIMS is not resting on its laurels. We intend to develop research at the world's highest level in the MANA project. In order to realize this, a world-class research system is also necessary. Therefore, simultaneously with advanced research in MANA, NIMS will also continue its innovative efforts to realize systemic reform, including ongoing internationalization, the introduction of a tenure track system for researchers,[*2] development of human resources, and reforms in the administrative division.

In 2003, NIMS launched a project called the International Center for Young Scientists (ICYS) with financial support from MEXT's Special Coordination Funds for Promoting Science and Technology, and continued a variety of activities over the following 5 years. By gathering outstanding young scientists from around the world, the ICYS program succeeded in creating an ideal environment for nurturing young researchers through mutual competition in a free and frank atmosphere in a "melting pot" of diverse nationalities, cultures, and scientific fields.

Although the ICYS project will be concluded at the end of the current fiscal year (March 31, 2008), NIMS plans to nurture young researchers by continuing and further developing the basic concepts of the ICYS in MANA. Our aim is to give the researchers fostered in this program attractive career opportunities as research leaders or as tenured researchers in the NIMS organization itself.

In the ICYS, NIMS established a support system for non-Japanese researchers in both their research and their everyday lives, and created an environment in which these international researchers could work easily, for example, by improving the English language capabilities of the administrative side as a whole. In MANA, we will further strengthen these efforts so that NIMS can evolve into an international core research institute.

Goals of MANA

This program will continue for at least 10 years, and will be extended for an additional 5 years for centers with particularly high achievements. The goal of the MANA concept is not only to develop MANA into one of the world's core institutes in nanotechnology and nanomaterials research 10 years from now, but also to ensure that NIMS itself evolves into the world's top materials research institute, with MANA in the leadership role.

"Mana" is a word of Polynesian/Melanesian origin that means a supernatural power to bring about good fortune or magical powers. Likewise, the MANA concept will play a key role in achieving our ambitious goals. With this new initiative, we expect dramatic progress at NIMS in the next 10 years.

[*1] The word nanoarchitectonics was first used at the International Symposium on Nanoarchitectonics Using Suprainteractions held in Tsukuba in 2000.

[*2] Tenure track system: A system by which young scientists become tenured researchers (permanent researchers) based on accumulated experience and a rigorous review of performance.

MANA Launch Interview

International Center for Materials Nanoarchitectonics

Aiming to be a Research Center that is Open to the World

Teruo Kishi
President, NIMS
Chief Entire-Project Officer, MANA

Please tell us about your hope for MANA as the Chief Entire-Project Officer for the project.

In this program, we are expected to create one of the world's top level research centers with "global visibility." For achieving this, we are required to improve the systems of NIMS as a whole to enable us to do the world's most advanced level of research. We devote all our energy to reform of the research system, including the administrative division and focus on promotion of real internationalization, introduction of a tenure track system, and development of human resources for research.

I would say that NIMS has already achieved an impressive degree of internationalization . . . .

Compared with where we started, that might be true, but we still haven't reached the level where we can be called an international core institute. We have to make further efforts in internationalization in the future. My dream is that NIMS will be a research center where researchers at all levels, including young scientists, post-docs, and graduate school and university students, and not just senior researchers from around the world are eager to do their research. This is precisely the aim of the World Premier International Research Center Initiative program. We would like to implement a variety of measures through MANA to achieve this.

What is the aim in introducing a tenure track system?

In MANA, we would like to implement a career development path that allows outstanding post-docs from other countries to become permanent NIMS researchers, including close to 200 post-docs in NIMS. To achieve this, first, we'll select top post-docs from around the world and place them in ICYS-MANA. Under this system, they will receive research funds and individual offices and can do research freely as independent researchers. After accumulating research results for 2 to 3 years, they can apply to become permanent researchers. This system is not a new challenge at NIMS. Our experience with the ICYS in the last 4 years will be very useful and can be a strength in this connection.

What are the targets for human resources development?

The most important target is the training of young researchers in their 30s. This is the major challenge for Japanese material science and technology, not just NIMS. We would like to foster a large number of independent, aggressive young researchers who can plan research projects based on their own ideas, obtain external funding for their projects, actively conduct exchanges with researchers in other countries, and also organize international conferences. This kind of researcher could be an excellent front man for NIMS. These researchers will make NIMS a more visible research center from outside.

For this, we have to improve their English language skills. How many Japanese can really hold their own in English with foreigners? NIMS has tried to improve the language skills of the people who support our research activities, for example, in administrative area. In the future, we should also improve our researchers' English level and international sensibilities to be the one of the world's top level research centers.

Based on our experience with the melting pot environment in the ICYS, we're well aware of the usefulness of bringing together diverse human resources. From this viewpoint, we will also actively try to hire female researchers and researchers from corporate backgrounds in the future.

Finally, do you have any other wishes?

As the host institute, NIMS committed full support to the activities of MANA. We are also searching for a new paradigm for NIMS through the activities of MANA, and we hope to lead an ideal research institute for the 21st century.

I hope that we can really be recognized as an "open institute" widely, from both inside and outside of Japan, in the near future.

Pioneering a New Paradigm in Materials Development

Masakazu Aono
Director-General, MANA

First, let me ask what types of research you will do at MANA.

The directions for research were designed from two viewpoints. Science and technology have both bright and dark aspects. The dark aspect is continuing to create serious problems at the global scale. Overcoming this and realizing "sustainable development" will be the most important challenge for the world as a whole in the future. Therefore, one viewpoint of research at MANA is to promote research on materials, which might be called the "mother of science and technology," with the aim of realizing sustainable development.

As the second viewpoint, because materials have this important responsibility, a shift to a new paradigm is needed in materials research. In particular, increasingly sophisticated requirements are now placed on materials, with the aim of enabling various innovative technologies that the 21st century will require. A new paradigm of materials development is necessary in order to respond to these needs. Naturally, this has to get beyond the conventional framework of metallurgy, materials chemistry, solid-state physics, and so on. It also has to go beyond categories like inorganic, organic, and biological. We express this by the term "materials nanoarchitectonics." The approach that views all materials in terms of atoms and molecules has succeeded in explaining the nature of materials that already exist, but it hasn't necessarily led to active creation of new functional materials. The research concept of materials nanoarchitectonics will be critical in the creation of new functional materials. This concept includes control of the arrangement of nanostructures and control of their mutual interactions which stand in the upper stage of the conventional approach.

However, just because I'm using the word "nano," please don't think that we're only interested in nanomaterials. We intend to work with materials of all types from the standpoint of nanoarchitectonics.

Concretely, what kinds of materials do you intend to develop?

One distinctive feature of materials development is its diversity. Also, in MANA, we will be trying to gather outstanding researchers in diverse materials-related fields from all over the world. For this reason, I don't think it would be appropriate to focus on a few tightly-defined directions from the first. Of course, it goes without saying that the general direction of research will be realizing sustainable development, as I mentioned at the outset. However, my personal dreams include realizing a room temperature superconductor, creating novel materials for so-called "brain computers," and the development of a completely new type of photoelectric conversion device.

The Challenge is Systemic Reform

Takahiro Fujita
Administrative Director, MANA

Could you describe the operating policy of the Administrative Division?

We understand that the aims of the MANA program are to carry out advanced research and, through this, to implement systemic reforms in NIMS. Based on this, the operations of the Administrative Sector will be divided between the Administrative Office, which will assist the researchers themselves, and the Planning Division, which will be responsible for systemic reform.

Then the Administration Office will take over the functions of the ICYS?

That's right. We already have considerable human resources, experience, and know-how which are useful in assisting foreign researchers in the ICYS project. MANA's Administrative Office will inherit those assets, basically in their present form. For example, in ICYS, we've had experience in recruiting several dozen non-Japanese scientists, so we could begin recruiting human resources for MANA immediately.

Although the ICYS program will end in March 2008, at the end of our present fiscal year, its functions will continue in the tenure track system in MANA.

What efforts will you be making in the area of systemic reform?

Actually, simultaneously with the establishment of MANA, we also created a Planning Division in NIMS itself. Of the nine front-office administrative sections, five which are deeply related to the operation of MANA have been placed in the Planning Division. These are the Integrated Strategy Office, Research Evaluation Office, International Affairs Office, Public Relations Office, and Human Resources Development Office. Systemic reform, which is another mission of the Administrative Office, will be implemented mainly by this Planning Division.

Because the managers of MANA and the front-office division of NIMS itself will take on problems in an organic manner, I believe that we will be able to implement systemic reforms quickly with a feeling of unity between NIMS and MANA.

Materials Reliability Center

Development of Evaluation Technology for Time-Dependent Damage of Structural Materials

The goal of the Materials Reliability Center is to develop more advanced life evaluation technologies for creep, fatigue, stress corrosion cracking, and other forms of time-dependent damage and failure of metal structural materials as materials infrastructure technologies, which are necessary in order to ensure a safe and secure living environment.

NIMS is conducting long-term creep tests of various types of heat-resistant steels, which now extend over a period of more than 40 years, in order to secure high reliability in high temperature materials for thermal power plants and nuclear reactors. We discovered that the creep rupture strength of high Chromium steels decreases drastically in the long-term region exceeding several 10^4 hours in comparison with curves for predicting rupture strength using the Larson-Miller parameter obtained from short-term data for <20,000 hours (**Fig. 1(a)**). In fatigue tests of steel materials, the number of cycles to failure increases as cyclic loading stress decreases, but below a certain stress, fatigue failure does not occur. This is termed the fatigue limit. Because the fatigue limit normally appears by approximately 10^7 cycles, conventional evaluations were conducted at around 10^7 cycles. However, in the Ultra-Steel Project (Steel Research Center, NIMS), a fatigue limit was not observed in a high strength steel with tensile strength exceeding 1200 MPa, but a phenomenon of substantially degraded fatigue strength was discovered in the high cycle region (**Fig. 1(b)**).

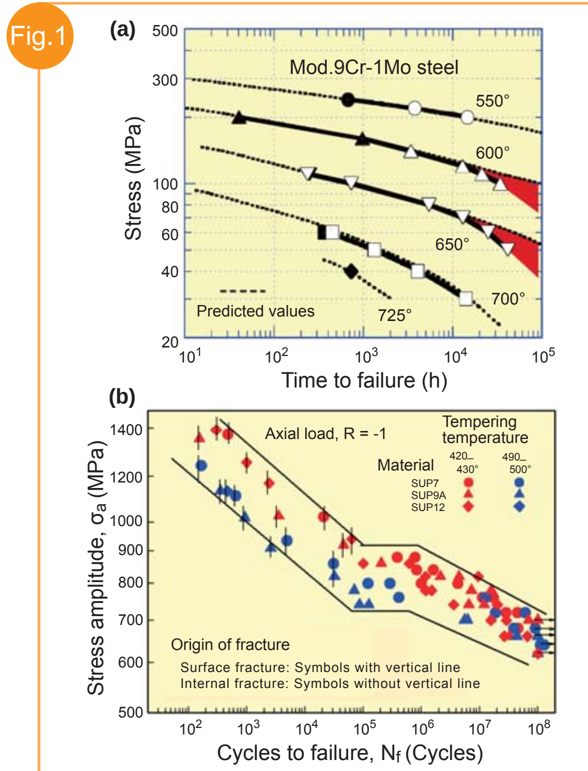
Therefore, the goals of the Materials Reliability Center are to evaluate the strength and physical properties of the nano- and microstructures of degraded/damaged materials utilizing advanced techniques such as nano-indentation (micro-hardness measurement), focusing on strength degradation by high cycle fatigue and long-term creep, and to develop more advanced life evaluation technologies by introducing theoretical simulation techniques. We are also carrying out research to clarify the mechanism of corrosion initiation and growth originating from stress corrosion cracking to enable life predictions in connection with stress corrosion cracking, which occurs in aqueous solutions containing chlorides and has become a serious problem, and research to elucidate the mechanisms of fatigue fracture and brittle fracture at ultra-low temperatures in order to contribute to improved safety in materials used in aerospace equipment.

In order to secure reliability in micro-machines, which are expected to reach practical application in the near future, high reliability will be necessary in the nano- and micro-components used in these devices. To this end, the Materials Reliability Center is carrying out research to construct a technological infrastructure for securing reliability by establishing technologies for creating micro-nano materials such as micro-wires and thin films and evaluation techniques for various physical and mechanical properties.

To promote these various areas of research efficiently, the six research groups shown in **Fig. 2** were established in the Materials Reliability Center. The Center is also contributing to accident analysis and optimum materials selection by database creation and international standardization activities for the research results obtained in its work in cooperation with the NIMS Material Data Sheet Station and the Materials Database Station.

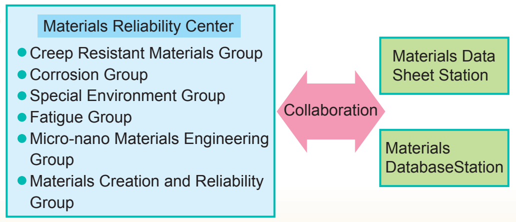
For more details: http://www.nims.go.jp/mrc/index_e.htm

Fig.1



(a) Relationship between stress and time to failure of improved 9Cr-1Mo steel, and predicted time to failure based on short-term data (<20,000h) using the Larson-Miller parameter. At times exceeding several 10^4 hours, time to failure shows a large decrease in comparison with the predicted values. (b) Fatigue characteristics of various high strength steels (SUP7, SUP9A, SUP12). No fatigue limit is observed, but fatigue strength decreases significantly in the high cycle region.

Fig.2



Materials Reliability Center
- Creep Resistant Materials Group
- Corrosion Group
- Special Environment Group
- Fatigue Group
- Micro-nano Materials Engineering Group
- Materials Creation and Reliability Group

Collaboration

Materials Data Sheet Station

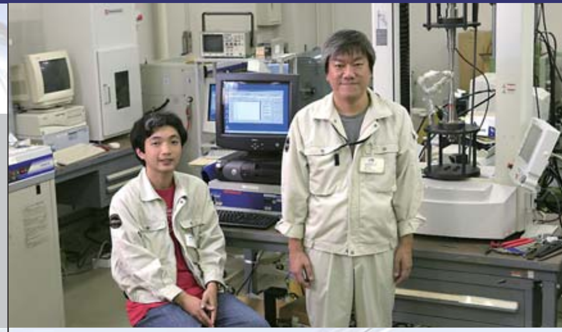
Materials DatabaseStation

Organization of the Materials Reliability Center

Ultrasonic Fatigue Test for Hydrogen Charged Materials

- Effect of Hydrogen on Gigacycle Fatigue Characteristics -

Fatigue Group, Materials Reliability Center



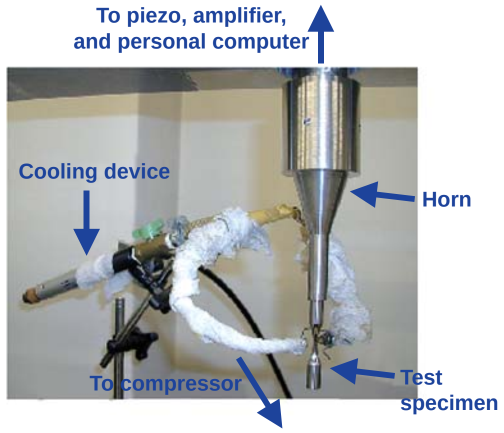
Yoshiyuki Furuya, Hisashi Hirukawa

The Fatigue Group is involved in research on fatigue fracture of metallic materials under cyclic loading. In particular, we have recently devoted considerable effort to research on gigacycle fatigue under cyclic loading exceeding 1 billion (10^9) cycles. This is considered to be a critical issue for the automotive and railway industries. The ultrasonic fatigue tester (**Fig. 1**) is a necessary and indispensable device for research on gigacycle fatigue. Because the ultrasonic fatigue tester makes it possible to perform fatigue tests at high frequencies of 20 kHz which is more than 200 times faster than with conventional technique, the time required for a 10^9 cycle test that normally takes 3-4 months can be shortened to only 1 day.

It has been pointed out that the effect of hydrogen is one factor in gigacycle fatigue in high strength steels. Considering the fact that hydrogen is a leading candidate for next-generation energy, it is essential to clarify the effect of hydrogen on the fatigue characteristics of metal materials. Against this background, we began research on the effect of hydrogen on gigacycle fatigue characteristics. The fundamental idea is to simulate a condition of exposure to hydrogen by the technique called hydrogen charging, in which hydrogen is electrochemically absorbed into a specimen, and then to evaluate the gigacycle fatigue characteristics of the material in an ultrasonic fatigue test. Large-scale equipment is necessary when actually performing tests in high pressure hydrogen environments. However, with the artificial hydrogen charge technique, it is possible to perform tests in an ordinary laboratory. Furthermore, with conventional fatigue test techniques, desorption of the absorbed hydrogen during the test becomes a problem because the test requires an extremely long period of time. This problem is solved by using an ultra-high speed ultrasonic fatigue tester.

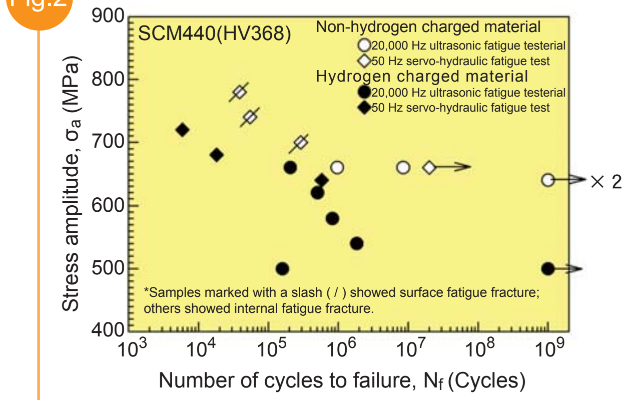
Fig. 2 shows typical fatigue test results. In the material without hydrogen charging, which was used as a reference materials in the test, fracture from the surface (surface fatigue fracture) occurred in the low life region of <10^6 cycles, and internal fracture occurred in the higher life region. In contrast to this, with the hydrogen charged material, the fracture mode was internal fracture in all cases, and fatigue strength was substantially reduced. These results mean that internal fracture characteristics are more strongly affected by hydrogen. Considering the fact that internal fatigue fracture is a cause of gigacycle fatigue, this result shows that it is necessary to perform tests up to the gigacycle region in order to evaluate the effect of hydrogen. We hope to contribute to realize a safe and secure society by steadily accumulating experimental results.

Fig.1



An ultrasonic fatigue tester. It is capable to reach the gigacycle region before the absorbed hydrogen in the material is desorbed as this is an ultra-high speed fatigue test devise.

Fig.2



Results of a fatigue test of hydrogen charged material. The sample material was a low alloy steel, SCM440, which had been tempered to HV368. The test environment was room temperature under atmospheric air. The stress ratio was R = -1.

Successful Development of a Diamond Fire Detection System

- With the Aim of Contributing to a Safe, Secure Society -

Optical Sensor Group,
Sensor Materials Center

(Background: Notre Dame Cathedral and the Seine River)

Group Leader
Yasuo Koide

The development of a simple, compact sensor system capable of detecting only flame or harmful substances quickly and with high sensitivity in strong midday sunlight or outdoors can be considered an important research challenge for securing a safe living environment for the nations. It was necessary to develop an ultraviolet (UV) light sensor which responds only to the wavelengths emitted by flame, harmful substances, (This is termed deep-ultraviolet light, or deep UV.) since ordinary optical sensors respond to sunlight. While photoelectric tubes of the UV sensor have already been applied practically as sensors for detecting flame today, the development of a solid-state device type UV sensor as a simple and compact flame sensor had been desirable. Also, more durable materials were necessary because virtually all materials are degraded by the high optical energy of deep UV.

Fig. 1 shows a photograph of a diamond fire sensor which was developed in the present research. The device is sealed in a small airtight package with a diameter of 9 mm and height of 5 mm, and is also impact resistant. The sensor consists of a epitaxial single crystal layer of a high quality diamond semiconductor and a newly-developed high melting point metal carbide electrode with extremely high heat resistance. It displays the world's highest performance as a solid-state device type deep UV sensor. As advantages, the new sensor offers low power consumption and longer life in comparison with existing sensors.

A general view of the "diamond fire detection system" which was developed using this sensor device is shown in **Fig. 2**. In this fire detection system, the diamond deep UV sensor device is used as the fire sensor. The system consists of a sensor section and an alarm section, and uses a signal processing technology and wireless transmission technology that are unaffected by sunlight. The sensor section is driven by one 9V dry cell and has a long service life, amply demonstrating the advantage of low power consumption of the diamond deep UV sensor. Envisioning popularization in general households in the future, the fire detection system is configured to transmit fire information detected by the sensor section to the alarm section quickly by infrared transmission, and to activate an audible alarm and/or alarm lamp.

In the future, stability with respect to deep UV light and light reception sensitivity will be further improved, aiming at practical application.

Fig.1

Photograph of the diamond fire sensor. The sensor device is sealed in an airtight package 9 mm in diameter and 5 mm high.

Fig.2

General view of the diamond fire detection system developed using the diamond deep UV sensor. From the right, the system comprises a sensing section, which contains the fire sensor, an alarm control section, and a warning lamp.

Construction of a Physical Model as a Guideline for Realizing Next-Generation Computer Chips

Advanced Electronic Materials Center (AE-MAC; NIMS), University of Tsukuba, Osaka University, Semiconductor Leading Edge Technologies, Inc. (Selete), Tokyo Electron Ltd., Chuo Denshi Kogyo Co., Ltd., Samsung Electronics, Hitachi, Ltd., and NEC Electronics Corp.

Toyohiro Chikyo
(NIMS)

Yasushi Akasaka
(Selete; currently, Tokyo Electron)

Heiji Watanabe
(Osaka University)

Naoto Umezawa
(NIMS)

Genji Nakamura (Tokyo Electron), Kenji Shiraishi (University of Tsukuba),
Kikuo Yamabe (University of Tsukuba), Osamu Ogawa (Chuo Denshi),
Myoungbum Lee (Samsung), Toshio Aminaka (Selete),
Fumio Ootsuka (Selete), Tooru Kasuya (Hitachi), Yasuo Nara (Selete),
and Kunio Nakamura (NEC)

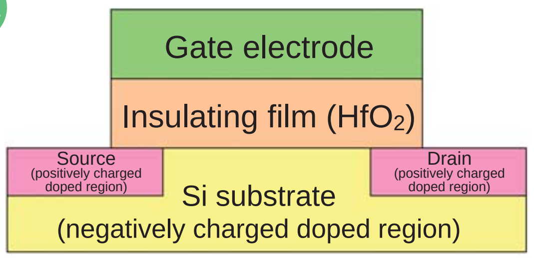
The transistors (metal oxide semiconductor field effect transistor: MOSFET) which make up computer chips (LSIs) have a structure in which a non-conducting film (insulating film) on the order of 1 nm (one-millionth of a millimeter) in thickness is sandwiched between the gate electrode and an Si substrate, as illustrated in **Fig. 1**. The thinness of a nanometer is equivalent to only several layers of atoms. Although transistor performance increases as the insulating film becomes thinner, it is physically impossible to achieve greater thinness than this. For this reason, use of a hafnium oxide (HfO_2) film, which has higher electrical permittivity, in place of the silicon oxide (SiO_2) that has been used until now in insulating films is being studied as one approach to achieving higher performance in transistors.

However, it has become clear that defects occur when LSI circuits are constructed using this material. Circuits are created by combining two types of transistors, i.e., n-type MOSFETs which pass a negative electrical current in the Si substrate, and p-type MOSFETs, which pass a positive current. The resulting device is called a CMOS (complementary metal oxide semiconductor) circuit. In both, the property of reversal of the plus/minus operating voltage is ideal, but when an HfO_2 insulating film is used, deviations occur in the operating voltage of the p-type MOSFET. Normally, this type of deviation can be adjusted by changing the electrode material, but it has become clear that adjustment is not possible with HfO_2 insulting films. This phenomenon is termed "Fermi level pinning" (FLP) because the energy called the "Fermi level," which normally differs depending on the electrode material, can no longer move, but rather behaves as though "pinned." We succeeded in clarifying the physical mechanism responsible for this phenomenon.

As shown in **Fig. 2**, when HfO_2 and Si are placed in contact, a tiny amount of oxygen escapes from the HfO_2 and reacts with the Si in an oxidation reaction. Chemical energy is necessary for this reaction. At this time, the escaping oxygen leaves vacancies (called "oxygen vacancies"), and electrons, which can move with comparative freedom, are induced in there. Because the electron requires more stable sites, they transfer to the electrode, causing a change in electrical energy. The FLP phenomenon is caused by balancing of the chemical energy and electrical energy in the system. Because this "oxygen vacancy induced FLP model" can explain a variety of experimental facts in connection with the FLP phenomenon, it has attracted attention as a useful model that provides an important guideline for MOSFET design. The NIMS Advanced Electronic Materials Center contributed to this research through the "High-k Net," which is an industry-university-IAI (Independent Administrative Institution) collaboration initiative for scientific understanding of high-k gate stacks. This achievement received the JJAP (Journal of the Japan Society of Applied Physics) Paper Award for 2007. (Paper title: "Modified Oxygen Vacancy Induced Fermi Level Pinning Model Extendable to P-Metal Pinning")

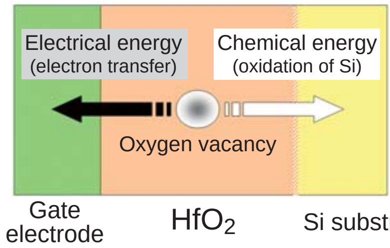
JJAP Paper Award medal.

Fig.1



Structure of a p-type MOSFET in which a positive charge carries the electric current.
(Transfer of the positive charge in the source region is prevented by the negative charge of the Si substrate; however, when a voltage is applied, the charge distribution changes, allowing transfer of the positive charge to the drain.)

Fig.2



Conceptual diagram of oxygen vacancy induced FLP model.

NIMS Facilities and Equipments

High Magnetic Field Station (Tsukuba Magnet Laboratory: TML)

Director
Tsukuba Magnet Laboratory
Department of Materials Infrastructure
Giyuu Kido

High Magnetic Field Station is known as the name of the Tsukuba Magnet Laboratory (TML) is one of the world's core centers in high magnetic field research. The TML has facilities capable of generating highest class steady magnetic fields and is engaged in the development of technologies utilizing magnetic fields. Since the TML was established, magnets have also been available to outside researchers and more than 60 research institutes have carried out joint research here.

In 2007, NIMS created the "NIMS Nanotechnology Support Network" in order to smoothly implement the "Nanotechnology Network" project sponsored by Ministry of Education, Culture, Sports, Science and Technology (MEXT). In carrying out this project, high expectations are placed on the various types of NMR spectrometers at the TML, including the 930 MHz NMR, as devices which enable analysis of the micro- and nanostructures of organic and inorganic compounds at the world's highest level.

The following describes the 930 MHz NMR magnet and 40T class hybrid magnet, both of which are available for joint use as "user facilities." In addition, the TML also has two magnets which are used in combination with 30 mK (millikelvin) dilution refrigerators, these being a 20T magnet (1.8K when operating) and 18T magnet (4.2K). These devices are mainly used in measurements of transport phenomena and similar studies. The TML also has an 18T general-purpose magnet (bore: 52 mm), which is used in evaluations of superconducting materials, and 5T (30 cm) and 12T (10 cm) cryogen-free magnets, which are employed in a variety of research on the uses of magnetic fields.

930 MHz NMR Magnet

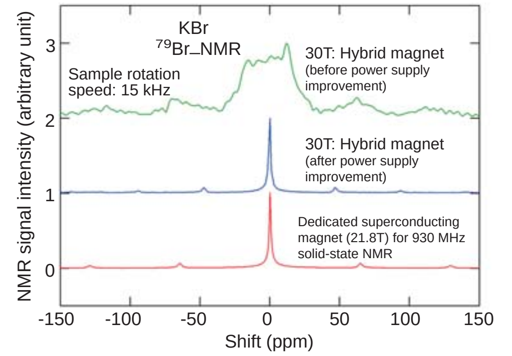
Since the 930 MHz NMR magnet was energized in March 2004, the superconducting coil has been operated in a persistent current mode and the magnet has continued to generate 21.84T, which corresponds to 930 MHz at the resonant frequency of the hydrogen atom nucleus. The experimental space is a room temperature chamber with a bore diameter of 54 mm. Measurements are performed by inserting a CP/MAS probe or MQMAS probe into the chamber. The 930 MHz high-resolution NMR Spectrometer make possible to perform high resolution solid-state experiments. In addition to the 930 MHz NMR magnet, the Tsukuba Magnet Laboratory has a total of five NMR devices, including solid-state high resolution 500 MHz and 400 MHz devices and 500 MHz and 270 MHz optical polarization devices for wide-ranging NMR use, and thus has the world's most complete lineup of solid-state NMR equipment. At present, the TML is conducting research on local structural analysis of nano functional materials, among other topics.

40T Class Hybrid Magnet (cover photo)

This hybrid magnet has a structure that combines a large bore superconducting magnet and a 15 MW water-cooled Cu magnet, and generates the world's second highest steady strong magnetic field. For experimental use, the Tsukuba Magnet Laboratory provides steady fields of either 35T (bore of room temperature chamber: 32 mm) or 30T (52 mm).

In FY2005, the power supply of the 15 MW water-cooled magnet was improved by introducing a MOSFET dropper, etc., greatly reducing fluctuations of the magnetic field and noise, which had been problems since this magnet was installed. As a result, it is now possible to perform far more precise evaluations of superconducting materials and magnetic materials. In addition, high sensitivity, high resolution NMR at 30T is now possible, opening the way to local structural analysis of elements which are important for practical use, such as oxygen, aluminum, and others.

NMR Spectra charts obtained using the 40T class hybrid magnet



NMR spectra of a reference specimen (KBr). These charts show that, as a result of improvement of the power supply for the water-cooled magnet and innovations in the specimen shape, shielding, etc., it is now possible to achieve resolution on the order of 3ppm in a 30T magnetic field.

[Methods of using facilities]

Two methods of using these facilities are possible, "joint use" and "external use." Applications are accepted at any time through magnet@nims.go.jp. Please see http://www.nims.go.jp/TML/english/ for more details.

Joint use

Under the joint use system, the user agrees to the provisions of a joint research agreement and is allowed to use the facilities of the Tsukuba Magnet Laboratory free of charge. In principle, users must replace consumables provided by NIMS. The research outcomes and resulting intellectual property rights are in principle jointly owned with NIMS. Users are required to submit a research report for each fiscal year.

External use

Under the external use system, incorporated research institutes use TML facilities on a fee basis. The user is not required to disclose the results of research, and any resulting intellectual property rights are owned solely by the user.

NIMS NEWS

New NIMS Fellow

(October 1, NIMS) ‥ NIMS named Dr. Osamu Mishima, a Senior Researcher in the Special Subjects Group, Advanced Nano Materials Laboratory as a NIMS Fellow, citing his "remarkable achievements in the field of materials, and expectations that he will make a major contribution to NIMS research activities in the future."

NIMS Fellow Mishima received the 52nd Nishina Memorial Prize in December 2006 for "Phase transition of the water/amorphous ice – Experimental studies of polyamorphism." His appointment is expected to contribute to a higher level of research activity in NIMS.

Osamu Mishima

Doctor of Engineering (1979). Finished his doctoral program at the Faculty of Engineering Science, Osaka University. Served as Assistant at the Osaka University Faculty of Engineering Science's Ultra-High-Pressure Experimental Laboratory and as a researcher in the Division of Chemistry, National Research Council of Canada before joining the High-Pressure Station, National Institute for Research in Inorganic Materials (a predecessor of NIMS), under Japan's Science and Technology Agency in 1985. Became an Independent Senior Researcher in the NIMS Advanced Materials Laboratory in 2001 and Senior Researcher in the Advanced Nano Materials Laboratory's Special Subjects Group in 2006. Appointed NIMS Fellow in October 2007.

Dr. Mishima's Comments on His Appointment

Research on water and ice is extremely interesting. Understanding these substances has been my life's work since I was student. I am very grateful that I have been able to continue this work at NIMS. It has gradually become clear that two different liquid phases exist in water, and the importance of this fact is now recognized. I have experienced the discussion and debate about water and ice over the past 20 years, and have been involved in the process of clarifying the existence of these two phases. In this, I've had the good fortune to taste the real pleasure of science. However, our understanding of water and ice is only provisional and is still evolving. As a NIMS Fellow, I hope to further advance this research.

NIMS Office Opened in University of Cambridge, U.K.

(October 2, 2007) – A NIMS Office has been opened at the Department of Materials Science & Metallurgy of the University of Cambridge, United Kingdom. NIMS Vice President Masaki Kitagawa and Managing Director Hiroshi Harada of the High Temperature Materials Center, Prof. Lindsay Greer, Head of Department and Professor of Materials Science (University of Cambridge), Prof. Colin Humphreys (University of Cambridge) and Dr. Neil Jones (Rolls-Royce) attended the opening ceremony. They all expressed their wishes to strengthen research collaboration by establishing this direct link between NIMS and Cambridge, each of which already had a cooperative relationship with Rolls-Royce. At the end of the ceremony, Dr. Kitagawa cut the ribbon to commemorate the opening of the NIMS Office (photo).

NIMS Vice President Kitagawa cutting the ribbon, Prof. Humphreys (left) and Dr. Harada (right).

For a 5 year period beginning in 1990, the National Research Institute for Metals (NRIM; one of NIMS's predecessor institutes) and the Department of Materials Science & Metallurgy at the University of Cambridge undertook an international joint research project titled "Atomic Arrangement Design and Control Project" of the former Japan Research Development Corporation (JRDC; now Japan Science and Technology Agency, JST). At the time, a NRIM Office was also established to conduct fundamental research on Ni-based superalloys and steels. The NIMS Office at the University of Cambridge continues to study Ni-based single crystal superalloys, and will be expected to function as a base for a wider range of joint research workscope between NIMS and the University of Cambridge.

Charles University-NIMS Materials Science Autumn School Held

(October 9-11, NIMS) ‥ In 2002, NIMS concluded Japan's first international joint graduate school agreement by an Independent Administrative Institution research institute with Charles University, which is a representative institution in the Czech Republic and is the oldest university in Central Europe, dating from 1348. Since then, NIMS has received five outstanding Ph.D. students selected in Charles University each year. These students conduct research at NIMS under the guidance of NIMS researchers.

Recently, the 1st Charles University-NIMS Materials Science Autumn School was held at NIMS with the aim of strengthening cooperation with Charles University. A total of 22 graduate students and their academic advisors attended from Charles University, enjoying research and personal exchanges in the course of workshops, tours of NIMS's facilities, and exchange meetings. In the future, NIMS plans to use activities of this type to foster young researchers in the materials sciences who will play an active role in international society.

Participants in the Autumn School and those concerned at NIMS.

NIMS NEWS

Ceremony Marking the Start of the International Center for Materials Nanoarchitectonics (MANA)

(October 18, Tsukuba) – NIMS held an Inauguration Ceremony marking the start of the International Center for Materials Nanoarchitectonics, or MANA, which was officially launched on October 1, at the Okura Frontier Hotel Tsukuba.

The Inauguration Ceremony featured greetings by Prof. Teruo Kishi, President of NIMS, and Mr. Akira Yoshikawa, Deputy Director-General of the Science and Technology Policy Bureau, Ministry of Education, Culture, Sports, Science and Technology, which were followed by an outline of MANA by Dr. Masakazu Aono, Director-General of the new project, and an explanation of internationalization at NIMS by Mr. Takahiro Fujita, Administrative Director. Finally, Prof. Gimzewski of UCLA in the United States and Prof. Joachim of the CNRS in France, who will participate as foreign Principal Investigators, described their resolution as they each look ahead to the project.

At the social gathering held after the Inauguration Ceremony, congratulatory remarks were delivered by President Yoichi Iwasaki of the University of Tsukuba and President Shin Takeuchi of the Tokyo University of Science, which are domestic satellite institutions in the MANA project, followed by informal conversation. The event, which also included NIMS Researchers taking part in the project and international researchers from the International Center for Young Scientists, in addition to visitors, concluded successfully.

Many of the visitors also participated in a tour of MANA-related facilities which was conducted prior to the Inauguration Ceremony.

Hello from NIMS

Ola!

From the sandy beaches of Alentejo (south of Lisbon, Portugal) to the peak of Mt. Tsukuba, it's about 12000 km – a rather radical shift to be done in one go, wouldn't you agree? To my heart's content, I had the opportunity to "take a break" in England for a couple of years before resuming my journey and heading to Japan. But, in all honesty, mine has not been a thoughtfully laid down plan for how life should be shaped.

And so it was that, in contrast to my ancestors who could take years to reach the coast of Nagasaki, I landed in Narita about one year ago after a comparatively short, direct flight from London. Holding a treasured bag full of salted cod fish and Earl Grey tea, I was swiftly accommodated in one of the hassle-free residences provided by JISTEC and then taken to meet my new colleagues at the Namiki site.

Glancing around in awe, I finally confirmed in-loco the much talked about facilities of NIMS - legend had that the number and quality of the transmission electron microscopes were breathtaking. Rejoice, no more two-week waits for a slot or having to diplomatically argue for the much sought-after prime-time sessions, no more dread of machines breaking down and having to stop for days, if not weeks. Clear September morning, no clouds in the sky, the future looked bright.

With time, as I steadily settled in, I started realizing the immensity of the things that there were to be discovered – from the temples in and around Kyoto to the landscapes of Takayama, from the tender complexity of the tea ceremony to the spiritual precision of Kendo (The Japanese martial art of fencing with bamboo swords.), the stroke of a new personal meaning for what a great poet once wrote "Suspect it first, cherish it ultimately."

About to hit the road again, still meddling in the Japanese habits and awkwardly stumbling on the Nihon-go, I am pleased to have pressed the Send button for that once speculative chance of working in this country.

Yes, it certainly has been a most exciting and fruitful ride.

Pedro M.F.J. Costa
Research Fellow (September 2006 - April 2008)
Nanotubes Group, Nanoscale Materials Center

[Standing by for the New Year]

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