Dr. Heinrich Rohrer (Nobel Laureate in Physics, 1986), who was an Adviser of MANA, passed away at 9 pm on May 16th, 2013.


We sivcerely pray that his soul may rest in peace.

All of us in MANA are devastated by this sad news. However,as we find solace in the many wonderful memories we have of him, we wish to express our most heartfelt appreciation for his earnest encouragement to us in MANA. Thank you very much indeed, Heini.

Masakazu Aono,
on behalf of all of Dr. Rohrer's friends in MAN

Event Reports

MANA International Symposium 2013 Held at Tsukuba

MANA International Symposium 2013, held at the Epochal Tsukuba International Conference Center from February 27 (Wednesday) through March 1 (Friday), proved a resounding success, with no less than 414 people in attendance to hear special lectures by Professor Georg Bednorz, Nobel Laureate in Physics 1987, and Professor Akira Suzuki, Nobel Laureate in Chemistry 2010, together with invited talks by 21 distinguished speakers and oral presentations by 16 more. Also of interest were recent MANA research findings introduced within 87 poster presentations.

4th MANA/NIMS Waseda University International Symposium

The 4th MANA/NIMS Waseda University International Symposium, was held at NIMS on March 11, 2013. Featured were presentations by graduate program professors, together with 46 poster presentations by affiliated researchers. More than 80 people attended.

6th MANA/NIMS Osaka University Joint Symposium on Advanced Structural and Functional Materials Design

The 6th MANA/NIMS Osaka University was held on March 18 at the WPI-MANA Auditorium. Researchers, postdocs, and students introduced their findings to colleagues through oral and poster presentations.

Newly Appointed Researchers

◆Associate Principal Investigator◆


Dr. David Bowler

◆MANA Scientist◆


Dr. Nobuyuki Sakai


Dr. Waka Nakanishi


Dr. Takuto Kawakami

◆MANA Scientist◆


Dr. Ikutaro Hamata


Dr. Piotr Kujawa


Dr. Shu Nakaharai

◆ICYS-MANA Researcher◆


Dr. Sudipta Dutta

Awards

MANA Principal Investigator Katsuhiko Ariga Admitted as a Fellow of the Royal Society of Chemistry

MANA Principal Investigator Katsuhiko Ariga has been admitted as a Fellow of the Royal Society of Chemistry, as reported by The Times newspaper.

MANA Researchers Win FY2013 Minister of Education, Culture, Sports, Science and Technology Commendations for Science and Technology

Commendations are awarded by MEXT to individuals who have increased motivation among science and technology practitioners and contributed to raising the level of Japan's scientific standards by producing remarkable achievements in the research and development of science and technology or in the advancement of scientific understanding.


Award ceremony

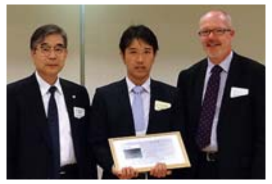
An award ceremony was held at the Ministry on April 16, 2013 and the following three MANA researchers received prizes:

Science and Technology Prize (for Research)
Dr. Takayoshi Sasaki
Project awarded: Creation of nanosheets by exfoliation of layered compounds and their applications

Young Scientist's Prize
Dr. Alexei A. Belik
Project awarded: Research on new oxides with multiferroic properties
Dr. Yusuke Yamauchi
Project awarded: Synthesis of functional inorganic nanoporous materials and their applications

Dr. Yamauchi Wins 2013 PCCP Prize

MANA Independent Scientist Yusuke Yamauchi is the proud recipient of the 7th PCCP Prize. The PCCP Prize is awarded annually to promising young researchers (up to 35 years old) by Physical Chemistry Chemical Physics, a journal published by the Royal Society of Chemistry, a London-based organization for advancing the chemical sciences. Each year the Chemical Society of Japan prepares a list of candidates at the behest of the RSC, with the award conferred at a ceremony held jointly with the RSC at the annual spring meeting.


Award ceremony

Two MANA Researchers Receive Chinese Government Award for Outstanding Self-Financed Students Abroad

Dr. Tang Xuebin, a post-doctoral student, and Ms. Jiang Xiangfen, a junior researcher, recently received the Chinese Government Award for Outstanding Self-Financed Students Abroad.


Award ceremony

CONVERGENCE No. 14, Eng. Ed., issued on June, 2013

Outreach Team
International Center for Materials Nanoarchitectonics (MANA)
c/o National Institute for Materials Science (NIMS)
1-1 Namiki, Tsukuba, Ibaraki, 305-0044 Japan

Phone: +81-29-860-4710
Facsimile: +81-29-860-4706
Email: mana-pr@ml.nims.go.jp
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.

wpi
MANA
International Center for Materials Nanoarchitectonics (MANA)
No.14
Jun.2013

CONVERGENCE

International exchange lifts the level of research in Japan
— Akira SUZUKI

A Global Network and a Little Tension Get Good Results
— Naoki FUKATA

Approach to Guiding Researchers to an Even Higher Level Sabbatical Leave and the Research Abroad Program

MANA's Research Outcome

Topological Nanoarchitectonics towards Robust Quantum Computation Based on Manipulation of Majorana Fermions — Xiao Hu

Supermolecules for Self-assembly and Sensing — Jonathan P. Hill

Assembly of cells using "cell adhesive" ~ Challenges for organ regeneration ~ — Tetsushi TAGUCHI

High-Performance One-Dimensional Nanostructure Photodetectors — Tianyou Zhai

International exchange lifts the level of research in Japan

Interviewew: Akio ETORI, Science Journalist

Akira SUZUKI

Professor Suzuki graduated from the Department of Chemistry, Faculty of Science, Hokkaido University, in 1954 and completed his doctoral degree at the Department of Chemistry, Graduate School of Science, Hokkaido University, in 1960. In 1961 he became an associate professor in the Department of Synthetic Chemical Engineering, School of Engineering, Hokkaido University, before becoming a postdoctoral researcher at Purdue University in the United States in 1963 (under Professor Herbert C. Brown). Professor Suzuki became a professor in the Department of Applied Chemistry, Faculty of Science, Hokkaido University, in 1973, then a professor at Okayama University of Science in 1994, and next a professor at Kurashiki University of Science and the Arts in 1995. He was a visiting professor at Purdue University in 2001 and at the Academia Sinica in Taiwan and National Taiwan University in 2002. He is currently a professor emeritus at Hokkaido University. He studied organoboron chemistry under the Nobel Prize Laureate Professor Herbert C. Brown at Purdue University, and applied this experience to cross-coupling reactions. Professor Suzuki was awarded the Nobel Prize in Chemistry in 2010 for his outstanding contributions to organic synthesis reactions using organoboron compounds. In addition, he has been awarded several other honors including the Weissberger-Williams Lectureship Award in 1986, the Chemical Society of Japan Award in 1989, the H. C. Brown Lecture Award in 2000, the Japan Academy Prize in 2004, the Person of Cultural Merit, Order of Culture in 2010, and membership in the Japan Academy in 2011.

Life-changing one book and one letter

—Congratulations once again, Professor Suzuki on being awarded the Nobel Prize.

I guess it was something that I didn't see coming. In fact, on the night before Professor Herbert C. Brown's 90th birthday celebration and lecture in 2002, my wife and I were having dinner with Professor Brown and his wife that he first said "I have been thinking about nominating Akira for the Nobel Prize." When I said, "No, I have not done such work," Professor Brown replied "It is not up to you." Nomination for a Nobel Prize requires a letter of nomination, and in Professor Brown's case, it took 8 or 9 years from when he was first nominated until he was awarded the prize. Professor Brown nominated me two years in a row in 2002 and 2003 before he passed away at the age of 92 in 2004. After that, I didn't hold out much hope. However, in October 2010, the phone rang while I was at home writing a paper, and when I answered I was told "We have some very good news from Stockholm. Today, the Nobel Prize Committee announced the prize for chemistry and has decided to award it to you, Professor Suzuki. Will you accept the award?" In my shock, I realized for the first time that Nobel Prize winners were contacted directly by phone.

—The efforts of the late Professor Brown played a big part in receiving the award. The research topic for which you were awarded the Nobel Prize was cross-coupling.

In organic chemistry, creating carbon–carbon bonds is essential, and cross-coupling is one means to achieve this. Although I received my award for cross-coupling using organoboron compounds, from an objective standpoint it is because cross-coupling is the most effective method for carbon–carbon bonds and is currently very widely used. During my Nobel lecture, I received massive applause when I said "I have not taken out any patents on cross-coupling using organoboron compounds and hope that everyone can use it freely."

Starting from the beginning, when I was young, I became inspired after reading a paper by Professor Brown on hydroboration, and when I wrote a letter to him, he replied "If you are interested then you should come here," and my study abroad was decided. I studied the stereochemistry of hydroboration during my time with Professor Brown, and at that time, many researchers thought that the organoboron compounds obtained by hydroboration were too stable to be used for organic synthesis. The predominant school of thought was that only highly reactive organometallic compounds such as organolithium compounds and organoaluminium compounds could be used for organic synthesis. However, these compounds suffer from the drawback that although they are highly reactive, they decompose rapidly in the presence of water. By comparison, organoboron compounds are stable and do not decompose in the presence of water. I thought that this was advantageous in certain ways, and even after I returned to Hokkaido University, I continued to work actively with my students on organic synthesis using organoboron compounds. At the time, this kind of research was pretty much not being done anywhere in the world, not even in Japan.

As I continued my research, I came to realize that organoboron compounds could be used for a variety of interesting organic syntheses. One aspect of this research was cross-coupling. Research on cross-coupling took up approximately one third of my work. The remainder was research on various organic syntheses using organoboron compounds.

Fortune favors the prepared mind

—Was there any serendipity in the path leading to the creation of cross-coupling?

If we limit ourselves to cross-coupling, then there was probably nothing particularly serendipitous. For me, encounters with serendipity came in other research. It played a role in coming up with the idea of reacting α,β-unsaturated carbonyl compounds with organoboron compounds as part of my research into creating C-C bonds, immediately after returning from my time with Professor Brown. I realized by myself that the carbon group attached to the boron atom should be able to transfer to the terminal carbon of a vinyl group via a pseudo six-membered ring structure formed by boron coordinated at the oxygen atom in an α,β-unsaturated carbonyl compound, and should thus form a C-C bond. When I actually asked a student to do this, the reply was "It worked professor! There's no absorption peak indicating a ketone with an attached α,β-unsaturated double bond." I asked my assistant to do additional testing, and when the reaction was confirmed, I quickly sent a letter to Professor Brown. Since Professor Brown also found this interesting and wanted to be involved in the research, we proceeded with the ketone reaction in my lab and the aldehyde reaction in Professor Brown's lab. My group gradually uncovered such details as that the compound with a methyl group attached at the α position carbon reacted at both 0 ° C and room temperature, and that the compound with a methyl group inserted at the β position carbon did not react at room temperature but reacted as the temperature was increased. However, in Professor Brown's group, although the compound with the methyl group attached at the α position carbon reacted, the compound with the methyl group inserted at the β position carbon did not react, even when the temperature was raised. Even after we had exchanged several letters, the reaction did not work well in Professor Brown's lab. Yet, when we performed additional testing in our lab, it seemed that the compound with a methyl group at the β position carbon was reacting. Even now, I remember that in reply to my letter informing Professor Brown of the results, he wrote something along the lines of "Chemistry should be international. Why is there such a big difference between the two locations in Sapporo, Japan, and West Lafayette, Indiana, United States?"

In fact, both of us were correct. You see, we had been using nitrogen gas as an inert gas. But a minute amount of oxygen contained within that nitrogen was exhibiting catalytic action which promoted the reaction. In other words, the organoboron compound was reacting with the small amount of oxygen and creating organic radicals which were affecting the reaction. By comparison, Professor Brown's lab was using nitrogen of 99.9999% purity, even at that time, and so naturally, there was no reaction because there was no oxygen. When they performed experiments by also adding oxygen, they observed the same reaction as our group. This is one example of the serendipity I experienced during my research on organoboron compounds.

Speaking of serendipity, while I feel that it is encountered not only in chemistry but throughout all fields of science, I feel that it is also encountered throughout our lives, not just in the world of science. As Louis Pasteur said long ago, "fortune favors the prepared mind." Serendipity surely favors those who put the maximum effort into their work.

Thoroughly reading one great book builds the foundation of knowledge for a researcher

—What is your message to young researchers?

Although it is good to read a variety of books, I recommend that you read one great book thoroughly in order to build your foundation of knowledge. Although I have read a wide variety of books, there have been only two that have greatly changed my life, and one of these is "*Textbook of Organic Chemistry*" by Louis F. Fieser. At that time, Professor Fieser asked publishers in Japan to create a cheap version of his book so that it would be within reach of university students in Japan and Asia. I liked this book and found it so interesting that I kept a tally on the back cover each time I read it, and in no time at all I found that I had read it 33 times. The other book is "*Hydroboration*" by Professor Brown which is about the topic I discussed earlier. I used to tell my students "You should read one great book completely. This will be extremely beneficial for your research."

I have heard that recently young people do not want to go overseas. I want to tell you that going to another country is beneficial. For example, even though you may think that it's not necessary to go abroad to study because high-level research on organometallic chemistry is being done in Japan, there are still many things that you can study only overseas. You can study the language of another country directly, and you can receive education and research guidance from specialist professors in the language of that country. A cultural aspect of Japanese is that much of the communication is left unsaid, but this is not always the case in other languages. If you can understand what the people of a country are saying and can explain your opinions clearly, then you can attain mutual understanding. I think that having discussions with people from a variety of countries and cultures broadens your thinking and the scope of your research. A variety of scholarship funding is also available these days, making your chances of going abroad far more likely than in the past if you want to go. I want to tell young people to feel free to go because they have the opportunity.

Giving international researchers a better understanding of Japan is also important

—What do you think of the role of MANA?

At MANA, approximately half of the researchers are from overseas. This is amazingly good; in the past, this would have been unbelievable. Whereas I spoke of the importance of going overseas earlier, the existence of places in Japan where international researchers can come and interact more and more with Japanese researchers is also important. While it is important for us to go overseas to study their culture and technology, I would also like to encourage people from around the world to come to Japan and learn about our country. On top of this, I would like all of the international researchers to learn the Japanese language and discover Japanese technology and culture before they return to their home countries. The attitude of giving other countries a better understanding of Japan is extremely important for our country. Surely, deepening our mutual understanding and promoting the exchange of information are important for raising the level of research in Japan.

—This is the sixth year of MANA. Please give us some advice for the growth of MANA in the future.

The sixth year of an organization is probably best described as still being in the early stages. I think that in the past, organizations worked hard with extremely high motivation in the early going. All of the researchers at MANA are similarly working hard. I have heard that MANA has a limit of 10 years, but I think that is probably too short. Since this is a place that makes an intellectual contribution to our country and was created by contributions from the national budget, it's a waste to talk of closing after 10 years. Research and education are things that inherently take a long time to bear fruit. It's also important to build upon the successes of MANA. How about if we all work together to put forward our current successful results and make them known to the country? Research results created over 10 years are a single step. I would really like to see the government support the continuation of MANA.

In Professor Brown's house

A Global Network and a Little Tension Get Good Results

Naoki FUKATA
Group Leader

We had an opportunity to talk with Dr. Naoki Fukata, currently head of the Semiconductor Nanostructured Materials Group and the youngest of the group leaders at NIMS. Since his 2007 appointment as PRESTO Researcher by the Japan Science and Technology Agency, Dr. Fukata has led a number of large projects to successful conclusions within, among others, the Next Generation World-Leading Researchers Program. What is Dr. Fukata up to now, and is he willing to share any secrets about group leadership? We asked to find out.

Dr. Fukata, word has it that you are researching materials for solar cells. How are those different from other materials you have studied?

Our group concept is pretty risky but, we think it's interesting—we are focusing on silicon, trying to tap unexplored structures and functions to bring out entirely new capabilities. We have spent years studying such things as impurity doping within semiconductors for application to transistors and the like, and we have also done much work on functional control by means of nanostructures. Now, we are bringing together those technologies to create nanowires and, by extension, to develop highly efficient solar cells that are inexpensive and place little burden on the environment.

Conventionally, solar cells consist of a flat, a two-dimensional structure of silicon p-n junctions that generate photovoltaic power. What we are working to develop is a three-dimensional structure of silicon nanowires, like pins sticking out of a pin cushion. Each wire acts as a solar cell with its own p-n junction, an arrangement by which we can pack together at least 100 times more p-n junctions within a given surface area. In another innovation, the cell surface shows an antireflective structure, which greatly cuts down on reflection losses. And, on a different but related note, when we take a substance down to the nanoscale, we start encountering different properties, different characteristics, which we utilize to create, with silicon alone, a solar cell material that acts as if it were instead made up of numerous materials.

It sounds like everything about your R&D of silicon nanomaterials is going really well.

Well, not always. For one, if we increase the area of p-n junctions to be 100 times bigger, we'll probably end up with 100 times more defects. So, in order to raise the efficiency of our solar cell, we have to find some way to overcome these defects.

Also, the solar power industry is strange in some respects. The emphasis is on cutting costs and only on cutting costs; when it comes to developing new solar cell materials, we run against a wall of conservatism. Japanese manufacturers have essentially been pushed out of overseas markets. If Japan hopes to regain its lead in this area, we'll have to smash through the barriers that currently limit the application of silicon.

Dr. Fukata, you are the youngest of the group leaders. How do you go about managing your group?

There are nine people in our group, and we are a diverse bunch, with members from India, China, Bulgaria (short term), Vietnam (short term), and Japan. We Japanese are in the minority, so we all communicate in English. We have different nationalities and come from different cultures; yet, while respecting those differences, we make no compromises and take no shortcuts. We try, we fail, we learn from our mistakes.

If I were older and had some charisma, perhaps people would follow me naturally. But you see I'm young, I don't look very dignified, and when I introduced myself to postdocs that arrive from overseas, they say "What, you're the boss?" People look at me, consider me an equal, at best, and don't take kindly to being lectured. I understand that. This also means that as the leader, I have to study. No one respects leaders that don't know what they're talking about. So I have to set an example, as a capable researcher, as a capable writer of papers. You can't talk down to group members to get them to do what you want, or you will soon find that you no longer have a functional group. My job goes well beyond securing research funds and extends to providing day-to-day assistance to group members. For instance, some overseas researchers can't read Japanese manuals, so we have to help with that. If there is an error in an experiment, we fix it. If they need some help with daily life, we provide it. What's also required for the job is a spirit of giving.

Of course, as I mentioned before, there's the issue of securing funds. Almost all of our research is conducted with external funding. If that stops, so does our research. I'm always worried about what we will be researching two or three years out, and how we will the funding that research. When applying for funds, it's important that the research theme and content be in tune with the times, and so I always have my antenna out to pick up that tune. This requires a certain keenness—a bit of tension—that I try to maintain on a daily basis.

How do you intend to move your group forward from here?

Well, it can be pretty hard to publish in our field. Sometimes you will see it, a postdoc who never smiles, except when looking at a copy of a paper fresh off the press. Then, there's a great big grin.

The single most important point in research is that a finding, no matter how small, deserves an assessment within its field. For instance, I usually make a few acquaintances at international conferences, and I make it a point to visit these newfound colleagues at their laboratories within a year. They are usually happy to see me again, and we often end up as good friends. This leads to the development of a global network, which in turn enables collaborative research projects across borders and provides numerous opportunities to make presentations at each other's organizations. And this, in turn, lets your work get assessed. In my group, our days are busy but we get along well. I think we all enjoy working together, and we strive to see that our findings get an assessment on the global stage.

Dr. Naoki Fukata (semiconductor physics)
1998 Ph. D., Division of Materials Science, University of Tsukuba
1998-2002 Research Associate, Institute for Materials Research, Tohoku University
2002-2005 Lecturer, Institute of Applied Physics, University of Tsukuba
2007-2010 MANA Independent Scientist, NIMS and PRESTO Researcher, Japan Science and Technology Agency
2011-present Associate Professor, Graduate School of Pure and Applied Sciences, University of Tsukuba. Currently Group Leader of the Semiconductor Nanostructured Materials Group

Approach to Guiding Researchers to an Even Higher Level Sabbatical Leave and the Research Abroad Program

MANA actively uses our broad network of contacts to get researchers postings at overseas universities and research institutions. In particular, we have established a unique cultivation system that strives to arrange overseas postings for young researchers. The introduction of a sabbatical leave system is also bringing a breath of fresh air to our research.

■ Collaborative Research with Charles University: A Diary of Working in Prague (Shinsuke Ishihara, ICYS-MANA Researcher)

With Dr. Labuta who travelled with me (MANA supramolecular group)

MANA has an international atmosphere and is a "melting pot" that attracts researchers in various different fields from around the world. Thanks to this, I was lucky to have the opportunity to conduct collaborative research with researchers from Charles University in the Czech Republic specializing in nuclear magnetic resonance (NMR). The collaborative research progressed well, and in October 2012 I was invited by Professor L. Hanykova of Charles University to go to Prague, where I spent one month conducting research. Charles University is one of Europe's oldest universities (established in 1348), and the excellence of the academic staff and the discussions that I had with students left a great impression on me. I was given an opportunity to introduce my research results at a weekly seminar, where I also talked about Japanese culture. I could meet again my friends from Charles University who had previously enrolled at MANA/NIMS, allowing us to form closer connections, both personally and professionally. My time in the Czech Republic greatly contributed to the progress of the collaborative research.

Social gathering with old friends

Lecture at the seminar

■ Research Abroad to MINATEC-Leti (Yoshiyuki Yamashita, MANA Scientist)

"MINATEC", one of the largest industry-academia collaboration clusters in Europe

I had been working in MINATEC-Leti, France as a visiting scientist for a year since Nov 2011. Leti is one of the biggest applied research centers for electronics in Europe and I was assigned to a member in a nano-characterization group. I performed the research on higher-k gate stack devices using NanoESCA.

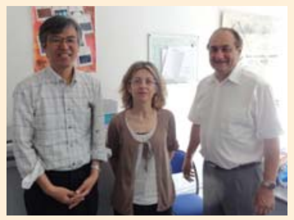
It was my first surprise that there were a large number of discussions every day and they were performed even at coffee breaks. However these discussions were beneficial for me to carry out my research effectively and understand French research style and French culture well.

I was also surprised at a 30 years old XPS apparatus showing the highest operation rate among apparatuses for surface analysis; it was equipped with automatic measurements for so many samples and easy-to-use operating system. According to my colleagues, this performance had been accomplished by interns coming every year; improvement of apparatus and novel preparation of the operating systems have been being done in order to keep the high performance .

During my stay in Grenoble, collaboration between NIMS and Leti was determined to be continued.Additionally I would maintain friendly contact with domestic and foreign scientists acquainted during this precious stay in Grenoble, which is a great asset in conducting future collaborative researches.

Football tournament among research institutes in Grenoble
Football team in our group was Best 5

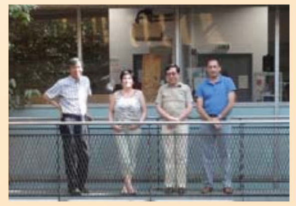
■ Sabbatical Leave in France (Takayoshi Sasaki, MANA Principal Investigator)



After a discussion

In July last year, I took the opportunity to visit the Bordeaux Institute of Condensed Matter Chemistry (Institute de Chimie de la Matière Condensée de Bordeaux, ICMCB) in France for one month. Every day, I traveled to the research center by tram from the guest house provided for me, and spent a lot of time with many of the researchers there holding discussions, exchanging information, and so forth. Although the pace of working was quite relaxed compared to Japan, I got a strong feeling that their original scientific accumulation and traditional research were treated as important, while at the same time the latest topics were also being addressed. This way of working has brought many original results and achievements.

Bordeaux is not only famous for wine, but also has spectacular streets in which many historical structures are still standing, and on my days off I walked around various places and was greatly refreshed by my activities despite my short time there.



At the seminar hall

Topological Nanoarchitectonics towards Robust Quantum Computation Based on Manipulation of Majorana Fermions

Xiao Hu
MANA Principle Investigator
Nano-System Field

Do you know that prime factorization is important for encryption? Actually to factorize a large integer quickly is difficult even using the No.1 computer in the world. This task can however be finished efficiently by a quantum computer, which is based on the superposition of wave functions, a unique property of quantum objects. Unfortunately, in many cases quantum states are fragile and collapse easily. Because of this decoherence problem, realization of large-scale quantum computation still remains challenging. Recently, a new idea called topological quantum computation (TQC) becomes a rising sun in this field, which makes use of topological property of quantum systems. Since topology is a global property and not influenced by local noises, it can be used for developing decoherence-free and thus robust quantum computer.

We have been pursuing the possibility to achieve TQC using quasiparticles of topological superconductivity, which behave similarly to the mysterious particles called Majorana fermions (MFs), which are equivalent to their own antiparticles. We have investigated nanometer-sized topological superconductors as schematically shown in Fig. 1. One vortex is pinned at center of each sample and samples are connected by constriction junctions. A MF appears at the edge when odd-number vortices are enclosed, while it disappears when the edge encloses even-number vortices. Based on this topological property, we successfully construct a way to transport and exchange the positions of two edge MFs by applying point-like gate voltage at junction positions in a designed sequence, which adjusts the connection between samples and thus tunes the number of vortices enclosed. The fantastic point here is that the charge-neutral (since particle equals antiparticle) MFs can be driven smoothly by gate voltage. We monitor the whole adiabatic process of transportation of edge MFs by solving the time-dependent Bogoliubov-de Gennes equation. The non-Abelian statistics upon position exchange (so-called braiding) of MFs is observed as displayed in Fig. 2, which is a must for TQC. The goal of achieving robust quantum computation is not far away.

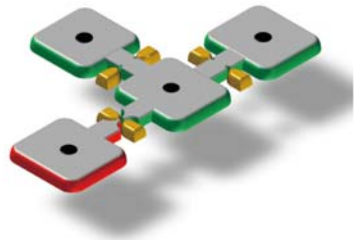


Figure 1 Schematics of a nano quantum device for generating and braiding edge MFs in topological superconductors by tuning gate voltages at constriction junctions.

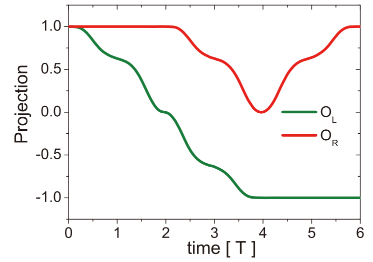


Figure 2 Simulated results based on time-dependent Bogoliubov-de Gennes equation. Upon braiding, the green edge MF reverses the sign of its wave function while the red one keeps its sign.

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Q.-F. Liang, Z. Wang, and X. Hu, *Europhys. Lett.* [Editors' Choice], **99**, 50004 (2012).

Assembly of cells using "cell adhesive" ~ Challenges for organ regeneration ~

Tetsushi TAGUCHI
MANA Scientist
Nano-Life Field

Extracellular matrix (ECM) is a functional scaffold which promotes adhesion, proliferation and differentiation of cells. Due to its excellent biological properties, various types of scaffolds like ECM have been developed for the regeneration of connective tissues containing large amounts of ECM. Cartilage, bone, and skin have been already regenerated *in vitro* and the regenerated tissues have been applied in the clinical field. Unlike these connective tissues, organs such as liver and pancreas have a large cellular component with little ECM. It is known that cells in these organs are interconnected via cell adhesion molecules and maintain its high functions. Therefore, different approach from fabrication of scaffold is required for the organ regeneration/reconstruction using cells. From these backgrounds, "cell adhesive", which can temporally bond among cells in order to assemble cells, was designed (Figure 1). This cell adhesive possesses hydrophobic units which can interpenetrate into phospholipid bilayer of cells as terminal groups or pendant groups in hydrophilic polymers. Polyethylene glycol (PEG)-based cell adhesive which has oleoyl groups in the terminal groups of PEG chains was prepared and added to the hepatic cell line, HepG2. As can be seen from Figure 2a, cell adhesive clearly promoted assembly of HepG2 cells. Also, albumin secretion, which is one of the important functions of hepatic cells, from HepG2 cells in the presence of cell adhesive was 4-fold higher than that from HepG2 cells in the absence of cell adhesive after the culture for 7 days. Similar to HepG2 cells, assembly of rat pancreatic beta cells RIN was observed after addition of cell adhesive. Insulin secretion from assembled cells was 3-fold high compared to cells without cell adhesive. Furthermore, mRNA revel of E-cadherin which is one of the typical cell adhesion molecules increased with increasing the concentration of cell adhesive, indicating that secretion of cell adhesion molecules was induced by cell adhesive. The developed cell adhesive can nonspecifically bond various kinds of cells and promote cell functions, therefore, it can be applied for organ regeneration as well as cell transplantation.

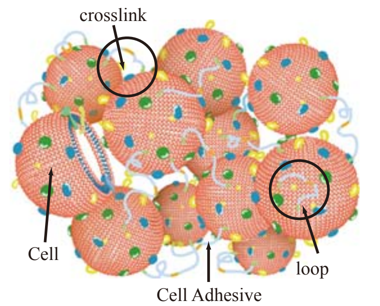

Figure 1 Assembly of cells using "cell adhesive".

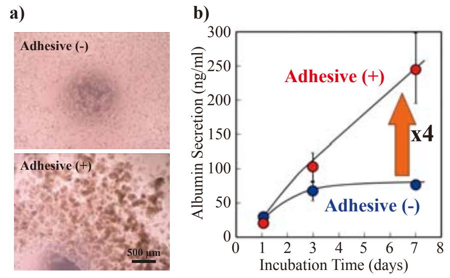

Figure 2 Assembly of hepatic cells (a) images of cell assembly, b) albumin secretion from assembled hepatic cells).

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Supermolecules for Self-assembly and Sensing

Jonathan P. Hill
MANA Scientist
Supermolecules Group

Functional organic molecules are excellent candidates for formation of highly structured nanoarchitectures because of their synthetic flexibility and wide ranging properties. These properties include self-assembly for formation of monolayer, nanotube or nanowire structures, semiconductivity for preparation of organic field effect transistors, and sensing activity. We have studied the supramolecular properties of molecules for assembly of complex organic nanostructures and have also been developing sensors for inorganic species, such as anions or cations, and chirality. These systems provide applications in organic nanoelectronics, sensing of environmentally deleterious substances (such as radiocesium) and in chemical analyses of pharmaceuticals.

In the self-assembly field, we have designed molecules for self-assembly of circuit-like nanostructures, which can be grown into selected forms and can self-heal if damaged. As shown in Figure 1a, trigeminal porphyrins self-assemble into fine nanowires (width: 9 nm, height: 3.5 nm) of excellent uniformity.[1] The nanowires can be erased and regrown into different structures allowing growth of novel circuit-like structures for connectivity in supramolecular circuits of the future.

On the other hand, supramolecules can exhibit sensing activity for inorganic species especially cesium where we have developed a sensor molecule that can selectively detect the element in its cationic form facilitating detection of radiocesium in soils by a simple fluorescence method.[2] This is important, in conjunction with existing methods, for mapping of contamination following releases of nuclear materials to the environment. It has also proved possible to tune this system for different cationic contaminants.

Finally, screening of enantiomeric excesses (*ee*) in chiral compounds was found to be possible using a supramolecular approach.[3] Complexation of chiral analytes with a unique tetrapyrrole molecule allows rapid estimation of the relative quantities of each enantiomer (Figure 1b). Because of its convenience, this analytical method is suitable for application in the pharmaceutical industry but also has potential in the study of enantioenrichment reactions or in investigations on the origin of homochirality in biological systems.

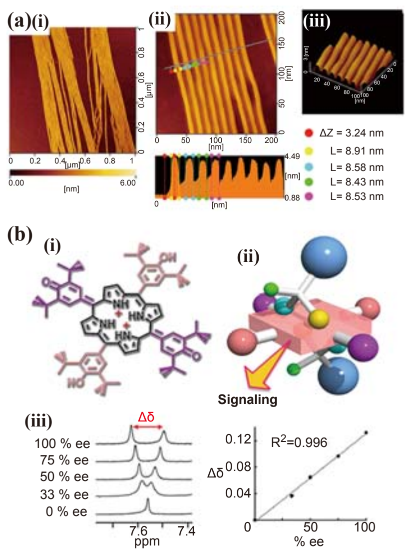

Figure (a) Atomic force microscopy images of self-assembled porphyrin nanowires. (i) nanowires, (ii) profiling indicating high uniformity, (iii) 3D projection of nanowires. (b) Detection of enantiomeric excess (*ee*) using unique tetrapyrroles. (i) Chemical structure, (ii) model of its complex with a chiral analyte, (iii) NMR spectra and correlation of peak splitting with *ee*.

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High-Performance One-Dimensional Nanostructure Photodetectors

Tianyou Zhai
ICYS-MANA Researcher

One-dimensional (1D) inorganic nanostructures have stimulated numerous studies due to their importance in basic scientific research and potential technological applications based on their specific geometries and distinct properties. Among many available nanoscale devices, the photodetectors are critical for applications as binary switches in imaging techniques and light-wave communications, as well as in future memory storage and optoelectronic circuits. With large surface-to-volume ratios and Debye length comparable to their small sizes, 1D inorganic nanostructures have already displayed superior sensitivity to light in diverse experiments [1, 2].

We have been involved in developing high-performance photodetectors based on 1D inorganic nanostructures, including the rational design of 1D nanostructures, the construction of the photodetector device, the investigation of the typical mechanism of photo detecting, and the improvement of the devices' performances [1, 2].

Herein, we introduce the recent achievements on the fabrication of ultrahigh-performance solar-blind photodetector employing individual single-crystal $In_2Ge_2O_7$ nanobelts as sensing elements [2]. $In_2Ge_2O_7$ nanobelts were fabricated by a vapor transport process using GeO_2, In_2O_3 and carbon as the sources. The single-nanobelt photodetector device was assembled by a standard microfabrication process. The SEM image and schematic of an individual $In_2Ge_2O_7$ nanobelt is inserted in Figure a and c. The nanobelt has a width of 270 nm, a thickness of 30 nm and a length of 2.7 mm, with its uncovered part exposed to the incident light. The device shows a high sensitivity to deep UV light with a cutoff wavelength of 290 nm, which is close to bandgap of $In_2Ge_2O_7$ (Figure a). The response at 230 nm is 2–3 and 3–6 orders of magnitude higher than that in the ultraviolet and visible light ranges, indicating high selectivity towards the solar-blind light (Figure b). The photodetector has high stable and reproductive characteristics and quick response time of < 3 ms. Furthermore, the photodetector shows the high responsively (3.9×10^5 A/W) and quantum efficiency (2.0×10^8 %). Based on the dependence of photocurrent on environment, and quantum efficiency on light intensity, the high performance of the $In_2Ge_2O_7$ nanobelts was ascribed mainly to surface traps, one-dimensionality, and high-quality single crystal character. Our results imply that the $In_2Ge_2O_7$ nanobelt is a great candidate for applications in high-speed and high-sensitivity photodetectors or optical switches.

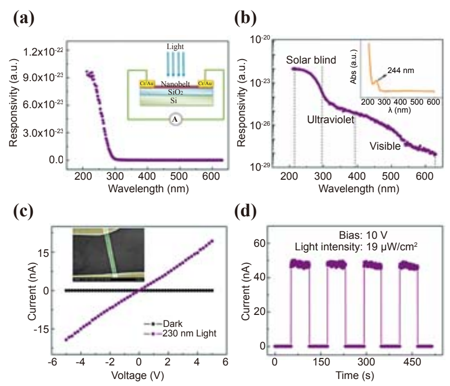

Figure (a) Spectral response of an individual $In_2Ge_2O_7$ nanobelt; (b) Logarithmic plot of (a) revealing high sensitivity and selectivity to various wavelength-light; (c) I-V curves of the device in dark condition and under 230-nm light illumination; (d) Reproductive on/off switching upon 230-nm light illumination.

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