Interview with Associate Professor Taro Hitosugi, WPI-AIMR

The Best of Man is Like Water

Encounter with Science

Administrative Director Iwamoto (I): I recall that you grew up in Kanagawa Prefecture, and graduated from a high school in Kanagawa.

Associate Professor Taro Hitosugi (H): I graduated from a prefectural high school in Kanagawa. Before that, I lived in the US because my father was a semiconductor engineer. I think that is where I first came into contact with science and technology.

I: How old were you when you went to the US?

H: I lived in the Silicon Valley from third to sixth grade. It is the city where the headquarters of Apple Computer is located. I was sent to a local school when I was in the third grade, but I did not understand any English and did not have any friends, so I kept crying for about a week (laugh).

I: That is only natural.

H: But after a week I had already blended in with the new environment. You do not need language to communicate with one another when you are a third grader or so. You can naturally make friends by playing ball and other things. So I was soon Americanized.

I: That is right. Because your father was a semiconductor engineer, were you familiar with semiconductors and the like since you were little?

H: Yes, these things were in my head at least. I think my father had an influence on me on that point.

I: So you came back to Japan after you finished elementary school.

H: Yes. And there was the superconductivity boom at the end of 1986, when I was in high school. There were reports about superconductivity in the newspaper every day, and although I did not understand much, I thought science was interesting. I think that was one of the turning points in my fate.

I: Oh, I see.

H: The impression I had at that time that "science is interesting" later came to have a meaningful impact. At that time it was only drummed into my head, and the impact was not strong enough for me to decide my path back then.

Until then, the superconducting transition temperature, which is the temperature at which materials become superconductive, had not increased much for decades. However, the discovery made by Dr. Bednorz and Dr. Müller of the IBM Zurich Research Laboratory led to a major paradigm shift in the world of physics, in which the superconducting transition temperature exceeded the liquid nitrogen temperature (77 K) all at once. And many researchers ceased their previous research and made a dive into the research of superconductivity.

I: These things happened then.

H: Yes. At academic meetings in the US, discussions normally continue from 9:00 a.m. till around 6:00 or 7:00 p.m., but at that time they continued till 6:00 a.m. I hear that discussion sessions were held all night long. This shows how excited everyone was and how eager they were to hear the latest reports on superconductivity at that time.

I: That is surprising.

H: People had the rosy idea of putting it into practical use, which can be said to resolve many of the challenges we are facing today. For example, with respect to electric energy, electric power is now produced and consumed in Japan. If the superconducting technology is established, however, it will become possible to generate power in the Sahara by photovoltaic power generation to be transmitted to Japan without any loss. This is just one example of how we would be able to resolve the energy issue. Therefore, my final goal in my research is to achieve superconductivity at room temperature.

I: I see. So while you were in high school you decided that you would absolutely major in science.

H: Yes, although at that time I did not intend to become a researcher.

I: Then you entered the University of Tokyo, and studied industrial chemistry in your undergraduate course.

H: Yes, I studied in the Department of Industrial Chemistry. But during the four years of my undergraduate course, I did not study at all.

I: What were you doing?

H: I was playing rugby all the time. I was playing rugby so much that my professor said, “You are among the five people in the Faculty of Engineering with the worst grades,” but I somehow graduated.

I: It is impossible to imagine you like that now.

H: Now that I think of it, what is important is the fact that I put all my energy into it for four years. Then, after I entered graduate school, I made a complete shift to studying.

I: So you concentrated on rugby during the undergraduate years.

H: I enjoyed it.

I: Did the University of Tokyo have a strong rugby team at that time?

H: It had quite a strong team then. It was like risking my life for it.

I: So you still have that kind of spirit.

H: Yes, I still have that spirit, really.

Company and University, and the Time Leading Up to the Decision to Become a Researcher

I: As was described in *Nature* (Vol. 466), after you completed your doctoral course, you first worked for a private company.

H: Yes.

I: And then you changed your path from a private company to a university. When you could have stayed at the university immediately after you obtained a Ph. D. from the graduate school, why did you choose to work for a private company?

H: At that time I wanted to see how my achievements would become truly useful in a tangible way. I wanted to make the technology I was involved in help improve people's lives and make people enjoy my technology. I thought I would be able to do such things if I worked for a company.

I: So you joined Sony Corporation.

H: Yes.

I: What kind of work did you mainly do at Sony?

H: I was first involved in the development of the optical disk. At that time we were developing new technologies that would go beyond the Blu-ray disk. So we had to think about what the market will be like in about 10 years, and develop products and technologies accordingly. We were in charge of optical disk development, so we had to envisage the future of the DVD. But then we reached a conclusion that in the future high-speed Internet would be widely used at homes, and that very high density semiconductor memories would come into the market; and that therefore there would be no room where optical disks such as DVDs could succeed. And so our development was discontinued.

I: Is that the way it goes?

H: As it turned out, that is the exact social trend seen today. Digital distribution is on the increase, and computers without CD-ROMs are becoming more common. Hard disks are increasingly replaced by semiconductor memories. Right now we have the Blu-ray technology ahead of the DVD, but we cannot think of many suitable applications after the Blu-ray. It means that the optical disk technology will go out of use.

I: So you were of course carrying out your research, but the company had to focus on such market trends in 10 or 20 years. That was the kind of environment you were in.

H: Yes.

I: Were you with Sony for about four years?

H: Yes, for four and a half years.

I: And then you went back to the university again.

H: Before that, there was one event that marked my life. As you know, we are manufacturing experts. We are very good at thinking what kind of technologies should be combined and what kind of technology development is required to produce products. On the other hand, I also felt that it would be impossible to see what would really happen to the technologies in the future without paying attention to how the technologies were delivered to people after they were made into products. That feeling is still with me today. So I wanted to have the actual experience of spreading the technologies and products I created. Sony is a very interesting company that allows even Ph.D. holders to be transferred to product planning or marketing or sales.

I: I understand.

H: I already mentioned that the optical disk development project was discontinued. I am by nature a person who pushes ahead with things I want to do, so I said I wanted to do marketing or sales which I had never actually had any experience in, and I started doing sales activities to sell Sony products to the world. I was in charge of sales of small VAIO, which was like today's iPhone. I was making presentations at press conference myself, explaining "This is Sony's new product, and this is Sony's strategy!" and making statements in magazine and newspaper interviews. I was involved in sales promotion in such ways.

While doing this kind of work, I was always thinking of what kind of work I should spend my lifetime doing. And then when I was 30, I finally found out what I should spend my lifetime doing; I decided to devote myself to research. Looking at the wide range of functions from research to the frontline of sales allowed me to find out for the first time what position I would enjoy the most. So I decided to go back to research, and make it my lifetime's work. Of course, I think this decision was greatly influenced by the fact that the idea that science was interesting was drummed into my head when I was in high school.

I: Oh, I see. Your experience in a wide range of things contributed to your decision.

H: There is another important thing. As I mentioned before, we were indeed making products such as the iPhone when I was in Sony, but they did not become hit products like today's iPhone. It was very frustrating, and I tried to figure out the reason. I came up with a conclusion that I was trapped in and bound by the belief that I was not allowed to do things in certain ways. So now I am constantly trying not to set limitations on myself as much as possible.

I: What was the limitation that was in your head at that time?

H: Let’s take the example of listening to music. Sony has a music company and therefore is very sensitive about copyrights. But the MP3 technology that triggered the success of the iPhone does not take the issue of copyright into consideration. Because we had a music company, we believed that we were not allowed to adopt technologies like the MP3 technology. That naturally made the product less user-friendly. That is one example of the limitations. Now I am telling myself never to set limitations on myself. If I succeed in something, it always serves as a restraint and it will become more difficult to achieve the next success.

I: There are no such limitations in research at universities by nature.

H: That is right. There are definitely fewer limitations than in companies. So I genuinely enjoy my research. Research at the university is fun. I always tell my students that if there is something they are interested in, they should take a shot at it and look for work they can spend their lifetime doing so they can live their lives to the fullest. I think there are quite a lot of people who are interested in something and want to do it, but cannot try it out and are reluctantly doing their current work with some dissatisfaction. I hope the students will not be like that, and that is the point of my message.

I: So it means that you should take interest in a variety of things to find out what you want to do for yourself.

H: Yes. I think you can have the greatest happiness if you can find out what you are going to spend your lifetime doing.

I: I agree. And then you became a researcher at the University of Tokyo and joined the AIMR about two months after its establishment.

H: That was in December 2007. If I am not mistaken, I heard that I was the first full-time researcher employed from outside Tohoku University. I also attended the opening ceremony of the AIRM that was held in November that year.

Characteristics of Research

I: Can you explain very briefly your research at the AIMR?

H: I can summarize it as an attempt to examine the characteristics of solid substances to achieve applications utilizing these characteristics. In simple terms, it is materials research for electrical products, to downsize and enhance the performance of mobile phones or to achieve higher speed and lower power consumption of computers, for example.

I: Therefore, it is important to measure the materials at an extremely micro level or examine their characteristics, among other things.

H: Yes.

I: I understand that the main tool you use for your research is the Scanning Tunneling Microscope (STM). You recently wrote a book called *Sosa Tonneru Kenbikyo Gijutsu* (Scanning Tunneling Microscope Technology) with Professor Hashizume as part of the *Butsuri-no-Sekai* (World of Physics) series of Iwanami Koza.

H: Yes.

I: Upon your recommendation, I read the first chapter of the book. People like Dr. Rohrer and Dr. Binnig appear in that chapter. You use the characteristics of waves and so on using the probe a sample.

H: We examine the atomic ordering or atoms themselves. Atoms are just so small at 10^{-10} meters, so people do not think that all things are made of particles. For example, water looks smooth, but it is also a collection of particles. The amazing technology that enables us to see each one of these particles became available in the early 1980s. And it caused a sensation in the fields of physics and chemistry.

I: Yes, and that was indeed the huge achievement made by Dr. Rohrer and Dr. Binnig.

So the microscope you have here in the AIMR is the STM?

H: Yes. The equipment we have on the first floor is the STM. We created laboratory equipment that we can boast to the world about, and we intend to press on with research using it.

I: I understand.

H: Things are comprised of atoms or molecules. So we are trying to understand them first, and then understand their aggregation. We are frequently discussing hierarchic structure at the AIMR, recently. It is the idea of viewing the clusters made up of atoms and molecules as a group, and viewing more than one cluster sticking together as a mass as well. We are heading for the direction of reestablishing materials science by breaking down the materials to such hierarchic structure.

I: In the end you are going to take a look at bulk properties.

H: Yes. In reality, at some level the materials start to have functions. We are trying to identify the origins of the functions and introduce a mathematical perspective, and establish new materials science by expanding this approach to more materials. These are the things we are discussing.

I: What you are working on now is very basic research. By the way, the AIMR has announced that the future direction of its output will be “green materials.” How will your research contribute to this end in specific terms?

H: One of the several projects we are working on is the development of lithium-ion batteries. We are quite focused on this project.

I: What kind of research is it specifically?

H: An electric car with a nominal range of 200 km was recently brought to the market. But the actual range will be decreased to around 100 km if the air conditioner is turned on or if the car is caught in a traffic jam. A range of 100 km is not even enough for a trip from Sendai to Tokyo. In order to make electric cars that can travel 500 or 600 km, technology to increase the capacity of batteries becomes important. Moreover, it is important that the batteries can be charged instantaneously. It would be a big problem if it took hours to charge the batteries, so it is necessary that batteries can be charged promptly. We are working to develop a technology to achieve these things, and the materials hold the key to its success.

I: I see. These things are important.

H: The other project is the research on transparent conductors, which are used in light-emitting diodes, solar cells and liquid crystal displays. An innovative improvement of transparent conductors will enable brighter lighting with lower power consumption and lead to the improvement in the efficiency of photovoltaic power generation. These things will lead to more green society. It is important here that we are heading for the direction of not using scarce metals. As the phrase "rare metal (critical material)" often appears in newspapers, there is the risk that we are going to use up all the elements with small reserves on earth, and industries will no longer be able to continue. For example, if the current situation continues, the liquid crystal display industry will be dead when the supply of indium runs out. So, transparent conductors that do not use indium will play an important role. On such a backdrop, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) is promoting the Elements Science and Technology Project, and Ministry of Economy, Trade and Industry (METI) is pushing ahead with the Rare Metal Substitute Materials Development Project. The research on transparent conductors is part of such projects.

I: I understand. So in that sense, your research will contribute greatly to green materials.

H: Yes. Our research consists of three pillars.

I: The three pillars are the understanding of oxides by the STM, lithium-ion batteries and transparent conductors.

H: Yes. These are all oxides. We are carrying out projects to understand oxides on the atomic level to put them to use for society.

I: That is wonderful. One of the characteristics of the AIMR is the fusion research. You stressed the importance of the fusion of research in the May 2010 issue of "The Monthly Journal of MEXT". Specifically, which groups are you advancing the fusion research with?

H: We often carry out research with people in the chemistry field, such as the Teizer

Laboratory or the Adschiri Laboratory.

I: In concrete terms, what kinds of research are these?

H: For example, together with Assistant Professor Hojo in the Adschiri Laboratory, we are attempting to create new materials by combining the technology of producing tiny nanoparticles using liquids, which the Adschiri Group excels at, and the vacuum technology in which we have strength. Currently the Adschiri Laboratory is able to produce square nanoparticles of 10 nanometers or less, and we are trying to add a function to them. We are trying, for example, to attach material B to the nanoparticle of material A, and create a new dumbbell-like material of A-B as a material with a new function.

I: That is indeed the fusion research.

H: It would be quite a challenge if we had to bring results in one or two years, but we have been making gradual progress through such efforts.

I: Do you think that the AIMR provides you with a favorable environment in which to work on such a fusion research?

H: I think it is a very comfortable environment because each laboratory is making efforts to enable cross-laboratory research. The other thing I like about it is that the people on the Katahira Campus of Tohoku University attach great importance to horizontal ties. In other words, I have a lot of opportunities to get to know people, even in laboratories I do not know.

I: Do you feel that Tohoku University has more opportunities like that compared to other universities?

H: Yes. I feel that there are definitely more such opportunities compared with the University of Tokyo, where I worked before. I think this Katahira has the culture that enables people to get to know various kinds of people. People who have worked for both the University of Tokyo and Tohoku University say that Tohoku University is extremely good in that you can have more horizontal connections. I have connections not only within the AIMR but also with the Institute for Materials Research (IMR) and the Institute of Multidisciplinary Research for Advanced Materials (IMRAM). Maybe I get to know people at the pub in Ichiban-cho (laugh).

I: Do you especially feel that way about the Katahira Campus?

H: Yes, I love the Katahira Campus. People are very friendly. I get to know a lot of people. It starts with lending or borrowing the equipment for collaborative research, and then your relationships widen. Connections are vital for research.

I: Within the AIMR, various active discussions are held among associate professors or lecturers in particular.

H: Yes, very active discussions are held. Those of us, particularly the people in this building (the AIMR Annex Building) are all new here, and we have a strong sense of unity from the beginning, so we have a lot of exchanges.

Lessons Learned from the Earthquake Disaster—Safety and Security

I: You told me about the STM, but what happened to the microscope when the earthquake hit on March 11?

H: There was less damage caused to the microscope itself than expected. I first thought it was a serious situation, but as a result of precise examination, we found that there was little damage.

I think there were two reasons for this. For one thing, it was fortunate that it was located on the first floor. The other reason is that there are a lot of devices incorporated in the microscope to isolate vibrations because it is easily affected by vibrations. Specifically, the microscope is equipped with a vibration isolation device called active damping system, which works to suppress vibrations that can be constantly felt when cars drive in the street, for example. So I think it suppressed the strong shaking, and it was able to avoid the worst shaking successfully. The STM that weighs 1.5 tons moved about 5 cm on the anti-vibration plate, but actually there was minimum damage.

I: That was good.

H: Yes, I really think it was good. The situation on the fifth floor was terrible, though.

I: Then the STM on the first floor can actually be used now.

H: Yes. However, we cannot conduct any experiment because of the continued aftershocks, since the STM is very vulnerable to the shaking of the ground. So although the equipment may be repaired, that is not the end of our battle. In short, we cannot conduct any experiment until the aftershocks are over. So time is very important.

I: Yes, that is the problem.

H: That is the very tough part. Further, in the laboratory on the fifth floor, gas cylinders that were fixed to the floor as part of the earthquake countermeasures fell, and various laboratory equipment and measurement instruments also fell, which are currently under repair. But we can manage things as long as they can be resolved with money. The problem is the time. A vast amount of time is being spent on recovery.

I: Because various kinds of research are advanced in the world in the meantime.

H: Yes. The most important aspect of the damage caused by the recent earthquake is that it has a great influence on a researcher's career. There is no way of recouping the time during which you cannot conduct any research. It is fatal for a researcher's career.

I: I understand.

H: This can only be overcome using your brains. It would mean that we may not be able to conduct any full-fledged research using the STM during the next six months or year, but we

have to do what we can ahead of time. All we can do is make changes to the research plan in a well-coordinated manner.

I: If you just sit and complain that things cannot be fixed or aftershocks do not end, you cannot move forward.

H: If you just sit and pray that the aftershocks will be over as soon as possible, it is not going to do any good. So you have to change the research plan. This is truly survival. At any rate, I think what is required of us is to produce output by using our brains.

Also, we suffered from a lot of psychological damage. After March 11, everyone was saying that we would pull things together somehow, and the new school year started on April 1, and we all thought we would make a new start, making preparations to resume our research. Then we were hit by an aftershock on April 7, and many things were destroyed again. If this is repeated, we are going to lose a lot of time....

I: It is a difficult situation from the perspective of maintaining motivation for research.

H: I think it would require less time and cost until recovery if we expected earthquakes to definitely occur and prepared for future earthquakes with thorough measures.

I also think that the earthquake posed a big question as to the modality of science. I had always used the words “safety” and “security” as synonyms, but I learned that they are quite different. I realized that the sense of “safety” is to understand in your head that your body will not be hurt and so on, and the sense of “security” is to understand in your heart that you can live a truly quiet and really peaceful life, I mean, a relief from the bottom of your heart. I think today’s science had focused on the aspect of “safety.”

I: You are referring to the announcements from governments such as, “the numbers are below the standard, so there is no problem,” and things like that.

H: Yes. You do understand that it is okay in your head because it does not harm you when seen from a statistical perspective. This is “safety.” But that alone is not sufficient. The absence of “security (a relief from the bottom of your heart)” leads to hoarding and harmful rumors. The important challenge for science to tackle is to consider what should be done to recover the sense of “security.”

When an accident occurs, for example, if it takes a long time till you can feel you are “safe,” it will be difficult to recover your sense of “security,” but if you can recover a sense of “safety” quickly, you may be able to recover your sense of “security” promptly as well. It is not only how fast you can do it, but I think the role of science is to help people recover their sense of “security.”

I: I agree. I believe that will then lead to social contribution.

H: Yes. I feel that Japan has the great ability of providing not only “safety” but also “security” to countries in trouble, and that by doing so Japan may be able to truly contribute to these countries. I do not know clearly what Japan should do, though. I strongly feel that we need to focus on the area of “security.” What are the materials that can help people recover their sense of security? There is a lot left for materials science to do.

I: It is important for Japan to learn lessons from these things and communicate to the people in other countries what we have learned.
H: It will be great if we can do that. I think Japan is good at these things; learning and creating new things based on what it has learned. I think that is the very thing that Japan ought to do.
I: I agree. This is important.

Research Environment Surrounding Young Researchers
I: From our point of view, you are a young researcher.
H: Thank you for calling me young (laugh).
I: You are Independent Investigator at the AIMR as well. As we head for the second phase, can you give advice to the people who are in the generation younger than you as to how they should move ahead with their efforts?
H: They are definitely all very motivated, so I have nothing more I can say to them. Rather, I feel it is more important to think about what we can do for them.

In that sense, one thing that is necessary is to establish a good research environment. This is also a challenge for the WPI. We receive a harsh evaluation every year, but we need to take a longer-term view of research. So a researcher needs to be properly evaluated based on his or her views or potential, even in cases where there has been no output yet. That way we can develop them as good human resources.
I: It is difficult, but that is the important point.
H: Currently, the researchers are often not evaluated based on such standards, but only based on their output such as the annual number of papers. I feel this approach is adversely demotivating them, which is not good. They are making their best efforts, so I think it is important that we view them from a long-term perspective.

At companies, it often happens that the mission of your division changes or the division becomes unnecessary because the policy of the entire company changes. Then people become preoccupied with these things the moment they happen, and they can no longer concentrate on their work. So unless it is decided in advance, from a long-term perspective, to which extent things are surely going to be completed, you cannot focus on your work. For example, suppose you are developing superior experimental equipment in the AIMR, if you feel you have to go to the next place soon, you cannot concentrate on your research.

I: Yes, I see your point

H: So it is important that the management people have a strong will. If their policies are clear and solid, I think the research performance will naturally follow.

I: That is the difficult part. Nowadays we surely have accountability, with the amount of competitive funds on the increase. On the other hand, it is understandable if it is a span of five years or so, but we are asked the number of papers every single year. It may be acceptable if it is at the level of being reflected in the annual salary and so forth, but the situation is quite harsh if it is going to change the direction or the destiny of the organization.

H: Yes, it is an important point because it is also related to the morale of the researchers. I think the current situation is that if the policies at the management level are not stable, people at the research level are not able to engage in research comfortably.

I: This issue is also related to the government's science policy.

H: I think that is exactly the point. If the government's science policy is to foster the WPI, and there is a certain timeframe set from the beginning, of ten years for example, it is necessary to at least ensure the management of the research institute without discussing whether it should be continued or not. Of course, when a certain degree of policy change is necessary, it needs to be implemented. But when the positions of the researchers are not guaranteed, solid research cannot be conducted. I think this is a big issue.

I: That may be true.

H: So I think all of us need to discuss again what kind of research institute would produce results. We need to reconsider both the policy decision of the research institute and the improvement of the research environment as combined issues.

I: I think the mobility of human resources is also important on the other hand.

H: It is very important. But I think it is more wasteful than anything when even the superior human resources become unnecessarily nervous and cannot achieve good performance. This is a very important point.

I: After all, research institutes are supported by the human resources.

H: If talented human resources do not come to us, our program will not succeed, either.

I: Yes, you are right.

H: When questioned whether the AIMR has an environment that attracts talented human resources, we should not hesitate in our answer even for a moment. It is a question of whether we can tell talented people to "come work with us" with confidence. We need to improve the organization so we can say that. I think this is the challenge we are going to face in the second phase.

I: Yes. This is probably going to be a major topic of discussion.

H: Yes. There are a lot of good things about the WPI, but I think there is still a lot left to do in terms of how to support foreign researchers. I do not think there is sufficient structure to incorporate the opinions of foreign researchers. So I think we may want to have regular opportunities to listen to the opinions of foreign researchers about their research environment.
I: I think our communication in English has improved significantly.
H: Yes, we have seen a lot of improvement in that area, but I am concerned about whether this place really provides positive opportunities for their career. In general, positive reports come to us easily, but negative reports are shut down to a management level, so we have to be particularly careful about that. I think we need to request the foreign researchers to provide us with negative reports.

In a company, the human resources department would communicate with the employees directly and listens to them to incorporate everyone's opinions. So we also need to have someone reliable in charge, and incorporate people's opinions without fail.
I: It is not that we are going to do that to evaluate people or anything, but rather to learn about the environment…
H: Yes, it is absolutely vital to ask about their research environment.
I: It is at least necessary to listen to them.
H: I think such a system should be established to provide active support to foreigners. If we can incorporate their opinions and create a good research environment, they feel happy about joining the AIMR, and they will tell other people, in the next institute they work, that they liked the AIMR
I: And they will speak to many people about us.
H: Yes. Without that, I do not think the brain circulation, which is the motto of the WPI program, will be realized. So the point is whether people can move to the next workplace, feeling happy that they spent time in the AIMR. In order to help people become happy here, of course it is important to make efforts by themselves, but I think how we approach them is also important. So it will be our challenge in the second phase to create such a system.
I: This is indeed a point we should think about as management.
H: I ask you to do so. I think it is one important point.

Everyone is motivated, so the issue is how to enhance their performance. I always believe that "the best of man is like water." It is not a *sake* brand (laugh). These are the words of Lao-tse, which mean that good things or successful events are like water. Water can freely change its shape and blend in with its surroundings, and benefits all things. Since the researchers are sufficiently motivated, if a good research environment is established, things will naturally run smoothly like water. Therefore, I think our role is to remove any obstacles that demotivate young researchers.

I: That is right. Thank you very much for sharing your opinion on a variety of issues today.

Interviewer: Administrative Director, W. Iwamoto

At Hitosugi Laboratory, WPI-AIMR Annex Building

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