Events

A Commemorative Ceremony for the Completion of NanoGREEN/WPI-MANA Building

On July 5, a commemorative ceremony for the completion of the new NanoGREEN/WPI-MANA building at Namiki site, NIMS, was held with over 150 attendees, including 116 guests. The ceremony began with an opening address by Dr. Suketatsu Ushioda, NIMS President. Then four guests, Dr. Ken-ichi Ishihara (the mayor of Tsukuba city), Mr. Koichi Morimoto (Deputy Director-General of the Research Promotion Bureau, METI), Dr. Tareq Kesh (Chair of Executive Board, Tsukuba Innovation Arena), and Prof. Toshihisa Kuroki (Director of WPI Program), made congratulatory speeches. They encouraged the researchers at MANA to express their great expectations that further promotion of fusion research will produce innovative results in various fields.

The 8th MANA-Cambridge/UCL-UCLA Nanotechnology Summer School

The 8th MANA-Cambridge/UCL-UCLA Nanotechnology Students’ Summer School was held at MANA, from August 27 to 31. The 19 participating students from MANA/NIMS, University of Cambridge, University College London, and UCLA were divided into three teams, where they became “agents” who should tackle the “Mission Impossible: Promoting ignorance, awareness, and crazy ideas” received from the instructors. The students spent much time for group work to execute the mission through active discussion and presented a mission report on the last day of the school.

MANA 5th Anniversary Memorial Symposium

On October 3, MANA’s 5th Anniversary Memorial Symposium was held with a total of 257 attendees to commemorate the five years since MANA’s inception. The Symposium started with a welcome address by NIMS President Dr. Suketatsu Ushioda and continued with three congratulatory speeches by Prof. Toshio Kuroki (WPI Program Director), Prof. Gunzi Saito (WPI Program Officer) and Prof. Sir Mark Welland (MANA Satellite PI at University of Cambridge).

Subsequently, MANA Director-General Dr. Masakazu Aono spoke about “Five-year journey and future challenges of MANA” and Prof. Yoshinori Tokura from University of Tokyo gave a special lecture entitled “Emergent electromagnetic phenomena in solids.” The later part of the program was entitled “Our Future Challenge in MANA” and consisted of eight oral presentations by the MANA researchers.

Newly Appointed Researchers

Dr. Li Hua Tong
Dr. Hui Li
Dr. Xuefeng Zhang
Dr. Shengliang Qu
Dr. Xiaohua Wang
Dr. Haojie Tan
Prof. Dr. Pingping Shi
Dr. Ying Wang

Awards

Received the Tsukuba Encouragement Prize

Dr. Yusuke Yamauchi, MANA Independent Scientist, received the Tsukuba Encouragement Prize from the Science and Technology Promotion Foundation of Ibaraki On July 29. The prize is awarded to young researchers living in Ibaraki Prefecture who have great potential for producing remarkable results in science and technology. The prize was given to Dr. Yamauchi for his marked work on “Toward effective utilization for rare metals: Development of new nanomolecular metals.”

Visitors

Deputy Minister of the National Science Council, Taiwan, Visited MANA

Prof. Chung-Yuan MOU, Deputy Minister of the National Science Council, Taiwan, visited NIMS on September 5, 2012. Prof. MOU received a MANA overview presentation by Dr. Takeda Fujita, MANA Administrative Director, and had a tour of laboratories in the WPI-MANA building. Prof. MOU is an expert of nano-materials science, in particular biomedical applications. He was actively involved in discussions with researchers at MANA.

CONVERGENCE

Researchers at the Forefront of Safeguarding the Earth and Society

— Kazuhito HASHIMOTO

There is No Room at the Bottom

James K. Gimzewski

Outreach Activities to Increase Public Interest

MANA’s Research Outcome

17β-Estradiol Polysaccharide Conjugates for Cardiovascular Therapies
— Françoise M. Winnik

Atomic-Scale Design of Novel Nanomaterials for Fuel Cell Electrodes
— Satoshi TOMINAKA

Toward the realization of artificial photosynthesis: Carbon Dioxide Reduction and Fuel Production by Oxide Photocatalysts
— Jinhua YE

Oxygen Diffusion in Perovskite Oxides
— Ken WATANABE
There is no doubt that usefulness is one of the key points. However, there are a number of obstacles to overcome before new materials reach practical application, something I learned ... this may sound slightly overstated but I would like to stress the importance of recognizing the ‘sense of crisis’ we face with our current situation, and the differences between the 20th and 21st centuries. Our globe has been rapidly changing in the past 100 years. I would like young researchers to be more aware of the changes that have taken place in the direction of scientific research and the role which scientists need to fill in today’s world. In the 20th century people simply could believe that development in science and technology would lead to greater happiness for mankind, and that society and the economy would maintain steady growth. It was an era when individual efforts contributed to the overall social welfare of people. The 21st century, however, has a completely different outlook. People no longer naively believe that development in science and technology leads to greater happiness for mankind, and that society and the economy will maintain steady growth. It was an era when individual efforts contributed to the overall social welfare of people.

The 21st century, however, has been closely linked in the mind of the public to biotechnology, information technology, and nuclear power. These have been developed for the benefit of mankind, and people believe that the future will be better if scientific research is carried out. Nevertheless, we must recognize that this is quite dangerous. The public is constantly on the lookout for new scientific research and how it will benefit mankind. If we are not careful, the public will not trust scientific research. In this context, we must be careful to ensure that the public will trust scientific research.

Kazuhito HASHIMOTO

After graduating from the Graduate School of Science, University of Tokyo (UT) in 1980, Mr. Hashimoto (D.Sc.) joined the Department of Applied Chemistry, UT in 1989 before assuming an associate professor in 1991. Dr. Hashimoto became a full professor at the Research Center for Advanced Science and Technology, UT in 1997, and served as a director from 2004 to 2007. He has been a professor at the Department of Applied Chemistry, UT since 2007. Dr. Hashimoto has been actively involved in the chemical investigation and design of interdisciplinary projects that include: Photofunctionalized Material Project sponsored by Korea Academy of Science and Technology (1993-1999), EPRI Project on Light Energy Conversion Project of the Japan Society and Technology Agency (2007-2012), NEDO Project to Create Photocatalytic Industry for Recyclophilic Society (2007-2012), and NEDO Microbial Catalyst-based Power Generation Wastewater Treatment Project (2012-2012). His interests revolve around the design, creation, and industrial use of new photo-functionalized materials, and cover a wide range of areas from semiconductor photocatalysis, organic thin-film solar cells, molecular-based magnetic materials, and molecular electrochemistry. Dr. Hashimoto has been awarded a number of prizes that include the following: IBM Japan Science Prize (1997), Prime Minister’s Award for industry-academic-government collaboration, Nikkei Earth Environmental Technical Prize (2004), Imperial Invention Prize, Yamazaki-Tsukita Prize (2006), and Chemical Society of Japan Award (2012). He is currently a member of the Science Council of Japan, MITI Industrial Structural Council, MEXT Council for Science and Technology, and MEXT Evaluation Committee.
There is No Room at the Bottom

James K. Gimzewski
MANA Satellite Principal Investigator, Nano-Materials Field
UCLA

There is no room for doing incremental research in today's world. Some 20-30 years ago there were relatively few scientists and it was an elitist community. Today we have too many young scientists. The education system has produced a glut of specialists with a narrow focus also in their later research. However, the basic idea of that system is antiquated being based on 19th century values which were appropriate for the industrial revolution and where knowledge was stored in libraries accessible to a few. Today's world is one of cheap human wave work forces as China aggressively expands and exports products on the international marketplace in its seemingly never ending quest to dominate global consumer markets. Additionally, in the USA, Japan and Germany robots, computers and advanced communication systems have replaced the majority of blue collar jobs while their companies ship many operations and activities overseas. This trend will continue rendering our societies in a new territory where the inequality of rich and poor will expand even further and unemployment will continuously increase.

In history over the past three centuries humankind has experienced revolutions driven by one essential thing: the innovative capabilities of the human mind. Innovation created the industrial, chemical, electrical and information-technology-communication, and some may say social revolutions. There are, what some have termed, singularities in the timeline of technology advancement evidenced by inspecting a graph of GDP growth with time. While one may be tempted to ascribe a specific invention, such as the computer or printing press, to the two singularities characterized by a dramatic change in slope around 1700 and again around 1950, it has been argued and quite convincingly that the mass availability of new communications systems (books and computers) enabled humans to innovate diverse new ranges of products and so create a criticality in their society. The washing machine, the walkman and so on result from emergent critically originating from Nikola Tesla genius innovations to transport and use electricity for useful tasks.

We need therefore to create new, not incremental, innovation that may create a societal and technology driven revolution. That to me is the underlying core of the MANA grand challenge. Innovation means top thinking and top working using creativity to its highest potential. There is no room at the bottom, none, for mediocre incremental research. Publishing another paper on some boring dry dead subject is the bottom. There is no room at the bottom in MANA but there is plenty of room at the bottom on the street.

There is a lot of room for mistakes along the path. Only through mistakes can innovation occur. Learning is through mistakes. This is essentially how the mind works and creates. Without mistakes mental stagnation sets in. Another essential ingredient of innovation is to aim high and to pick a challenge that may seem impossible at the time. Aim for the sky and take a risk. One can only take on such a challenge with a strong heart as well as a strong mind. A samurai spirit is needed and a sword that can cut through obstacles on the way. It's necessary to destroy old thoughts and ways on the path to innovation. Without change and breaking established paths can new ideas succeed in being realized. The final and underlying pillar of innovation is absolute unrelenting intent and determination but tempered with a sensitivity and nimbleness to adapt to the developing environment. The plasticity of the mind and its ability to adapt to its surroundings is an essential trait of intelligence.

I am known for my work on the scanning tunneling microscope yet I have taken on a very different challenge. I want to create a machine that thinks, a machine that possess physical intelligence. I want to create a machine designed to think, to solve operational and real world problems. Such a system does not exist and promises to cause a revolution one might call the post-human revolution. Such a machine cannot be created with the von Neumann architecture of CMOS. There is some evidence that emergent intelligence is occurring within the highly interconnected world wide web of social networks and that power law avalanches such as the Arab spring and stochastic behavior such as the non gaussian flash crash of the trading markets are inevitable consequences of slow driving in any highly interconnected network. MRI studies of the human brain also show similar behavior in their dynamics. Together with Aono-san we decided that the atom switch is the basis of an intelligent machine. In this ‘atomic brain’, the neuromorphic characteristics of long and short term memories have already been demonstrated. The next step is underway by using random networks of some billion synthetic synapses per square centimeter. We have discovered such systems exhibit power law dynamics, self-organized criticality, recurrent dynamics and memory.

Such a system has a resemblance to Alan Turing’s proposed unorganized machine also comprised of random interconnections of NAND gates. Yet in our experimental embodiments we have shown that our approach can result in an attractive material system.

In conclusion, we have shown the feasibility of creating a machine with senses exceeding ours endowed with a capacity to think that may well exceed the vast majority of the world’s people.

Outreach Activities to Increase Public Interest

Achieving wider recognition of the results of excellent research necessitates the appropriate information being provided to both the public and other experts. MANA is actively involved in various outreach programs in both the Japanese and English languages that include experts in materials science and other researchers, as well as the general public, including elementary school right through to college students. Websites, as well as paper based and other media are used to disseminate information, while events and seminars are held to promote interactive discussions. Below are some of MANA’s recent activities.

**Web-based Information Resources**

MANA’s latest research findings are reported in a timely manner via the on-line “MANA Research Highlight” series that aims at providing information on materials science to experts through out the world. Volume 3 of the on-line series, which was released on July 26th, 2012, highlighted “Bone tissue engineering: Attaching proteins for better regeneration.” In addition, some guest speakers’ presentations made at MANA International Symposium are also made accessible on-line via use of a special web streaming technique that simultaneously displays both a video of the speaker and the slides that their presentation involve.

**Publication Activities**

MANA was the first Japanese research institution to feature in a special issue of Advanced Materials, which was published on January 5th, 2012. Advanced Materials is one of the leading peer-reviewed journals that specializes in materials science. MANA also featured in an August 2011 special on-line issue of the international materials science journal, Science and Technology of Advanced Materials. Moreover, MANA publications that aim at lay people include the picture book Nima’s Adventure and the cartoon The Challenging Daily Life, both of which have earned very positive reputations.

**Educational Events**

MANA organizes a variety of educational events for junior and senior high school students that involve nanotechnology and materials science.

**Idea Contest “Challengers for the Future”**

Jointly sponsoring the event with the WPI-Advanced Institute for Materials Research (WPI-AIMR), MANA launched an idea contest for young students, in which the participants make suggestions on the possibilities of materials science.

**Summer Science Camp**

As part of the Summer Science Camp 2012, which was sponsored by the Japan Science and Technology Agency, MANA received 10 high school students chosen from across the country, who joined a 3 day program to enjoy hands-on experience with cutting-edge nanotech developments.

**WPI Research Center Joint Symposium**

A series of WPI Research Center Joint Symposiums, which first commenced in 2011, provides a wonderful opportunity for junior and senior high school students to directly interact with front-line scientists. This year MANA will host the symposium on November 24 in Tsukuba, Ibaraki.

Other activities include: a workshop at Science Agora 2010; Science Cafes “Melting Pot Club”; lectures by Nobel Prize laureates; a booth presentation at the Science and Technology Fest held in Kyoto; a joint presentation by the six WPI research centers at the 2012 AAAS Annual Meeting held in Vancouver; and MANA International Symposium. MANA aims to promote public interest in scientific research through the abovementioned outreach programs.
17β-Estradiol Polysaccharide Conjugates for Cardiovascular Therapies

The steroidal hormone 17β-estradiol (E2) has been studied extensively in the context of cardiovascular therapy, ever since it was reported to exert beneficial effects on cardiovascular diseases. The foremost role of E2 is to regulate sex-related processes via estrogen receptors (ER) located in the cell nucleus. This genomic action of E2 takes place over periods of a few days to a few weeks. The effects of E2 in cardiovascular processes are believed to occur much faster and be mediated by a small population of ERs located in the cell membrane, not in the nucleus (Figure A). For maximum cardiovascular beneficial effects, E2 must be able to interact with membrane-associated ERs without activating nuclear ERs. To achieve this goal, E2 was conjugated to chito-san phosphorylcholine (CH-PC), a non-toxic water-soluble membrane-mimetic biopolymer, known to support the growth of various cell lines, including endothelial progenitor cells. Thin films of CH-PC-E2 (Figure B) were prepared by spin casting aqueous CH-PC-E2 solutions on a hydrophilic silicon wafer. Angle-resolved XPS analysis of the dried films revealed a significant E2 enrichment of the topmost layer of the film (Figure B), attributed to the preferential migration of E2 towards the film/air interface upon drying (Figure C). To probe the location of E2 in CH-PC-E2 films exposed to aqueous media, films spin-coated on quartz crystals were rehydrated with a phosphate buffer saline (PBS) in a Quartz Crystal Microbalance with dissipation (QCM-D). The QCM-D signals recorded upon injection of PBS solutions (10 to 100 nM) and flushing with buffer indicated that ER was adsorbed permanently on CH-PC-E2 films. Overall, this study provides strong evidence that E2 conjugates are able to activate specifically non-genomic E2 pathways and are promising candidates for use in cardiovascular therapies.

Atomic-Size Design of Novel Nanomaterials for Fuel Cell Electrodes

Fuel cells are one of the important power sources for reducing carbon dioxide emissions, and in order to diffuse them widely highly-functional electrode materials need to be developed. Since their requisite properties are tough such as catalyst activity, large specific surface area, chemical and electrochemical stability, conductivity, and low cost, many researchers have been conducted all over the world. I have designed electrode materials at atomic scale, taking into consideration phenomena occurring at a different scale from atomic to micron scale. Moreover, by investigating the materials rationally, innovative devices and systems are also developed.

Herein, I introduce recent achievements on nanostructured electrode materials of titanium oxides, which are expected to be applicable not only to fuel cells but also to electrochemical industries. Titanium oxides are chemically stable, and some of their reduced phases exhibit high electrocatalytic activity. These properties promise reduced titanium oxides as promising alternative to carbon materials, which are not stable in fuel cell working conditions, but their surface area was not enough.

Recently, our research group succeeded in the synthesis of nanometrically reduced titanium oxides via a low-temperature reduction approach. The materials thus obtained were easily oxidized to rehydrate and their structure was determined to be corundum, which was known to be semiconductive. Through electron microscope analyses, atomic diffusion inside materials was found to be important for such conversion to metallic ones (Figure 4a).

The method can convert nanometrically reduced TiO₂, which have been synthesized by many groups, into highly functionalized materials with morphol- ogy retention, thus we believe that our approach is versatile and will be applied widely. For example, rod-shaped nanotubular TiO₂, which have been synthesized by many groups, into highly functionalized materials with morphol- ogy retention, thus we believe that our approach is versatile and will be applied widely.

The results strongly indicate their application as electrode materials alternative to precious metals.

For these applications as electrocatalysts, further research works are under investigation. Also, in order to acquire better understanding of conductive mechanism, detailed analyses on atomic structure and electronic structure will be reported soon.

Toward the Realization of Artificial Photosynthesis: Carbon Dioxide Reduction and Fuel Production by Oxidation Catalysts

Artificial photosynthesis, or the solar-powered process of producing oxygen and hydrocarbon fuels from water and carbon dioxide, could be the ultimate technological solution to the resource and environmental problems mankind faces, for example the energy shortage and global warming. Development of this new technology is part of WPI-MANA’s three grand challenges.

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Oxygen Diffusion in Perovskite Oxides

Perovskite oxides exhibit many kinds of electric property such as insulator, semiconductor, ionic conductor, mixed conductor (electron and ion). Due to its property, perovskite has been widely used as solid oxide fuel cell, photocatalysts, electronic surface and so on. In order to control such electric property of the perovskite oxides, the oxygen defect is one of the important factors. In this study, I focus on the oxygen tracer diffusion in perovskite oxides with an isotopic O²⁻ (mass number = 18), to evaluate the oxygen defect in solid. From those diffusion data, we can discuss about the oxygen defect in solid, because the oxygen diffusion in perovskite oxide can be attributed to an oxygen vacancy migration. Here, I’d like to show you the result of the oxygen diffusion behavior in BaTiO₃. Figure 1 shows the cross-sectional O²⁻ concentration map of the reduced BaTiO₃ ceramics by annealing at 1300°C. The O²⁻ concentration in the grains was almost constant. On the other hand, the O²⁻ concentration was drastically decreased around the grain boundary. Therefore, it was found that the grain boundary of the reduced BaTiO₃ acts as a blocking layer against the oxygen diffusion. In general, it is well known that "the grain boundary acts as the fast diffusion path for mass transport", because of its high-defect structure. However, the obtained findings in this study is precisely opposite result. In addition, it was found that the blocking behavior strongly depends on the diffusion temperature, reduction treatment. Furthermore, any impurity phase around the grain boundary was not observed by the element mapping, but the element mapping of the SIMS images (Figure 4b) suggests that the formation of the blocking layer is related to the local defect structure around the grain boundary and we need to reveal relationship between the local defect structure and its function, in order to discover a new function of the material.