NIMS NOW International

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Special Feature
NIMS Venture Companies

On my retirement, Prof. Teruo Kishi

On my retirement: Looking back on 8 eventful years

On June 30, 2009, I retired from the National Institute for Materials Science (NIMS), after reaching the age of 70 and serving for 8 years as President. I feel that I have been very fortunate in my professional and personal life, particularly in recent years, thanks to the generous support of many people in NIMS, as well as countless other friends and colleagues. I would like to take this opportunity to express my heartfelt thanks to all those who made this day possible.

The mission of NIMS as an Independent Administrative Institution, or IAI, is to "create advanced research facilities and conduct research of a different type from that at universities in constant awareness of innovation." This has been my guiding principle for the past 8 years and 3 months since NIMS was launched as an IAI. One direction for research at NIMS in the future will be "problem-solving research and development" in areas such as the environment, energy, and safety. For this, the introduction of organic and polymer materials will be essential. On the other hand, because Japan has made nanotechnology a key part of its national policy for the future, we have also put great effort into "promotion of nanotechnology and nanotechnology-based materials development."

In constructing the research organization/research system at NIMS, we have been particularly mindful of the establishment of graduate school programs, internationalization, and industry-IAI collaboration. Because youthful vitality is needed in public institutions, I am pleased that we have been able to create joint graduate schools with a number of universities in Japan and other countries. Our successful operation of the International Center for Young Scientists (ICYS) helped to create a multicultural "melting pot," and this led to the selection of NIMS for the MEXT* World Premier International Research Center (WPI) Initiative in 2007 and the establishment of the International Center for Materials Nanoarchitectonics (MANA) at NIMS under the WPI program. We have also promoted a wide range of cooperation with industry involving both domestic and international companies, and have carried out many joint research projects. This work is ongoing, as NIMS continues to build a system that can contribute to society.

Research achievements must be highly evaluated from both the viewpoints of materials science and engineering (innovation). Because the two are interrelated, a constant circulation between basic research and applied research is essential. During these past 8 years, research at NIMS has gained considerable recognition in the international scientific community. Before NIMS became an IAI, we ranked 31st in the citation index for scientific papers in materials science published by Thomson Reuters. I am very happy to say that our citation index has risen dramatically and we now rank 3rd in the world (1st in Japan) in this field. In the future, I hope that NIMS will make further efforts to ensure that these remarkable scientific results escape the "Valley of Death" and reach fruition in practical applications. Moreover, by crossing the Rubicon, the buds of even more outstanding basic research are born. It may be that serendipity – which can also be considered one of the true pleasures of materials research – is found in this kind of research cycle.

What is important for NIMS now is to realize a free research environment while keeping its gaze fixed firmly on its targets, including those in national policy. From this perspective, I feel that the future of NIMS can be seen in the "young independent researchers".

Finally, on retiring from NIMS, I would like to express my sincere respect for all those concerned, both in and outside NIMS, as well as my very best wishes for the continuing development of this wonderful organization as a core institute in materials research.

* MEXT: Ministry of Education, Culture, Sports, Science and Technology

Midsummer 2009
Teruo Kishi

Greeting from the New President

I have accepted the Presidency of National Institute for Materials Science (NIMS) effective on July 1, 2009, succeeding the previous President, Professor Teruo Kishi. On this occasion I would like to introduce myself and also to indicate my thoughts regarding the management of NIMS.

My research field is solid state and surface physics, and I have studied physical and chemical surface phenomena by means of optical and electronic spectroscopy. Before coming to NIMS as a fellow last April, I served as President of Japan Advanced Institute of Science and Technology. I used to visit Namiki site as an Executive Advisor for the International Center for Young Scientists (ICYS).

NIMS has made a great progress under the leadership of President Teruo Kishi, after incorporation as an Independent Administrative Institution in 2001. It has become a highly regarded research institute domestically as well as internationally, particularly in terms of the number of papers published and the number of citations. We should be proud of this record. Now it is time to direct our effort to raise the quality of research papers.

NIMS has moved ahead in the internationalization of research environment through the initiatives taken by ICYS. Now it is considered one of the most progressive institutions in the area of internationalization among the universities and research institutes in Japan. However, the real goal is to make NIMS a true global Center of Excellence in materials science research. We still need to continue our effort for further improvement. For internationalization it is certainly important to recruit best talents from abroad, but it is even more important to send our staff abroad. I hope to encourage particularly young research staff to spend extended time in foreign research laboratories.

NIMS is different from universities in being an organization whose main purpose is to execute national policies in the area of materials science research. We must be clearly aware of this primary mission. For our nation, securing sufficient resources for energy and food is of utmost importance. Thus we should carry out research that will answer these national requirements. At the same time it is imperative that we minimize the effects of human activities on the global environment. Thus we must plan a research strategy to minimize negative effects on the global environment. It is my hope that NIMS can contribute significantly toward solutions to these global issues.

The research carried out at NIMS has two aspects, science and engineering. The goal of engineering research is to find ways to produce useful materials, while scientific research seeks to discover the physical principles underlying the properties of matter. In both types of research the most important thing is to think on your own and execute experiments for yourself. My motto in scientific research is "Think for yourself" and "Do it yourself." I hope many of our colleagues will agree with me and practice these ideals in their daily work.

Finally I wish to emphasize that we should enjoy our research. In my career I have been fortunate enough to truly enjoy my work as a physicist. However, an administrative job like presidency is not something to enjoy doing, but rather a job that must help others enjoy their work. I hope to serve the people at NIMS so that they can enjoy their work and accomplish their goals.

Sukekatsu Ushioda

"The True Value of Materials is in their Use"

Launching and supporting NIMS-authorized ventures to utilize research results and return benefits widely to society

As a research institute specializing in materials research, NIMS has achieved many impressive results in basic research on the properties of materials and the creation and evaluation of new materials.
Although these results have made an extremely important contribution to academic fields, this alone does not mean that NIMS has completely fulfilled its role.
It is necessary to return the research results widely to society, contributing to the benefit of as many people as possible, by actually applying and commercializing those results.
The idea that "the true value of materials is in their use" is one of the missions of NIMS. Support for venture companies is a policy for giving concrete form to that mission.
This Special Feature introduces five NIMS venture companies.

Company Name	Date of Establishment	Representative	Capital (JPY)	Address	Contact
Oxide Corporation	October 18, 2000	Yasunori Furukawa President & CEO	350 million	1747-1 Makihara, Mukawa, Hokuto, Yamanashi, Japan	Tel: 81-551-26-0022 sales@opt-oxide.com
SWING Ltd.	May 20, 2003	Akemi Kitamura President	20 million	4-13-61 Azuma, Tsukuba, Ibaraki, Japan	Tel: 81-29-855-8869 swing@opt-swing.com
Materials Design Technology Co., Ltd.	September 12, 2003	Akihiro Ishibashi CEO	10 million	Shinagawa Intercity Tower A 28F, 2-15-1 Konan, Minato-ku, Tokyo, Japan	Tel: 81-3-6717-4096 info@materials-design.co.jp
Probe Laboratory Inc.	August 22, 2006	Teruaki Fujito CEO	7 million	1-7-17 Kawasaki, Hamura, Tokyo, Japan	Tel: 81-42-555-2064 prob.lab@tbt.t-com.ne.jp
Comet, Inc.	December 26, 2007	Setsu Suzuki President & CEO	23 million	1-1 Namiki, Tsukuba, Ibaraki, Japan	Tel: 81-29-855-8055 info@comet-nht.com

Oxide Corporation

Oxide Corporation is a venture company which was established in 2000 and has attracted worldwide attention for its unique nanometer-level technology for controlling the quality of high-performance optical single crystals. Its products are indispensable in ultra-high speed optical communications, laser devices, and similar applications.

Oxide means a "chemical compound that contains oxygen." The company's name embodies the mission, laid when the venture was launched, of "providing the world with unprecedented new oxide single crystal materials."

Single crystals are crystals in which the component elements are aligned regularly in a designated direction. They are widely used in daily life, in objects ranging from jewel stones such as diamonds, sapphires and rubies, to semiconductor materials such as silicon and gallium arsenide.

The oxide single crystals developed at Oxide are transparent to light and have various functions which enable control of optical properties in response to external information signals such as electricity, light and stress. These are indispensable basic materials for breakthroughs in the opto-electronics field.

One strength of Oxide Corporation is that it possesses production technology that dramatically enhances the quality of single crystals.

Artificial synthesis of single crystals is usually performed by the so-called "pulling" technique from a melt. In contrast, Oxide succeeded in commercializing stoichiometric lithium niobate single crystals and stoichiometric lithium tantalite single crystal for the first time in the world by developing a new technique called the double crucible method with automatic material feed to the level of a single crystal production technology.

(An interview with Oxide's President, Yasunori Furukawa, can be found on page 7.)

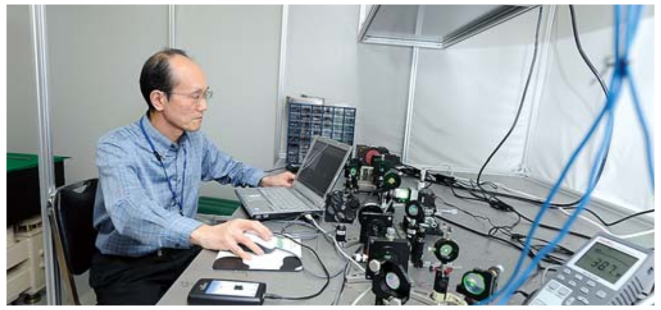
SWING Ltd.

SWING Ltd. was established in May 2003 with the objective of developing the research results at NIMS to practical application, and assessing the value of those results.

The company was approved as a NIMS-authorized venture, and produces and sells the developed crystal materials and devices to promising customers.

SWING, as one of the venture companies of a national organization, is committed to contributing to society by putting priority on development of high quality lasers can be used for practical applications in medical treatment and environmental measurement.

The company received the NanoTech Manufacturing Award in the Tsukuba Venture Awards in February 2009. Followings are our main products.



- QPM frequency conversion devices
- Photorefractive crystals
- High quality EO crystals
- Fluoride crystals for laser
- Photonic granting devices

Comments by Kenji Kitamura, Director of SWING Ltd. (NIMS Fellow)

We began basic research on methods of controlling defects 20 years ago. Originally, we were not aiming at practical application, but we found out an important fact that the defect controlled crystals grown by a NIMS original method were very suitable for fabricating wavelength conversion devices. This led to the realistic development and commercialization of the devices.

As my own belief, when we create outstanding materials, I very much want them to be used. I considered launching a venture company because I wanted make these materials available to the world.

If we can commercialize products ranging from the device level to laser light sources, we can expect a quite sizeable market. For this reason, we want to expand our business in U.S. market. It is best to carry out development close to the market.

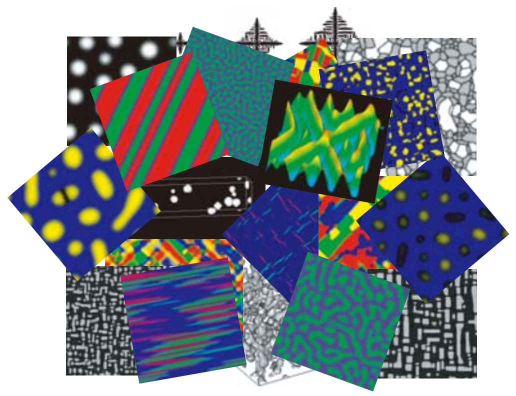
Because we started up the venture for disseminating our research results in the larger world, we presently outsource all of our sales activity to Oxide Corporation rather than handling it ourselves.

Materials Design Technology Co., Ltd.

Materials Design Technology Co., Ltd. (MDT) was established in September 2003 to market databases, software, and know-how for the design of new alloys with target functions. It supplies products to various manufacturers in the metal materials, automobile, machinery, and electrical industries, as well as universities, and also provides consulting services.

Metal alloys are made by mixing of multiple elements in varying proportions. Because the optimum composition ratio and other features are frequently obtained by repeated trial-and-error experimentation, the development of an efficient theoretical design method was desired.

To that end, MDT is currently engaged in business in the following 3 core areas, based on the "Simulation Method for Nano-scale Microstructure Evolution in Practical Materials" developed by NIMS.



- Simulation of structure formation by phase field method
- Various alloy-related thermodynamics databases
- Multi-component phase diagram calculation software "Pandat"

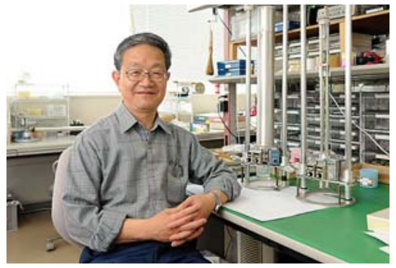
Comments by Kiyoshi Hashimoto, Director of Materials Design Technology Co., Ltd.

Our laboratory was launched as a result of a collective desire among researchers at NIMS, Tohoku University, National Institute of Advanced Industrial Science and Technology (AIST), Kyushu Institute of Technology, and Interscience Co., Ltd. to make their research products available to the world. At present, the company has annual sales on the order of ¥20 million, but our great dream for the future is to transform it into a company with distinguishing features that others cannot match.

For example, because wider use of lead (Pb)-free alloys is an important environmental issue, we believe that our thermodynamics database for Pb-free solder and other products have high potential in overseas markets.

For the moment, our focus is on phase field simulation of structure formation, which we hope to commercialize and release as a product between this year and next year.

Probe Laboratory Inc.



Probe Laboratory Inc. was established in August 2006 with the objective of designing and producing, operating, selling, and supplying nuclear magnetic resonance (NMR) probes (detectors), and providing consultation services relating to the probes.

As suggested by the name Probe Laboratory, this is a company where highly skilled craftsmen hand-make products in response to individual orders. Its President, Teruaki Fujito, is an engineer who was involved for many years in manufacturing probes at JEOL Ltd. Because slight modifications in the performance and features of probes are necessary, depending on the NMR application, the object to be detected, and similar factors, ordered products are produced by hand using sophisticated techniques, and are highly valued. A single multi-purpose probe is inadequate because a probe that can do anything is, in fact, a probe that can do nothing.

These specialized probes, made in the corner of the NIMS laboratory using NIMS equipment, are indispensable to their users.

Comments by Teruaki Fujito, CEO of Probe Laboratory Inc.

In a manner of speaking, Probe Laboratory is a senior citizens' workshop. If I can offer a place where older craftsmen who are masters of their work can enjoy making things, I don't think it's necessary for the company to grow or be extremely profitable.

At the moment, I toil along by myself to make and deliver products that each take around 4 months to complete. Since the probes are made to order and each one is different, this is the limit, and each product is one of a kind.

There is a saying "Nothing is hard to a willing mind." I'm satisfied to make outstanding probes that cannot be made elsewhere. Due to the limited output, I have no plan of expanding abroad. If I can pay for the labor and materials, that is all I ask. It doesn't hurt to have a company like this, does it?

Comet, Inc.

Comet, Inc. was launched in December 2007 by a group of management personnel and researchers and technical people with long experience and knowledge in the field of functional materials.

New functional materials hold great potential as solutions to the environmental, energy, and resource problems now confronting humankind.

The company's objective is to provide support for the discovery and development of new functional materials in the knowledge and equipment aspects. With combinatorial high throughput technology as its core, Comet also offers consulting services for material searches and foundry services, and carries out material development on a contract basis. In addition, the company sells high throughput synthesis and evaluation devices, and provides facilities and materials libraries.

Comments by Setsu Suzuki, CEO of Comet, Inc.

Combinatorial techniques were originally a means of chemically producing drugs. For example, it may involve mixing three types of substances while altering them gradually to change their composition. We thought that this approach might also be applicable to thin film processes, and thus could be used in material development. We have received commissions for projects from various companies and have provided a wide range of samples to automobile manufacturers, camera makers, and others.

In the years ahead, we plan to expand our business in overseas market. We hope that Comet, Inc. will continue to grow its scale constantly.

Working as a CEO is demanding. It is easier to be an employee. But as an engineer, it is interesting because the requirements of each customer are different.

The Significance of NIMS Ventures

As introduced above, NIMS has currently authorized five venture companies. One has achieved remarkable growth, and has left NIMS' support and become fully independent. The remaining four companies are still young and in the stage where they are searching for directions for growth, but all appear to have unique futures.

In any case, the primary objective of the NIMS ventures is to return to society the outstanding materials created at NIMS, along with the development capabilities that made those materials possible, based on the NIMS motto that "the true value of materials is in their use." Although the companies may be small in number and scale, all of the NIMS ventures aim at business operations that truly contribute to society, and NIMS technologies are supporting their efforts.

Creating new and different single crystals

Dr. Yasunori Furukawa
President & CEO, OXIDE Corporation

Dr. Yasunori Furukawa, President & CEO of Oxide Corporation, studied single crystals for 12 years at the R&D Center of Hitachi Metals, Ltd. He went on to study in the US at Stanford University for a year and subsequently joined the National Institute for Research in Inorganic Materials (NIRIM), one of the predecessors of NIMS, and launched Oxide Corporation in 2000. The venture company has posted impressive growth since its establishment.
The Oxide Corporation is located in a quiet mountainous area in Yamanashi Prefecture. NIMS NOW visited Oxide Corporation in early May, and asked Dr. Furukawa about the history of his company.

What led you to set up a venture business?

Simply, I wanted to develop the results of our research to the practical level so the public could evaluate this work. That's why I was intent on finding practical applications for my research results.

Actually, NIRIM had a well-funded research budget, excellent equipment, and exceptional human resources. At that time, I felt that the researchers were mainly concerned about their research and did not give much thought to applications of their work that could benefit society. That's why I was intent on finding practical applications for the results of my research.

While working on government projects, I produced results from research, filed patent applications, and wrote research papers. As time passed, I was approached by various people wanting to use the new materials, and I transferred technology to several major firms that wanted to use it commercially. However, even after 2 years, none of them had succeeded in commercialization. so I decided that I had to set up my own firm.

Why did you locate in Yamanashi?

Speed is essential when you launch a venture. In particular, specialized production equipment is needed to produce oxide single crystals. There was a manufacturer of single crystal production nearby, and the region is home to numerous processing firms which are skilled in ultra-precision polishing techniques. In addition, Yamanashi Prefecture is active in assisting venture firms with many public support.

And we mustn't forget the environment. It was particularly crucial that the site had a stable infrastructure for making single crystals.

Most of our business negotiations are done over the internet. From this viewpoint, our location isn't a handicap. All in all, I think I was right to set up business in Yamanashi.

What do you have in mind in terms of developing your business?

Until today, we have stuck to our original philosophy of "creating new and different single crystals" by working closely with our clients to develop the single crystals that clients really want. As a result, clients understand that Oxide can accept orders requiring painstaking development. The new single crystals that are the result of these efforts have been used in various devices and systems.

When I consider what is necessary for the company to grow, our customers must feel that Oxide is indispensable. I am constantly thinking about how we can achieve this.

Around 60% of our revenues are from single crystals, and the rest from sales of modules and devices, divided equally between the two. On average, we have maintained double-digit annual growth in sales. As we go forward, we also need to focus on strengthening our financial base.

Where do you see your company going from here?

In general, our future will basically be an extension of our present operations. However, instead of simply expanding the size of the business, I would like to make Oxide a more balanced company by finding market niches where we can secure a high market share and offering a number of unique high-profit products.

Another key word is globalization. I can envisage partnerships whereby, for example, we supply competing foreign firms with our materials, they commercialize products using the materials, and we then obtain and sell the products here. This could emerge in clearer form 3 years or so from now.

Any message as the first venture of a National Laboratory to those who follow in your steps?

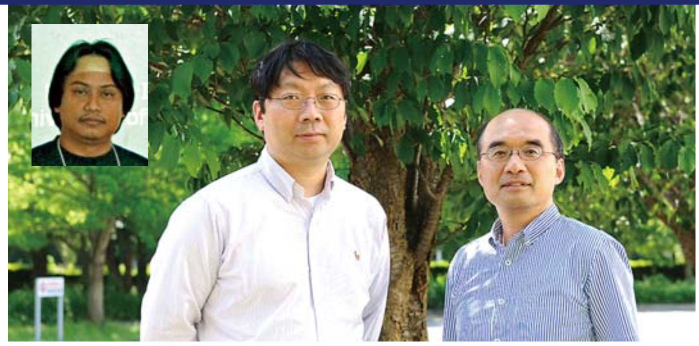
We strongly desire to repay the many persons and institutions that have given us their support by making this business a success. At the same time, we will also be happy if the modest experience of Oxide Corporation can provide a useful reference, if only in a small way, to researchers who come after us and are considering their own launching businesses. If I can offer only one word of advice to those persons, I would say what ultimately determines the success or failure of a startup is the certainty of the company's fundamental technical capabilities.

A Photocatalytic Material Made with Clay

Creation of Novel Photocatalytic Material Composed of Ubiquitous Elements

Nanostructure Control Research Group,
Photocatalytic Materials Center

† Affiliation with NIMS at time of research; now at University of the Philippines.



C.S. Pascua† Kenji Tamura Group Leader Hirohisa Yamada

Photocatalytic materials have long attracted attention in realizing a safe, secure, and sustainable society because they can be applied to decompose harmful chemical substances upon exposure to light, and in the generation of hydrogen and oxygen through the decomposition of water. Although oxide semiconductors such as titanium dioxide (TiO_2) and zinc oxide (ZnO) are generally well known, we have focused on the use of smectite clay minerals due to their ubiquitous composition in the Earth's crust such as silicon (Si), aluminum (Al) and magnesium (Mg). By combining these clay minerals with ZnO, we were able to compensate for the disadvantages of using ZnO in environmental purification, particularly in aqueous systems where it undergoes photodissolution and losses its photocatalytic properties. By the combination of smectite clays and ZnO properties (i.e. stability in aqueous systems and photocatalytic activity), we have created a novel photocatalytic material that is environmentally benign.

Clay minerals exist in large quantities on the Earth's surface. It has been used in a wide range of applications such as ceramics, cosmetics and medical products. The smectites represent one of the most useful clay mineral. Its basic structure includes an octahedral sheet of joined hydroxides of Al and/or Mg octahedrons sandwiched by two silica tetrahedral sheets built from SiO_4 tetrahedrons joined in a hexagonal network (**Fig. 1**). Observation with a transmission electron microscope (TEM) revealed that these minerals display a distinctive form of silicate nanolayers that are about 100nm size extending in two dimensions (**Fig. 2**).

The photocatalytic smectite we have created has Zn in all metal sites of the octahedral sheets which was achieved through a geomimetic process - learning from the process by which natural clays are formed on the Earth crust. To put it simply, dilute aqueous starting materials were used and reacted below the boiling point of water. Its photocatalytic activity was verified by observing the decomposition of a sorbed blue dye called methylene blue under ultraviolet light irradiation. The degradation of methylene blue is marked by discoloration and finally complete bleaching (i.e. clear and transparent) of the dye.

Due to the nanometer-scale layered structure of the photocatalytic smectite, it can be aggregated in a way that would increase its effective reactive surface area. It can also be used to form clear transparent films and coatings. Furthermore, it is stable in aqueous systems at a wide range of pH – far greater than the applicability of ZnO. It also has a very high affinity and adsorptive capacity for organic matter that increase its effectivity in decomposing organic contaminants. This novel photocatalytic smectite can make an important contribution to solving the Earth's environmental problems.

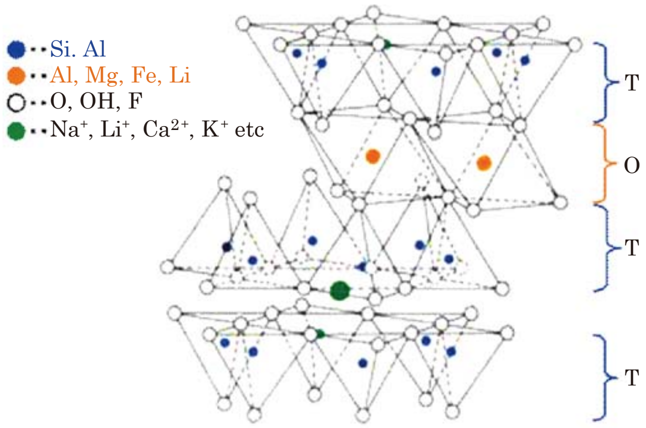


Fig.1 Schematic diagram of the structure of smectite. Smectite has a basic structure in which a octahedral sheet (O) is sandwiched by 2 tetrahedral sheets (T), and exchangeable cations exist between the layers of this basic structure.

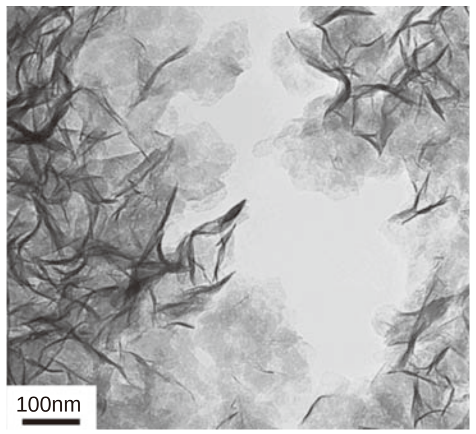
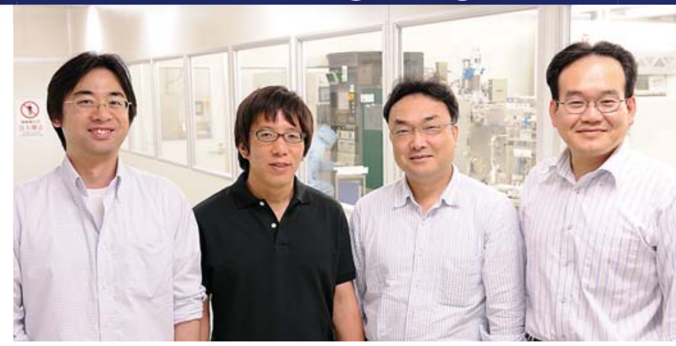


Fig.2 Transmission electron microscope image of the developed photocatalytic smectite.

Development of Full Color Filter Using Surface Plasmon

Nano-Integration Facility,
Nanotechnology Innovation Center



Manager
Naoki Ikeda, Daiju Tsuya, Yoshimasa Sugimoto, Yasuo Koide

Using the phenomenon called surface plasmon resonance, it is possible to control light that does not obey the conventional laws of optics such as refraction and diffraction. Focusing on aluminum as a material, we carried out a study aiming at practical application of nanophotonic devices, beginning with color filters. This study encompassed work from optimization of the structural parameters to simulation of optical properties, as well as the fabrication process itself.

Surface plasmon is compressional wave of electrons that bind with light existing at the surface of a metal. With the noble metals such as silver and gold, which had been the object of research to date, it is in principle difficult to obtain resonance in all the wavelengths of visible light because the resonance frequency of these metals is too low, while the difficulty of microfabrication was also a weak point from the practical viewpoint. Therefore, we selected aluminum as a metal with which resonance can be obtained in the entire range of visible light wavelength from blue (400nm) to red (800nm). Aluminum is also an abundant global resource and is used in a variety of applications, taking advantage of its excellent corrosion resistance, light weight, and ease of fabrication. In this research, we succeeded in forming a hole array with a 300-400nm period in an aluminum thin film by using the semiconductor microfabrication techniques of electron beam lithography and reactive-ion etching.

If the aluminum thin film in which the hole array was formed is irradiated with white light, light of a wavelength 1.65 times the period of the array (3.3 times the diameter of the holes) excites surface plasmon, and energy conversion occurs from light to surface plasmon and from surface plasmon to light, resulting in transmission and propagation of light (**Fig. 1**). **Figure 2** shows an electron microscope image (top) and transmitted light image (bottom) of the surface plasmon color filter which was fabricated in this work. As can be confirmed from the **figure**, a 5- color (red, orange, yellow, green, and blue) filter was realized by the high accuracy nanoscale hole array.

With color filters using surface plasmon resonance, control of color and brightness is easy, and filters can be produced on flexible transparent films. Based on these advantages, application to future ultra-high resolution displays and image sensors is foreseen, and a dramatic improvement in light extraction efficiency is expected by incorporating these devices in light-emitting diodes.

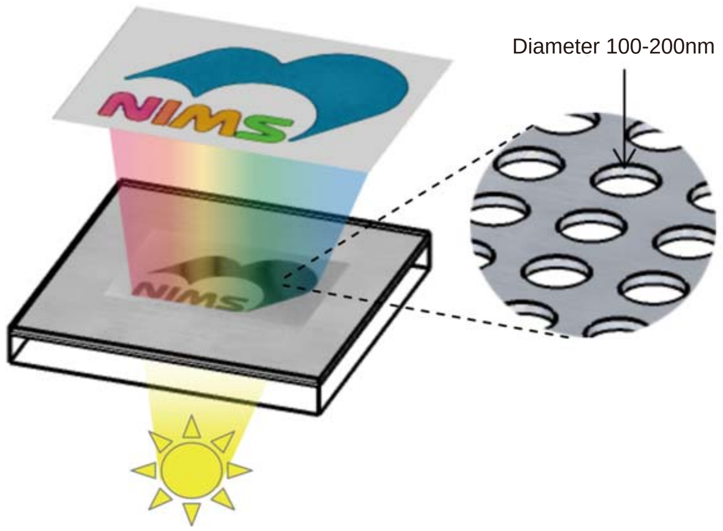


Fig.1 Schematic diagram of the surface plasmon color filter.

Fig.2 Surface plasmon color filter fabricated in this research. Top: Scanning electron microscope image, bottom: transmitted light image.

F/A/C/E フェイス interview

The multi-element combinatorial sputtering apparatus, which is capable of automatically synthesizing three different elements into compounds in arbitrary composition ratios on a single substrate, was developed by Dr. Toyohiro Chikyow, Managing Director of NIMS Advanced Electronic Materials Center, and his colleagues. It not only opens the way to producing the optimum material in a short time, but also provides an entirely new viewpoint for materials science.

A New World Brought About by the Synthesis of Combinatorial Materials

Toyohiro Chikyow

Managing Director,
Advanced Electronic Materials Center

You majored in electronic communications in graduate school. Could you explain why you chose to work at a materials research center?

In graduate school, I studied semiconductors physics under a professor who had great prescience and advised me to join the National Research Institute for Metals (NRIM), which was one of predecessors of NIMS. He said "A variety of materials will be important in semiconductors in the future, so you should join a materials research laboratory if you want to do long-term research." On his advice, I decided to move to materials research field in 1989.

After joining NRIM, I worked in the fabrication of quantum dots. A compound semiconductor made up of gallium arsenide (GaAs) was used for quantum dots. As North Carolina State University excelled in this field at that time, I spent a little more than one year at that university in 1993, where I met a dramatic experience. One month after my arrival, there was a fire in our laboratory, and most of the equipment was ruined except for a device for vapor deposition of oxides. This tragedy led me to study the deposition of oxides on silicon substrates for a year, and formed the basis of my current research.

How did your research on the vapor deposition of oxides lead to research on the synthesis of combinatorial materials?

In the United States, I did research on how to deposit an oxide called cerium oxide (CeO_2) on silicon substrates. After my return to Japan, I continued this work in joint research with the Tokyo Institute of Technology. CeO_2 has very high permittivity, and in the field of integrated circuits, it is a candidate material for gate insulating films called high–κ materials (κ: permittivity). As the scale of integration increases, silicon dioxide (SiO_2) insulating films based on conventional technology become thinner, and so that, the leak current due to the quantum tunnel effect increases. This is an obstacle to higher integration. To solve this problem, we are moving toward adoption of a next-generation basic structure in which we use thick high–κ membranes to prevent leak and thereby ensure transistor operation. The fire in North Carolina gave me an opportunity to do this before anyone else.

In 1999, I participated in the "Combinatorial Materials Exploration and Technology (COMET) Project," a joint research project with the Tokyo Institute of Technology and developed techniques in this connection which I then used to investigate high–κ materials. A combinatorial synthesis apparatus can automatically synthesize chemical compounds of any combination of three different elements on a single substrate. In the past, it took 100 experiments to change the ratios of three elements in a composition at intervals of 10%, but in contrast, the new apparatus makes it possible to do the same in a single experiment, enabling us to identify immediately a composition corresponding to the target function. We call this screening.

What materials have you found?

Recently, we successfully found a high-κ oxide which has higher permittivity and is capable of forming a direct junction with Si. When an ordinary high-κ materials deposited on silicon, SiO_2 is always formed at the interface and the resulting permittivity is lowered by SiO_2, The new high-κ material forms a direct junction with Si and keep a higher permittivity after the deposition. It is a chemical compound with a system made up of five elements, Ce, Hf (hafnium), Al and Si and oxygen and has an extremely complex composition and I could not find such complex materials if I did not use the combinatorial technique.

What amazed me was to find researchers who were looking for domains with low insulating performance for sensor devices while we were carrying out screening to find domains in which exhibit high insulating region for high-κ materials even though we are handing same kinds of oxide materials. As combinatorial technology gives us systematic data on combinations, and when we accumulate such data, researchers in various fields can use it to find candidates that they want. This experience changes the way that we see materials. For example, Titanium oxide (TiO_2), a wide gap semiconductor, is known as a photo catalysis. By doping, we can obtain transparent conductive film or it becomes a magnet by do cooperation. It is also a high-κ material. Using combinatorial technology, it enables us to understand the nature of TiO_2 from multiple points of view, leading to new discoveries. This cycle of discovery is a distinctive feature of combinatorial material synthesis.

Do you have any advice for young researchers?

When you are young, it is important to refine your abilities in your specialty. At the same time, it is also important to widen your field of vision and not lose your curiosity about various things. Interchanges between researchers in different fields are a start in that direction.

The 3rd Symposium on Heat Resistant Steels and Alloys for High Efficiency USC Power Plants 2009

(Jun. 2-4, 2009) The 3rd Symposium on Heat Resistant Steels and Alloys for High Efficiency USC Power Plants was held in the Conference Room at the NIMS Sengen Site June 2-4. This Symposium is held jointly by China's Central Iron and Steel Research Institute (CISRI) and the Korea Institute of Science and Technology (KIST) as a conference for discussion of the results of research on the achievement of high strength in heat resistant materials, which are necessary for reducing CO_2 emissions and conserving energy resources by improving the energy efficiency of thermal power plants. The recent meeting at NIMS followed the 1st Symposium, which was held at CISRI in 2005, and the 2nd Symposium at KIST in 2007.

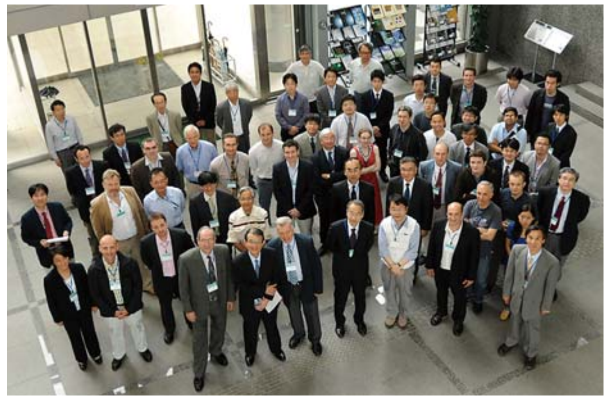
A scene from the Symposium.

This year, approximately 60 persons from 8 countries participated in the Symposium. In addition to technologies for achieving high strength in ferrite/austenite high temperature steels and Ni-based superalloys, etc., a wide range of recent research results in connection with next-generation ultra-super critical (USC) thermal power plants were also reported, including topics such as steam oxidation resistance, welding, simulation techniques, and others, and lively discussions were held.

Because realizing higher efficiency in thermal power plants is an urgent issue for every country as the world attempts to solve energy and global environmental problems, this was an extremely significant symposium.

8th Japan-France Workshop on Nanomaterials

(Jun. 15-17, 2009) The 8th Japan-France Workshop on Nanomaterials was held at NIMS (Sengen Site) over a 3-day period from June 15 to 17. The Workshop was launched in 2000 to promote presentations of advanced research, exchanges of human resources, and joint research, with the participation of leading nanomaterials researchers representing the two countries of Japan and France. An Organizing Committee was established under President Teruo Kishi of NIMS as the representative of the Japanese side and Prof. Jean Etourneau (formerly Director of the Bordeaux Institute of Condensed Matter Chemistry) on the French side, and workshops were held alternately in Japan and France. In addition to presentations by first-class researchers, since the 5th Workshop in Bordeaux in 2005, young researchers have also participated in poster presentations, and effort has been put into the development of the young human resources who will be responsible for this field in the future. The 2009 Workshop featured lectures in the field of nanomaterials by 20 researchers from France and 32 researchers from the Japanese side (including poster presentations). A total of approximately 115 persons participated during the 3-day period. After the end of the Workshop, participants from the French side were given a tour of the laboratories at MANA. Thanks to the support of many people, the Workshop concluded successfully.



All participants gathering at the main entrance

Promoting the formation of "Tsukuba Innovation Arena [TIA] nano"

(Jun. 18, 2009) National Institute of Advanced Industrial Science and Technology (AIST: President: Tamotsu Nomakuchi), National Institute for Materials Science (NIMS: President: Teruo Kishi), and University of Tsukuba (President: Nobuhiro Yamada) have agreed to form a world-class nanotechnology research and development center in Tsukuba City, which is to be called the "Tsukuba Innovation Arena [TIA] nano," and in cooperation with the Committee on Industrial Technology (Joint Chairman: Ryoji Chubachi) of Nippon Keidanren (Japan Business Federation).

The facilities that will form the core of nanotechnology research and development will be constructed on the campuses of AIST and NIMS, which are located in Tsukuba City, the three parties will cooperate in promoting research and development and efforts to train human resources.

From left, Dr. R. Chubachi, Dr. N. Yamada, Dr. T. Nomaguchi and Dr. T. Kishi

UW/NIMS MolAT Forum

(Jun. 11-12, 2009) The 2-day joint forum of NIMS and the University of Washington (UW: located in Seattle, Washington, USA) was held at UW on June 11-12 jointly with the Center for Nanotechnology Conference.

In April 2008, NIMS opened a NIMS Overseas Operation Office in UW and is energetically promoting collaboration with UW, such as an International Joint Graduate School Program. With these efforts, a proposal of a new international joint research and education program (MolAT: UW-NIMS Institute for Molecular Architectonics) has been submitted to the US National Science Foundation (NSF).

The Forum began with an outline of the program by Prof. Ohuchi of UW, followed by invited guest lectures and presentations about photonics, energy and bio-nanotechnology by NIMS researchers and UW assistant professors. These presentations deepened the mutual understanding of their researches.

On the afternoon of June 11, a reception hosted by Japan's Consul-General in Seattle, the Honorable Mitsunori Namba, was held at the Consul-General's residence. The reception was crowded with a total of approximately 100 participants, including the NIMS researchers, professors from UW, members of the Japan-America Society of Seattle, people from Japan Chamber of Commerce and Industry, and other related persons in the Japanese community. Introductions of NIMS by Vice President Tetsuji Noda and the NIMS/UW office by NIMS Fellow Kenji Kitamura helped attendees to understand about NIMS collaborative activities overseas.

As for future events, a NIMS visit by UW professors and research collaborations are scheduled with the aim of building a closer relationship.

Reception at the Consul-General's residence

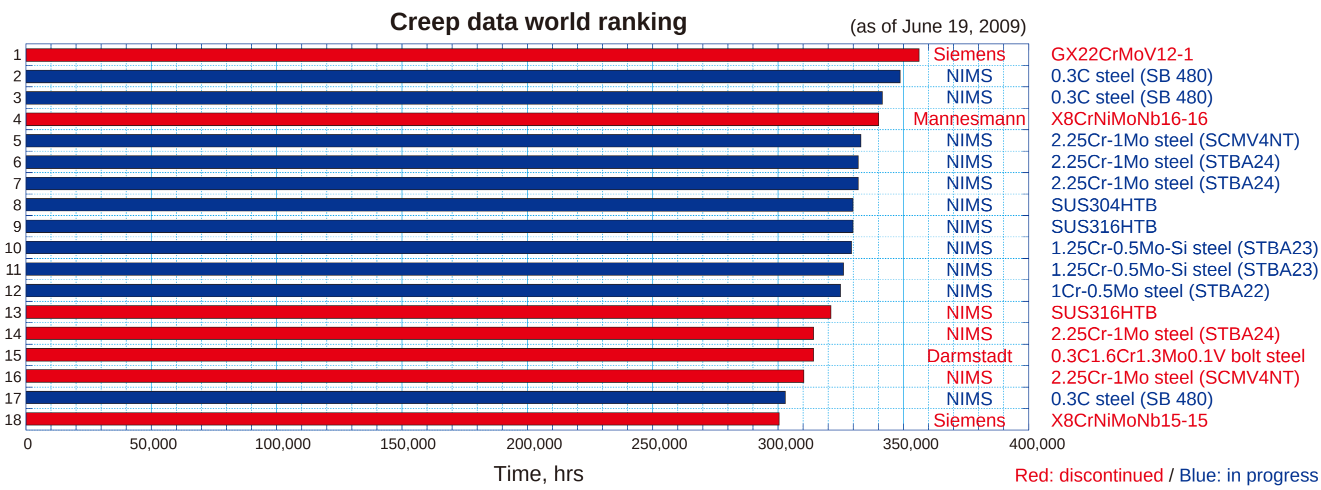
NIMS Obtains Creep Deformation Data Exceeding 40 Years

(Jun. 18, 2009) NIMS celebrated that the creep test at the Meguro Site has passed the 40 year mark and achieved a creep test time of approximately 348,310 hours. The test was begun by NRIM* on June 18, 1969, which was about a month before the Apollo 11 moon landing.

The longest creep deformation data in the world were reported by Siemens in Germany. However, that test was discontinued in 2000 after reaching a test time of 356,463 hours. The NIMS data for 40 years is ranked 2nd in the world, after the Siemens data. NIMS has already obtained 3 sets of creep rupture data exceeding 300,000 hours, and the creep test of 11 specimens, including the one which exceeded 40 years reported above, has passed 300,000 hours and is currently continuing, with the aim of setting a new world's record for long-term data.

Creep test facility at Meguro-site

*NRIM: National Research Institute for Metals, one of the predecessors of NIMS



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