from Tsukuba, Japan to the world

NIMS NOW International

National Institute for Materials Science

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Research Frontier

Polymorphism Based on Supramolecular Fullerenes

- Freedom in the Creation of Nanotech Parts with Desired Shapes -

Takashi Nakanishi
Supermolecules Group
Organic Nanomaterials Center

Nanocarbon, represented by fullerenes, which consist of 60 carbon atoms linking in the shape of a soccer ball, and carbon nanotubes (CNT), which are formed by elongating fullerenes in a cylindrical shape, are widely considered to be a next-generation material with expected applications in numerous fields, including electronic materials, electrode materials, catalyst carriers, and biomaterials. However, direct handling of these nanocarbon materials is extremely difficult in their existing shapes and nanometer size. The ability to easily create the desired shape and appropriate size is the key to treatment of nanocarbon as a material which can be used in actual applications.

In the existing methods of using fullerenes as materials to date, reproducibility was poor and individual preparation of designated fullerene derivatives was necessary in order to fabricate a certain designated shape. In the present research, we developed a processing technology which enables free manipulation of diverse shapes using fullerenes as the material. The technology requires only synthesizing a fullerene derivative (**Fig. 1a**) with a comparatively simple shape, for example, using triple long-alkyl chains modified on the fullerene, and changing the conditions under which the molecule is dissolved in alcohol or ether-based solvents.

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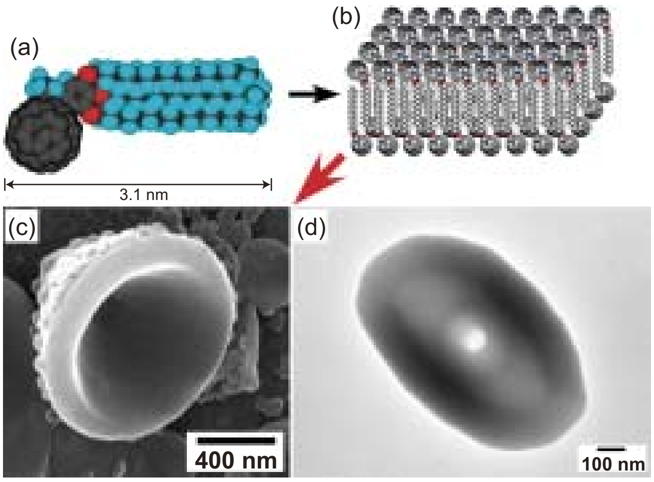


Fig. 1 (a) Synthesized a fullerene derivative (red: oxygen, black: carbon, dark blue: nitrogen, light blue: hydrogen), (b) self-organized bilayer membrane structure, (c) SEM image of supramolecular self-organizing cone structure, (d) TEM image of cone structure.

in this issue

NIMS News

Visit by South Korean Delegates

South Korean delegation and NIMS executives.

(July 11, NIMS) -- Dr. Woo-Sik Kim, Deputy Prime Minister & Minister, Ministry of Science and Technology, Dr. Hwa-Young Park, President, Korea Institute of Machinery & Materials (KIMM), Dr. Shin-Won Kang, President, Korea Basic Science Institute (KBSI) and the other delegates visited NIMS. NIMS and KIMM signed a comprehensive agreement for research collaboration. They also visited Center for Young Scientists (ICYS) and laboratories on nanotechnology.

Dr. Kim (left) showed a great interest in the R&D of Atomic Electronics.

Success in Observation of Nanoscale Defects in Optical Waveguide

- Enabling Nanoscale Inspection of Optical Integrated Circuits -

Tadashi Mitsui
Nano Photonics Group
Quantum Dot Research Center

Optical integrated circuits are devices which switch the paths of optical signals themselves between optical fibers without replacing the optical signal with an electrical signal. Because high speed, large capacity information transmission networks are possible, development of these devices is expected. However, observation of external appearance is inadequate for inspection of optical waveguides. Direct investigation of how light is actually passing through the device and whether any abnormalities exist is necessary. In particular, with the recent trends toward increasingly high integration and accuracy, it is no longer possible to ignore the effects of nanoscale defects. We developed a Near-field Scanning Optical Microscope (NSOM) with a function for separating and observing the linear polarized light component, and investigated the effect of micro-defects and extremely weak strain in optical integrated circuits on light propagation.

The NSOM is a type of scanning probe microscope which measures the distribution of light intensity at the nanoscale by placing an optical fiber (diameter: 50 nm) with a fine pointed tip at a position 10 nm from the specimen surface and detecting evanescent light leakage. By using a special optical fiber called a polarization-preserving optical fiber, we succeeded in observing the separated polarized light component (**Fig. 1**).

In this work, we made an indentation close to an optical waveguide of polymeric material and investigated its effect (indentation depth: approx. 8 µm). **Figure 2a** is an ordinary optical micrograph, **Fig. 2b** is an image of the topograph of the part shown by the square, and **Fig. 2c** and **2d** are polarization NSOM images of the same region as in **Fig. 2b**. In the part shown by white contrast in **Fig. 2c** and **2d**, light propagates in the optical waveguide from left to right, as shown by the orange arrow. The incident light is vertical polarized light (E⃗◉). Focusing on the contrast at the far side (A) and near side (B) to the indentation in the optical waveguide, in **Fig. 2c** and **2d**, the intensity is reversed in parts A and B. This contrast shows the intensity distribution of the linearly polarized light component, with **Fig. 2c** shown by light blue and **Fig. 2d** by red, respectively. At **Fig. 2c**, part of the vertical polarized light (green in **Fig. 1**) changes to horizontal polarized light (light blue). As the cause of this change, it is thought that the light was scattered by a nanoscale disturbance in the organic molecule chain due to applied stress, and as a result, vertical polarization converted to horizontal polarization. We believe that the method of inspecting optical waveguides using the polarization NSOM developed in this work opens the way to realizing higher performance optical integrated circuits.

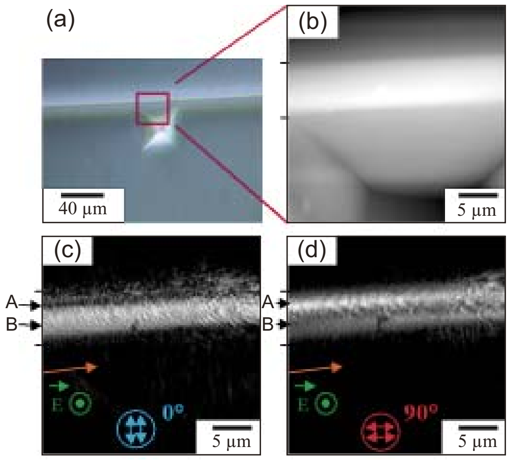


Fig. 2 (a) Optical micrograph of the optical waveguide, (b) topographic image of the polymeric optical waveguide around the indentation, (c) and (d) polarized NSOM images of the same region.

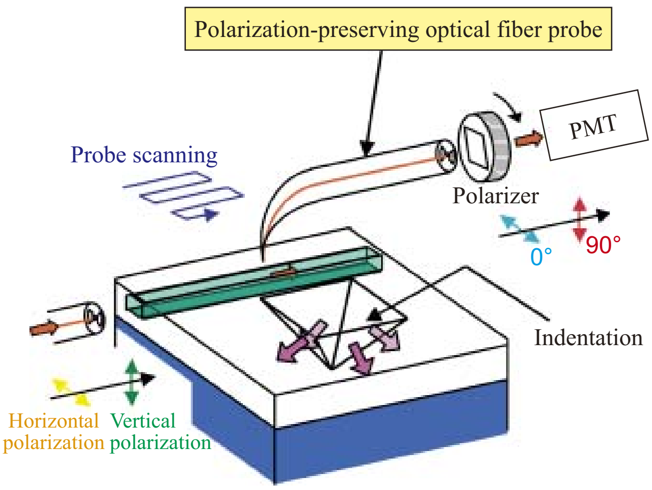
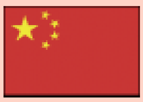


Fig. 1 Observation of optical waveguide using Near-field Scanning Optical Microscope (NSOM).

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

NIMS News

NIMS Signs MOU with Central Iron & Steel Research Institute, China



(June 28, China) -- The Titanium Group of the NIMS New Structural Metals Center signed an MOU for research collaboration with the R&D Center on Ti-Al Intermetallics, High Temperature Materials Research Division, Central Iron & Steel Research Institute (CISRI), China. The CISRI was established in 1952 as the most comprehensive research organization in China specializing in iron and steel metallurgy. In 1999, the CISRI was transformed into a large technical-oriented enterprise engaged in diversified fields including the development of iron-, nickel- and Ti-based structural materials, metallurgical technology, and sales of developed products. Taking advantage of this signing, the two institutes plan to promote exchanges of researchers and research information and carry out cooperative research in fields related to the Ti_2AlNb-based high temperature titanium alloys.

Prof. Li (right), Director of the R&D Center on Ti-Al Intermetallics, High Temperature Materials Research Division, and Dr. Hagiwara, Leader, Titanium Group, New Structural Metals Center.

Successful In-Vitro Cartilage Regeneration with Expected Shape

- Toward Tailor-Made Therapy for Patients with Osteoarthritis, Etc. -

Toshimasa Uemura, Yoshimi Ohyabu
Biofunctional Materials Group
Biomaterials Center

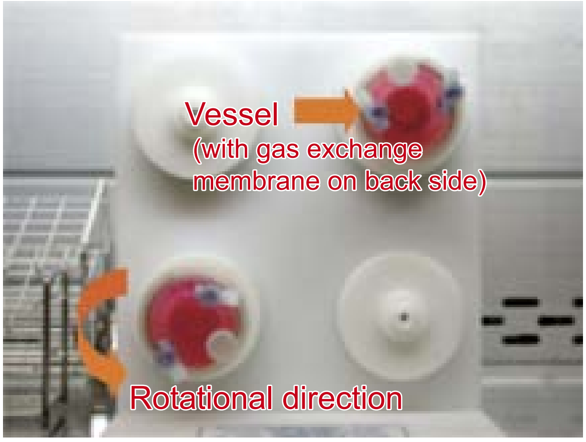


Fig. 1 RWV bioreactor.

High expectations are placed on the development and clinical application of cartilage regeneration technology as a method of therapy for cartilage patients with osteoarthritis (OA). However, because cultured cartilage cells, unlike other tissues, undergoes necrosis due to in-vitro two dimensional cell culture, a large-scale cartilage tissue regeneration technology applicable for extensive cartilage loss still has not been established. Using an RWV (rotating wall vessel) bioreactor (**Fig. 1**), which simulates a microgravity environment, we developed a novel cartilage regeneration technology in which marrow stromal cells are cultivated using collagen sponge (**Fig. 2**) as a scaffold material in order to solve this problem in the conventional cartilage regeneration technique and enable application to regeneration of 3-dimensional cartilage tissue in a large scale. Marrow stromal cells from the patient's marrow cells have pluripotency, which means that they have the capacity to differentiate into various types of tissue, such as bone, cartilage, fat, and ligaments, and differentiate into cartilage tissue during 3-dimensional cultivation based on an appropriate differentiation-inducing factor. However, in ordinary in-vitro cultivation, the cells sink to the bottom of the Petri dish due to the gravity on earth. As a result, only a 2-dimensional sheet is formed, and the characteristics of cartilage cells are lost. We therefore adopted a novel cartilage regeneration technology using an RWV bioreactor which was developed in order to realize 3-dimensional culture in a microgravity environment approaching zero gravity. Because the RWV constantly changes the direction of gravity acting on the cells by rotating a cylindrical vessel with a gas exchange membrane around the horizontal axis, as a time average, the RWV can simulate a microgravity environment with 1/100 the gravity on the earth's surface. Furthermore, by controlling the shape of the tissue (see **Fig. 3**) using collagen sponge with various shapes as cell scaffold material, we also succeeded in constructing high strength cartilage tissue with strength approximately 1.5 times that of tissue cultivated without scaffold material. In the future, we plan technical development aiming at clinical application.

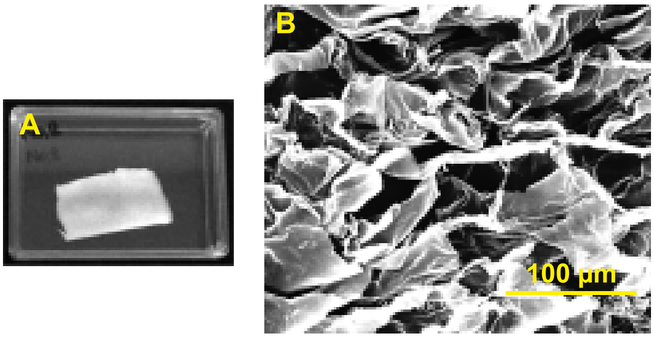


Fig. 2 A) Unmolded collagen sponge. B) Scanning electron microscope (SEM) image of A.

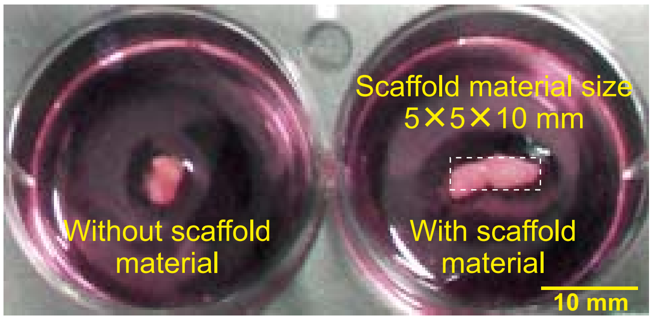


Fig. 3 Cartilage structure with (right) and without (left) using scaffold material.

For more details: http://www.nims.go.jp/bmc/index_e.html

NIMS News

MOU with Lund University, Sweden

(June 29, Sweden) -- The NIMS Quantum Dot Research Center signed an MOU with the School of Engineering (LTH), Lund University, Sweden. LTH is engaged in outstanding research and development centering on original methods of fabricating semiconductor nanostructures using aerosols. The two sides plan exchanges of researchers and research information, joint research, and other activities in the field of semiconductor nanostructural materials, beginning with joint research on the creation of semiconductor nanostructures, represented by quantum dots, and evaluation of their properties.

From left, Prof. Jönson, Dean of the LTH, Prof. Deppert, Dr Koguchi, Managing Director of the Quantum Dot Research Center, Dr. Kuroda, Nano Photonics Group of the Quantum Dot Research Center, Dr. Sakoda, Group Leader of the Nano Photonics Group.

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

Ferromagnetic Nanosheet

- New Fabrication Procedure for Future Spin-Electronic Devices Using Solution-Based Bottom-Up Nanotechnology -

Minoru Osada, Takayoshi Sasaki
Soft Chemistry Group
Nanoscale Materials Center

Assembly of functional or structural nanoscale materials, in the same way that children play with building blocks, is one of the dreams of nanotechnology. We are investigating new fabrication procedures for future spin-electronic devices using solution-based bottom-up assembly of functional nanoblocks.

The key requirement for such a building-block approach is to create functional nanoblocks with advanced physical properties such as electrical conductivity, magnetism, and dielectric properties. In designing spin-electronic devices, we focus on oxide nanosheets (**Fig. 1a**), which are obtained by delaminating a layered host material into its elementary sheets through soft-chemical procedures. The nanosheets often exhibit novel physicochemical properties that are inherent to their highly two-dimensional nature with a molecular thickness. Recently, we found that Co-substituted titania nanosheets ($Ti_{0.8}Co_{0.2}O_2$) act as ferromagnetic nano-blocks at room temperature, and their multilayer films exhibit a robust magneto-optical effect (Kerr rotation in **Fig. 2a**) at 260-300 nm, which is the shortest operating wavelength attained so far. This strong magneto-optical effect in the UV range is promising for exploring future magneto-optical applications such as high-density recording and optical isolators operable with UV lasers

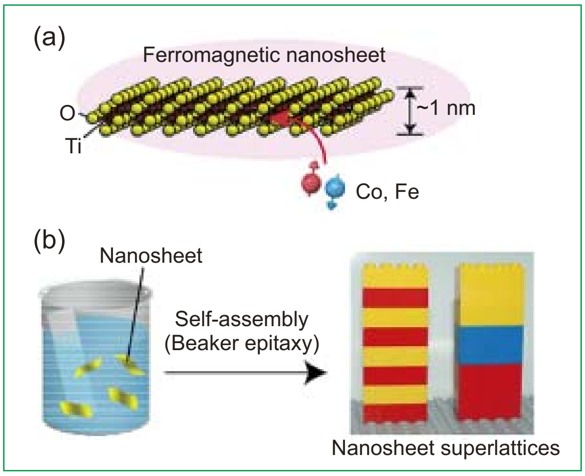


Fig. 1 (a) Atomic architecture of titania nanosheet. (b) Schematic illustration of solution-based building-block approach (LEGO block version).

The availability of ferromagnetic nanosheets will open up possibilities for designing complex devices by forming artificial superlattices via solution-based layer-by-layer assembly (**Fig. 1b**). To demonstrate this next level of complexity, we fabricated superlattices such as $(Ti_{0.8}Co_{0.2}O_2/Ti_{0.6}Fe_{0.4}O_2)_5$ using another magnetic nanosheet ($Ti_{0.6}Fe_{0.4}O_2$) (**Fig. 2b**). Interestingly, these superlattices either enhanced or suppressed the magneto-optical Kerr response by neighboring layers, strongly suggesting interlayer coupling. These results, as well as the absence of costly fabrication lines, offer the potential for rational design and construction of high-efficiency magneto-optical devices by forming various nano-architectures and superlattices. The next stage of our investigation will be the design of new multicomponent nanosystems and nanodevices with a range of sophisticated functions, targeting future applications in optical communications and storage devices.

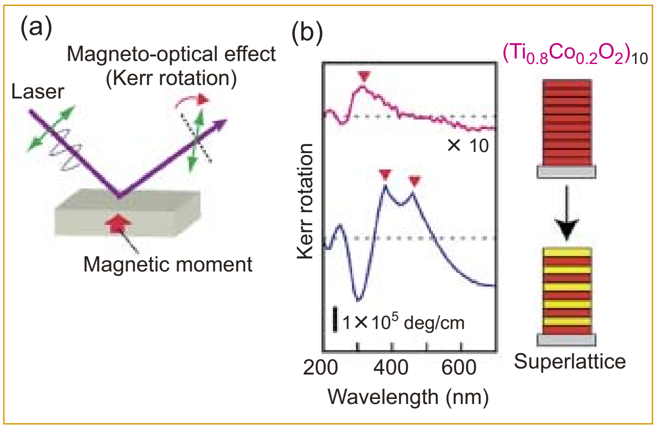


Fig. 2 (a) Schematic explanation for magneto-optical Kerr effect. (b) Design and construction of magneto-optical devices by forming nano-architectures and superlattices. Upper right: 10-layer multilayer film of Co-substituted nanosheet $(Ti_{0.8}Co_{0.2}O_2)_{10}$, lower right: artificial superlattice $(Ti_{0.8}Co_{0.2}O_2/Ti_{0.6}Fe_{0.4}O_2)_5$ with alternating Co- and Fe-substituted nanosheets.

For more details: http://www.nims.go.jp/softchem/index-e.html

NIMS News

NIMS Exhibits at Farnborough International Air Show, U.K.

(July 17-23, London) -- At the Farnborough International Air Show held in the United Kingdom, NIMS exhibited leading-edge research achievements such as the Ni-base single crystal superalloy developed by the NIMS High Temperature Materials Center. The Farnborough Air Show, along with the Paris Air Show, is one of the world's two most important air shows, and features more than 1400 exhibits by airlines, aircraft manufacturers, engine manufacturers, materials and parts makers, universities and research institutes, consulting firms, and publishers, as well as flight shows, an outdoor exhibition of aircraft, and press presentations.

From the first day of the exhibition, the NIMS booth received a large number of visitors from leading engine manufacturers and aircraft manufacturers, including Rolls-Royce, GE, CFM, IAE, Airbus, and others. In addition to receiving wide recognition for NIMS and the High Temperature Materials Center, it was possible to present the advantages of the developed alloy. Because NIMS was able to obtain a wide understanding of future trends in aircraft, engine, and materials development by collecting and exchanging information with other booths and attending press presentations, this was also an important experience for the development and practical application of alloys.

Scene at the NIMS booth on Private Trade Day.

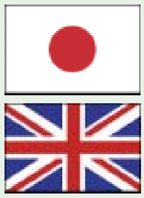
4th NIMS-Max Planck Workshop

(July 6-7, NIMS) -- The 4th NIMS-Max Planck Institute (NIMS-MPI) Workshop was held at the NIMS Namiki Site. This workshop is based on a comprehensive research agreement with the Max Planck Institute for Metals Research (Max-Planck-Institut fur Metallforschung), Stuttgart, Germany. The theme of this workshop was "Report of Research Achievements to Date and Seeds for Future Joint Research." The results of joint research carried out by the two institutes to date were presented, and research for confirming their validity and at the same time discovering seeds for future joint research were introduced. NIMS researchers made a total of 10 presentations, while researchers from the MPI side made 8. A total of 32 persons participated during the 2-day period.

Workshop participants.

Although this is a workshop in which the participants visit the respective institutes alternately each year, there were reports on research that is only possible through joint work by NIMS and MPI, taking advantage of the distinctive features of the two research institute, leaving an impression that this joint research is steadily bearing fruit. Those concerned with experimental and research work also deepened their understanding through visits to laboratories during the workshop period. Next year's workshop is scheduled to be held in Germany July 5-6.

The 3rd Japan-UK Nanotechnology Summer School



(July 10-14, NIMS) -- The 3rd NIMS-IRC Nanotechnology Summer School was held at NIMS with 14 students from the University of Cambridge, University College London, and University of Bristol attending from IRC and 18 students from the University of Tsukuba, Osaka University, Xi'an Jiaotong University (China), and Charles University (Czech Republic) participating on the NIMS side. Students presented their most recent topics of study in the field of nanotechnology and had fruitful discussions to deepen their knowledge. In addition to the exchange of scientific knowledge, the participants had pleasant interchanges through a soccer game and an excursion. The 4th Summer School will be held next year at Cambridge.

Mr. Ed Crossland (center right) and Mr. Takafumi Uemura (center left) won the Best Presentation Award.

Enthusiastic discussions were carried on.

Research Frontier

< Continued from p.1

Fullerene Supermolecules with Various Shapes

Here, we will introduce several of the shapes we were able to fabricate. First, the fullerene derivative is formed using a bilayer membrane structure in which alkyl chains assume an interdigitated arrangement by self-assembly (**Fig. 1b**, page 1). With this fundamental structure as a sub-unit, it is possible to obtain a spherical structure (vesicle) (**Fig. 2a**), a tape-like fiber structure elongated in one dimension (**Fig. 2b**), a disk shape with a film thickness of only several nm (**Fig. 2c**), and a seashell-shaped cone structure (with a fine hole approximately 50 nm in size at its tip) (**Fig. 1c**, **1d** on page 1 and **2c**). It can be said that this is an innovative technology which enables free and extremely simple, low cost fabrication of various kinds of nanocarbon using a single fullerene as the material, simply by changing the solvent. As one interesting point, it can also be said that this is a dimensional-controllable new carbon material in which the structures of the fabricated supramolecular fullerenes correspond to nanocarbon materials including the fullerene (0-dimensional), carbon nanotube (1-dimensional), graphite sheet (2-dimensional), and carbon nanohorn (3-dimensional).

Taking advantage of the inherent electrical conductivity and

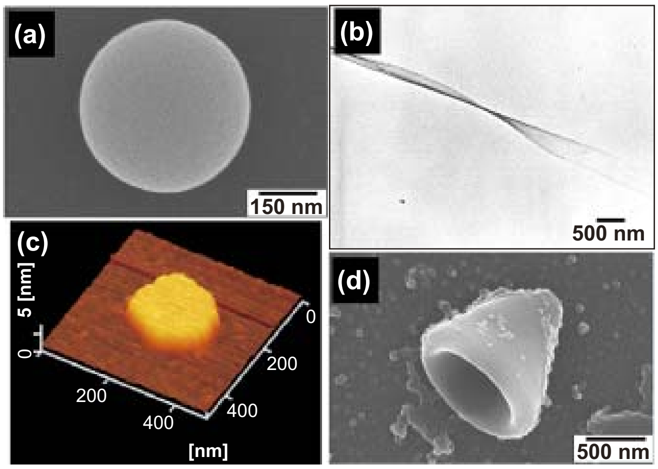


Fig. 2 Images of hierarchical supramolecular objects of the fullerene derivative formed in different solvents. (a) SEM image of spherical vesicle. (b) TEM image of fibrous structure. (c) AFM image of single bilayer nanodisk. (d) SEM image of cone object.

other properties of fullerenes, a wide range of applications can be expected, including drug delivery and capsules for metal particles (spherical structure), electronic wiring (fiber structure), nanosize condensers (disk structure), and size selection of biomaterials such as viruses, etc. and catalyst carriers utilizing the relatively large surface area (cone structure). At present, we are engaged in research in these various directions.

For more details: http://www.nims.go.jp/onc/super/index_e.html

Hello from NIMS

Coming from a country which is known as the Land of Smiles, Sawadee krub ("hello" in Thai). My name is Pornthep Chivavibul from Thailand. Having joined NIMS in April 2006, I am a new member of the Coating Materials Group, although I am not exactly new to Japan, as I have been living in this country for the past nine years, mostly in Tokyo. I recall the first step I took in Japan at Narita Airport on April, 1997. I spent six years at the University of Tokyo earning my Master's and Doctoral degrees. Before coming to NIMS, I worked at the Central Research Institute of Electric Power Industry (CRIEPI) in the field of Non-Destructive Testing (NDT). Currently, I am working on developing thermal spray coatings. The process generally starts off with spraying and property evaluation. You can find me mostly in the polishing room, hardness test room, and SEM room. During my free time, I enjoy ikebana (flower arrangement) lessons, which I started about three years ago, and I was recently certified as an ikebana instructor by the Sogetsu and Ryuseiha schools, so I am taking on a new challenge of teaching ikebana. Anyone who is interested, please feel free to ask me for a private lesson. Besides ikebana, I also enjoy exercising, aerobic dancing, and cooking.

Pornthep Chivavibul (Thailand)
Research Fellow (April,2006 - April, 2007)
Coating Materials Group
Composites and Coatings Center

[Author (center) with Dr. Shinoda (left) and Dr. Watanabe]

[Japanese dwarf beauty-berry, redginger]

[Barroom plant, Sweet pea, Broadleaf umbrella fern (bleached)]

NIMS Summer Events 2006

Summer Science Camp for the high school students of Japan

Kids-Doctorate Program for the elementary/middle school students of Tsukuba
August 23-25

Mini-Doctorate Program for the middle school students of Ibaraki
August 2-4

NIMS Beer Party
July 27

The 3rd Japan-UK Nanotechnology Summer School (See page 5)
July 10-14

NIMS
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