CONVERGENCE

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International Center for Materials Nanoarchitectonics (MANA)

Akira TONOMURA

B.Sc. in Physics from University of Tokyo (1965), joined Central Research Laboratory of Hitachi, Ltd. (1965), Senior Researcher at Central Research Laboratory and Advanced Research Laboratory (1985), Research Director of "Electron Wavefront," a research project focusing on new technology (1989 to 1990), Fellow of Hitachi, Ltd. (1999 to present), Foreign Associate of U.S. National Academy of Sciences (2000), Group Director, Single Quantum Dynamics Research Group, Frontier Research System, RIKEN (2002 to present), President of Japanese Society of Microscopy (2003 to 2005), member of Japan Academy (2007). Holds doctorates in engineering and science.

At Hitachi, Ltd., Dr. Tonomura developed electron beam equipment and did related applied research. He studied electron beam energy loss and developed field emission electron guns for use in electron beam holography, then focused on electron beam holography using high-coherence electron beams from 1974 onward. He has produced a major body of work in the field of electron microscopy.

Question the fundamentals!

A willingness to accept challenges makes breakthroughs possible.

❖Interviewer: Akio Etori, NIMS publishing adviser

Giving young people the potential to create new things

Q: Dr. Tonomura, you are active in various aspects as a fellow at the Hitachi research labs and as a group leader at RIKEN. What is the present state of electron microscopy research in Japan?

Japan has become a leader in the development of electron microscopes by building a strong foundation in technology and applications, as well as the academic aspect. Dr. Sumio Iijima in carbon nanotubes, Dr. Yoshinori Fujiyoshi in biomolecules, Dr. Kunio Takayanagi at Tokyo Institute of Technology, Dr. Tsuneyoshi Kuroiwa at Rikkyo University, and others like them are Japan's unrivaled leaders in their fields. There simply aren't people overseas who have achieved comparable results. But all the leading people in Japan, including myself, are getting on in years. We'd like to bring new people to the fore, but circumstances have changed.

On the other hand, new waves are starting to impact electron microscopy. A new aberration correction that extends the present limits of resolution has been invented in Germany. Government projects in North America and Europe are making good use of this lens technology, and Japan has fallen behind somewhat.

Q: Earlier you said, "We'd like to bring new people to the fore, but circumstances have changed." What do you mean by that?

In the past, university professors also did development work. However, in today's Japan there is little enthusiasm for putting in the months and years of work needed to develop new equipment. Universities no longer offer courses in electron microscopy. Now the focus is on the latest computers, and no one is interested in making things any more.

Over the last two decades or so most research projects in Japan have had a term of five years. This means their results are evaluated after two or three years. In the past, University professors had access to discretionary funds, but not now. You must compete for funding or you can't do research. This makes things very difficult for someone like me who wants to do development work.

Q: Is a competitive approach to allocating research funding a bad idea?

It's not that competitive funding is bad. But it's hard to do development work unless you work in units of decades. It would be nice to have all the equipment you need and be able to produce results in just five years.… But you have to produce new basic technology, and unfortunately this requires sustained research over decades.

Q: Dr. Tonomura, you're one of the 30 leading Japanese scientists selected by the Funding Program for World-Leading Innovative R&D on Science and Technology, and you've started development work on atomic resolution holographic electron microscopes. What are the aims of this project?

We are developing a microscope that uses electron beam holography to achieve atomic resolution. In Japan, work on electron beam holography technology has been underway since 1989 under national projects, and we're world leaders in the field. Ultrahigh-voltage electron microscopes are another area where Japan is preeminent. We are building on the foundation of these two technologies and adding aberration correction technology to achieve world-class performance enabling observation of the world of atoms and molecules. In addition to providing tools that give a deeper understanding of natural principles, with these experiments we hope to deepen the possibilities for new theories that go beyond existing theories.

You can't achieve new things without developing new equipment. I want to give young people the potential to build such new equipment.

Young people require a willingness to accept challenges and plenty of energy

Q: Many young researchers possess the makings of truly outstanding scientists, but they often don't reach their full potential. Do they lack passion?

I suppose so. They seem satisfied with how things are. People overseas are doing revolutionary, completely amazing experiments. Last April I went to the United States to attend the National Academy of Sciences. At an international conference at Harvard University participants spoke of experiments to verify fundamental aspects of the general theory of relativity or to determine the mass of photons. The participants were all young, but it was very stimulating.

These days, Japanese people may be good at finding answers to questions they are given, but they're less interested in questioning the basics or trying something completely new. They should learn from the vitality and the eagerness to accept the challenge of achieving breakthroughs that we see overseas.

Q: That is a very valuable point. It seems that Japanese researchers are too focused on projects, but it is also important to create an environment of the sort you describe.

In my day, there were lots of people doing interesting things in physics with electron microscopes. It was that kinds of the environment, so I studied things like holography. Sometimes I was asked, "What's the use of that?" Nevertheless, everyone worked together on things, such as making samples that a small group couldn't accomplish on its own. Everyone had their own work to do, but we would help each other out because it was interesting. That sort of thing would not be possible today.

We need to train the new generation who will succeed us. Otherwise, what we built will have no purpose. So I want to build things that are good, things that are new and only being done in Japan. That's because once you build something, you can teach people how to modify it for different purposes. By developing equipment and also developing ways to train new people, I want to pass down the ultrahigh-voltage electron microscope technology we have created to those who follow.

Q: What policies would be good for making Japanese research more international?

To carve out new ideas, energy is needed in addition to passion. Japanese people have become too easygoing. To change the present situation, we need to invite stimulating, hard-working people from overseas to come and work with their Japanese colleagues. Overseas researchers will come to Japan if they think they can do good work here. Outstanding people have incentives to work overseas, so we must create an attractive environment here as well.

But it's hard to attract young people looking for permanent employment with fixed-term projects like we have here. In particular, people in their 30s and 40s tend to opt for safe choices.

Strategy for remaining a leader in Asia

Q: As a researcher, what are your views on Japan's future?

A great deal of money is being spent on science and technology. This is money the Japanese people have entrusted to us, and we must make good use of it in training younger researchers. Nowadays, it seems that young people are used as tools to produce short-term results. Results are given priority over young people's ambitions. If young people are forced to produce results quickly, they can't really develop as individuals and can only strive to follow others. We need to come up with ways to train researchers with the longer term in mind.

Q: In Japan today the general public's confidence in science itself seems low.

Yes, that's right. That's why we really need to convince the public of the value of science and technology. Vast sums of money are being spent, after all. For example, there needs to be more coverage in the newspapers and mass media. That's why we need to take on exciting new challenges. We need to think of ways to achieve leadership, by considering the circumstances, making a strategy, and holding our own in Asia at least.

That's why I hope that MANA will continue to produce world-class research results and heighten the value of its presence.

——Thank you very much.

Photo taken at the symposium "Fundamentals and New Technologies in Quantum Mechanics" held at Hitachi Central Research Laboratory in August1983. From left, Dr. C. N. Yang, Dr. Y. Aharonov, and Dr. Tonomura.

MANA-UCLA partnership to shape future nanotech

James K. GIMZEWSKI
• Distinguished Professor, UCLA
• Director,
CNSI Nano & Pico Characterization Core Facility

We at MANA asked Dr. Gimzewski about future research objectives and his endeavors at the University of California, Los Angels (UCLA) lab, one of MANA's Satellite Operations.

Promising collaborative efforts

——What are your research objectives for the future?

I am involved in the nanotech field, since I wish to have my research have a great impact on society. I look to find something that changes our world in a dramatic, positive manner. Although it is not yet clear what such an impact will be, I hope to see medical applications of nanotech gain wide acceptance. As such, I am collaborating closely with the medical school at UCLA.

With this collaboration, I am working to help detect illnesses in addition to quantifying the results of joint research involving human health. There is nanocharacterization work ongoing, and it is expected that the results will be applied to clinical settings in the not-so-distant future. Actually, we are also developing a new computer that simulates the action of the brain and the neurons, which could help augment the human brain when it should be necessary, but more about this later on.

Looking at the research status today, there are many technological advances taking place in relation to the medical profession, such as those involving microscopy techniques. However, despite such improvements that could mean changes in mechanical properties as regards small-scale tools, there is a need to expand the medical applications to include diagnostics, working closely with pathologists for example.

Being able to grasp the "softness" of cells could go a long way to finding problems related to metastasis with a much higher accuracy than is currently possible. This is why working with a big medical school like that at UCLA is of vital importance.

Although it is at an early stage, such joint activities could lead to a combination of diagnostics and therapy (call it "theranostics") which can be realized, based upon information exchange and cooperation between medical doctors and physical scientists who may have differing perspectives but can as a team understand the mechanisms involved.

MANA Brain, nanoparticles foci

——What kind of research is the UCLA lab conducting?

We have two main foci, one of which is the computer simulating the action of the brain and the neurons that I mentioned earlier. It is dubbed the MANA Brain, an artificial synaptic connection network. It is based on Dr. Masakazu Aono's atom-switch technology in combination with technology I developed for patterning materials; unlike conventional switches, the Aono switch is based on ion use rather than on use of electrons.

In a nutshell, it has the capability to "memorize"— to keep the information over a long term, after carrying out many short-term activities that help build up the "memory" thereto. It will behave as a network, like the human brain with learning capability, constituting a multistate "neuromorphic" system, where some connections can be stronger or weaker, as is the case for a neuronal synapse. An alternate form of computation can be realized in such a manner.

The issue to be cleared yet is potentiation and how to "wire up" the system. It is obviously not simple to wire up synapses, since we wish to make sure "neuroplasticity" is realized by the system like in the human brain. It could perhaps help patients suffering from ailments related to the brain. The MANA Brain could plausibly replace neurons, even cure Alzheimer's disease.

The MANA Brain will have a fractal circuit and a dendritic nature, generating a system without the need for programming since it will be "self-learning"; it may even come close to emulating the human consciousness in the future.

——You mentioned two foci at the UCLA lab.

Yes, the other focus at our lab, this being the first time MEXT has funded a project with such close collaboration (including lab space!), involves very small crystals that can generate X-rays.

I want to make an array of atomic-size X-ray sources for use in different kinds of microscopy with said very small crystals. I am also involved with CNSI, standing for the California NanoSystems Institute, and thus working on very small things in general. Dealing with entropy is the big issue here, so we aim to surmount such effects on things very small.

——What message would you like to give to young researchers in this field?

I would dare say the future is almost totally dependent on young Japanese researchers, since this is where a radical shift in tech is needed. Our planet requires an alternate approach, something that can alleviate the von Neumann bottleneck. Nanotechnology is the most important thing on Planet Earth, in terms of sustainability.

Young researchers have a great marvelous opportunity, through inspiration, creativity, imagination and innovation to change the outlook. I believe we are at a crucial point in our history, and we need young people to view the big picture while altering the situation from the nanometer level.

Dr. Gimzewski has led the research field concerning mechanical and electrical contacts with single atoms and molecules using scanning tunneling microscopy (STM) since 1985, when he took images of molecules successfully using STM.
He has also been involved in projects such as those involving X-ray sources, direct deposition of carbon nanotubes and single-molecule DNA profiling.

Satellite Research

One element that is absolutely essential to the carrying out of research by MANA is satellite research.

There are 28 Principal Investigators (PIs) at MANA, and of these 8 are guest researchers affiliated with outside research institutions. Satellite offices are set up at the home institutions of these guest researchers.

Satellite institutions provide support for joint research in fields that cannot be covered by NIMS alone. The satellite PIs act as mentors to young researchers at MANA. It goes without saying that the satellites also serve as bases for disseminating and collecting information.

In this way, the satellite institutions act as a key element in MANA's research efforts. They enable MANA to function as a first-class facility for research work while functioning as advance bases enabling MANA to further extend its network of contacts.

At present MANA has a total of six satellite institutions, in Japan and overseas. They collaborate closely with MANA to advance innovative research related to nanotechnology.

University of California, Los Angeles (UCLA, U.S.A.)

Prof. James Gimzewski helped lay the groundwork for the nanoscience and nanotechnology of today through his work at the IBM research lab in Zurich, Switzerland. After moving to UCLA, he has done work on the fusion of nanotechnology and biotechnology while also pursuing highly original research in areas such as the creation of a desktop nuclear fusion device. His joint research with MANA deals with the use of nanomaterials to rewire the nerve cells in the brain, thereby creating artificial synapses .

MANA dispatches postdoctoral research fellows for extended stays at UCLA to engage in joint research.

Georgia Institute of Technology (GIT, U.S.A.)

Prof. Z. L. Wang's publications have been cited more than 15,000 times in the work of his colleagues, and he is considered to be one of the world's top researchers in the nanotechnology field. At this MANA satellite basic and fundamental research is underway on growing crystals from one-dimensional nanoscale materials, as nanomaterials with possible energy-related applications, observation of the growth of such crystals, and evaluation of their properties.

MANA dispatches individual research fellows to GIT to engage in joint research.

Cambridge University (United Kingdom)

Prof. Mark Welland is Head of the Nanoscience Centre at Cambridge and, in addition to being a world leader in the fields of nanoscience and nanotechnology, has served as science advisor to the British Prime Minister. While utilizing MANA's functions as an ecosystem, he has gone beyond these functions to conduct research on the creation of new substances and materials. Professor Welland has been conducting research at MANA with three graduate students since October 2008.

Centre National de la Recherche Scientifique (CNRS, France)

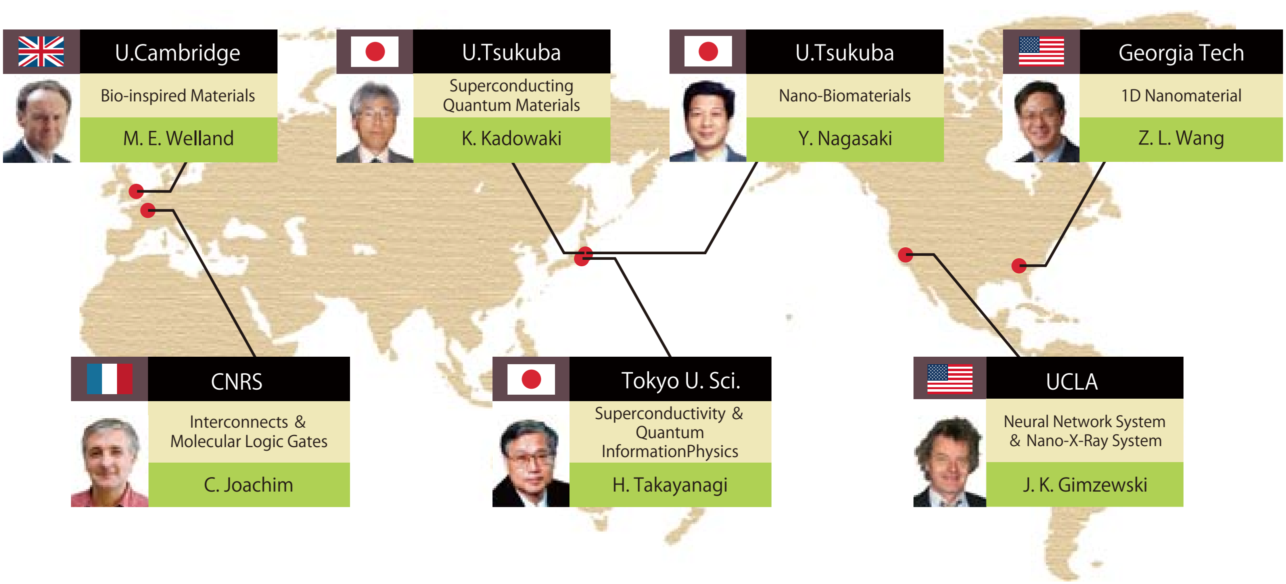
Prof. Christian Joachim is the world's leading authority on the explication of the state of electrons in nanostructures, in particular the state of electrons in functional molecules, by calculation from first principles, and he is passionate about the goal of making unimolecular devices a reality. In his joint research with MANA he is doing basic work in molecular logic gates and the magnetic properties of molecules with the aim of developing new materials for next-generation nanodevices and brain computers.

University of Tsukuba

Prof. Kazuo Kadowaki is known for his research on electronically correlated materials, in particular high-temperature superconductivity, and Prof. Yukio Nagasaki is famous for the development of nanobiofunctional materials using polymer synthesis technology as a basis. The University of Tsukuba and MANA are separated by only a short distance, and young researchers from both institutions frequently visit the two satellite research labs to engage in joint research.

Tokyo University of Science

With the participation of Prof. Hideaki Takayanagi, a top researcher in the field of superconducting devices, MANA provides a venue for integrated research by Tokyo University of Science and MANA personnel. Some of their most prominent work is on the use of nanotechnology to create new superconducting devices.



Hand-operated nanotechnology

Katsuhiko ARIGA
有賀 克彦
Principal Investigator (PI)
Nano-Materials Field

As a matter of fact, nanotechnology has already spread to a variety of areas. Hyperfine circuits, too small to be discernable by the unaided eye, are used in machinery, and nanomaterials are used in medicines. These are both products of nanotechnology. Nevertheless, in order for us truly to derive the benefits of nanotechnology, to hold nanotech in our hands, we must be able to manipulate the nano world ourselves. My colleagues and I are laying the basis for a new field, never seen before, that we call "hand-operated nanotechnology." I will describe a technology for grabbing molecules by using hand movements as one example of this.

In actuality, it is not normally possible simply to grab molecules using our hands, so we use the concept of "super" molecules. The concept of supermolecules means that aggregations of molecules exhibit behavior that far exceeds that of the individual constituent molecules. To make it possible to drive by hand molecules that open and close as shown in the figure, we form a supermolecule film with a thickness of only one molecule on the surface of the water. When the film is pinched by hand from the sides, the molecules that were open become closed in order to form a more compact structure. By using this molecular opening-closing behavior it is possible to grab the molecules in the water. In other words, by moving the film laterally by hand, we can, by means of the molecules in the film, capture or release other molecules that are our target. We have also successfully identified amino acid by using molecules to twist other molecules.

In a related area, we are also working to develop a compact system based on the assumption that it should be possible to create a freely stretchable film not only on the surface of water but in other places as well. If we do this it will be possible for everyone to use hand-operated nanotechnology in such applications as trapping or sensing poisons, administering drugs, and transmitting electrical signals via chemical substances. When this happens, nanotech will become a freely usable technology that is familiar to everyone, and we will be able to experience its true convenience.

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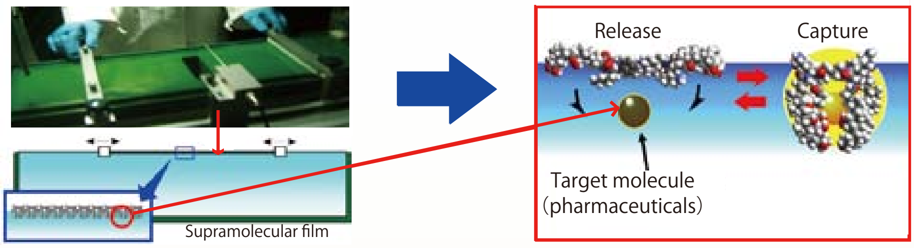
K. Ariga *et al. Adv Colloid Interface Sci*, 2010; **154**(1-2): 20-29.
K. Ariga *et al. Sci Technol Adv Mater*, 2008; **9**(1): 014109.



Visible-size motion
(compression & expansion)

Control a molecule's motion
(in the world of nanotechnology)

Tailoring materials and interfaces for regenerative medicine

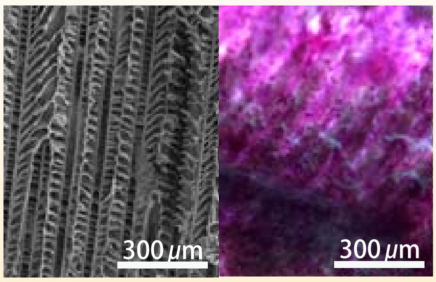
Enrico TRAVERSA
エンリコ・トラベルサ
Principal Investigator (PI)
Nano-Green Field

Tissue engineering and regenerative medicine represent a concrete alternative to face the growing demand for organ transplantation, which sometimes is the only possible treatment for rescuing patients. *In vitro* reconstruction of tissues might occur with a proper selection of the scaffold and cells, and of their interaction. The reconstruction of healthy thick tissues still remains one of the main problems of tissue engineering, due to the lack of blood vessels. If oxygen and nutrient perfusion, usually supported by bloodstream, is not provided, no more than three cell layers can grow *in vitro* without death.

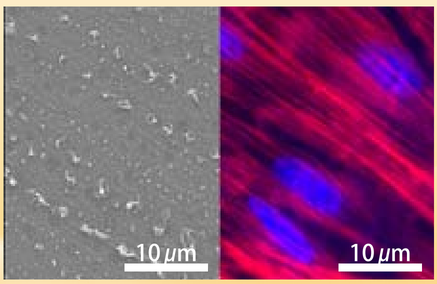
We were able to develop highly perfusive biodegradable scaffolds for thick soft tissue reconstruction. As shown in the figure, we prepared by directional thermally induced phase separation (dTIPS) 1 mm-thick 3D scaffolds made of poly-L-lactide (PLLA), a biodegradable polymer, with an overall porosity of 93% and an interconnectivity of 90%. After seeding with mesenchymal stem cells (MSCs), healthy, confluent tissues were reconstructed after 14 days *in vitro* static culture, exploiting the highly porous microstructure of the engineered scaffolds.

We also fabricated bio-supports aligning cerium oxide (CeO_2) nanoparticles within poly (lactic-co-glycolic acid) (PLGA) matrices, and compared to unfilled or titanium oxide (TiO_2) nanoparticle loaded PLGA films. Aligned growth of stem cells was observed only for scaffolds incorporating oriented ceramic nanoparticles (nuclei in blue and cytoskeleton in red). Improved stem cell proliferative activity was observed for CeO_2 nanocomposites, due to the antioxidative properties of nanostructured CeO_2. Stem cells were controlled to induce their aligned growth only by the oxide nanoparticles, showing that mechanical cues might be very important.

References
C. Mandoli *et al. Adv Funct Mater*, 2010; **20**(10): 1617-1624.
C. Mandoli *et al. Macromol Biosci*, 2010; **10**(2): 127-138.



Highly porous PLLA scaffolds made by dTIPS (left) and healthy, confluent MSC tissue reconstructed after 14 days *in vitro* (right).



Aligned CeO_2 nanoparticles within PLGA matrice (left) induced oriented stem cell growth (right) and improved cell proliferative activity.

Quantum mechanical simulation of redox reactions

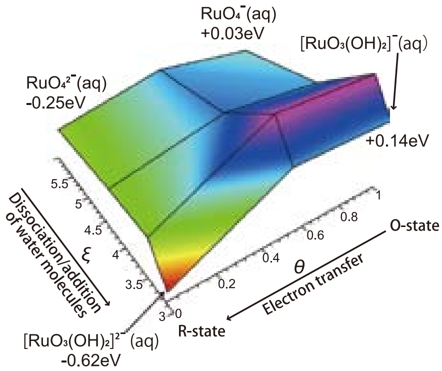
Yoshitaka TATEYAMA
館山　佳尚
Independent Scientist

Redox (reduction & oxidation) reaction plays a key role in many technologies for energy and environmental issues, such as photocatalysis, fuel cell and photovoltaic cell. It is defined as chemical reaction coupled to electron transfer process, which causes energy transfer, formation and dissolution of molecules. Important hydrogen evolution ($2H^+ + 2e^- \rightleftharpoons H_2$) and water dissociation ($O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$) are the representative examples. However, little known are the microscopic mechanisms on the electronic and atomic scale.

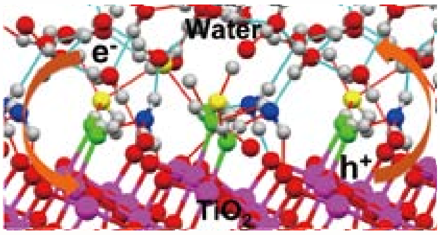
In order to elucidate such redox reactions in energy and environmental issues, accurate descriptions of the electron transfer process and the subsequent structural reorganization are essential. Then we have developed and demonstrated first-principles molecular dynamics techniques for free energies and reaction pathways of redox reactions, based on density functional theory (a quantum mechanical theory for many-electron systems). Our calculation techniques are found to be very universal and consistent with the famous Marcus theory of electron transfer. They allow us to elucidate the microscopic mechanisms of redox reactions in more detail.

Recently, we have been working to apply these techniques to redox reactions on solid/solution interfaces, which are the main reaction sites for catalysts and electric cells. Our calculations semi-quantitatively show the change of efficiency of interfacial redox reactions (ex. decomposition of organic species or water molecule), depending on the interfacial structure. With these computational techniques, theoretical design of interfacial redox reactions would be realized in future.

Reference
Y. Tateyama *et al. J Chem Phys*, 2007; **126**(20): 204506.



Free energy surface of water-splitting redox reaction ($RuO_4^- + H_2O + e^- \rightleftharpoons [RuO_3(OH)_2]^{2-}$) (Violet=high, Red=low)



Atomistic model of photocatalyst (titanium dioxide/water interface)

Self-propelled micro/nanobots

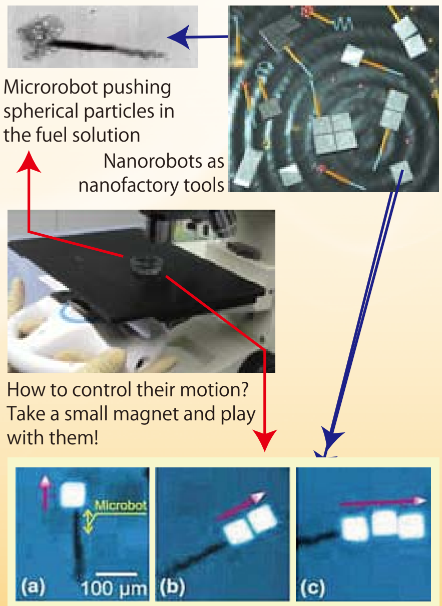
Samuel SÁNCHEZ
サミュエル・サンチェス
IFW Dresden
(ICYS-MANA Scientist)

A dream where one could fabricate nano-submarines by using nanotechnology tools is not-too-distant as we imagined some years ago. These nanorobots could be injected in the body, transport medicine in the human body, might someday be used as surgery tools, and detect and destroy toxic organic molecules in polluted water.

The dream of artificial nanomachines is to mimic fascinating examples of biological motors such as the rotary flagella propelling bacteria.

Recently, several approaches (cm-scale "boats", bimetallic nanowires and microtubes) succeeded on the catalytic conversion of chemicals (e.g. hydrogen peroxide) into kinetic energy (motion). The catalytic platinum contained in their structure decomposes H_2O_2 fuel into oxygen and water, and the bubbles of oxygen formed propel the nanomachines by recoil (similarly as rockets or submarines). Like some molecular motors into the cell, the artificial nanorobots are immersed in their own fuel.

By using nanotechnology techniques, we synthesized tubular structures (containing Ti/Fe/Pt thin films). The inner catalytic surface (Pt) serves as reaction chamber and gas-collecting cavity, thrusting a tail of oxygen gas. Like swimming bacteria, they move autonomously. We use the tubular microjets (microrobots) to develop tasks which require full control over their motion and high propulsion power. We achieved the selective loading of large number of polymeric particles as well as metallic nanoplates, their transport and delivery into specific targets. They are easily directed by an external magnetic field which allows selective manipulation of different microobjects randomly suspended in solution. By modifying the inside of the microrobot with biocatalytic molecules (e.g. enzymes), we could use different chemical fuels to power themselves and use them in biomedicine, energy conversion, environmental applications and other fields.



Microrobot pushing spherical particles in the fuel solution

Nanorobots as nanofactory tools

How to control their motion? Take a small magnet and play with them!

Microbot loading and transporting metallic nanoplates

Reference
A. A. Solovev *et al. submitted to Adv Funct Mater*, 2010.
DOI: 10.1002/adfm.200902376
S. Sanchez *et al. J Am Chem Soc*, 2010 in press.

MANA International Symposium Held

MANA International Symposium 2010 was held over three days, from March 3 to 5, 2010, at Tsukuba International Congress Center. Ten distinguished researchers from Japan and overseas, including Prof. M.R.S. Rao, President of the Jawaharlal Nehru Centre for Advanced Scientific Research in India, were invited to give presentations. There were also 28 oral presentations and 99 poster presentations highlighting the research findings of MANA projects and emphasizing their excellent progress. This was the third MANA International Symposium, and the attendance total of 351 exceeded of last year. Many lively discussions took place.

MANA Evaluation Committee

On March 5, 2010, the 2nd International Center for Materials Nanoarchitectonics Evaluation Committee meeting was held at the Tsukuba International Congress Center.

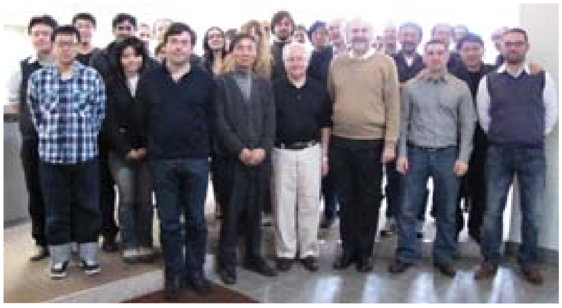
After the results of the three-day MANA International Symposium were announced, Cambridge University Prof. Anthony Cheetham, Chair of the Evaluation Committee, and others participated in an in-depth discussion of the previous action plan, collaboration with satellite institutions, and activities moving forward.

James Gimzewski on NHK TV Program

MANA Principal Investigator Prof. James Gimzewski was interviewed by NHK and the result was broadcast as part of the NHK television show "A Proposal for the Future: The Nanotech Revolution Will Change the World" on January 31 and February 4, 2010.

Hakone International Workshop :
Materials nanoarchitectonics for sustainable development

A workshop on "materials for health, environment, and energy" which enabled sustainable development was held in Gora, Hakone, from March 24 to 26, 2010. As a majority of researchers were from foreign countries, the research exchange among different fields was materialized. This workshop received support from a program for fostering personnel for advanced research of the Japan Society for the Promotion of Science.



Newly Appointed Researchers

Kohei UOSAKI
Principal Investigator
Nano Interface Group
Specialization:
Surface physical chemistry
From Hokkaido University
April 2010

Ryuichi ARAFUNE
Independent Scientist
Specialization:
Surface science
From University of Tokyo
April 2010

Satoshi TOMINAKA
MANA Researcher
Nano Interface Group
Specialization:
Electrochemistry, fuel cells
From Waseda University
April 2010

Five new ICYS-MANA Researchers (postdocs) joined MANA.

Awards

Yusuke YAMAUCHI
64th Annual Award for Advancements in Ceramic Science and Technology, Ceramic Society of Japan
April 1, 2010

Inoue Research Aid for Young Scientists, Inoue Foundation for Science
February 4, 2010

Kohei UOSAKI
Chemical Society of Japan Award, Chemical Society of Japan
March 27, 2010

Masanori KOHNO
Young Scientist Award, Physical Society of Japan
March 21, 2010

Masayoshi HIGUCHI
Marubun Academy Award, Marubun Research Promotion Foundation
March 3, 2010

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"**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.