AIMR Magazine

Advanced Institute for Materials Research

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[AIMR in the world]

Gateway to Industry

Introducing Materials to Market. Practical Aspects

Alan Lindsay Greer
Head of Department of Materials Science & Metallurgy, University of Cambridge
AIMR Principal Investigator

[Feature Article]

Carving out the Future through Biomimetic Materials Science

Hiroshi Yabu
AIRM Associate Professor

[Series]

Math and I

Kuniyasu Saitoh
AIMR & RACMaS Associate Professor

The Resurrected Lab

Masaru Tsukada
Former AIMR Administrative Director & Principal Investigator

Fresh Eye

Daisuke Takano
Fukushima High School

Column

Susumu Ikeda
AIMR Director Research Support Division

[Conversion to the Next Generation]

"Transformation toward the Future Society"

What Science and Technology Can Do

Isamu Takahara × Hiroshi Suito

Toyota Motor Corporation, BR-Frontier Research in Policy and Technology Department, General Manager
University of Tsukuba, R&D Center for Frontiers of MIRAI in Policy and Technology, Director & Specially Appointed Professor

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World Premier International Research Center Initiative

“Transformation toward the Future Society”

What Science and Technology Can Do

Tuesday, November 13, 2018. At the R&D Center for Frontiers of MIRAI in Policy and Technology, University of Tsukuba

Declining birthrates and an ageing society, a shrinking working population, regional disparities, low economic growth, and disaster measures—the social issues that Japan needs to address are already emerging. The government is attempting to resolve these social issues while simultaneously achieving economic growth, through the realization of a “Super Smart Society” (Society 5.0) ahead of the rest of the world. Science and technology innovation plays an extremely important role in bringing about such social transformation. For this issue, we spoke to Professor Takahara, who is promoting the creation of an advanced model for such science and technology innovation, and Professor Suito, who aims to bring about science and technology innovation as a mathematician, about their outlook on the future society under the title “What Science and Technology Can Do.”

Hiroshi Suito

AIMR Mathematical Science Group Leader & Principal Investigator
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Isamu Takahara

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Vision of the Japanese society in 2050

Suito: Toyota has published the "Toyota Environmental Challenge 2050," setting out new challenges with the aim of achieving a sustainable society.
Takahara: In addition to facing energy restrictions, Japan, which has little natural resources, is experiencing the emergence of many issues in the local communities as it moves toward a future society, including declining birthrates and an ageing population, regional revitalization, and natural disaster measures. These social issues are difficult for individual companies to resolve on their own. We believe that it is necessary to identify solutions through open innovation, with collaboration between industry, academia, and the government.
Suito: Looking at the contents of these challenges set out by Toyota, they seem to be closely related to the "Society 5.0" vision drawn up by the Cabinet Office in the 5th Science and Technology Basic Plan.
Takahara: "Society 5.0" is an initiative that seeks to realize the fifth "Super Smart Society" ahead of the world, following after the four types of society: hunting and gathering society, agrarian society, industrial society and information society. By proposing a next-generation automobile and traffic infrastructure, Toyota aims to contribute to the realization of "Society 5.0" through the implementation of mobility innovation in society.
Suito: This initiative seems to be a great leap away from Toyota's business of producing motor vehicles as means of transportation. However, mobility innovation does play a significant role toward resolving issues in the local community through advanced technologies such as automated driving and fuel cells, and toward the establishment of social infrastructure for the public interest through the utilization of IoT and AI, in areas including agriculture, childcare, and disaster prevention.
Takahara: The technologies that motor vehicles require today cannot be supported by traditional automotive engineering alone. I rather believe that the fusion of different disciplines is fundamental, such as electrification with a view to moving away from fossil fuels, the application of automated driving technology, and the utilization of driving data. In the future, mathematical science will probably become a powerful and indispensable approach for securing freedom of movement and liberating us from the constraints of time and space, and for bringing about the realization of a society where people can move about safely, freely, and smoothly.
Suito: I agree. Naturally, the fusion of different disciplines is essential for resolving current and future issues. Personally, since about 10 years ago, I have been carrying out interdisciplinary collaborative research with clinical physicians through the frameworks of the Sakigake (PRESTO) and CREST programs under the Japan Science and Technology Agency, in strategic research areas in mathematics. Then I have moved to AIMR and extended my collaboration to materials scientists. AIMR has established its identity as a center for collaboration between materials science and mathematics. However, rather than having mathematics "take orders" from materials science, AIMR aims to create a new field in mathematics through issues that have not been resolved through the application of materials science. In other words, it aims to realize "Mathematics inspired by Materials Science." Furthermore, AIMR offers strong support for the interdisciplinary fusion research of young researchers in particular, through an approach known as the "Fusion Research System." Under this system, materials science researchers and mathematics researchers work together on specific themes, and advance on intensive research with a certain degree of budgetary measures in place. It has produced extensive outstanding research.
Takahara: In your explanation earlier, you spoke about issues that are difficult for individual companies to resolve on their own. In addition to interdisciplinary fusion, I get a real sense that the fusion of different industries, or the fusion of industry, academia, and government, are of great importance. To achieve that, Toyota Motor Corporation has established the R&D Center for Frontiers in Social Planning (F-MIRAI) jointly with the University of Tsukuba. This Center has been set up in the same building as the International Institute for Integrative Sleep Medicine, which, like AIMR, has been selected by the World Premier International Research Center Initiative (WPI) for its advanced track record in interdisciplinary fusion research and collaboration with other institutions. F-MIRAI is carrying out activities with the aim of becoming a full-fledged center for organization-to-organization fusion research between industry, academia and government.

Human resource development toward the realization of a future society

Suito: When we think about the Japanese society in 2050, it will, of course, be helmed by the young people of today rather than the people of our generation. Hence, it is necessary to uncover and nurture human resources which will take on leadership roles in the society of the next generation.
Takahara: Great importance is placed on this aspect as well as "Society 5.0." We need human resources who are equipped with a high level of expertise and broad horizons, as well as the ability to create the rules of the future. To nurture such young people who will play an active role in society in the future, Toyota Motor Corporation participated in "GRIPS (Graduate-level Research in Industrial Projects)-Sendai 2018," organized by Tohoku University's Research Alliance Center for Mathematical Sciences last fiscal year, as a sponsor corporation.
Suito: This program has been held since 2001 by the Institute for Pure & Applied Mathematics (IPAM) of UCLA, after which it spread to the international circles (editor's note: In Berlin since 2010, and Hong Kong since 2011). In Japan, it was organized for the first time in 2018 at AIMR, Tohoku University, and sponsored by Japanese companies.
Takahara: Toyota Motor Corporation has selected the research theme "Design for the next generation energy and mobility platform."

Suito: Another sponsor participating in the initiative was NEC, which presented its research theme "Reliable wireless networking systems for industrial Internet-of-Things." For these two projects, a total of 10 students, comprising four American students and six Japanese students, have been accepted for an eight-week research period.
Takahara: In our project, we asked the students to consider and build an optimal strategy for the operation of e-palette in the near future when automated driving becomes reality, through the use of real-life mobility data. (Editor's note: "e-palette" is an electric vehicle for companies, targeted at the B2B market. It is characterized by the ability to change specifications, just like a palette, to match the needs of the user. All functions ranging from vehicle control to automated driving can be managed integrally through a cloud service, via the vehicle interface.) We participated in three days—Opening Day when we delivered an explanation of the project, the Mid-term Presentation when we received an interim report on the progress of the research, and Project Day when the final report was presented. During the period of research, how did the participating students manage?
Suito: As the students had completely different fields of specialization, I think they were all fumbling and finding their way at the beginning. However, a student who demonstrated leadership abilities to tie the project together emerged, and they were able to divide up the workload on their own. During the project period, the members of the Toyota team visited MEGA@WEB at Odaiba, operated by Toyota. There, they had the opportunity to be exposed to future mobility systems and I believe it was a good experience for them. During the eight-week research period, they appeared to face several difficulties in various aspects, however, they overcame these obstacles with the characteristic of cheerfulness and optimism of youth.
Takahara: Indeed, I wondered during the Mid-term Presentation if we had communicated the project theme accurately to them. However, during the Final Report, I gained a real sense that they had worked much harder than expected. By making mathematics the common language, we were greatly rewarded as it facilitated understanding and dialogue about the students' ideas.
Suito: After the program ended, we received positive feedback from the students, including comments such as "I have learned that things that cannot be accomplished alone can be achieved by working together with people from different disciplines," "I learnt the importance of team work and diverse ways of thinking, and how important mathematics is," and "I have gained confidence through the ability to tackle challenges in different disciplines." Of these, the comment "I felt that mathematics is very interesting" left an especially deep impression on me.
Takahara: This is a very honest opinion, isn't it? Not "I have developed an understanding of mathematics." (laughs)
Suito: I think this is, in essence, a different type of "interesting" from what a senior high school student feels as "interesting" when he or she solves a problem in the textbook. This student did not major in mathematics, and made this comment about mathematics being interesting in reference to the new and refreshing sensation of surprise at how mathematics, in addition to the own field of specialization, can help one perceive the world in such a way. People who do not major in mathematics feel that mathematical ideas, ways of thinking, and approaches to research are "interesting" and incorporate it into their own fields of study. Conversely, mathematicians incorporate the ideas, ways of thinking, and approaches to research from other disciplines. This is fusion research in the truest sense of the word, and I feel that we should aim to realize such initiatives.
Takahara: However, it is necessary to put in a continued effort in order to realize "Society 5.0" through such initiatives, and it is important to have a sustainable financial base. From this perspective as well, I would like to appeal for the application of mathematics to solve social issues, and for the support of industry, academia, and government as a whole.

Lively discussion during a GRIPS coffee break.

What science and technology can do in order to bring about the realization of future society

Suito: Now, we were on the subject of continued efforts toward human resource development. What are the types of projects that are in the pipeline for the future?
Takahara: In this project, we took up the theme of urban areas, for which mobility data exists in reality. However, Japan has rural agricultural areas as represented by "Satoyama" (upland areas near farming villages). In the future, I believe it will be the rural regions and agricultural areas where public transportation services are required, that will have a need for the social application of mobility innovation in the future society.
Suito: How can this be applied to the rural agricultural areas?
Takahara: I am not thinking about enhancing convenience by urbanizing the rural agricultural areas. Rather, I would like to propose forms of mobility that respect the laws and approaches of land use that have been deeply rooted in Japan's agricultural and rice cultivation culture since ancient times, and which are in harmony with agricultural villages.
Suito: Will this take an opposite direction from the previous project?
Takahara: It is in the same direction in the aspect of harmony between communities and mobility in the future society. The late Hiroyuki Watanabe, who worked for many years on the development of the Toyota Crown and was the first Program Director for the Automated Driving System under the Cross-Ministerial Stra-

tegic Innovation Promotion Program (SIP), had always focused on the "Satoyama" as Japan's world-class ecosystems found in places such as Shirakawago. "Satoyama," which has become integrated with nature through many years of farming, possesses unique ecosystems. The objective is to introduce next-generation mobility into the "Satoyama" in order to enhance convenience without changing the spatial order.

Suito: Are there any specific regions that you are considering as the subject for this "Satoyama" research project?

Takahara: For example, the former Yasato Town (now merged with Ishioka City) in Ibaraki Prefecture, located east of Mt. Tsukuba. It is surrounded by a C-shaped basin, and scattered with farming villages with rich water resources. Thanks to these unique topographical conditions, the area has retained a strong character of its culture for many years. In addition, its cadastral maps from the Meiji era have also been preserved. By superimposing points of reference that have existed there for centuries including ancient monuments, signposts, temples, shrines, and cemeteries, with accurate modern maps, we have been able to build data on the changes in the use of the land that the people of this region have passed on in an unbroken line from the past.

Suito: What are your impressions after comparing the maps of the Meiji era with modern-day maps?

Takahara: Land use has undergone changes as a result of the relevant laws and regulations, as well as technological development from the Meiji era through to the Showa and Heisei eras. I would like to extract the features from this data for machine learning, in order to predict what agricultural villages of the future will be like in 2050.

Suito: Listening to this story, when looking at maps from the Edo era, I get the sense that persistent homology, which AIMR is conducting research in relation to the analysis of material properties, can be applied here. Moreover, as the spread of culture is also a combination of advection, diffusion, and reactions, I believe that mathematics can also be involved.

Takahara: Mega solar power plants that hold a large number of solar power panels are currently being constructed in this region. Why has the land use evolved in this way? How has the movement of people changed alongside changes in land use? In order to maximize improvements to convenience by introducing the latest mobility technology, while conserving the spatial order of the region, what kind and what quantity of mobility systems should we introduce? For example, if we were to introduce fuel cell vehicles, where would that be, and how many? While it would be efficient to set up hydrogen supply stations, would they not upset the spatial order of the region? I anticipate that we will be able to identify many issues and approaches through the application of mathematics.

Suito: In my own research to date, I have promoted collaboration with clinical physicians, environmental scientists, and materials scientists based on mathematics and mathematical science. Through our dialogue here, I have also developed a newfound interest in social engineering, which is directly related to human societies and lifestyles.

Takahara: With that objective in mind, we would certainly like to participate in GRIPS-Sendai in FY2019 as well, with the project "The order of space and new mobility service." Furthermore, we would also like to propose another expanded project for this fiscal year.

Suito: Thank you for your proposals. For the mathematics researchers at Tohoku University, and for the researchers of AIMR, which is providing the venue as the co-organizer, I believe this will be an exciting and stimulating event. We would definitely like to work together again in 2019.

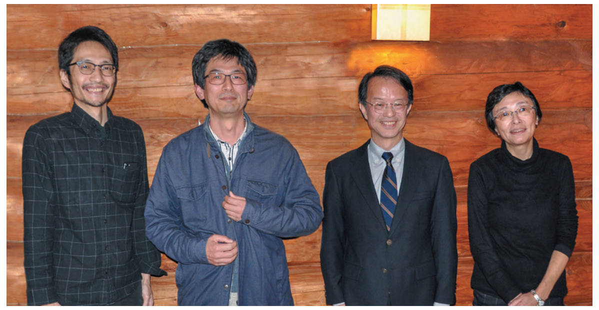
What we need in order to realize social reform

Suito: I feel that the current pace of societal change has dramatically increased compared to the past. On the other hand, there is no change to the need for much time and effort to bring about social system reforms. What do you think is necessary in order to bring about the social system reform that can cope with such societal change?

Takahara: Naturally, industry-academia-government collaboration is important, and I believe that universities, local governments, and clusters comprising multiple corporations will put their best effort into building up concrete initiatives to address the economic and social issues for the region in the future. We, the industry, should consider engaging in industry-academia collaboration from a long-term perspective toward expanding the areas of cooperation and creating future industries. For universities, I hope that they will collaborate with industries in an open manner, and promote an alignment and realignment style of team research with an orientation toward projects that are focused on competitiveness.

Suito: Such trends will drive the country's measures and science and technology policies, and stimulate the reform of social systems.

Takahara: As a start to open industry-academia collaboration, GRIPS-Sendai 2019 aims to increase the number of mentors and provide multifaceted support for participants. Specifically, we plan to cooperate with Professor Akiko Yoshise, head of the Department of Policy and Planning Sciences, Graduate School of Systems and Information Engineering, University of Tsukuba, Professor Mamoru Taniguchi and Associate Professor Hiroyasu Ando from the Department of Policy and Planning Sciences of the same faculty at the University of Tsukuba, and Professor Masaki Fujikawa, course leader for the Course in Strategic Frontiers for Regional Revitalization. Today, we plan to hold an informal discussion after this talk.



At the informal gathering (From right: Professor Yoshise, Professor Suito, Professor Taniguchi, and Associate Professor Ando)

Suito: We will also continue to put effort into the initiative. What other elements do you feel are needed to realize social reform?

Takahara: There is a need to pay attention to speed, which you brought up at the beginning of our talk. Universities in Europe and the United States have strengths in the sustainable research infrastructure such as the scale, speed, networks, and finances for industry-academic collaboration. I think that industry-academia collaboration in Japan should aim to create their own innovation ecosystem instead of following the model of the West.

Suito: In relation to its collaboration with overseas research centers, AIMR is also making a strong push in this direction. However, I feel that there are also areas where there is a difference in speed.

Takahara: I have great expectations for AIMR's unique initiative, which engage in materials science research that incorporates a mathematical perspective. Going forward, I hope that it can deepen its collaboration with Toyota Motor Corporation and the University of Tsukuba, as well as contribute to the development of research aimed at problem-solving for future societies.

Suito: AIMR also aims to bring about a better society by deepening collaboration while using GRIPS-Sendai as a stepping stone in this direction. Thank you for the invaluable talk today.

Takahara: I will continue to cheer for the development and continuity of GRIPS-Sendai. We will definitely participate again this fiscal year. Thank you.

Isamu Takahara, Ph.D. (Social Engineering).

Joined Toyota Motor Corporation in 1988, where he was responsible for the design and development of new vehicle models such as the Crown and Lexus GS. After working as a company leader in global development and design innovation, he served as the head of the BR-VI Department, Director of the VA Development Division, and General Manager of the BR-Frontier Research in Policy and Technology Department before taking up his current post. He is engaged in research on the creation of social infrastructure based on the themes of next-generation mobility and future societies, serving as a member of the Energy Strategic Committee under the Council for Science, Technology and Innovation of Cabinet Office and the executive committee of the Council on Competitiveness-Nippon.

Hiroshi Suito

Born in Ueda City, Nagano Prefecture in 1961. After graduating from the Faculty of Science, Chiba University, he worked in companies before enrolling in the doctoral course at the graduate school of Chiba University in 1996. Thereafter, he took on positions as Assistant Professor at Chiba University and Professor at Okayama University before joining AIMR at Tohoku University in 2017 as a Professor and Leader of the Mathematical Science Group. His fields of specialization include applied mathematics and numerical simulation. To date, through programs such as JST Sakigake (PRESTO) and CREST, he has engaged in fusion and collaborative research of mathematical science with various disciplines including medical science, environmental science, and materials science.

INDEX

Editor
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Gateway to Industry

Introducing Materials to Market. Practical Aspects

Efforts of people who support AIMR as international research institute

Head of Department of Materials Science & Metallurgy, University of Cambridge
AIMR Principal Investigator

Alan Lindsay Greer

AIMR Director Motoko Kotani with Alan Lindsay Greer at an informal meeting before the interview.

The SELECTA winter school entitled "Gateway to industry: Introducing materials to market. Practical aspects" was held by UCAM (University of Cambridge) on January 7-12, 2018. We had the opportunity to talk with the organizer of the school, Professor Alan Lindsey Greer, department of Materials Science & Metallurgy, University of Cambridge as well as principal investigator at AIMR. He explained the materials science education in Europe, future collaboration with Tohoku University and university globalization.

Text and photo: Nobuyuki Nishiyama
(Thursday, January 11, 2018. At Arthur Lyttelton Room, Selwyn College, Cambridge)

— First, could you explain what the "SELECTA project" is?

The SELECTA project is funded by the Horizon 2020 program of the European Union. It brings together approximately fifteen collaborating institutions, which is a mixture of universities and companies, and it's focused on electrodeposition to become more environmentally friendly. This means using safer chemicals to do the deposition, and choosing different materials, for example to take lead out of some deposited thin filters and so on. And this particular winter school is coming relatively late in the four-year program, so the fifteen participants, they're called early stage researchers, it effectively means they're students working for their PhD, and they're now nearing the end of their projects.
We thought it would be a good idea to structure the school around a series of what we call mock interviews. So, we invented three jobs, three types of job for the students to apply for, namely academic post-doc, application scientist in industry and scientific editor position. And they could choose which to apply for and then everyone was interviewed. They had to submit their CV and other details, and they had to give a ten-minute presentation at the beginning of the interview. Then we had a question and feedback session. And everybody watched this, so the various students could see the other students being interviewed. So it turned out to be extremely interesting and we hope it was a valuable lesson for everybody.

— That's not only purely scientist. It's a three kinds of job.

But all involving science, a science background.

— In my understanding, the first two positions—academic postdoc and applied scientist in the industry—are connected to future jobs. However, I wonder how the position as a scientific editor or scientific communicator will give them some kind of training for future professions where they can use that kind of expertise.

We took an advertisement from a scientific journal, and it was advertising for an associate editor, and they looked for somebody with a PhD who is a research scientist who wants to move into something a bit different. So, as they say, you're no longer working in benchtop science, but you need to know the science. And they even specified a scientific specialty within materials that they wanted somebody to be more expert in. And they made the point that the job is partly being an editor in the sense of receiving papers, selecting reviewers, judging the reviewers' reports, but a major part of the job is also writing editorials and writing scientific news stories. So there were the two aspects of the job. We thought it was a good exercise for the students, because it gives them practice in just thinking about other possibilities for how they could be employed.

— Can you tell us more about the main purpose of this school?

The purpose of the school is actually the training of the students. So, these networks are called training networks. Although there are various scientific deliverables, the real deliverable is not scientific results, but trained people. I always say it's the most important part of our job. The output of the university is people. In fact, despite being head of school, I teach first-year undergraduates, give them lectures, but consider that to be an important part of the job.
I would say that for materials people, and materials of course is a very broad subject, it is a great time to be alive and starting out in research in that area, because there are so many challenges, like energy delivery, cutting the pollution, recycling, that materials is the subject that's needed to solve the problems. So I could even think we should call this the materials century to solve some of the major global challenges.

— What do you think about the achievement of such a school?

The achievement will be well-trained people who actually are excellently networked with each other. So we have a series in the research program of so-called secondments, meaning students will have to spend a month or three months in another laboratory in order to understand how work happens in another place—this is working out very successfully. We have people who are doing, let us say, molecular dynamics modeling as their main project, but spending some time in an experimental lab to get a feeling for what it is like to do a physical experiment, and I think they find that quite a good experience.
And the young people today seem to be very concerned about networking. They know that if they want to find out about something, they know who to contact, because they have already worked with that person. So, it will be almost like producing an effective team at the end of the project, but the team will be dispersed across the world, but still in contact with each other.

— Let's talk about the future collaboration between University of Cambridge and Tohoku University. Our university was selected as Designated National University and strengthen the four kinds of research fields, namely materials science, spintronics, next generation medical care and disaster science. Of course, materials science is included. You are a professor of University of Cambridge and also a PI at AIMR. Do you have any plans or ideas on how to strengthen the collaboration between our universities?

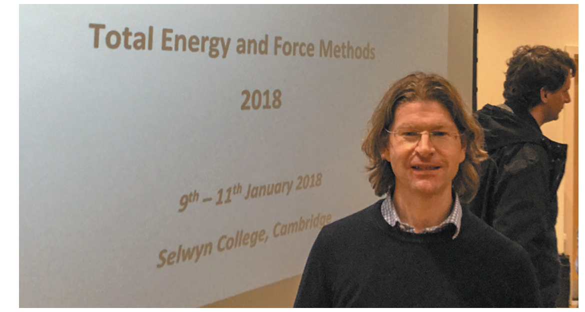
I think that the theme that we have highlighted in the past is quite similar for Cambridge and for Tohoku, that if you have top level institutions, you have to be quite careful in choosing your partners, and the basis for choice is 'best with best'. And so, in these areas, this is a very happy coincidence to bring together Cambridge and Tohoku, and we know Tohoku has its great strengths in these four areas. Clearly there's been a long-term collaboration in the materials science area. Furthermore, I could see developing much more also in spintronics. The chemical school in Cambridge is growing fast, and we have the largest biomedical campus in Europe. So, I think we should be doing something with the medical school in Tohoku, that would be a good line to follow, and in disaster science as well. Unfortunately your university is specialized in disasters of tsunamis and so on. There's some interest here, but this is an area where Cambridge has more to learn from Tohoku than the other way around, in my opinion. But I think so much of the history is suggesting that there are lots of good opportunities for collaboration.
Well, I think the good thing is that young researchers are already in a good place at the AIMR, and in general, Tohoku University supports this area, but so does the Japanese government, and I think they've got excellent facilities and a really strong and growing international outlook, so it seems to me a perfect start for a good career.

— Japanese universities are not international at all and the ratio of international students, metallurgists and staffs etc. are very low compared with other countries. Like Great Britain, Japan is an island country, but unlike the British, the Japanese have a very common conformal nature and do not naturally understand other ways of thinking or different cultures; basically they are very shy and not trained to express their opinion. Therefore, life at universities here can be very difficult for foreigners. Do you have any advice or idea how Japan could overcome this situation?

Yes, I would first of all comment though that's generally true of Japanese universities in comparison with other places. But AIMR has actually targeted having a more international attitude, which I think is for real. In my opinion, you need to bring the young people together in real schools. We've had this winter school for our research project, but actual schools where there would be lectures and coursework, so the study sense like international study center in particular research areas bringing students together from across the world would be a good thing. Because if they spend intensively two weeks with each other, and then the question is whether that could to some extent be done at the undergraduate level for senior level undergraduates.
I think for young foreigners, having an opportunity to visit Japan is highly attractive. They might not want to go to Japan to do their PhD, but they would be very eager to go to Japan for some shorter period, and then they might find that they do want to do a PhD in Japan or a post-doc or whatever. Short, but not one or two days, more intense. Something like that. In time to really get into the system, I think. I also think Japanese people are too paranoid about this. That you're not as un-international as you think.
As for the attitude of Japanese students, well that takes quite a bit of … of course, maybe to solve that problem you need to put it outside of Japan. It will not make much difference, it might make a little difference. But you're then isolated. But the real difficulty we found in Cambridge colleges is that Japanese students are much happier to be separated. Because if they are together, then they have to follow the Japanese rules, whereas if they are isolated, they fall into the Western rules.

— Thank you for your many valuable and notable ideas.

EVENT REPORT



Total Energy and Force Methods Workshop 2018 Held

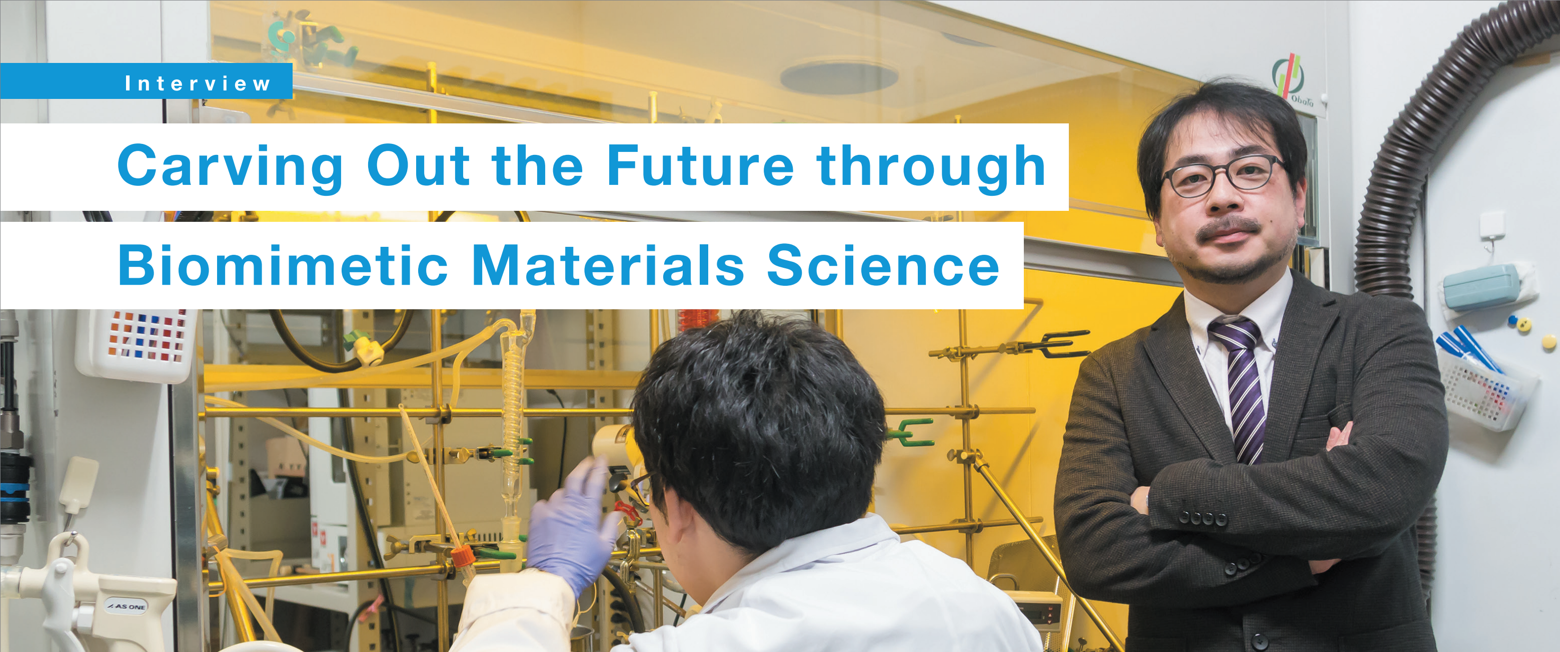
The "Total Energy and Force Methods Workshop 2018" was held at Selwyn College (University of Cambridge) from January 9 to 11, 2018, and attracted about one hundred participants. The organizer, Prof. Chris J. Pickard of University of Cambridge, who is also a Principal Investigator (PI) at AIMR, described the scope and goals of this event, "This event is also known as the **mini** total energy workshop, and every two years, on the odd years, there is the so-called **maxi**-workshop, which is more like a conference, with large numbers of people and held at the ICTP, Trieste (Italy). [1] At this mini-workshop, the focus is scouting out new directions for the materials theory community, such as new density functionals, or machine-learning or path integrals, and to provide ideas for the big conference." In fact, regarding the collaboration between materials science and mathematics, AIMR has a lot of common goals.
"It's supposed to be a more informal place for a smaller group of people to get to know each other well and have good discussions about our field," Pickard added and continued, "We've made sure to keep a mix between very senior scientists, and also some very junior researchers who have just started out. The idea is that, in the coffee breaks, in the poster sessions, as we can see we're pushed together, there is no way to hide. We have lunch together, and we're going to have dinner together tonight. So everyone gets to talk with everyone else."
About the achievements of the workshop, Prof. Pickard forecasted, "I think time will tell. I hope that it has played a role in setting the agenda for future research. So when people are exposed to the different problems that people are having, there'll be some collective guidance from the community to solve some of these problems. I hope now that having seen, say these challenges in the fundamental things like Brillouin zone integration, people will go away and think, 'well, we've really got to solve this.' And then, maybe in five or six years, someone will come back with the answer."
Asked about future collaboration with AIMR, he answered, "Our plan is to very soon establish a joint post-doc position between myself and Tohoku University, and they will work on merging mathematics, theory and modeling. So this will be a bridging topic. I think you can talk to Prof. Greer about the high level view. But for me, I've taken the opportunity to work with Tohoku with great enthusiasm, because of this vision of Prof. Kotani and the others. I'm a theoretical physicist who likes the mathematical side of things, in a materials science department with a long history and tradition, from metallurgy onwards … I see this as a big part of the future of material science."
At the end, he ambitiously concluded, "I think my comment would be that there's a lot more to be done in this field. Sometimes you hear people stand up and say, 'Everything's finished, quantum computers are going to take over, machine-learning is here.' But my experience is, things turn up, and if you put enough attention and enough passion into looking for problems, you find them. There are problems to be solved everywhere, and a lot of fun to have."

[1] Website for upcoming maxi workshop: http://indico.ictp.it/event/8658

(Thursday, January 11, 2018. At The Diamond Room, Selwyn College, University of Cambridge)

Interview

Carving Out the Future through Biomimetic Materials Science



Hiroshi Yabu

AIMR Junior Principal Investigator, Associate Professor

Create new materials modelled after living things—that is a major theme in my research. To achieve that, I am engaged in research that uses "things that can be picked up or held in the hand" as the subject. In AIMR, which continues to pursue the frontiers of materials science at atom level and nano level, I may be an unconventional materials scientist who is carrying out research from a macro perspective. To begin with, I had not moved into the field of materials science from physics or chemistry as many AIMR researchers did, but rather from biology. In that sense as well, I am somewhat unusual in this research institute.

Consistently engaged in research on polymers

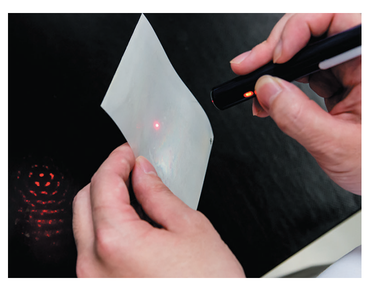
I was born in Wakayama Prefecture and raised in Aichi Prefecture until senior high school, then I entered Hokkaido University. I had moved from Aichi to Hokkaido simply because I had wanted to go somewhere far away. I wanted to escape from the culture of the environment that I had been raised in, and move to a whole new world.

At university, I enrolled in the Department of Biological Sciences. As a student, I had learnt to carry out structural analysis of proteins and analysis of biomolecules, and I wanted to be a life scientist. At graduate school, I was a member of Professor Shimomura's research laboratory, which was conducting research on polymers, and I received my doctor's degree in chemistry. Our cells are all "put together" through the mutual interaction of molecules. There has been a long-established field of study known as "molecular architecture chemistry," which seeks to recreate that using artificial polymers. Hence, my current research is a development from the research work I had been involved in at the laboratory I was affiliated to in graduate school. I had moved from biological science to chemistry, then to materials sciences, but I consider myself to have been consistently engaged in research on polymers.

Let me introduce some of the research work that we are carrying out in my current research laboratory.

The first is the water-repellent surface of honeycomb film. Honeycomb film is a porous film made from polymers. To make the film, the polymer is dissolved in a solvent, applied thinly, dried, and made into film. When we want the film to dry quickly, we sometimes blow on it; however, the film that has been blown dry will always look cloudy-white after it has been completed. If we examine this surface under a microscope, we would see an infinite number of small holes in it. Moisture in the breath condense on the surface, and these sections become tiny holes. As the holes are shaped like honeycomb, the film is called "honeycomb film."

The processes after that were originated in our research laboratory. While the honeycomb film has many spherical holes in its surface, its inside is hollow as the parts where the holes are connected link with each other. One day, a student from the research laboratory peeled off the surface of the honeycomb film. When he did so, the film split on the top and bottom, and the surface of the bottom part was shaped like a pin-holder used in Japanese flower arrangement. When water was dripped onto that surface, it did not spread across the surface. Instead, the water droplets rolled around. I thought that it resembled the leaves of the lotus plant, because it is highly water repellant. I wrote a paper on this and it won an award at an international academic conference. This was what led us into the field of biomimetic material design that is conscious of the surface of the lotus leaf.



If a light is shone onto the honeycomb film, many fine hexagonal holes can be seen.

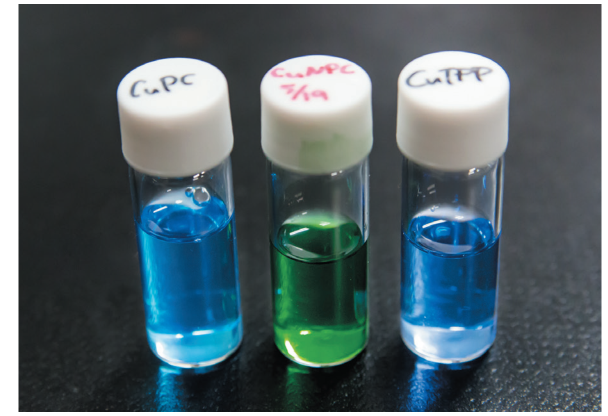
Biomimetic material design that reproduces colors

What a beautiful butterfly … It is called a morpho butterfly, which has wings with an uneven surface structure that reflects only blue color. On the other hand, the wings of the jewel beetle with its gorgeous colors is structured with many layers of membrane, which is how the colors are produced. So, colors are developed through various methods.

The jewel beetle has a structure comprising 10 layers of membrane. However, even if we were to attempt to recreate that with artificial materials, it would not be possible to produce those colors unless we use about 60 layers. It was something that could not be realized easily through artificial means. In our research laboratory, we combined black pigments, strengthened the reflection, and succeeded in reproducing the colors of the jewel beetle using about five layers of membrane. This is biomimetic material design that reproduces colors.

We also carried out research on the Japanese tiger beetles. First, we began with the work of collecting the elusive insect! (laughs) When I held a research seminar at Hokkaido University, everyone in the seminar went to collect the insect. The tiger beetle (Cicindela japonica) that lives on trees has a beautiful blue color, but the Miyama-tiger beetle (Cicindela sachalinensis) lives on the ground and is brown. I believe it is colored brown as a form of protection on the ground. The way that this brown color is produced is very interesting. The tiger beetle has an uneven surface structure like the morpho butterfly, which produces beautiful colors selectively. The Miyama-tiger beetle does not produce the brown color using color pigments, but produces it through the same surface structure as the tiger beetle. I believe that it first had this surface structure, then descended to the ground later. Over time, swarms of tiger beetles that produce brown color survived to become the Miyama-tiger beetles that we see today. I wrote two papers about multilayer membranes and the Japanese tiger beetles. For a living thing, it is important to minimize the impact of the external environment on the internal parts of the body as far as possible. For that reason, they have evolved with various contrivances on the surface of their bodies. It is very interesting to study the surface structure of living things as we can discover various things.

Morpho butterfly with its complex and beautiful colors.



Highly transparent liquid pigment dispersion achieved through nanosizing with micelle. Nanosize is achieved through a capsule that imitates the membrane structure of a living thing.

Life science, materials science, mathematics. Aiming for two-step academic fusion

Next, I will talk about mussels. Mussels produce an adhesive protein (protein that contains catechol) from its byssuses to help them stick to rocky areas. This protein is a highly effective adhesive, and holds firmly even in the sea. If we were able to incorporate this function into an artificial material, it might be possible to produce a powerful adhesive. With this in mind, I began to carry out research into this area. This involved applying a catechol group to an organic polymer in order to transform it into an adhesive. We are currently exploring this together with corporate researchers, and we think that it may be possible to use this as an adhesive for plastic materials and metallic materials.

Last but not least is our research on nanoparticles. If a solvent that mixes with water is used when making honeycomb film, the polymer precipitates as a sphere and becomes a nanoparticle. We initially created nanoparticles from various materials and studied their properties, but at one point, I realized that it may be possible to produce nanoparticles with a virus-like structure. I think that this is an idea made possible because of my background in life science. Artificial polymers have a complex tangled structure similar to a ball of yarn, but a virus has an extremely well-designed structure. I thought that the principles behind their creation are probably different, and started on elucidating these principles together with applied mathematician Yasumasa Nishiura (then Principal Investigator at AIMR; now Professor). This was an analysis that incorporated the perspective of mathematics. If we could describe the principles in mathematical terms, it might be possible to apply the design principles of viruses to artificial materials in the future. This research was made possible only because I had come to AIMR. Conducting research in materials science by using life science as the basis, then transcribing that in mathematics. This is two-step academic fusion. I do not think I could have done it alone.

The 3D structure of a polymer nanoparticle produced using a 3D printer. Understanding is deepened through discussions that involve the tangible output from discussions with mathematicians.

The philosophy of researchers facing growing proximity between science and industry

I have introduced some of the work from my research laboratory. For me, research not only uncovers a broad scope and possibilities, but also helps me to find new possibilities for myself. Through the potential in my research subjects, I am able to experience a real sense of "Ah, so I can do this, too!" Although my work is in the field of applied science or practical science, it is my constant desire to do something related to physical science, and to pursue the roots and origins.

When I visit Europe or America, I feel that science is becoming ever closer to industry. However, I have found that it is not overwhelmed or swallowed up by industry; rather, the output from industry-academia collaborative research is returned to fundamental science. Even though it appears to be becoming increasingly "industrialized" on the surface, underneath that, the output is continuously and properly being drawn into the massive academic system. These researchers, especially European scientists, are engaged in scientific work with a firm and steadfast philosophy. If not, it would become meaningless to conduct research at universities.

Recently, Japanese academia is also gradually drawing closer to industry. It appears to be putting the focus on pursuing practicability in its collaboration with industrial circles. However, increased proximity between science and industry that is beneficial to the academia is not such a simple matter. I think that we should continue with these efforts resolutely, in order for the Japanese academia to learn from scientists in the West and continue to build up a massive academic system.

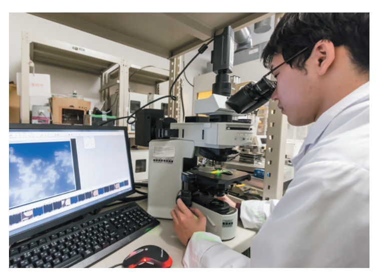
Carving out the future through integrated science

When I was an assistant professor at Hokkaido University, I was engaged in the development of a device that produces honeycomb films by generating condensation, in collaboration with a corporation. This was a wonderful learning experience for me and gave me the opportunity to expand my horizon. This was because I developed the habit of being conscious of the big picture when the device failed to work properly, with perspectives such as "In such circumstances, I should repair the equipment" or "At such times, I should do something to the material." If I only had the perspective of a chemist, I would probably have been focusing only on the materials. At that time, I realized that it is necessary to apply "integrated science" for the practical use of science. In other words, it is necessary to have a "macro" perspective and way of thinking. In Japan, science is divided into basic and applied science, but I think that the mindset of researchers of basic science would expand if they could have such experiences. It would be good for basic scientists to have a stronger awareness of the applied sciences, and for applied scientists to have a stronger awareness of basic science. The division into basic and applied science is probably one of the problems in Japanese sciences. If we were to adopt this way of thinking, I do not think anyone would come up with the idea of shrinking the field of the humanities in universities, which caused a row some time back. This is because education that includes knowledge of the humanities forms the basis of both basic and applied science.

As for my future prospects as a researcher, first, I would like to expand the field of biomimetic material design steadily. I would like to combine the merits of living things and manmade things to create something completely new. Currently, I am exploring various aspects of this field with other researchers in the university, such as the possibility of producing wearable electrodes using biomimetics.

Next, I would like to discover a universal law. Materials science creates the impression that it involves thorough and detailed study into individual subjects, but I take the opposite view, and wish to discover laws from a macro perspective.

Next—and this is probably something that is natural to me—I would like to continue learning various things from living things in the future. Using living things, or "nature" as a model is probably the right approach to take for someone who is involved in the work of editing the natural sciences. With this conviction, I aim to continue with my regular research work.



(December 4, 2017. At the Yabu Laboratory in the AIMR Laboratory Building)

Math and I

Part 2

Staying Together with Math as a "Neighbor" into the Future

$$\frac{\partial f}{\partial t} + \mathbf{v}\cdot\frac{\partial f}{\partial \mathbf{r}} + \frac{\mathbf{F}}{m}\cdot\frac{\partial f}{\partial \mathbf{v}} = \iint (\chi f' f_1' - f f_1)\, g\, d\Omega\, d\mathbf{v}_1$$

Kuniyasu Saitoh
AIMR Associate Professor

In 2011 he completed his doctoral degree at the Graduate School of Science, Kyoto University. In the same year, he became a postdoctoral researcher at the University of Twente (the Netherlands), and Assistant Professor at AIMR, Tohoku University, in 2016. Since 2018, he has been working as Associate Professor at AIMR and the Research Alliance Center for Mathematical Sciences (RACMaS), Tohoku University.

Another approach to look at mathematics

Math and I … ? Is it acceptable for me, as someone who is not a mathematician, to discuss this subject? I am a physicist.

Born in Nagano, I attended Kyoto University where I majored in physics. Since senior high school, I have felt a sense of mystery about physics and aspired toward it for some vague reason. At university, I had initially aimed to study astrophysics, but began to engage in the research of "theory of granular materials and numerical study" during my master's program. In other words, I was studying the behavior of powder materials, or just "powder." For example, when wheat flour is released from a bag suddenly, the powder clumps together and then gradually crumbles. I carry out simulations, for example, on the movements it follows when it crumbles. This is known as statistical physics, and since then, I have continued to carry out such research on powder materials.

Physics is the "study of models." It is a science where we create stories about the changes that things undergo. These are theoretical stories created using mathematical formula. We start with the description of micro phenomena, and move on to the explanation of macro phenomena. That is why I used to think of mathematics as a tool and means of description. On the other hand, mathematics, as a field of learning, is rooted in conceptual ideas, and it then moves on to description from these concepts. Mathematics covers a wide range of concepts and it looks at data through a different filter from physics and looks for regularity. Mathematics talks about "regularity," while physics talks about "phenomena."

Since I joined AIMR, the presence of mathematics has continued to grow ever larger for me from day to day. Previously, I had considered mathematics to be a method, and had the impression of it as something that exists "in the background" of physics and chemistry. However, after coming to AIMR, I learnt that mathematicians carry out analysis directly on materials (substances). I learnt that there are two methods for carrying out research on materials—observation through physics, and observation through mathematics. For myself, as a physicist, mathematics is another approach that I should refer to.

Currently, I feel as if I were working together with a friend who has come from a different country called "mathematics." As I collaborate with mathematicians, I am gradually and continuously incorporating mathematical approaches within myself. I actually feel that I am gradually getting closer to becoming a mathematician.

A mathematical formula that is important to me?

That would naturally be the Boltzmann equation which I encountered during my master's studies. This equation is an important formula for statistical physics, and fluid equations as well as other formulas can be derived from it. Furthermore, it is a formula that connects the micro elements to the final macro exits. The process from "micro to macro," and the "movements" or in short, dynamics … For a physicist like myself, these are two very important things.

Since coming to AIMR, mathematics has changed from a "method" to a "neighbor" for me. Going forward, I would like to deepen communication with mathematicians and incorporate concepts from mathematics into physics. In other words, that is a fusion of mathematics and physics. Through that, I believe it would be possible to create new genres and academic disciplines.

(Tuesday, November 28, 2017. At the Mathematical Science Group Laboratory in the AIMR Main Building)

The Resurrected Lab Part 2

From the trial-and-error of an untrodden path, to the establishment of an identity

Masaru Tsukada
Former AIMR Administrative Director / Principal Investigator

In this series, we introduce an "indelible scene in the lab" that had an impact on the particular researcher's life.

In 1970, he completed his doctoral degree program at the Graduate School of Science, the University of Tokyo. He became a research associate there in the same year, Associate Professor at the Institute for Molecular Science in 1976, Associate Professor then Professor at the School of Science, the University of Tokyo, in 1982 and 1991 respectively, and in 2004 Visiting Professor (Full-time) at the Faculty of Science and Engineering, Waseda University. From 2008, he served as a Principal Investigator at AIMR, Tohoku University, and worked as Administrative Director (Specially Appointed Professor) from 2012 to 2018.

What is something that has left the deepest impression on me? That would, of course, be around the time I was appointed as Administrative Director of AIMR. This story probably takes place in the larger frame of the "revitalized research institute" rather than "the resurrected lab." Since receiving my degree in 1970, I have devoted the past 40 years solely to research and education. I believe it was a certain day soon after the start of the year in 2012 when I was appointed as Administrative Director and tasked with the job of coordinating administrative and operational matters that I had neither experience nor knowledge of. It was truly a bolt out of the blue, and I remember being a "lump" of anxiety.

After I completed my doctoral degree program at the Department of Physics, Graduate School of Science, at the University of Tokyo, I became research associate of Professor Yasutada Uemura from the same department and spent two years as a postdoctoral fellow at the Technical University of Munich. After that, I then worked five years as Associate Professor at the Institute for Molecular Science. Although I had begun with condensed matter physics as my major, I decided to engage in surface science research, which was becoming increasingly prevalent at the time during my stay in Germany. At the Institute for Molecular Science, I got to know excellent young researchers in the field of physical chemistry, and gained a real sense of how important fusion research was. After my time at the institute, I returned to the University of Tokyo in 1982 as Associate Professor, served as Professor until 2004, and approached mandatory retirement without incident. Meanwhile, I carried out research in areas such as surface science based on electronic states, the development of novel computation methods with a focus on first-principles, the dynamic process of surfaces accompanying electron transfer, the physics of micro-clusters, the basic theories of scanning probe microscopy, the theories of carbon nanostructures, and the theories of nanostructures and molecular devices, while educating the next generation at the same time. After I finished my term as Visiting Professor at Waseda University, I was invited to be a Principal Investigator (PI) at AIMR, and became a member of Tohoku University. During my time as a PI at AIMR, I enjoyed carrying out research with young researchers, with a focus on areas such as research of electrical and atomic elementary processes in liquid/solid interface, and the fundamental theories of atomic and molecular bridged systems and nanodevices. I have never lost my interest in science after that, even to the present day. As a theoretical researcher, I have been blessed with the opportunity to engage in joint research with numerous excellent experimental researchers to date, including Toshio Sakurai, Chuhei Oshima, Kunio Takayanagi, Yoshitada Murata, Masakazu Aono, Seizo Morita, Hirofumi Yamada, Motoichi Ohtsu, Kazuhiko Hirakawa, Takeshi Fukuma, and Taro Hitosugi. I am truly happy to have had an enjoyable and stimulating research life.

As we all know, AIMR is one of the first five research centers selected to be a part of the World Premier International Research Center Initiative (WPI Program) of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and was established in October 2007 as WPI Advanced Institute for Materials Research (WPI-AIMR). I joined the Center in April 2008 as a Principal Investigator. I further developed theories in condensed matter physics and surface science, and sought to promote interdisciplinary fusion research. In the few years after I took up position as Principal Investigator, I planned a WPI-Joint Seminar about once every other month as the main event of the research laboratory, where experimental researchers and theoretical researchers interact with one another and explore the sprouting shoots of joint research. This later developed to become the AIMR Joint Seminar, an event under the AIMR organization. The development of new concepts in materials science through such interdisciplinary fusion was something that was demanded of AIMR. On the other hand, in order to realize the characteristics of the WPI Program, namely the establishment of "excellent research standards and an outstanding research environment which appeals top-level researchers from around the world," AIMR made many efforts to create the best research environment in order to attract many researchers from outside Japan.

During this time, the Great East Japan Earthquake struck in March 2011, and AIMR sustained severe damage. A little while before this blow, I would occasionally hear from the former Director of AIMR, Professor Yoshinori Yamamoto, about the great difficulties the Center faced with regard to the overall direction of the research fields of the Center, and the clarification of its identity. Alongside with the restauration from the earthquake damage, many of the faculty engaged in enthusiastic discussions for successive days on what should be done about AIMR's identity, with a view to preparations for the interim evaluation at the five-year mark of AIMR's establishment. As a result, in tandem with driving forward the new attempt of introducing mathematics into materials science, the Center welcomed Professor Motoko Kotani to AIMR as its Deputy Director. The key members, including Deputy Director Kotani, held many policy meetings, where they shared the policy of taking a bird's-eye view from the perspective of mathematical principles on functional clusters built up through materials research, reorganizing them, extracting the common elements, analyzing the mechanism of these elements, and providing new guidelines for materials development (feedback).

At the same time, Deputy Director Kotani explained that obtaining the desired function (material) is an "inverse problem" for conventional materials science that focuses on analyzing substances, and that it would be easier to deal with this "inverse problem" mathematically, by treating the functional element (we called the element "function") as a basic unit without tracing back to the atom and molecule. She proposed that solving the "inverse problem" of complex systems would, in itself, be a new challenge. Based on this proposal, the Center established, through trial and error, the scheme of establishing interface units to link materials science and mathematics, introducing target projects, promoting fusion research, and introducing "brain circulation" within the university. In particular, the introduction of an independent group of young theorists, known as the "interface unit," drew much attention from the WPI Committee. However, the proposal of a new identity for AIMR as a center for the collaboration between mathematics and materials science was regarded as a trial, implemented under a "provisional license," as it was the first attempt of its kind in the world, at the research institute level.

To accelerate the implementation of these schemes and move AIMR into the next phase, Professor Kotani was appointed as the Director of AIMR in April 2012. At the same time, my research life suddenly underwent a major change. I was appointed as Administrative Director. It is embarrassing to admit, but I had neither any knowledge nor experience in administrative work and the operation and management of a research center. I remember wondering every day about what I could do. In the book Nihon no Jinruigaku (Anthropology of Japan) by Juichi Yamagiwa and Keiichi Omoto (published by Chikuma Shobo), which I had read recently, I found the following lines: "Physics teachers do not know much about the world, and particularly about human beings. All they know is physics." I thought this was a wise saying and a precise description of me at that time. I felt that there was no way I could fulfill the role in the same way as the preceding Administrative Director Wataru Iwamoto, with his wealth of administrative experience, and Administrative Director Toshio Sakurai before him, a global leader in the field of surface science, and who had put every effort into the management of AIMR. I decided that the only way was for me to tackle the projects one by one, carefully and sincerely. As I literally went through the process of "trial and error" repeatedly, it became my daily routine to exert myself to the utmost to accomplish my daily duties. Fortunately, we had the world-class research output generated by many Principal Researchers, and I took pride in having faithfully and steadily realized the schemes that had been established beforehand. The new attempt to introduce mathematics into materials science received a passing mark in the evaluation by the Committee in 2014, and I believe, subsequently resulted in the establishment of the "AIMR identity" that has remained firm and unwavering today. Looking back, I could not possibly have achieved this on my own, and I acknowledge anew the immense support that I had received from the former Deputy Administrative Director Shinichi Sato and then Associate Professor Susumu Ikeda (now Director of the Research Support Division). I would like to take this opportunity to express my heartfelt gratitude to them.

AIMR, which has steadily produced outstanding research results and achieved progress according to its initial plans, applied for an extension of its research period prior to the estimated conclusion of its 10-year term at the end of March 2017. However, how do you submit an application for an entirely unprecedented program? The research division and administrative division worked as one to find a solution to this problem, and this left a deep impression on me. It is necessary to receive an "S" evaluation in the screening in order to obtain approval for the extension. All members of the staff and faculty, under the leadership of Director Kotani and Associate Professor Ikeda, put in their utmost efforts. As a result, we received an "A" evaluation which was below the "S" evaluation that we had hoped to get, failing to obtain approval for the extension. However, this "A" evaluation was still deemed to be an extremely high rating. I felt that the excellent leadership of Director Kotani at this time and the unity of all the staff and faculty had undoubtedly become the foundation for AIMR today. AIMR graduated from MEXT's WPI Program last fiscal year and moved on to become a WPI Academy member, and at the same time, became independently managed as an internal department of Tohoku University. With that, the Advanced Institute for Materials Science underwent a renewal and changed its former Japanese name, while the English name and its abbreviation remained the same.

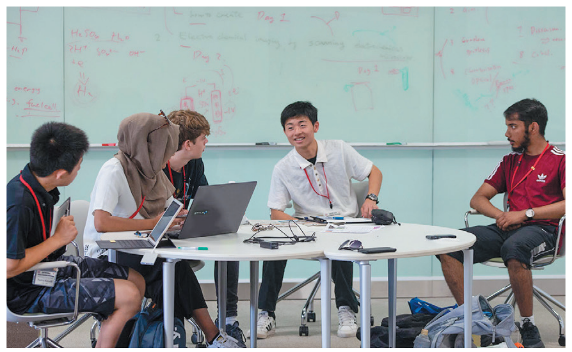
There is other good news. In June 2017, Tohoku University was accredited as one of the first three "Designated National Universities" in Japan. This is deemed as the result of Tohoku University's efforts to push to the forefront its initiatives in further promoting its strengths: disaster reconstruction, advanced medicine, spintronics, and materials science. For materials science, which is one of these strengths, I truly hope that the Institute for Materials Research, with its long history as an affiliated research institute of the university, the Institute of Multidisciplinary Research for Advanced Materials, the Institute of Fluid Science, School of Engineering and Graduate School and Faculty of Science that have sent countless outstanding students out into the world, as well as research centers that are closely related, will work closely with AIMR and demonstrate a synergistic effect to create a materials science hub. In order for Tohoku University to become one of the top 30 universities of the world that enjoy respect from around the globe by 2030, I hope that the materials science hub will continue to progress going forward and play a part toward the realization of that goal. I sincerely wish you all the best in the future.

Fresh Eye

The 2018 Tohoku UK-Japan Young Scientist Workshop was held from July 30 to August 5, 2018, with the primary aims of fostering a global perspective, raising motivation to communicate in English, and developing the ability to express oneself and take action through presentations and discussions with students of the same age group from a different country. Ten senior high school students selected from Fukushima High School, a Super Science High School (SSH) accredited by MEXT, and the Clifton Scientific Trust in the UK, visited AIMR and tackled two research topics in their groups. We spoke to Daisuke Takano from Fukushima High School, who attended this workshop.

— First, well done for your work during this week. Could you tell us about your motivation for participating in this workshop?

I entered senior high school this year, and began living in a slightly different environment than before. First, I was surprised at the large number of people who had had experience interacting with foreigners. I, however, had not had such an experience before. Meanwhile, I heard about this workshop. The opportunity to interact with senior high school students from the UK through science in this activity appealed to me, so I decided to participate in it.



Daisuke Takano (in the middle) taking part in a conversation in English with students from the UK.

— After your visit, what are your impressions of AIMR?

For a start, I was surprised at the liberal atmosphere of this research institute. This was the first time I had an impression of what it feels like in a research laboratory at university, but I had always thought that research institutes are very solemn and serious places, with rows of rooms like a hospital where scientists carry out their research. However, the moment I stepped through the doors of AIMR, I saw light coming in through the atrium, as well as spacious communication spaces with a calm atmosphere, creating an open and free impression. The research laboratory of Associate Professor Akichika Kumatani, who hosted me, also had a free and peaceful atmosphere; in fact, when I asked if there was any significance to the words written on the transparent partitions in the room, I was told that they were there to prevent people from walking unknowingly into the partitions!

The research laboratory was filled with devices and equipment that I had never seen before. Among these, I was told that some were even made by the researchers themselves. I truly felt that this is a place where cutting-edge research is carried out.

— What research topics did you deal with?

Under Associate Professor Kumatani in the research laboratory that I was a member of, I worked on the creation of a graphite molecule (graphene) that is one atomic layer thick. First, we used scotch tape to make the graphite molecule thinner, then used two methods to determine if the molecule was one layer thick.

— Did the research proceed as you had anticipated?

The research itself proceeded smoothly, and three to four layers of molecules were found as a result. However, we failed to find a molecule with the thickness of a single atomic layer. It was assumed that the number of times that the molecules were divided into layers using scotch tape was too small.

— How about communication with the British senior high school students?

When I first joined the program, I tried to use correct grammar and translated Japanese texts literally into English, so I would often get stuck for the right words and not be able to keep up a conversation.

Gradually, however, I learnt that it was possible to communicate adequately even if there were some mistakes in grammar and vocabulary, with the help of gestures and facial expressions. This made it possible for me to converse with the British senior high school students about science during the train ride on the way to the research laboratory, for example.

— Last but not least, could you tell us your impressions on participating in this program, and your future dreams?

Through this program, I felt anew the importance of English conversational skills. Earlier, I said that it was possible to communicate adequately with gestures. But at the same time, I felt that it is necessary to use the English language accurately in the scientific world. This is because a minor misunderstanding in science can have a significant impact on the research outcome. There were also instances when I completely misunderstood the explanation of research contents that was delivered to me in English. Although there have been advancements in the development of simultaneous interpretation technology, I would like to be able to express the unique rhythms of English, the unique characteristics and personalities of individuals, and even the desire to participate in a conversation. As I aspire to further my ambitions in science, I aim to continue learning English and participate often in practical exercises such as this program. I am truly grateful for this invaluable experience.

— We hope that you realize your dreams. Thank you.

COLUMN

Miyagi Soubun 2017: Study Tour at AIMR

(Susumu Ikeda, AIMR Director Research Support Division. Thursday, August 3, 2017)

The 41st National Culture Festival for Upper Secondary Schools (Miyagi Soubun 2017), a senior high school culture festival that features arts and culture presented by senior high school students representing all prefectures from across Japan, was held in Miyagi Prefecture. Musical performances including choral singing and brass bands, art exhibitions of painting and calligraphy, Japanese board games such as Go and Shogi, speeches, theater, traditional folk performances, and many other forms of artistic and cultural activities were presented at various venues. In the natural science category, a research presentation session was held at Ishinomaki Senshu University in the morning of August 2 and 3. In the afternoon of the second day, the participants were divided into several groups to carry out study tours at Ishinomaki Senshu University, Tohoku University, the Ishinomaki coastal region, Izunuma, Mt. Kurikoma and other places. At Tohoku University, a total of about 360 senior high school students and their teachers were divided into eight groups of about 45 people each. They visited the Faculty of Science, the School of Engineering (two courses), the Faculty of Pharmaceutical Sciences, the Faculty of Agriculture, the School of Medicine, the International Research Institute of Disaster Science (IRIDeS) and AIMR. Although many of the places that the students visited were faculties linked directly to the further studies of the senior high school students, IRIDeS and AIMR were requested to be included in this study tour as they have many points of contact with Super Science High School (SSH) schools in their regular outreach activities.

On the day of the tour, Deputy Administrative Director Susumu Ikeda (now Director of the Research Support Division) first gave an overview explanation of the WPI program and AIMR at the Seminar Room on the second floor of the AIMR Main Building. The students then had a tour of the state of the art equipment and facilities groups in the Common Equipment Room. Thereafter, the students split up into three groups and alternately visited the Takahashi Lab, Orimo Lab, and Yabu Lab for 40 minutes each.

Assistant Professor Katsuaki Sugawara (now Associate Professor) delivered a lecture on superconductivity at the Takahashi Lab. He presented actual experiments demonstrating how electrical resistance falls and the state of superconductivity is achieved when a superconducting material is cooled with liquid nitrogen, and how a magnet placed on top of a superconducting substance floats in space (Meissner effect). He also gave an explanation about graphene, a sheet material made of carbon that is only one atom thick, which he has recently been conducting research on. As graphene (a graphite sheet comprising multiple layers of graphene was used in the experiment) has high thermal conductivity. When it is held in one's hand, heat from the fingers is transmitted instantaneously across the entire graphite sheet, and bringing the edge of the sheet into contact with ice can cut the ice like a razor. Assistant Professor Sugawara demonstrated this, and allowed the students to experience it for themselves, generating exclamations of incredulity and surprise.

In the Orimo Lab, Associate Professor Hiroyuki Oguchi introduced research equipment such as a special experimental device for handling hydrogen and a large-scale computer used for theoretical calculations. He also delivered a lecture in the Seminar Room on the structure of a fuel cell that makes use of the electrochemical reactions of hydrogen to extract power. After that, the senior high school students and their teachers used a fuel cell kit to produce an actual fuel cell, injected hydrogen gas to generate electricity, and checked that the motor was running. Using a tester, they measured the voltage generated, and learnt that there is still room for technological improvement for extracting energy without any wastage, at a lower voltage than predicted through theories on electrochemical reactions.

Associate Professor Hiroshi Yabu (Junior Principal Investigator), representing his own research lab, delivered a lecture on biomimetics (technology of imitating living things), which involves learning the characteristics of living things and applying them to materials. By observing the surface of a lotus leaf and the fingertip of a gecko under the microscope, it can be seen that they have unique microstructures, which led to the discovery of a water repellant effect and adhesiveness. In the process of evolution, living things have acquired such a special microstructure in order to gain more advantageous properties, which contributed to the preservation of the species. By learning about the relationship between properties and unique structures that go beyond the human imagination, and using the same structures to manufacture materials through artificial methods such as self-organizing system, it is possible to develop new materials with functions such as water repellant effects and adhesiveness. While students study physics, chemistry, biology, geology and other subjects separately at senior high school, biomimetics is a typical example of a new research discipline that fuses knowledge, experience and technology of different disciplines including biology, physics and chemistry. An interesting aspect of research at university is the cultivation of such new disciplines, and it is important to have a wide range of interests. These were the points that the students took away with them.

After receiving the official request for a study tour from the chairperson of the natural science category of Miyagi Soubun 2017, and based upon many discussions with the teachers-in-charge at senior high schools in Miyagi Prefecture, the decision was made to visit the three research laboratories above in consideration of the balance of research fields. We would like to thank the teachers of the senior high school students in the prefecture who recommended AIMR as a site for the tour, and who took care of prior arrangements and managing the tour on the day itself, the senior high school students from across Japan who visited AIMR on the day, the teachers who accompanied the students on the long journey, and the Takahashi, Orimo and Yabu Labs that kindly accepted the request for the tour.