CONVERGENCE

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MANA

International Center for Materials Nanoarchitectonics (MANA)

Harry KROTO

Ph.D. in Molecular Spectroscopy from University of Sheffield (1964), Professor, University of Sussex (1985), Fellow of the Royal Society (1990), Royal Society Research Professor (1991). Co-recipient, Nobel Prize for Chemistry (1996). President, the Royal Society of Chemistry (2002). Francis Eppes Professor of Chemistry, Florida State University (2004).
In 1985, Dr. Kroto together with researchers at Rice University in Houston, created a soccer ball-like C_{60} molecule by using graphite vaporized with a laser. The C_{60} molecule was dubbed "buckminsterfullerene" (more popularly known as "buckyball") and is the most symmetrical carbon molecule known to exist in interstellar space. In 1991, Japanese scientists discovered nanotubes, a structural C_{60} relative – and this discovery opened up the new scientific field called nanotechnology, which enables manipulation of materials at the molecular level.

WPI Program & MANA:

Paradigm Shift for the World

❖Interviewer: Ames Pomeroy, IP-L Communications Inc.

Q: In 2007, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) launched the WPI Program* in order to establish a global top-level research hub that takes a "visible" form. What you think about the WPI Program, as a system?

I think it is a good program, aiming to pursue tangible "science & technology" – in particular through work related to fundamental science – which is of utmost importance for all of us on this planet Earth, in this era of worldwide problems such as global warming and issues related to depletion of resources. The scientific community must indeed look for technical fixes while being shown to be a visible part of the moving force behind such fixes.

Seemingly, the only way to do so is to take the course of action that Japan has taken, making available environs where young creative people can take up these technical challenges. The economic dilemma involved is the need to convince the government to use taxes, which Japan can do with ease. In Western nations, the emphasis is upon "strategic" science rather on basic science because it seems governments need to promise something solid in return for using tax money, in order to not only explain but cajole the public into approving the spending.

Perhaps it is not that well known yet around the world, but the WPI Program in Japan is on the right course. Japan has the best record, especially in terms of funding. It appears that Japan provides fertile ground where people who are serious about conducting research, focusing on the core topics. It behooves Emerging Countries to consider setting up programs based upon the WPI Program model.

Q: MANA is based upon the new concept of "Material Nanoarchitectonics" — seen bringing about a paradigm shift for materials science. What are your views concerning this Nanoarchitectonics concept, from the perspective of developing materials?

The language usage is one aspect that requires clarification. Words should have meanings, ideas should have consequences. "Nano" refers to the nanometer-order (10^{-9}), however it is the "next big thing" paving the way for a paradigm shift. The concept provides a method of producing complex and functional systems, in a more effective yet less costly manner. Such systems could soon encompass living systems, i.e., life itself.

The paradigm shift is that in the 21st century, the perspective until now, approach from the top-down, such as using a tree to produce a table, will shift to approaching from the bottom-up. The breakthroughs are currently being approached where the simple systems are being synthesized. The consequent followthrough will be to synthesize the more complex and functional systems. Call it nanoscience, call it nanotechnology. As an allegory it is a huge "pond" covering chemistry, materials, engineering, condensed matter physics and molecular biology, where the ripple effects can have big impacts.

Actually, it is a "pond" where there is not much expertise accrued as of this time, so the best way to go about it is to get the smartest young people around at MANA, hopefully making sure that they do not drown (or as the case may be blow up or even capsize the boat) but other than that as long as they are offered stability probably "let them go for a swim" and go about things freely.

Linking R&D to the future: A wide-ranging/ 3D system

Q: Linking R&D into innovation is especially important for future nanotech research. How best can research results be linked into innovation and practical use?

Research results would need to attract interest, be open while being able to keep a rein on them, but being someone who was interested in becoming a graphic designer, I think there needs to be freedom to do "one's own" stuff. The best results are those playing to the researcher's own expertise. It should be from a setting of a university, mainly founded in teaching, not be of obvious value to industry.

I am concerned with the pressure these days for young researchers to do work in the area of strategic rather than fundamental science. The pressure, these can dampen enthusiasm, threaten the chances of a breakthrough occurring by pressing work on people who are not keen to do so. In fact, pressure can be downright dangerous. Young researchers should be offered stability, not offered carrots for "producing results" as measured from commercial standpoints and whipped for not. Therefore, I am quite bothered by this "cash nexus" thinking. I am thus not interested in patents, for example.

Q: MANA expends much effort to nurture young researchers, as was the case under ICYS. To further this thrust, the "Double Mentor, Double Affiliation, Double Discipline" (3D) system has been adopted. How can the creativity of young scientists be "drawn out" upon human resources development?**

I'm not quite sure how to promote good science. But as long as it is not too prescriptive, I see 3D to be a good idea, to have at least two mentors from differing disciplines and being able to experience two organizations, hopefully it is enough to capitalize on the creativity availed by the situation. It might be that the totally unexpected can be found by participating in the MANA system.

Obviously the researchers are adults, but to draw out creativity of the young scientists, I would say "treat them like children in a playroom, to explore and learn freely, and one out of five can give MANA something 'valuable'"; by no means should the young scientists be made to feel uncomfortable. In fact, I believe young people should be going more to cafes (drink coffee, tea and even other types of beverages should the occasion be fitting) in order to do "good science" since they can think, confer and exchange ideas in comfort. Ideas catalyze action. So for more action, let them interact more!

World-level can be attained by traveling the world, experiencing the "Melting Pot"

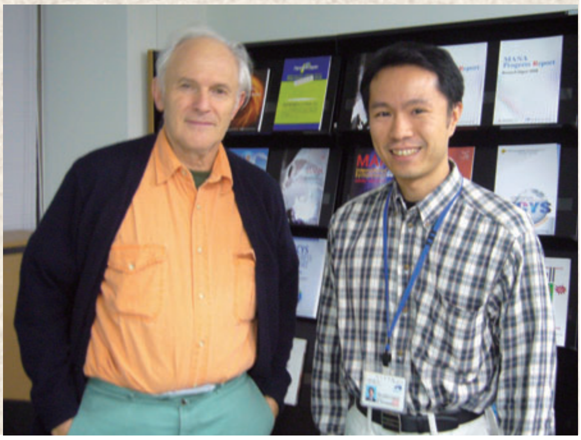
Q: To produce young world-level researchers, it is essential that they study abroad. Yet, many Japanese youths these days apparently prefer not to go overseas to study. What action plan would you suggest in order to inculcate young Japanese with a more international perspective?

These days, it is vital for people to go abroad, if one wants to learn of and from other people. I think in case of young Japanese researchers, they need to be acclimated to the English language early on. Things have changed since I first came to Japan in 1979, but the culture is less of a problem now. It is likely the apprehensiveness regarding the language skills that are acting as a barrier for young Japanese not wanting to study overseas.

In my case I spend a few years in Canada and then at Bell Telephone Laboratories, Inc. in the U.S., and traveled extensively. But I had the "security of mind" knowing that I could stay on or return to the U.K. to become a professor, which I am happy doing now, or become a graphics person, which I would have become should after my first five years teaching I wanted to quit and re-enter school to study graphic design. I think this may not be the case for young Japanese scientists, there appears to be much pressure on them. Then again, these days gaining a grant from the National Science Foundation is tremendous pressure as well...

*WPI Program: World Premiere International Research Center Initiative. A term-limited research program in Japan launched by MEXT, aimed at building highly visible, world-class research centers that attract top researchers from around the world.

**ICYS: International Center for Young Scientists. A NIMS research center which gathers talented young researchers internationally to conduct independent research in a "melting pot" environment, mixing different research fields and cultures.



One-to-one discussion between Mentor Harry Kroto (left) and MANA Independent Scientist, Jun Nakanishi (right).

Photocatalysis technology saves the world

Jinhua YE

- Principal Investigator
  (Managing Director, Photocatalytic Materials Center)
- Specialty: Photocatalytic materials
- Academic degree: Ph.D., University of Tokyo (1990)

Embodying the excitement of reading SF in Japan

——What were your motives for becoming a scientist, and what were the reasons for choosing Japan as the place to work?

I have always loved reading science fiction, not the stories about aliens but those illustrating true natural phenomena, such as "Altered state of consciousness." When I was in elementary school, I read a science fiction story about a scientist building a castle of man-made diamonds, and I really enjoyed it. Carbon and diamonds have the same composition but not the same properties because the atoms are arranged differently. This made a strong impression on me and I wanted to be involved in related work. Another reason was that, being Chinese, I had studied the history of the Cultural Revolution* and political upheaval and I believed that science and technology should be little affected by politics and would always be needed. So I chose science.

I had hoped to do research in Japan because when I arrived here, in 1984, Japan was a world leader and highly admired. I passed the exam for a government-financed overseas study program and entered the University of Tokyo. I mainly studied crystal structures and material properties and then shape memory alloys and superconducting materials. Eleven years ago, my coworker in superconducting materials studies moved on to photocatalysts, and I have been deeply involved in photocatalysts ever since.

——There are few female researchers in Japan, and they are sometimes treated differently than their male counterparts. Have you experienced any difficulties?

I have not been strongly aware of being a woman. In China, it is natural for both men and women to have a working life and make social contributions. When both husbands and wives have jobs, the husbands tend to be kind to the women at their workplace. It is natural to spend little of their time with coworkers involved in childcare or elder care. They understand that such circumstances come to all people.

On the other hand, workplaces in Japan are like "battlefields," and the attitude towards working women can be very difficult. I especially had some difficulty when my child was little. When I had to travel to remote regions in Japan and oversea countries for conferences, finding a person to take care of my baby was a big issue because our parents and relatives were not in Japan. I somehow managed the situation by asking for help from friends and hiring part-time babysitters. At this point, I feel that my being a working mother was not detrimental to my child but, in fact, had a good effect on her upbringing.

Dream technology for solving environmental and resource issues

——What were the most impressive events in your research life?

There are several. One was during my doctoral course when I revealed the crystalline structure of an unknown material that I had synthesized. For example, the X-ray pattern of a substance can be calculated if its crystalline structure is known, but the crystalline structure cannot be determined from X-ray patterns. Thus, I had to construct model after model and repeat the calculations. After several stressful weeks, everything was suddenly solved at once. I will never forget that moment.

I was also very happy when a paper of mine was published in "Nature" in 2001 although it was under joint names. Also, when I was in my thirties, I raised research funds totaling 200 million yen from outside. It made my efforts worthwhile. Reviewing my life, if there is anything that I missed, it would perhaps be simply enjoying life because I have been too busy (smile). Research is limitless, and study will never end.

——Finally, what dreams do you have about studies on photocatalysts?

Widely known and implemented photocatalysts** are those used for purifiers with low environmental impact. But they do not function unless irradiated by ultraviolet rays, which comprises only a small portion of solar rays. We are now developing new materials that can also use visible light such as that emitted by fluorescent lamps. When completed, it will no longer be a dream to save the earth with them. If we can produce hydrogen from water by using natural light, we would be able to obtain an inexhaustible supply of energy. In our laboratory, we are at the stage of improving the efficiency of hydrogen production.

Global warming is another issue. By using photocatalyst materials, collected carbon dioxide can be converted into other materials and reused. Converting carbon dioxide into methanol, methane and other chemical resources will help solve not only global warming but also the energy issue.

Photocatalytic materials have huge potential. As part of a long-term project now underway at MANA, we are conducting basic studies to understand what determines the efficiency of photocatalytic reactions, what should be controlled to sharply increase the efficiency, and so on.

*Cultural Revolution: The Cultural Revolution in China (late 1960s to early 1970s) was a movement aimed at creating a new socialist culture in opposition to feudalism and capitalism. Although it started as a general revolution, it developed into extreme violence against entrepreneurs and intellectuals.

**Photocatalyst: Photocatalytic material can purify the environment due to their strong oxidation power when the surface is irradiated by solar rays or fluorescent light, which removes contacting toxins such as organic contaminants and bacteria. Principal functions include air purification, deodorization, water purification, antibacterial performance, and self-cleaning.

Internationalization of MANA

Research support provided in English as lingua franca

Melting Pot Café

On the fifth floor of the MANA Building is a cafeteria called the Melting Pot Café, where there are always researchers relaxing and chatting.

One afternoon, a group of young researchers were having a chat and enjoying their coffee. They were American, British, Indian, Italian, Swedish, and Japanese, creating a global atmosphere. Various languages were spoken, but the common language was English. Let's listen to them for a while.

"This institute is well equipped, which makes it easy to do my research." (Sweden)

"The leader is wonderful and very patient when giving advice." (UK)

"I can devote all my time to research, free from other duties." (Japan)

"I'm glad that everyone at MANA speaks English." (USA)

"I learn something new every day." (Italy, female)

"I'm often surprised by differences in culture, but it's fun to learn about them." (India)

The International Center for Materials Nanoarchitectonics (MANA) consists mainly of principal investigators (PI), young scientists (MANA Scientists), postdoctoral fellows, graduate students, and independent scientists (MANA Independent Scientists) and super-postdoctoral fellows (ICYS-MANA Researchers), who have their own research themes. The total number of members in MANA and its seven satellite institutes in and outside Japan exceeds 200, of which over half are non-Japanese. Over 120 researchers visit MANA every year as lecturers at seminars and symposiums, outside coworkers of MANA researchers, internship students from all over the world, graduate students of the cooperative graduate school, mentors living abroad, etc.

The MANA Office and the secretaries of principal investigators are in charge of office work in English, which is the common language at the institute. Accompanying families receive assistance in matters such as finding hospitals, childcare facilities, schools, and residences, and other necessary information through the support system of NIMS.

Bilingualism

After the NIMS International Center for Young Scientists Project was launched in 2003, information about NIMS has been provided in both Japanese and English. All systems at NIMS are in principle provided in both Japanese and English. Smoother communication is a priority issue, and a full-scale English training program for all NIMS office members, which involves correspondence courses with schooling and overseas training, was the first step toward making English the common language.

For researchers from abroad, there is a guidebook in both English and Japanese that covers the necessary items for working at NIMS, including useful information about coming to Japan, starting work at NIMS, conducting research, and leaving NIMS. The guidebook is revised about once a year.

Orientation

A laboratory tour is held every month using the guidebook. Newcomers are required to join, and there are 15 to 20 participants every time. During the tour, explanations are given on laboratory safety control, use of common facilities, processing of study results (papers, patents, references, etc.), working hours, work-related accidents, vacations, paydays, taxes, pensions, research-related insurance, process for purchasing goods, etc. The tour provides a good opportunity for researchers to understand the entire scale and atmosphere of NIMS.

Research support system

For use of the common experimental facilities of MANA, training and support are also available in English. Senior members, who have a detailed knowledge of the research environment of NIMS, are ready to provide advice on conducting experiments and raising funds.

Japanese language and culture classes

Japanese language classes are offered for non-Japanese-speaking researchers. Cultural events are also frequently held providing the opportunity to experience Japanese traditional culture such as ikebana and Japanese tea ceremony.

Settlement of disputes

Differences in culture and custom sometimes cause friction, but most disputes are attributable to individual characteristics and an "ignorance of the world." Respecting each other is the basis for avoiding and settling disputes, and a consistent attitude towards reconciliation is also important.

(Akio Etori)

Melting Pot Café where researchers from all parts of the world gather to chat

Laboratory tour given in English

Multi-color electronic paper

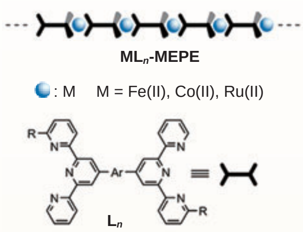
Masayoshi HIGUCHI
樋口 昌芳
Independent Scintiest

Electronic paper is attracting attention as a novel display that will supersede today's liquid-crystal, plasma and organic electro-luminescent (EL) displays. Unlike conventional displays, the image on electronic paper remains even after the power is switched off, and so electronic paper is expected to be a resource- and energy-saving display that will replace paper media such as newspapers. The electronic paper existing today is monochrome (black and white), and efforts are underway to develop color electronic paper.

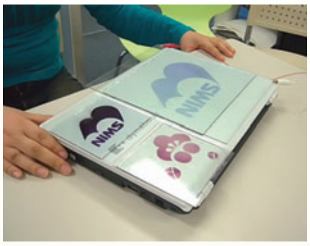
Tungsten oxide and electric conductive polymers have electrochromic properties and change color by electrochemical oxidation and reduction. Color electronic paper is expected to be produced by developing suitable electrochromic materials for electronic paper.

We have developed a novel eletrochromic material (organic-metal hybrid polymer) that is highly stable and capable of displaying various colors. The polymer is a macromolecular complex of metal ions and organic ligands and develops color by metal-to-ligand charge transfer (MLCT) absorption. We discovered that the polymer gained and lost color in response to electric potential (electrochromic phenomenon) when the polymer film was formed on a glass sheet installed with transparent electrodes and was oxidized and reduced electrochemically. Colorization and decolorization occurred below and above the oxidation-reduction potential of the metal ions in the polymer. We also discovered that three colors can be displayed by changing the voltage applied to a hybrid polymer consisting of a single polymer chain with two kinds of metal ion introduced.

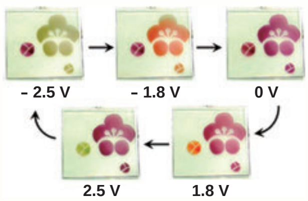
A display device, which was prepared using the polymer, displayed colors repetitively in a reversible manner with a voltage (3V) of two batteries. Studies on color electronic paper will be continued with a focus on the polymer.



Structure of the organic-metal hybrid polymer



Display device using the hybrid polymer



Changes in color by voltage change

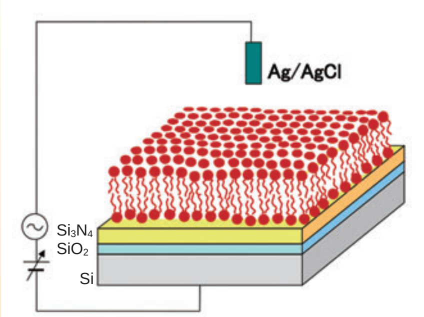
Self-assembled lipid bilayer-gate field effect device for detection of bio-molecules

Yuji MIYAHARA
宮原 裕二
Principal Investigator (PI)
Nano-Bio Field

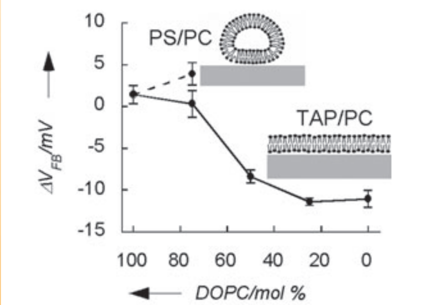
Recent rapid progress in nanotechnology and life sciences has clarified that various biological phenomena can be understood in relation to nanometer-scale events. Such a research in the field of nanobio-technology is expected to contribute to diverse fields, including medicine and drug development. We have been investigating nanobio-devices that can convert information in biomolecules or cells into electrochemical signals by chemically and physically controlling the nanostructures at solid-liquid interfaces. One of the advantages of such nanobio-devices is that target biomaterials can be easily detected without fluorescent labeling.

In general, field effect devices are fabricated with a dielectric film and a semiconductor substrate. Target biomolecules or cells are immobilized on the surface of the dielectric film, and a change in electrical charge on the film is detected as a change in conductivity or capacitance of the semiconductor. We have developed a device for detecting the electrical charge of biomolecules as a change in capacitance by forming lipid bilayers, which is a model of cell membrane, on a field effect device that has a $Si_3N_4/SiO_2/Si$ structure. Because the structure (thickness of only several nanometers), charge and composition of lipid bilayers can be precisely controlled, the devices should provide us with basic knowledge necessary for analyzing the detection principles of electrical phenomena that occur near lipid bilayers, such as charges of cell membrane and material transport by membrane proteins.

In this series of studies, we discovered that the responses of the device changed depending on the content of charged lipids and there were screening effects caused by salt concentration and charge effects of gate material surfaces. We will further investigate integration of biodevices with membrane proteins and cell membranes in order to understand the principles of operation of cell membrane devices and develop biodevices for analyzing membrane proteins.



Structure of a lipid bilayer-gate field effect device



Control and detection of lipid bilayer charge

Research

Novel laser based on Josephson effects of superconductivity

Xiao HU
胡 晓

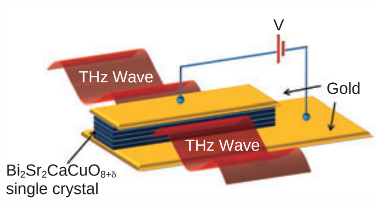
Principal Investigator (PI)
Nano-System Field

Terahertz (10^{12} Hertz, THz) electromagnetic (EM) wave is useful in many important applications such as DNA diagnosis, drag inspection, and observation on ultrafast dynamics of electrons in materials. However, strong and compact source of THz waves is not available so far.

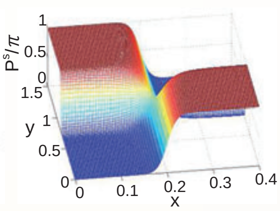
Josephson effects are associated with the quantum tunneling of Cooper pairs across the Superconductor/Insulator/Superconductor structure, called Josephson junction, which induce composite wave of the phase of superconductivity and EM oscillation. Based on this principle, a research team of Argonne National Lab of US and University of Tsukuba of Japan succeeded recently in stimulating strong monochromatic EM wave from a mesa structure of single crystal of high-T_c superconductor $Bi_2Sr_2CaCu_2O_8$.

This layered superconductor behaves in many aspects like a sequence of Josephson junctions stacked along its c axis with huge inductive coupling, since the stacking period is as small as 1.5 nanometer. Analyzing the coupled sine-Gordon equations as the mathematical model of the material, we have discovered a novel dynamic state of the superconductivity phase. Under the DC voltage bias, the system develops a π phase twist inside each junction when superconductivity phases are rotating overall, which provides a strong coupling between the standing wave of Josephson plasma and the driving current. When the bias voltage is tuned appropriately, a cavity resonance in the mesa of single crystal takes place with the amplitude of Josephson plasma enhanced greatly, which results in large dc current injection into the system and strong radiation of THz waves from the edge.

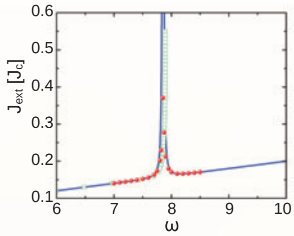
Our theory provides a consistent explanation on the experimental observations, and predicts that the optimal radiation power is larger than the observed value by orders of magnitude. These results reveal the possibility of a novel quantum source of EM wave based on a principle different from the conventional laser.



Schematic setup of the generator of terahertz electromagnetic wave based on the intrinsic Josephson junctions of high-T_c superconductor.



π superconductivity phase kink in a Josephson junction



Large supercurrent associated with the cavity resonance of the superconductor mesa.

Evolving mesoporous materials:

Creating metallic nanospaces using molecular templates

Yusuke YAMAUCHI
山内 悠輔

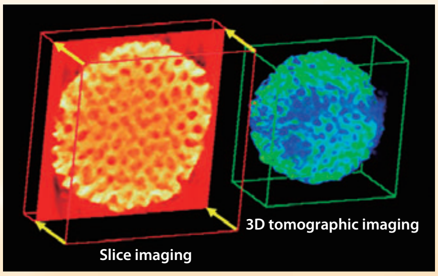
Independent Scientist

Mesoporous (nanoporous) materials have a number of minute menoscale (2 to 50 nm) pores. Mesoporous silicon dioxide (silica) can be easily synthesized by using surfactant micelles as templates. We are developing novel mesoporous materials that have metal frameworks by applying the concept of existing mesoporous material synthesis and using an electrochemical process to deposit metals around molecular assemblies.

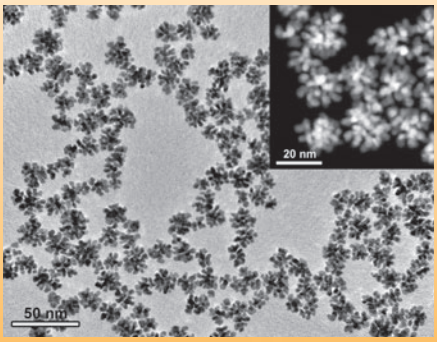
Mesoporous silica is silicon dioxide and so does not conduct electricity. On the other hand, mesoporous metals have high electric conductivity and can be used as electrodes, and so are promising materials for sensing and usage in batteries. As electrochemical reactions can take place on the entire exposed surface, which is large due to the many mesoscale pores, mesoporous metal electrodes are highly active and diffusive. Mesoporous metals can also be used to detect specific molecules by controlling the size of mesopores precisely so as to allow only molecules of a specific size to penetrate into the pores and react within the electrode.

Recently, we have proposed a solution process, which is a rapid method for synthesizing a large quantity of mesoporous metals, for the first time in the world. Platinum nanoparticles shaped like kompeito sugar candy were rapidly synthesized by reducing platinum ions within a dilute surfactant solution. Using the interactions between surfactant molecules and platinum, nanometer-scale irregularities were formed on the surface of platinum nanoparticles. The resultant surface area was over 55 m^2/g, which is the largest value for platinum nanoparticles ever reported. The nanoparticles were also found to be highly stable when heated.

Synthesis technologies for precise structural control are still under development, and it is necessary to fabricate more highly controlled mesoporous metals. Aiming to express functions that are directly attributable to the meso structures, basic studies on synthesis will be developed into actual feasible applications.



TEM tomography of mesoporous platinum



TEM image of *kompeito*-shaped platinum nanoparticles

News & Topics

MANA International Symposium 2010

The WPI Center for Material Nanoarchitectonics of MANA announces that it will hold an international symposium on Nanotechnology and Material Science for 3 days from March 3 (Wed.) to 5 (Fri.), 2010. In addition to invited talks by distinguished scientists from Japan and overseas, MANA researchers will be giving oral and poster presentations on their latest research findings. Everybody is welcome to attend (and admission is free).

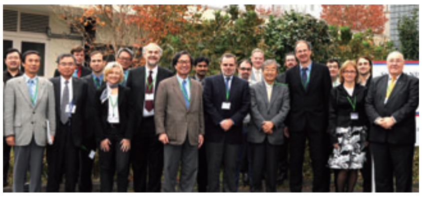
Date: March 3 (Wed.) to 5 (Fri.), 2010
Place: Tsukuba International Congress Center, Tsukuba Epochal, Tsukuba, Japan
For details, please visit the official website at:
http://www.nims.go.jp/mana_2010/

Osaka University–MANA Joint Symposium on Advanced Structural and Functional Materials Design

The Osaka University–MANA joint symposium was held on December 10, 2009 at the Suita Campus of Osaka University. The symposium was supported by the Global COE Program.

NIMS–WUT–EMPA Joint Workshop on Nanomaterials for Sustainable Development

The joint workshop among the National Institute for Material Science (NIMS), Warsaw University of Technology, Poland (WUT) and Swiss Federal Laboratories for Material Testing and Research, Switzerland (EMPA) was held at the NIMS Namiki Site on November 12 and 13, 2009.



MANA-URTV Joint Workshop on Nanostructured Materials for Sustainable Development

On October 13, 2009, the MANA–URTV (University of Rome Tor Vergata) Joint Workshop on Nanostructured Materials for Sustainable Development was held in Rome. A collaborative agreement between NIMS and URTV in the fields of polymeric fuel cells and nanotoxicology was concluded at the workshop.

Symposium on Frontiers in Nanotechnology and Materials 2009

The symposium, co-organized by MANA/NIMS and the Research Center for Advanced Science and Technology (RCAST) of the University of Tokyo, on Frontiers in Nanotechnology and Materials, was held on October 23, 2009 at the Okura Frontier Hotel Tsukuba. The symposium featured lectures by the world's leading scientists from Japan, the United States and Europe in addition to a special talk by Teruo Kishi, the Former President of NIMS.


Teruo Kishi, Former President of NIMS

Newly Appointed Researchers

Kazunori Takada
Principal Investigator (PI)
Rechargeable Battery Material Group
Specialty: Solid-state chemistry
January 2010

Eriko Watanabe
Independent Scientist
Specialty: Photosensing, Photoinformation Processing
From Japan Women's University
November 2009

Hidenori Noguchi
MANA Scientist
Nanointerface Group
Specialty: Surface (photo-) electrochemistry
From Hokkaido University
November 2009

Awards

Kohei Uosaki
Electrochemical Society (ECS)
ECS Fellow
October 5, 2009

Naoki Ohashi
American Ceramics Society
Richard M. Fulrath Awards
October 26, 2009

Kohsaku Kawakami
Japan Society of Calorimetry and Thermal Analysis (JSCTA)
JSCTA Award for Young Scientists
September 29, 2009

Jun Nakanishi
Japan Society for Analytical Chemistry
Award for Younger Researchers
September 25, 2009

CONVERGENCE No. 4, Eng. Ed., issued on February, 2010
Planning Team
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URL: http://www.nims.go.jp/mana/

"Convergence" is the keyword used to symbolically describe the entire project of MANA, where outstanding researchers from around the world assemble and converge in the "melting pot" research environment to bring together key technologies into nanoarchitechtonics for the creation and innovation of new functional materials.