from Tsukuba, Japan to the world

NIMS NOW

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RESEARCH FRONTIER

Modified TiO_2 coatings as non-sacrificial anodes for cathodic protection applications

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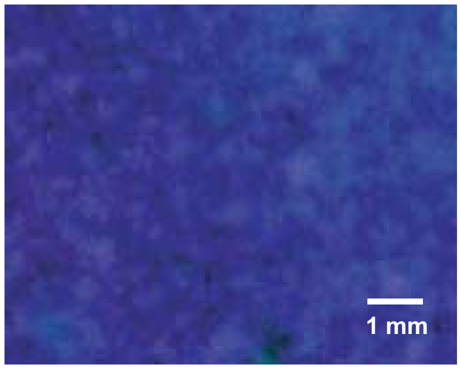
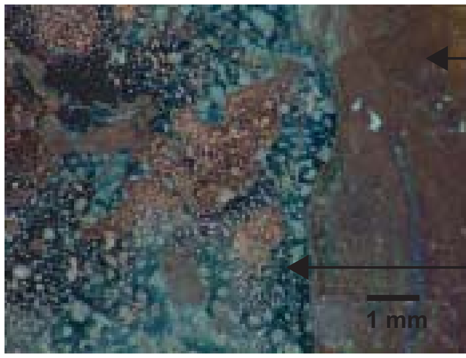
Materials Information Technology Station (MITS)

Cathodic protection of buried or offshore structures is usually carried out either by using sacrificial anodes or by an impressed current method. The use of sacrificial anodes has one main disadvantage namely limited life time and because of this, a periodic replenishment becomes necessary. The use of the photoeffect of TiO_2 coatings over metals on exposure to ultraviolet (UV) illumination is expected to solve the above-mentioned problem. The basic principle of photo cathodic protection is that the transfer of photogenerated electrons from a TiO_2 layer coated on the metal serves as a means of lowering the electrode potential of the metal. Since the TiO_2 coating does not get consumed during the process of protection, it is named as a non-sacrificial anode. A sol-gel derived plain TiO_2 coating however has certain limitations namely requirement of a high heat-treatment temperature (~ 500℃) and its non-functionality in dark, i.e. in the absence of illumination. We have optimized the heat treatment temperature for a commercial TiO_2 sol and by electrochemical characterization of TiO_2 coatings on transparent conducting ITO glass substrates, found that a low temperature of 200 ℃ is sufficient to realize an efficient photoeffect. We could also realize that when SnO_2, another n-type semiconductor was coupled to TiO_2 and illuminated under de-aerated conditions, an efficient transfer of photogenerated electrons from TiO_2 to SnO_2 occurred and a charging of Sn^{4+} took place. On cessation of illumination, there was a slow discharge of the stored electrons still exhibiting a sufficiently negative electrode potential. The charging of the electrode was confirmed by a red shift of the absorbance of the coating on transparent conducting glass substrates (as shown in **Fig. 1**). The original colour of the coating was blue. This charge storage property of TiO_2 coupled with SnO_2 was verified for its suitability for cathodic protection of copper with and without UV illumination. < Continued on p.4



(a) - ITO coated with TiO_2+ SnO_2 - before illumination



(b) - after illumination

Fig. 1 Change in colour of the TiO_2-SnO_2 electrode coating on ITO glass substrate from blue to red after UV illumination indicating that there is a charging of SnO_2 taking place during illumination.

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Giant Field-Induced Strain Effect Based on Novel Principle

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Materials Physics Group
Materials Engineering Laboratory (MEL)

—Contributing to the Creation of Environment-Friendly Pb-free High-Performance Piezoelectric/Electrostrictive Materials—

Piezoelectric materials are widely used in actuators, sensors, and similar devices, owing to their ability of changing dimension under an applied voltage and, conversely, generating voltage under applied force. However, such piezoelectric effect is very weak, and this limits the usefulness of the effect. In this research, based on a new principle we discovered a large electro-strain effect 40 times greater than that in conventional piezoelectric materials. Besides, our new materials are based on Pb-free $BaTiO_3$, being environmentally friendly.

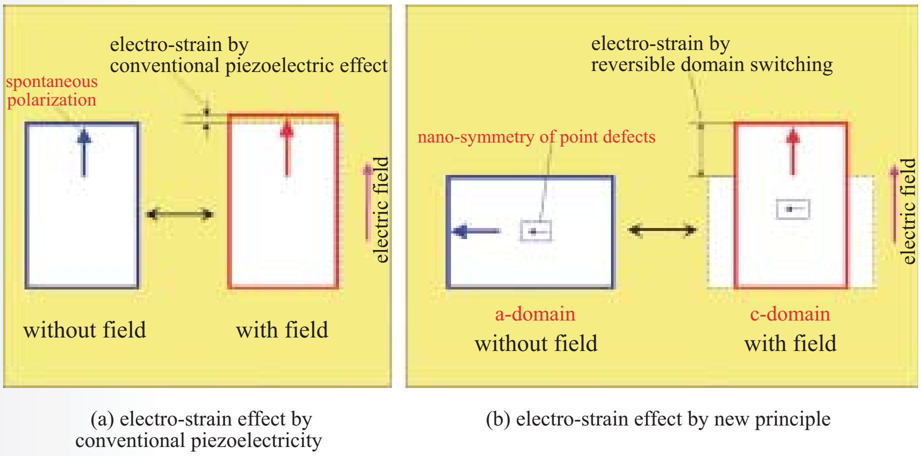

Fig. 1 Comparison of basic principle of electro-strain by conventional reversible piezoelectric effect and giant electro-strain obtained by new principle.

Structurally, piezoelectric materials are characterized by separation between the centers of plus and minus ions. When an electric field is applied to this type of material, a tiny shift occurs in the ions, causing contraction in the crystal as a whole. This is the basic principle of the conventional piezoelectric effect (**Fig. 1a**). However, this piezoelectric effect is in principle extremely weak. For example, even with lead zirconate titanate (PZT), which displays the largest conventional piezoelectric effect, this change is only approximately 0.01 % at a 100 V/mm field. Thus, the range of applications is limited with this piezoelectric principle. Furthermore, PZT, the most widely used piezoelectric material at present, contains harmful lead and is thus subject to strong restriction from the environmental viewpoint. Development of substitute materials has therefore become an important global task.

Very recently we proposed a new principle which is different from the conventional piezoelectric principle described above, and on this basis, discovered a huge electro-strain effect (field-induced deformation). The new principle is explained in the following.

Domains with different electrical polarizations exist in piezoelectric materials (**Fig. 2**). The polarization between the domains has an angle of 180 °, 90 °, etc., depending on the crystal symmetry. When a field is applied, domain switching occurs and the direction of polarization aligns along the direction of the applied field. As shown in **Fig. 1b**, when a field is applied, the a-domain (perpendicular to field direction) switches to the c-domain, and the direction of polarization coincides with that of the field. Accompanying this domain switching, there is an exchange of the short and long axis for the low symmetry ferroelectric phase. The magnitude of the strain associated with this process equals the difference between the long and short axes, which could be in theory as large as 1-5 %, depending on material systems. This value is several tens of times larger than the conventional piezoelectric effect. However, because domain switching is normally irreversible, this huge piezoelectric effect is normally irrecoverable (i.e., a one-time effect), and thus had no practical use.

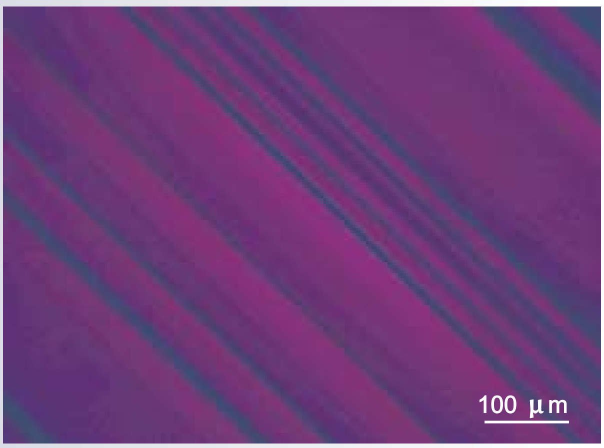

Fig. 2 Domain pattern of $BaTiO_3$ single crystal. Huge electros-strain is realized as a result of this domain switching.

In previous work, we discovered the principle of nano- symmetry of point defects. (As illustrated in **Fig. 3**, the statistical distribution of point defects in the nano range has a universal property of conforming with the symmetry of the crystal when in equilibrium.) Utilizing this principle, we performed aging treatment (long-term holding at a constant temperature) to control the symmetry of point defects to coincide with the crystal symmetry (**Fig. 3b**).

If a field is applied in this state (**Fig. 1b**, **left**), domain switching occurs (simultaneously generating huge electro-strain, as in **Fig. 1b**, **right**). When the field is removed, the force of the point defects causes the new domain to return back to its original domain state, and consequently the shape also returns to the original shape. In other words, it is now possible to realize huge reversible electro-strain by a new principle.

To obtain this recoverable electro-strain effect, the material must contain certain doping elements and be subjected to aging treatment. **Fig. 4** shows the electro-strain effect of a $BaTiO_3$ sample containing a trace amount of Fe Huge reversible electro-strain of 0.75 % was obtained in a low field of 200 V/mm. This value is as much as 40 times larger than that of a typical PZT piezoelectric material and is also more than 10 times larger than that of PZN-PT single crystals, which have been known recently for its large electro-strain effect. Furthermore, similar large electro-strain effect was also discovered in single crystals of K-$BaTiO_3$, suggesting that this new principle is general.

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World's First Wavelength Conversion Device in Crystal Quartz

—Fabrication of Periodic Twin Structure by Precise Twin Control—

Sunao Kurimura, Kenji Kitamura
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Advanced Materials Laboratory (AML)

The type of quartz called "rock crystal" has long been prized as a precious stone and is a representative single crystal material used in quartz clocks and cell phones. Because it is essential to eliminate twins and obtain homogeneous single crystals when manufacturing quartz oscillators and similar devices, extensive efforts have been made for developing twin elimination techniques. However, in the present work, we turned this concept on its head and, as a result, successfully fabricated a laser-wavelength-conversion device. This device is expected to be applied to ultraviolet lasers and high-power lasers.

The Opto-Single Crystal Group of the AML has been engaged in research on wavelength conversion devices based on a polarization reversal structure using ferroelectric single crystals. Ferroelectrics have spontaneous electrical plus and minus charges or spontaneous polarization, which can be reversed by applying an electric field. With spatially periodic reversal, these materials function efficiently as wavelength conversion devices. However, due to their transparency window, output wavelength is limited to 300 nm in conventional ferroelectrics, and no polarization-reversed wavelength conversion device was reported being applicable to deep UV.

On the other hand, quartz crystals are thermally and chemically stable and are a transparent material up to a UV wavelength of 150 nm. Although used in optical filters and retardation sheets (wave plates), this material had not previously been used in wavelength conversion because polarization reversal was not possible. It would be possible to realize a wavelength conversion device applicable to the UV region of wavelengths under 300 nm if the same structure as the polarization reversal structure in ferroelectrics could be obtained in a quartz crystal, which is a dielectric.

In the present work, we succeeded in realizing a polarization reversal structure by artificially fabricating a twin structure in a quartz crystal (**Fig. 1**). In ferroelectrics, this structure is patterned by applying an electric field, but in quartz crystals, the same structure is demonstrated by applying stress. When stress is applied to a crystal with height differences on the surface, twins form successively in a periodic structure, as shown in **Fig. 2**. Although quartz twins have been investigated from the viewpoint of mineralogy in research on stress and temperature during earthquakes, in the present work, we adopted the completely new concept of using twins as a new technology for creating devices. By applying this technology to control fine twins with a periodicity of 125 μm, we realized the world's first laser wavelength conversion device (**Fig. 3**) and succeeded in converting low-energy infrared light to high-energy green light.

As future goals, we hope to realize a finer periodicity by improving twin control precision, aiming at conversion to UV light.

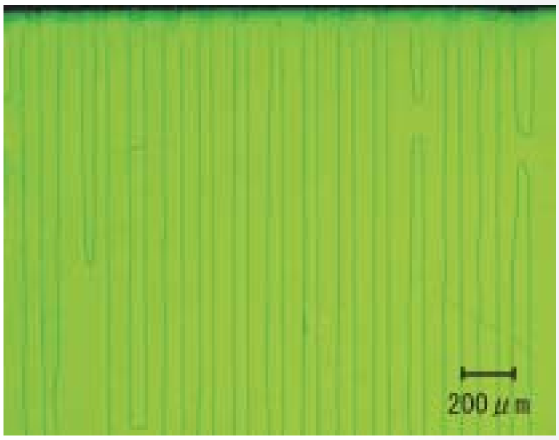

Fig. 1 World's first crystal periodic twin structure (period: 125 μm).

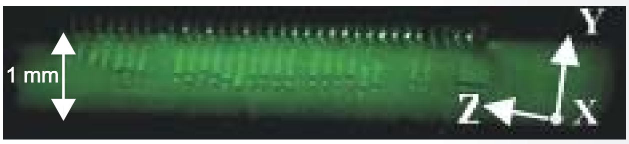

Fig. 2 Image of real-time observation of periodic twin fabrication (period: 125 μm).

Fig. 3 Wavelength conversion of infrared light to green light by a quartz wavelength conversion device.

For further information, please visit: http://www.nims.go.jp/osc/index_eng.html

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France Honors NIMS President Kishi

The French government has honored NIMS President Kishi with the title of Officier de l'Ordre National du Mérite (Officer of the National Order of Merit), France's second highest civilian award, for his many contributions to research exchanges and cooperation between Japan and France, including Japanese · French workshops on nanomaterials and invitation of French researchers to NIMS. The title was conferred on Dr. Kishi on March 16 at the French Embassy in Minami-Azabu, Tokyo by France's Ambassador to Japan, Mr. Bernard de Montferrand.

Fabrication of Carbon Nanotube Probe by Dielectrophoresis

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Materials Engineering Laboratory (MEL)

Carbon nanotubes are fine, string-like cylindrical carbon molecules with a diameter of approximately 1 nm and length of 1 to 10 μm, and thus have a high aspect ratio (length/diameter ratio) of more than 1000:1. Based on this feature, promising applications in electric field-induced electron emission and high-resolution, long-life scanning probes are expected. However, for such applications, it is often necessary to attach the nanotubes to another material. To date, we have attempted to apply various methods, such as placing the tip of a graphite or silicon material in contact with a nanotube composite or growing the carbon nanotube directly on a metal tip by chemical vapor deposition (CVD), but these methods have met with difficulties in adhesion, reproducibility, and process control, etc.

In the present work, which was carried out as joint research with the University of North Carolina at Chapel Hill in the United States, dielectrophoresis was applied as a new process, and carbon nanotube probes have been successfully fabricated from single-walled carbon nanotubes. The experiment was conducted at room temperature using water as a solvent. A schematic diagram of the fabrication method and a photograph of the actual fabrication process are shown in **Fig. 1**. A voltage was applied between the metal tip and an aqueous solution containing nanotubes, causing a nanotube to adhere to the tip. The tip was then drawn, producing a string-like nanotube bundle attached to the metal tip. This process usually produces carbon nanotube-based probes with practically 100 % yield (**Fig. 2**). The assembled nanotube string is always parallel to the metal tip, and the length of the nanotube string can be easily controlled by varying the experimental parameters such as the drawing speed. A theoretical analysis has also been carried out to clarify the role of the electric field in the process of assembly.

When the probe fabricated in this work was used in a scanning tunneling microscope (STM), which is an indispensable tool in nanotechnology research, clear, extremely high-resolution images were obtained. The probe also shows higher durability in comparison with conventional metal probes. In addition, such carbon nanotube-based probes are promising as point electron sources with improved performance such as power saving longer service life.

In the future, we plan to conduct research and development to realize a point electron emitter and will also carry out research aimed at expanding the applications of the carbon nanotube-based probes in the medical field, for example, as a component in medical X-ray sources.

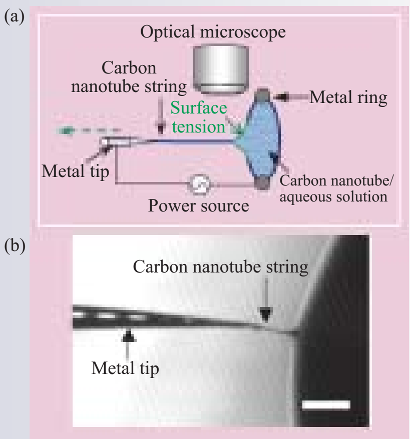

Fig. 1 (a) Schematic diagram of carbon nanotube probe fabrication method used in this work, and (b) photograph of nanotube probe during fabrication process.

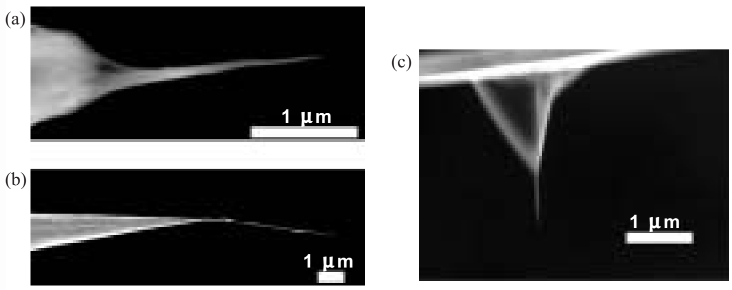

Fig. 2 (a) and (b) Carbon nanotube probe fabricated on metal tip and (c) carbon nanotube probe fabricated on tip for general-purpose atomic force microscope (AFM).

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Modified TiO_2 coatings as non-sacrificial anodes for cathodic protection applications

Copper canisters are proposed to be ideal materials for holding high-level nuclear wastes, which will be kept in nuclear waste repositories deep underground. Under anaerobic conditions inside the earth, photo cathodic protection may be envisaged as appropriate for preventing corrosion. The gamma rays emitted from the high level wastes could themselves form a source of UV illumination provided suitable radiation converters are used in the TiO_2 anode coating. In this context, the TiO_2-SnO_2 composite coatings were investigated for cathodic protection of copper. It was found from electrochemical characterization that the coatings functioned as efficient anodes for a cathodic protection of copper (as seen from **Fig. 2**) and impedance measurements on the TiO_2-SnO_2 coated copper substrates showed high and constant capacitance values (3000 mF/cm^2) over a wide range of applied potentials (-400 down to -800 mV).

Thus, TiO_2-SnO_2 system proves to be an efficient and promising anode for a non-sacrificial photo cathodic protection of metals.

For more details, please refer :Raghavan Subasri and Tadashi Shinohara, Electrochem. Comm. 5 (2003) 897-902.

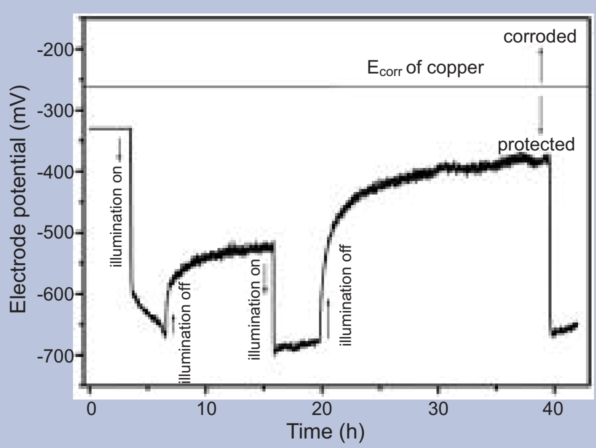

Fig. 2 Variation of electrode potential of copper coated with the TiO_2-SnO_2 coating in 0.3 % de-aerated NaCl solution, with and without illumination showing the slow recovery of electrode potential even after cessation of illumination; λ_{UV} = 360 nm.

For more details of the group, please visit: http://www.nims.go.jp/corrosion/index_e.html

Commercialization of New Artificial Bone Regeneration Material

Toshiyuki Ikoma, Masanori Kikuchi
Regeneration Materials Group
Biomaterials Center (BMC)

—Marketed with Approval of the Ministry of Health, Labour and Welfare—

The Biomaterials Center (BMC) and Osaka University (Prof. Hideki Yoshikawa) have jointly developed a high-strength porous hydroxyapatite ceramic with excellent biocompatibility (**Fig. 1**).

Hydroxyapatite, one of calcium phosphate compounds, is well known as the main inorganic component of bone and teeth in vertebrates including human beings and has the property of direct bonding with bone when implanted into it. The hydroxyapatite ceramic, synthesized by a neutralization reaction of orthophosphate and calcium ions in an aqueous solution followed by sintering at high temperature, is also recognized as an extremely safe material.

A porous structure of the bone regeneration material newly developed in the present work, as shown in **Fig. 2**, consists of spherical pores, 150-200 μm in diameter, and interconnected pathways, larger than 10 μm in diameter, among the pores. This three dimensionally interconnected porous structure permits osteoblasts to enter the material and following new bone ingrowth.

This porous ceramic is being used clinically as a bone regeneration material for treatment of fractures and other diseases in older patients to solve the problems of conventional bone regeneration materials. The conventional materials have two major disadvantages, one is the insufficient interconnection of pores which caused delay or no bone formation in the materials, another is the low mechanical strength which caused fracture as well as collapse of porous structure. In contrast, the newly developed material has high mechanical strength because the fully interconnected pores consist of dense sintered wall, and no breakage has been observed either during or after surgery. These advantages have enabled reducing the healing period by approximately 2 months in comparison with conventional artificial bone.

This material has already completed clinical trials at Osaka University, and satisfactory bone regeneration has been observed in implantation in numerous patients with benign osteosarcoma, bone fractures, and osteoarthritis.

The new material was approved for manufacture as a medical product by the Ministry of Health, Labour and Welfare in May 2003. Since the autumn of 2003, it has been manufactured by Toshiba Ceramics Co., Ltd. and marketed by MMT Co., Ltd.

Fig. 1 Newly developed artificial bone material. (Photo shows various available forms, including granules in front.).

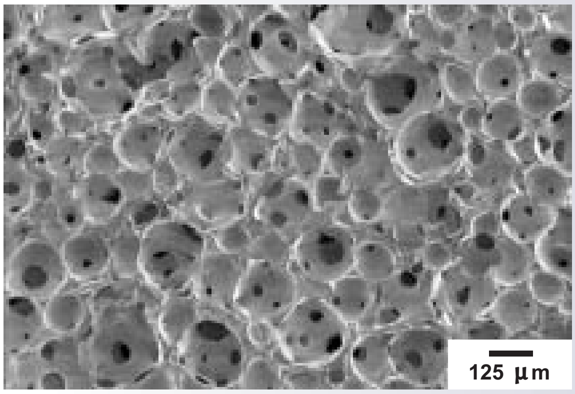

Fig. 2 Spherical pores interconnected each other. Cells intrude through the interconnected pores.

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Giant Field-Induced Strain Effect Based on Novel Principle

This newly-discovered giant electro-strain effect is expected to create large potentiality for large-stroke applications and in situations where the conventional weak piezoelectric effect could not be applied. Moreover, as another important benefit, because no lead is used in the materials which display the huge electro-strain effect, these results are expected to contribute to the development of environment-friendly high-performance piezoelectric materials.

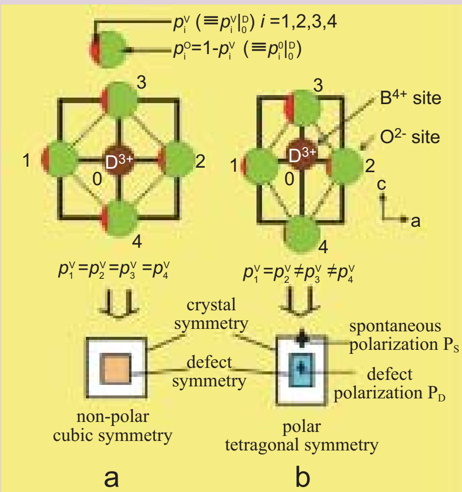


Fig. 3 Principle of nano- symmetry of point defects. The distribution probability of point defects in the nano-range around a given point defect has a symmetry conforming with the symmetry of the crystal when in equilibrium.

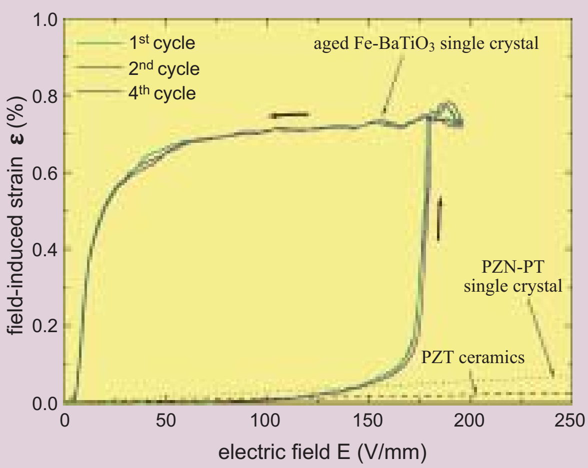


Fig. 4 Giant electro-strain in ferroelectric material obtained by nano-symmetry property of point defects.

For further information, please visit: http://www.nims.go.jp/kisobussei/index_e.html

Steel Research Center Signs MOU with Max Planck Institute (MPIE)

On February 26, the NIMS Steel Research Center (SRC) signed a memorandum of understanding with the Max-Planck-Institut für Eisenforschung GmbH (MPIE, Max-Planck-Institute for Iron Research), located in Dusseldorf, Germany. Based on exchanges over many years, the two organizations agreed to hold mutual visits and exchanges of researchers, and will also promote exchanges of research results related to steel internationally. A commemorative symposium was held on the day of the signing, and included presentations of research on both sides aimed at deepening the mutual understanding between the two groups. This MOU is expected to encourage international exchanges on basic research on iron and steel materials.

NIMS Exchanges Memorandum with Shanghai Institute of Applied Physics

In March, the NIMS Nanomaterials Center (NMC) and Nuclear Analysis Technology Dept. of the Shanghai Institute of Applied Physics (SINAP), Chinese Academy of Sciences (CAS) exchanged a memorandum of understanding (MOU) on research cooperation in the fields of beam technology and nano-science. SINAP was established in 1959 as the Shanghai Institute of Physics and Chemistry and has been a driving force in the fields of radioisotope use technologies and ion beam applications. The institute is currently developing active programs in the fields of synchrotron radiation and nanotechnology, including carbon nanotubes and nano-particles. Recently, the SINAP was selected as one of two major bases for the nanotechnology project established by CAS. Based on this and other moves to further strengthen the research system for nano-science, the institute will promote research cooperation in beam technology and nano-science in order to heighten the level of mutual research activities between the two institutes.

11th International Symposium on Advanced Materials (ISAM 2004)

The 11th International Symposium on Advanced Materials (ISAM 2004), hosted by the NIMS Advanced Materials Laboratory (AML), was held at the Toshi Center Hotel in Tokyo March 7-10. The conference brought together a number of well-known international and Japanese researchers, beginning with Prof. Galen D. Stucky, and was the scene of active debate on frontiers in nano-materials and colloid chemistry.

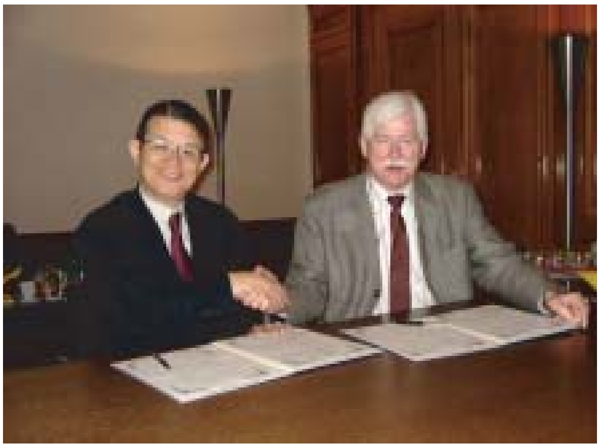
The 3rd International Conference on Smart Materials and Systems

The 3rd International Conference on Smart Materials and Systems organized by Materials Engineering Laboratory (MEL) of NIMS and the Research Institute of Industrial Science and Technology (RIST), Korea was held on March 10-11 at the Tsukuba International Congress Center. Many interesting topics such as health monitoring techniques using wireless LAN and laser acoustic emission, self-healing materials, the smart devices using self-controlling materials, shape-memory alloys, and magnetostrictive materials, and damping materials were presented and discussed animatedly.

NIMS Concludes General Agreement with ETHZ, Switzerland

On March 24, 2004, NIMS concluded a General Agreement on Comprehensive Research Cooperation with the Eidgenössische Technische Hochschule Zürich (ETHZ, Swiss Federal Institute of Technology Zurich). ETHZ is one of the most distinguished science and technology universities in Europe and is also well known as the college from which Albert Einstein graduated. NIMS and ETHZ have collaborated for years on a wide range of research initiatives concerning Biomaterials, Nanomaterials, Metallic Glass, etc., and this agreement is expected to further boost the number of future collaborations.

Prof. Kishi, President of NIMS, and Prof. Ulrich W. Suter, Vice President for Research, ETHZ, attended the signing ceremony held in Zurich. Through this agreement, a broader spectrum of cooperative research efforts including exchange of researchers is planned, and one scientist from ETHZ has already joined the International Center for Youth Scientist (ICYS) of NIMS as an ICYS fellow. ICYS is also delighted to host a second scientist from ETHZ starting in July.



Conclusion of General Agreement with CNRS, France

On March 25, in Paris, NIMS concluded a General Agreement on Comprehensive Research Cooperation with the Centre National de la Recherche Scientifique (CNRS, French National Center for Scientific Research). CNRS is France's public organization for conducting basic research, with more than 10,000 researchers and 1,300 service and research units. NIMS has played a proactive role in the last four implementations of the Japan-France Workshops on Nanomaterials, while also developing a wide range of cooperative research initiatives on materials and substances with affiliated research organizations. These collaborative efforts prompted the two organizations to conclude this agreement, which aims to enhance the number and scope of Japan-France collaborations on Nanomaterials and Nanotechnology.

Prof. Kishi, President of NIMS and Prof. Jean-Luc Clément, Director of International Affairs, CNRS, convened at the signing ceremony and expressed their commitment to developing a closer cooperative tie between the two organizations.

A Symposium for the Interdisciplinary Academic and Technical Information Exchanges 2nd Nanotechnology Symposium - JAPAN NANO 2004

The 2nd nanotechnology symposium, JAPAN NANO 2004, was held over a 3-day period from March 15 to 17 at Tokyo Big Sight (Ariake, Tokyo) with a total of more than 1200 participants.

The first keynote speech, "The Scientist and Japanese Society", was presented by Prof. Noyori, President of RIKEN, and the second keynote speech, "Nano Carbon Materials: Science and Applications." was presented by Prof. Sumio Iijima of Meijo University. These were followed by a total of 15 invited lectures in 5 fields, bionanotechnology, nano IT device, nano-fundamentals/characterization, nanomaterials, and nano IT fundamentals, providing an overview of advanced nanotechnology research and development in Japan by leading front-line researchers.

Regular sessions for young researchers were divided among three venues, and included presentations in the fields of nano-fundamentals/characterization, nano IT device, nanomaterials/processing, and bionanotechnology. Participants actively discussed a total of 54 talks. In addition, the " Nano Virtual Lab Project ~For Inter-fields and Inter-organization Research~ " was held as a joint session with the Japan Science and Technology Agency (JST) and nanonet. A total of 13 presentations were given in this connection, including an explanation of the aims of creating virtual laboratories by fields, and researchers in various fields exchanged ideas on this new approach.

NIMS NEWS

MITS 2004 Events

As part of MITS 2004, a series of events was held March 15-17 under the general direction of the Materials Information Technology Station (MITS) of NIMS. The NIMS-RIMAP Risk-Based Engineering Workshop, International Symposium on NIMS Creep Data Sheet, and NIMS-MPA Workshop drew a total of 220 participants from Japan, the United States, Germany, Italy, Denmark, Finland, and Korea, and featured enthusiastic discussions.

2nd BMC-NIMS Symposium

The Biomaterials Center's 2nd BMC-NIMS Symposium was held on March 12-13 at the Tsukuba International Congress Hall, EPOCAL. The theme of the symposium was "Fusion of Medicine and Biomaterials for Supporting a Healthy and Safe Society." The opening day featured a keynote speech by Prof. Hiroyuki Abe, a member of the Council for Science and Technology Policy (CSTP), Cabinet Office, on science and technology policy in Japan. On the first day, Mr. Jotaro Kozaki, Editor-in-Chief of the Nikkei Biobusiness magazine also spoke on the rapid changes taking place recently in the bio industry/business models, which was followed by a lively panel discussion on business opportunities, medical-engineering cooperation, and legal regulations. On the second day, Japanese and international researchers, including 5 guest speakers from overseas, discussed recent research in the "Nano-Bio Fusion Field." At the same time, Director Toshie Tsuchiya of the National Institute of Health Sciences (NIHS), Ministry of Health, Labour and Welfare spoke on recent thinking and domestic and international trends in medical equipment safety. A total of 202 persons from universities, independent administrative institutions, hospitals, prefectural governments, and business participated in the 2-day symposium, indicating the high expectation placed on NIMS' role in advanced medicine in the 21st century.

2nd Japan-China Workshop on Automobile Materials for Environment and Safety (AMES 2004)

This workshop was held on Thursday, March 11 as a concrete cooperation project activity based on the memorandum of understanding signed in May 2002 between China's Central Iron and Steel Research Institute (CISRI) and the NIMS Steel Research Center (SRC). The meeting included discussion of areas to be taken up jointly by China and Japan, with safety/environment and materials as the main topics, and also provided a valuable opportunity for understanding recent trends in China, which is currently experiencing remarkable economic growth.

For more information, please visit: http://www.nims.go.jp/stx-21/

Introduction of New Fellows

Dr. Masakazu Aono

Doctor of Engineering (1972). Completed doctoral course at Tokyo University School of Engineering. Joined National Institute for Research in Inorganic Materials as Researcher in 1972, and became Senior Researcher at the same Institute in 1976. Joined RIKEN as Chief Researcher in 1986. Appointed Professor, Osaka University Graduate School of Engineering in 1996. Appointed Director-General of the Nanomaterials Laboratory, National Institute for Materials Science (NIMS) in August 2002 (concurrently with position at Osaka University). Named NIMS Fellow in April 2004.

Dr. Tetsuya Tateishi

Doctor of Engineering. Completed doctoral course at Tokyo University School of Engineering. Served as Senior Researcher at the National Institute for Advanced Interdisciplinary Research (NAIR), Professor, Tokyo University School of Engineering, and Professor, Tokyo Denki University. Named NIMS Fellow in April 2004.

Dr. Hiromoto Nakazawa

Doctor of Science. Completed doctoral course at Osaka University Graduate School of Science (1969). Served as Researcher in the Institute of Scientific and Industrial Research, Osaka University, Special Senior Researcher at the National Institute for Research in Inorganic Materials of the Science and Technology Agency, and Professor at Tohoku University Graduate School of Science. Named NIMS Fellow in April 2004.

Semiconductor Circuit using Switch with Controlled Metallic Atom Migration Realizes Circuit Recombination

NIMS, NEC Corporation, and the Japan Science and Technology Agency (JST) have jointly developed a switch which utilizes metallic atom migration in a solid electrolyte. Using this element, the group trial-manufactured basic circuits for programmable LSIs employed in a wide range of applications and successfully realized recombined operation with the circuits. The use of recombined circuit elements achieves approximately 10 times greater circuit utilization efficiency than in conventional LSIs.

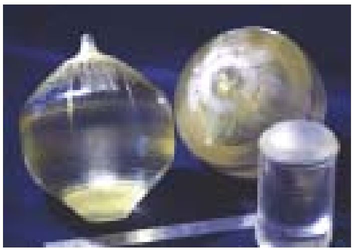
A programmable LSI which enables circuit recombination whenever necessary would allow a single chip to perform multiple functions, which conventionally requires dedicated LSI chips, thereby improving the performance of many electronic devices, such as mobile devices and digital television, as well as facilitating multi-functionality. Using the atomic switch developed in this work, chip size can be reduced to one-tenth that of conventional programmable LSIs, while operating speed can be improved by about 20-40%, making it possible to design programmable LSIs with a wider range of applications.

These research results were announced at the International Solid-State Circuits Conference (ISSCC 2004) held in San Francisco, California February 16-18. Part of these results was obtained through the research process on research topics in ongoing research on strategic creative research projects at JST.

Development of Wavelength Conversion Device for High Power Operation in Wide Near -Mid IR Wavelength Region

Wavelength conversion device of periodically poled stoichiometric $LiTaO_3$. Nd:YAG laser beam (1064 nm wavelength) can be converted into a laser beam of wavelength in a range from 1.4 to 4 microns.

A team led by Dr. Kenji Kitamura, Director of the Opto-Single Crystal Group in the NIMS Advanced Materials Laboratory (AML), has developed a simple laser light wavelength conversion device for the near-mid infrared region which is suitable for medical therapy, security and environmental measurement applications and use as a light source for spectrum analysis. The developed wavelength conversion device is a rod-shaped, 2 x 2 x 35 mm^3 made using a stoichiometric lithium tantalate ($LiTaO_3$) single crystal with periodically poled structure, and enables high power operation at a maximum average output of approximately 10W. As wavelength conversion can be obtained simply over a wide wavelength range when the new device is used in combination with commercial small-scale solid-state laser, a wide variety of applications is expected. This outcome of research is commercialized by a venture company, SWING Ltd. incubated in NIMS.



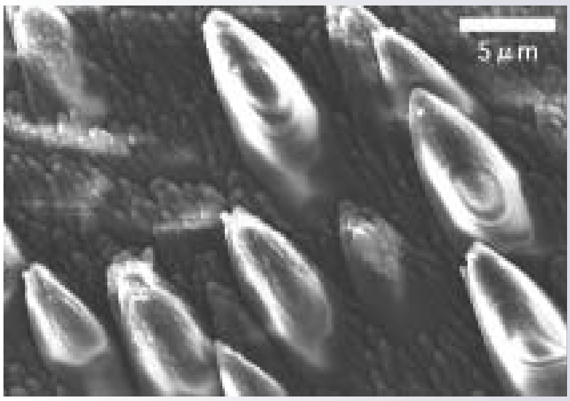
For further information, please visit: http://www.nims.go.jp/osc/index_eng.html and http://www.opt-seing.com/

Development of Simple Disassembly Technique for Micro-level Interconnects

A team in the NIMS Ecodevice Group, Ecomaterials Center (EMC) led by Chief Researcher Naoe Hosoda has developed a simple micro-level disassembly technique for electronic interconnects by using low melting-point metal in connections. The technique can be applied to the removal of chips from electronic boards in computers and cell phones, and is expected to be useful in recycling electronic parts.

Development of Novel Synthesis Process for Boron Nitride Thin Film

A team under Chief Researcher Shojiro Komatsu in the Non-Oxide Ceramics Group, Advanced Materials Laboratory (AML) has succeeded in synthesizing a novel boron nitride thin film which displays high field electron emission characteristics in comparison with conventional thin films. As a distinctive feature of the synthesis process, an emitter shape with a micron-order protruding tip is formed by self-structuring in a one-step synthesis process. The new process will simplify device fabrication work in comparison with conventional processes, resulting in substantially reduced costs, and is expected to contribute to a large reduction in the price of next-generation high-definition, large-screen televisions and other electronics.



Scanning electron microscopy (SEM) image of the emitters with dimensions of ~10 μm. The cone-shaped emitters are aligned towards the incident 193 nm laser light irradiated during the growth by plasma-assisted chemical vapor deposition from diborane and ammonia.

For further information, please visit: http://www.nims.go.jp/sialon/index.html

Prof. Kroto visited ICYS

Prof. Sir Harry W. Kroto, 1996 Nobel Prize winner for chemistry for the discovery of fullerene (C_{60}), has visited ICYS as Executive Advisor on April 27, 2004. Ten ICYS research fellows have got the opportunity to have one-on-one discussion with Prof. Kroto about their research works.

At the gathering after the discussion, Prof. Kroto encouraged research fellows by saying, "I never expected to win the Nobel Prize. It was an accident out of the experiment which was not very interesting to many people but was interesting to me. The only advice I can give you is to do things you are interested in."

NIMS NEWS

2nd NIMS International Conference - Photocatalysis: Fundamentals and Applications

The 2nd NIMS International Conference on photocatalysis was held from February 1 to 3, 2004 at the Shonan Village Center in Hayama, Kanagawa Pref. with more than 150 participants from Japan, Germany, Italy, the United States, China, Korea, France, the United Kingdom, Canada, Taiwan, the Czech Republic, and other countries. The Plenary Lecture as the opening talk of Prof. A. Fujishima, the president of the Kanagawa Academy of Science and Technology, was followed by the 35 oral presentations, including the keynote lectures and invited talks. In addition, the 62 papers were presented in the poster session. All of presentations including the 17 papers from NIMS (1 oral and 16 posters) attracted keen interest from participants. As the conference subtitle suggests, this was a comprehensive symposium covering topics from basics to applied technology, which won high marks from those participating. Due to the limitation of transport facilities, the majority of participants lodged at the site, and they continued to exchange ideas until late at night, making this a particularly significant event.

Ajisai Flower (Hydrangea) May 22

Though not counted as one of the four seasons, Japan has tsuyu (rainy season) from late May to mid-July.

It is a gloomy time, but there are many pretty flowers blooming at this time. Ajisai is one of the most popular flowers of the season and you can view it in many gardens, parks and temples.

NIMS

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National Institute for Materials Science

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