NIMS NOW INTERNATIONAL

NATIONAL INSTITUTE FOR MATERIALS SCIENCE

2017
4

Research Network and Facility Services Division

KNOWLEDGE and FACILITIES

Providing truly helpful research support to all scientists

Research Network and Facility Services Division

KNOWLEDGE and FACILITIES

Providing truly helpful research support to all scientists

Materials research has made significant progress in association with advancements in research equipment.
The wide array of equipment at NIMS–including an ultrahigh-resolution electron microscope and an NMR system that generates world's strongest magnetic field–have made it possible to pioneer a nanoscale world and have contributed to many impressive research accomplishments.
These devices are genuinely valuable assets for Japan's scientific community.

Skillful engineers capable of operating these sophisticated devices also are an indispensable asset.
They regularly and properly maintain the equipment and make enhancements as needed, and they have amassed specialized knowledge and experience in dealing with novel materials.

The NIMS Research Network and Facility Services Division (RNFS) supports frontline research and development by making these assets available to a wide range of researchers.
What is the driving force behind RNFS's support of the various research projects?
How can the resources of RNFS be effectively utilized to accelerate the development of next-generation power device materials?
This issue of NIMS NOW will focus on the RNFS' efforts to support all types of researchers.

ES

Yasuo Koide

NIMS

Hiroshi Amano

Nagoya University

Metal organic chemical vapor deposition (MOCVD) system (middle), which has undergone numerous modifications. When Amano and Koide were college students, their first mission was to construct a prototype of this system.

Knowledge and Facilities
SPECIAL TALK

To increase the performance of gallium nitride materials

“Amano-Koide Collaborative Research Lab” launched

Three Japanese scientists won the Nobel Prize in Physics in 2014 for their invention of blue light-emitting diodes (LEDs). The accomplishment is attributed to successful gallium nitride (GaN) crystallization. Due to its high-performance potential, GaN is currently attracting attention as a material for next-generation energy-saving power devices. Professor Hiroshi Amano of Nagoya University and NIMS Executive Vice President Yasuo Koide launched a joint laboratory to evaluate and understand the properties of GaN crystals with the goal of increasing their performance.

Joining forces to develop next-generation power devices

Koide: In order to strengthen collaboration between the Nagoya University research group led by Professor Amano and NIMS, he and I established the Amano-Koide Collaborative Research Lab at both NIMS RNFS and CIRFE, IMaSS, Nagoya University in March 2017. We have been working together on the MEXT (Japanese Ministry of Education, Culture, Sports, Science and Technology) Program for research and development of next-generation semiconductor to realize energy-saving society since April 2016. The objective of this program is to develop next-generation energy-saving power devices. To achieve this, we have established a collaborative framework consisting of Professor Amano's group, which is responsible for growing GaN crystals, a NIMS group, which characterizes the crystals, and Nagoya University Designated Professor Tetsu Kachi's group, which develops power devices using the crystals.

Amano: We can grow crystals, but after they are processed into transistors and other devices, we lack the resources to properly characterize their functions. As such, I thought we needed to work with other groups capable of analyzing and characterizing crystals to determine whether our crystal products meet a set standard. I felt that it was fortunate that MEXT program was started and was able to use it to launch the collaborative research lab.

Koide: Many researchers in NIMS are experts on materials measurement and characterization. We organized a group of about 25 researchers with expertise in the analysis and measurement of photoelectric properties and microstructures in order to characterize GaN crystals produced by Professor Amano's group. This was NIMS's first-ever attempt to organize a team to characterize semiconductor materials.

Building confidence in materials we have worked on since graduate students

Koide: Professor Amano and I were both students at Nagoya University at around the same time, and we both worked in Professor Isamu Akasaki's laboratory. Professor Amano was then a second-year graduate student working to improve the quality of GaN crystals for use in blue LEDs. His efforts later bore fruit and he and Professor Akasaki shared the Nobel Prize for it. I was a year senior to Professor Amano at the time, and was working to produce aluminum gallium nitride (AlGaN) crystals and investigating their photoelectric properties.

Amano: I remember that. Akasaki Labo-

Hiroshi Amano

Professor,
Director of the Center for Integrated Research of Future Electronics (CIRFE), Institute of Materials and Systems for Sustainability (IMaSS), Nagoya University; also a NIMS Distinguished Fellow

Yasuo Koide
Executive Vice President,
Director of the Research Network and Facility Services Division (RNFS), NIMS;
also a Designated Professor,
Institute of Materials and Systems for Sustainability (IMaSS),
Nagoya University

ratory was the first group to study GaN and AlGaN. They are both vital power device materials today.

Koide: However, at that time, silicon carbide and zinc selenide were drawing attention, and nitrides were largely being ignored. Despite no external support and a great deal of criticism, Professor Akasaki resolutely persisted with nitride research. I am even more amazed by his determination today, perhaps because I am now about as old as he was at the time. Even worse, no commercially-available crystal growing equipment was compatible with nitrides at that time. Professor Amano and I had to construct equipment ourselves before we could perform crystal growth experiments. Today, Nitrides are recognized as essential material to the development of next-generation power device due to their high breakdown voltage.

Seeing more potential in GaN

Amano: Silicon (Si) is currently the most prevalent material used in power devices, with a market estimated to be worth as much as tens of billion dollars annually. However, Si's intrinsic limitations make it inappropriate for use in the development of next-generation, high-performance power devices. GaN is a promising replacement for Si as its performance may be 10 to 40 times higher.

If GaN were to replace Si, the size of AC adapters, for example, could be reduced by about 90%. The downsized adapters could then be installed inside personal computers, thereby eliminating the need for PC users to carry heavy adapters. Moreover, if GaN semiconductors can be used as high-frequency generators, it would be feasible to wirelessly charge electronic devices.

Koide: You are talking about the technology to charge electric vehicles wirelessly while they are moving, right? That would be a world-changing technology. I have also heard that the size of mobile phone base stations has been reduced using GaN. In any case, next-generation power devices can be put into practice only by using GaN or materials with similar properties.

Amano: That is correct. However, it is still not practical to replace Si with GaN because it is difficult to produce clean and stable GaN crystals due to its hardness and rigidness. It is much more challenging to produce crystals of compounds than those of single elements, such as Si. GaN has already been in practical use as a blue LED material. However, GaN crystals used in LEDs are not very reliable as power device materials because they have 0.1 to 1 billion defects per square centimeter. In other words, their crystal structures are disordered. I wonder why they are able to glow brightly despite their numerous defects.

Koide: Throughout the history of semiconductors, it was commonly believed that crystal defects make inferior semiconductors. However, the emergence of GaN semiconductor materials has changed this.

Amano: While widespread use of GaN materials is anticipated, it is difficult to produce defect-free GaN crystals. Therefore, it is crucial for us to be able to distinguish problematic defects from non-problematic ones. I think that will be a focus in our ongoing joint research efforts.

Unconventional approach to the analysis and evaluation

Amano: When Dr. Koide organized a group of materials measurement and evaluation experts, he intentionally included those without expertise in nitrides. This strategy is in fact producing desirable results. Many nitride specialists tend to confine themselves within conventional beliefs and do not take a creative approach to observing crystals. For example, textbooks on crystals state that only three types of dislocations (linear misalignment of atoms in a crystal) exist: screw, edge and mixed dislocations. However, we have discovered that there are more than three dislocation types since we began working with NIMS researchers. This finding will be helpful when we perform crystal defect evaluations later on.

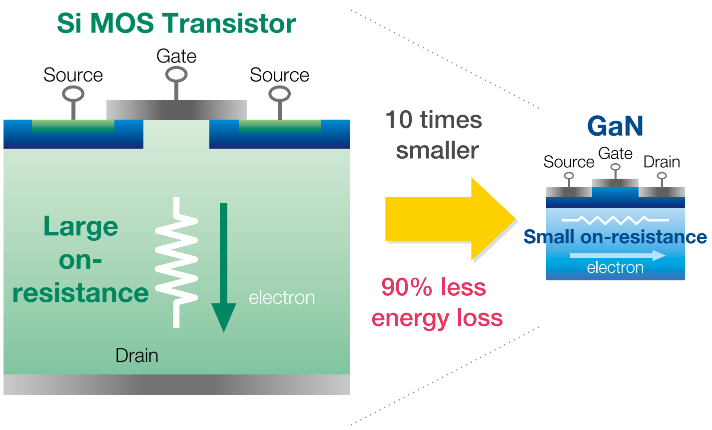
Koide: In addition, we also observed interface structures at the atomic layer level. We were able to accomplish this using the resources of the Amano-Koide Collaborative Research Lab.

NIMS RNFS is equipped with 177 pieces of research equipment for use by NIMS researchers and researchers from private companies, universities and other research organizations. The RNFS is also equipped with 18 electron microscopes of various types. In this joint research project, we were able to observe interface structures composed of GaN and oxides using a high-resolution, most advanced electron microscope.

Amano: That was a very significant accomplishment. It was the first time I was able to actually observe interface structures after learning that they probably influence the performance of power devices. Interfaces between different, stacked materials are delicate and separate very easily. As such, high levels of skill are required to prepare interface samples appropriate for microscopic observation. This task was successfully undertaken by NIMS researchers, skillful in handling these types of materials.

Developing materials that can be used with safety

Koide: I am certain that the NIMS members participating in this joint research project are enjoying the opportunity to apply their expertise in the evaluation of GaN materials. We have established a good system for this type of project. I hope to maintain it and discover new crystal phenomena. Our ultimate goal is to develop energy-saving power devices. The role of NIMS in this joint project is to analyze and evaluate materials, thereby supporting the efforts of Professor Amano' group to produce crystals, and of Professor Kachi's group to develop devices and systems.



The amount of energy loss is directly proportional to the thickness of the device,
⇒which means that the thinner the device, the lower the amount of energy loss.
The performance of a GaN material may be 10 times higher than conventional materials. If this proves to be the case, GaN-based devices could be 10 times smaller and reduce energy loss by 90% compared to conventional materials.

Amano: It is becoming increasingly important to develop reliable GaN materials for use in power devices in automobiles, trains, aircraft, etc. To achieve this, it is critical that we thoroughly understand the properties of GaN materials through appropriate analysis and evaluation. We need to simultaneously develop a method of producing crystals with minimal defects. I think the collaborative research lab will play a significant role in developing low-cost products, which people can use with safety. The research we conducted 30 years ago did not attract attention, so I was able to perform my work at my own pace. Things have changed since then and this joint project is now under pressure to produce results. However, I am sure that my long experience and steady efforts in studying this material will pay off in our current endeavors.

(by Akiko Ikeda, Sci-Tech Communications)

KNOWLEDGE and FACILITIES Interview

Nobutaka Hanagata

Deputy Director of the Research Network and Facility Services Division (RNFS)
Director of the Nanotechnology Innovation Station
Coordinator of the Biomaterials Field, Research Center for Functional Materials

—Making 177 analytical instruments available to support all interested researchers—

RNFS provides analytical support and much more

Composed of seven stations that make research facilities available for use by NIMS and other researchers, the Research Network and Facility Services Division (RNFS) is equipped with a wide range of material processing facilities and analytical instruments. In addition, they have staff members with expertise in the use of its facilities who can support all research taking place at NIMS, not just that of NIMS researchers.
We asked RNFS Deputy Director Nobutaka Hanagata about the RNFS's efforts to support researchers from all over the world.

Sharing equipment and ideas

Advanced materials research requires the use of high-quality material processing facilities and analytical instruments that enable high-precision microfabrication and accurate analysis of unique samples. NIMS's RNFS meets those demands by making a range of state-of-art equipment available to researchers, putting full-time technical support staff in place and improving the functionality of equipment.

RNFS employs a total of 265 staff members—including 65 researchers and 36 engineers—to support the wide range of research projects taking place at NIMS and elsewhere. "Our engineers are committed to supporting the research projects of others without carrying out their own research. Some even have Ph.D.s," said Hanagata, highlighting their strong professionalism.

RNFS's equipment includes an NMR (nuclear magnetic resonance) system—which generated the world's strongest magnetic field in 2014—and one of only few scanning helium ion microscopes (resolution of 0.35 nanometers) in Japan.

What specific types of support does RNFS offer? We asked Hanagata about its research support services, with emphasis on those provided to non-NIMS researchers. The Center for Nanotechnology Platform, which was established within the RNFS, is responsible for liaising with them.

Nanotechnology platforms were established across Japan in line with the MEXT (Japanese Ministry of Education, Culture, Sports, Science and Technology)-sponsored "Nanotechnology Platform Japan" Program—a 10-year program started in 2012. Under the program, universities and national research organizations across the country with facilities and analytical instruments compatible with nanotechnology and expertise in their use provide both hardware and software support to interested private companies and university researchers. NIMS RNFS plays a central role in this program by making its 177 analytical instruments at seven stations available to external researchers. In addition, the RNFS provides information on facilities and equipment available at platform organizations across the nation to facilitate research efforts. For

Services provided to users of shared-use equipment at NIMS

Equipment use	After receiving the required training and authorization, users can independently operate desired equipment and collect data.
Technical assistance	Users can operate desired equipment with the assistance of NIMS staff.
Substitute equipment operator	NIMS staff members operate equipment for users.
Research collaboration	NIMS staff members partially carry out users' research projects. They also suggest research ideas and future research directions.

example, RNFS staff advises on appropriate equipment to meet specific research objectives.

The RNFS also holds more than 20 annual workshops for non-NIMS researchers and technicians under its "School for NIMS open facility users" program. The workshops include a seminar that demonstrates results produced using the equipment available at the RNFS and on-site demonstrations of research facilities and equipment (see p. 16 for details).

"It is difficult for individual laboratories to maintain a full range of up-to-date equipment, as upgrades are costly. Another issue is that not enough people are capable of properly operating research equipment. Therefore, it is essential to share these resources in order to promote nanotechnological advancement and innovation all over the world. It is also critical to develop highly skilled personnel. People who obtain new knowledge and skills at NIMS can apply them at their research bases. Serving as a collaboration hub, we intend to provide both equipment and skills to all interested researchers without hesitation."

Offering a range of services, from equipment use to research collaboration

Four types of services are available to external researchers which allow them to use specific NIMS facilities and equipment (table above).

Hanagata said, "We have simplified our service application procedures to enable us to efficiently support a large number of researchers." Interested researchers need only agree to the "Terms and Conditions" on the website. After users are finished using equipment, they are asked to submit a simple report. "We publicize the report, in principle. However, some users (e.g., company researchers who are creating new product prototypes) are reluctant to have their reports publicized. We accommodate the concerns of these users by allowing them to use station facilities and equipment without publicizing their reports," said Hanagata. The RNFS staff carefully listens to users' requests in advance and responds flexibly to their needs.

Producing satisfactory results through in-depth analysis

The use of these services by external organizations, such as universities and private companies, has increased by more than 100% over last five years, resulting in 466 uses in FY2016. Hanagata said, "Many of our clients are repeat users. The number of new users who report hearing about our services from existing users is also increasing. Some may think that NIMS has set very high standards and regulations that match its national R&D institute status. However, once they experience our services, they are likely to find them more user-friendly than expected." Some user organizations are seemingly completely unrelated to materials fields. In fact, they use RNFS services for unique purposes. For example, some food company users observe soybean microstructures, while other users observe muscular activity in Oryzias spp. (small fish) as a part of a space science project.

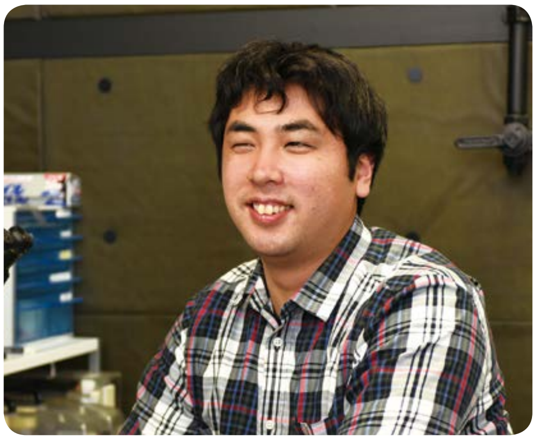
Hanagata said, "My expertise is actually in biology. Researchers at the Nanotechnology Innovation Station—at which I serve as a director—are currently investigating techniques to detect cancer at early stages in collaboration with medical doctors in hospitals. These doctors have told us that they previously used a private analysis laboratory to study RNA base sequences of cancer patients before they came to us. Unfortunately, the lab only provided the doctors with analytical results without explaining how they should be interpreted. Thus, they were unable to utilize the results effectively. They visited us for a consultation after that experience."

Comparing the RNA base sequences of cancer patients with those of healthy people reveals no differences. Even if a difference were detected, it would be impossible to know its implications. However, statistical analysis of the data may yield meaningful information. From this perspective, we conducted joint research with the doctors in which the NIMS group undertook the analysis of base sequences and statistical analysis.

"NIMS collaborators used their great expertise not only to support the research project to the analysis stage but also several steps beyond that," said Hanagata proudly.

"I have heard that certain overseas research groups possess nothing but offices and use shared facilities similar to the nanotechnology platforms to conduct their research and publish their studies in prestigious scientific journals. This example proves that researchers can carry out research without possessing expensive research equipment and facilities if they have good research ideas and plans. Scientists engaged in interdisciplinary research projects may require extra knowledge in addition to their own expertise. Our know-how may be useful in expediting the work of many researchers. I look forward to receiving many inquiries about our services."

(by Kaori Oishi)



Comments from Users

University

Mastering electron microscopy will give researchers an edge. Interested student researchers should check out what NIMS has to offer.

Project Assistant Professor
Innovation Research Center for Fuel Cells
University of Electro-Communications

Takao Gunji

The RNFS's Transmission Electron Microscopy Station is equipped with a range of advanced TEMs. Takao Gunji has been using electron microscopes at NIMS to develop fuel cell electrode catalysts since he was a graduate student.

—Please tell us about your research.

I am developing fuel cell electrode catalysts. Platinum, which is commonly used as an electrode catalyst material, is very expensive. Therefore it is desirable to develop platinum-free catalysts or catalysts that require only a small amount of platinum. From this viewpoint, I have proposed creating an alloy of platinum and an inexpensive metal while increasing the catalysis surface area by processing the catalysts into nanoparticles. Because a catalyst's activity is closely related to the atomic structure of its surface, it is critical to observe the atomic structure under an electron microscope before deciding on the direction of catalyst development.

I have been observing electrode catalyst materials I have synthesized under a very high-performance TEM (JEM-ARM200F) at NIMS. Also, during last fiscal year, I was able to clearly identify different nanoparticle surface conditions of palladium-copper (Pd-Cu) alloy, caused by thermal treatments at the atomic level (Figure). This material is a promising alternative to platinum.

—How did you know about NIMS' TEMs?

I participated in a NIMS internship program when I was a first-year Master's student at Kanagawa University Graduate School. I worked at a NIMS research laboratory for about a month where I participated in a cutting-edge research project, and I was surprised by the range of state-of-art electron microscopes available. They were much more advanced than those at my university. The following year, I participated in a student training program at the NIMS' Transmission Electron Microscopy Station, which gave me another opportunity to use its microscopes. Program participants spent five days learning how to use electron microscopes and prepare samples. In the end, we were authorized to use the equipment at the station. I have been using NIMS' electron microscopes for the five years since.

I was first assigned to a "technical assistance" category where I learned how to use electron microscopes with the assistance of skilled staff members. It was difficult to learn how to use the electron microscopes, but after five or six training sessions, I moved up to the "equipment use" category and received permission to use the microscopes by myself, thanks to the patient instruction I received from the NIMS staff. NIMS has a solid support system which I still use when I attempt unfamiliar techniques.

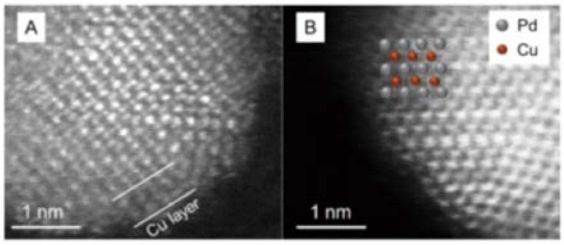
—How has your experience with electron microscopes since university helped your current research activities?

I have been a Project Assistant Professor at the University of Electro-Communications since April 2017, after obtaining my doctoral degree. When I applied for this job, I emphasized my electron microscope proficiency as a professional strength. I believe that having this skill is a great asset in certain research fields.

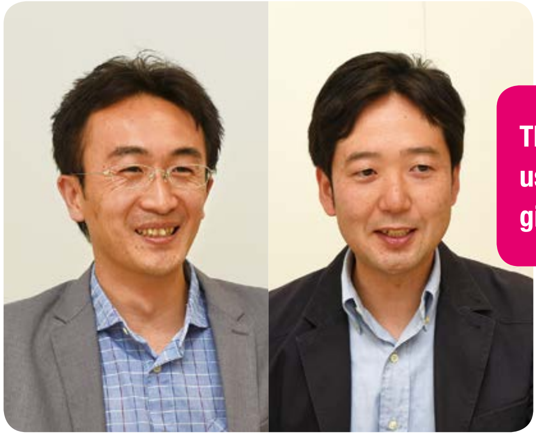
I hear that it is still uncommon for college students to use electron microscopes. I hope more students have the opportunity to use them in the future. The research university researchers are able to conduct is often limited by available equipment. By making its advanced devices available to external researchers, NIMS enables them to carry out a wider range of research.

(by Shino Suzuki, PhotonCreate)

Gunji operating a transmission electron microscope (TEM).



Electron microscope image of palladium-copper (Pd-Cu) nanoparticles treated at 400°C (A) and 700°C (B). Nanoparticles that underwent an annealing process at 700°C have an orderly arrangement of Pd and Cu atoms and high catalytic activity. Here, an annealing process refers to a thermal treatment to enhance the orderliness of atomic structures.



Comments from Users

Private sector

The NIMS facility is equipped with a full range of equipment, allowing us to carry out every step, from processing to evaluation. And they give full consideration to the specific needs of private companies.

Analog Device Development Engineer
Analog LSI Business Division
Sony Semiconductor Solutions Corporation
Masashi Yanagita

Analog Device Development Engineer
Analog LSI Business Division
Sony Semiconductor Solutions Corporation
Katsuhiko Takeuchi

The RNFS's Nanotechnology Innovation Station is equipped with state-of-art microfabrication devices and nanoscale observation/characterization/measurement devices. Masashi Yanagita and Katsuhiko Takeuchi have been studying working principles of next-generation semiconductors under development using these devices.

—How did the two of you find out about the NIMS facility, and what is your objective in using it?

Yanagita: We have been using the NIMS Nanotechnology Innovation Station since 2015 in order to identify working principles of next-generation semiconductors we are developing. The station has a good reputation among other researchers at our company who have used it in the past. We found out about the facility from them.

Takeuchi: We also explored the possibility of using other facilities. After a great deal of research, we came to the conclusion that the NIMS Nanotechnology Innovation Station is most suitable for our purposes in terms of its equipment range, ease of use, fees and other factors.

—What was the most critical factor which made you choose NIMS?

Yanagita: We do not want to disclose certain information due to the nature of our business. If NIMS had required us to disclose all information concerning the experiments we planned to perform there, we probably would not have chosen it. Fortunately, NIMS was well aware of this and gave full consideration to these private sector-related needs. We felt able to use the NIMS facility with a sense of security. That was the decisive reason for our final decision.

—What is your impression after actually using the NIMS facility?

Yanagita: All of the equipment is always properly calibrated, allowing us to get started right away. However, more than anything, the helpful support provided by NIMS' staff is its most attractive asset. NIMS staff members are experts on the equipment and have rich body of experience with and knowledge of semiconductor materials. When we encounter a problem, they give us helpful advice. That is very encouraging.

Takeuchi: In addition, when we ask their opinions on the approach to certain tasks, they give us suggestions on each step, starting with which equipment to use; we really appreciate that. Because they are much more knowledgeable about the equipment and materials than we are, we have learned a lot from them.

—I have heard that your company also has a variety of research equipment.

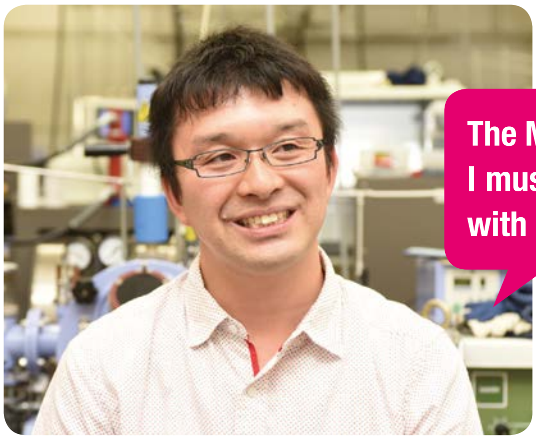
Takeuchi: That is true, but NIMS has a very extensive array of advanced equipment that allows microfabrication of semiconductor materials on site. That is a very attractive feature for us.

In addition to that equipment, we are now using NIMS' electrical property evaluation instruments as well. Our company also has evaluation devices, but since we fabricate semiconductor devices here, it is more convenient for us to evaluate their electrical properties at NIMS than it would be to bring them back for evaluation using our company's facilities. We also often encounter situations in which we want to carry out an evaluation while the fabrication of semiconductor devices is underway. Depending on the result of the evaluation, we can quickly change the fabrication conditions before creating prototypes and evaluate the final products again. This allows us to perform experiments speedily.

Yanagita: Sony's mission is to create novel products. It is sometimes difficult, however, for us to carry out a completely new project using only our own equipment that is already optimized for other purposes. The NIMS facility allows us to pursue our innovative work using cutting-edge equipment.

(by Shino Suzuki, PhotonCreate)

Takeuchi using a high-speed maskless exposure system in the clean room facility. The system—which is used to draw patterns on a substrate coated with a photoresist—reduces both cost and time before exposure as it does not require users to produce photomasks.



Comments from Users

NIMS researcher

The Materials Analysis Station is an excellent facility. I must confess that I am almost reluctant to share it with others.

Researcher,
Magnetic Materials Analysis Group
Research Center for Magnetic and Spintronic Materials

Taisuke Sasaki

The RNFS's Materials Analysis Station is equipped with instruments for X-ray diffraction analysis, chemical analysis and surface and microbeam analysis. It provides analytical information to NIMS and other researchers upon request. It is also indispensable for Taisuke Sasaki's research, the development of dysprosium-free neodymium magnets.

—What are your objectives in using the Materials Analysis Station?

Observing the internal microstructures of materials is a critical step in developing new materials. For example, the properties of metal materials are dictated by their microstructures. To develop heat-resistant neodymium magnets, it is vital to properly distribute dysprosium within the magnets. We are pursuing heat-resistant, powerful neodymium magnets using only a small amount—if possible, zero—dysprosium, which is a rare and expensive metal. We have been using an electron probe micro-analyzer (EPMA) at the station for this project.

The distribution of chemical elements within materials is generally observed using a scanning electron microscope (SEM) equipped with an energy-dispersive X-ray spectrometer (EDS). Our group owns an EDS but it does not allow us to accurately observe the distribution of dysprosium within magnets. The EPMA, by contrast, enables us to precisely analyze the concentrations and distributions of dysprosium.

It would be convenient if our group owned an EPMA. However, the operation of the equipment is highly technical and we use it only occasionally. We are fortunate that the Materials Analysis Station makes this equipment available to all NIMS researchers.

—I have also heard that your group often requests that the station perform chemical element analysis.

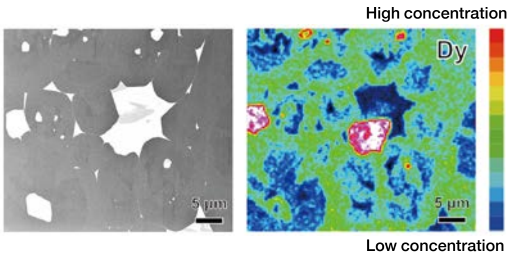
We also use the station's services to carry out ICP-OES (inductively coupled plasma optical emission spectrometry) frequently. In materials development, we determine the ratio of chemical elements that will compose the material, mix the elements based on the planned ratio, create sample materials by heating and cooling the mixture and evaluate the properties of the samples. However, because different chemical elements evaporate at different temperatures, their concentrations sometimes differentiate during heating, causing discrepancies between the planned and final ratios of elements. As little as a 0.1% difference in the ratio of an element will alter the properties of a material. For this reason, we need to accurately analyze the elemental composition of sample materials.

When station technicians perform ICP-OES, they measure the amount of each element to 1/10,000 of a milligram and report the mass of each element to 1/1,000 of a percentage point. Accurate and reliable analysis by skilled technicians has been an indispensable asset in our research efforts.

—What are advantages of commissioning the analysis to the section inside NIMS?

We could ask private companies to perform the analysis. However, that would be very time-consuming, as we would need to follow a lengthy procedure: first requesting a quotation, then placing an order, shipping samples, receiving data and paying for the services. By contrast, when we request that the station conduct the analysis, we only need to fill out an application form and take our samples to the floor above our lab. In addition, we produce many samples during the process of systematically changing the compositions of chemical elements in our experiments. Since all of the samples need to be analyzed separately, the speed of the analysis is a significant factor. We sometimes want to communicate with technicians about analytical methods and the interpretation of data when we deal with new materials or when we have questions on data. This can be done easily if we work with the section inside NIMS. That is also a great advantage.

(by Shino Suzuki, PhotonCreate)



Concentration distribution of dysprosium in a neodymium magnet observed using an EPMA.

A solution containing dysprosium was sprayed onto a neodymium magnet and allowed to diffuse into it. The magnet was then observed using an SEM (left) and an EPMA (right). The EPMA image shows the concentration distribution of dysprosium resulting from X-ray analysis, and the visualized dysprosium diffused into crystal grain boundaries.

Comments from Staff

NIMS engineer

We use our extensive expertise to perform accurate and reliable analysis for researchers.

Engineer,
Chemical Analysis and X-ray Diffraction Group
Materials Analysis Station,
Research Network and Facility Services Division (RNFS)

Akio Iwanade

The RNFS researchers and engineers have been supporting research activities at NIMS and elsewhere using processing facilities and analytical instruments. Akio Iwanade is one of the engineers working diligently to handle various analytical requests.

—Please tell us about the functions of the Materials Analysis Station.

We analyze the composition of materials, which is a vital step in the development and improvement of materials. We accurately analyze a full range of elements, from very low to high concentrations, in metallic and ceramic materials. Another important task is to develop new methods of analysis, since the various types of analytical data that is necessary to understand the properties of materials is ever-evolving. In addition, we actively work to ensure that our analytical techniques become national and international standards based on the knowledge we have built.

—You receive many requests for analysis. Some require the use of highly specialized equipment while others require general-purpose equipment.

If an analysis can be performed using general-purpose equipment, many researchers may be inclined to use their own equipment. However, proper equipment maintenance and operation requires knowledge, experience and financial resources. Many factors can potentially influence analytical results. For example, researchers must ensure that the equipment is operating normally and that a material sample is accurately weighed, fully transferred into a decomposition vessel and completely decomposed and dissolved into a solution before analysis.

To perform these steps correctly, careful equipment maintenance, including calibration and accuracy confirmation, is essential. We check the accuracy of our electronic balance using calibration weights before each use and replace the weights before they expire. This practice allows us to ensure the traceability* and reliability of our analytical results.

A material sample needs to decompose into a solution before it can be analyzed. We occasionally encounter materials which have never before been analyzed, and which we therefore do not know how to decompose into solution. However, we have access to the rich storehouse of know-how developed by our predecessors and we use this resource to search for potential solutions.

—Can users of this service do anything to facilitate analysis?

If users can provide us with as much information as possible on their material samples in advance, we are more likely to be able to obtain optimum results quickly.

Optimum analytical methods vary depending on the type of material to be analyzed even if the objective of the analysis is the same. Different instruments have different characteristics, and therefore need to be used selectively for specific situations. For example, an inductively coupled plasma optical emission spectrometer (ICP-OES), of which I am the main operator, is capable of quantifying approximately 70 elements at once. However, we have to be careful about the fact that some elements have lower quantification limits. For example, manganese can be quantified at relatively low concentrations, while silicon and phosphorus cannot. For this reason, we sometimes suggest different methods when very low concentrations of silicon and phosphorus need to be measured accurately.

Unless we need to measure extremely small amounts of elements, we may suggest measurement methods that enable results to be obtained more quickly.

As such, it would be helpful if users of the service consult with us and inform us of their sample materials in advance. We also encourage postdoctoral researchers, who need to obtain their results within short timeframes, to use our services. We hope to continue to help researchers while nurturing the trust and expertise built by our predecessors.

(by Kaori Oishi)

An ICP-OES is available at the Materials Analysis Station. This equipment is used to analyze the chemical elements of which a material is composed. A solution containing the elements is converted into a mist which is then introduced to argon plasma. This causes the atoms in the solution to undergo thermal excitation and emission lines. These emission lines are separated into its component wavelengths, and this information is used to identify the elements present. In addition, the intensity of emission line is used to quantify the concentrations of individual elements.

* Analytical results are said to be "traceable" if the accuracy of the analytical instrument used is maintained by regularly correlating its readings with those of a standard device with a smaller margin of uncertainty. This practice ensures that the accuracy of the instrument is consistent with national or international standards.

RNFS Organization

The Research Network and Facility Services Division (RNFS) promotes materials development by making its expertise and cutting-edge facilities available to NIMS and other researchers.

- **RNFS**
  - Administrative Office
  - Materials Manufacturing and Engineering Station
  - Materials Analysis Station
  - Transmission Electron Microscopy Station
  - Synchrotron X-ray Station at SPring-8
  - High Magnetic Field Station
  - Nanotechnology Innovation Station
  - Numerical Materials Simulator Station
  - Center of Nanotechnology Platform Japan
    - NIMS Microstructural Characterization Platform
    - Promotion Office for Microstructural Characterization Platform
  - NIMS Nanofabrication Platform
  - NIMS Molecule and Material Synthesis Platform
  - GaN Evaluation Area
  - Amano-Koide Collaborative Research Lab

■ Seven specialized research stations with facilities, equipment and staff (purple)
■ "Nanotechnology Platform Japan" Program supported by MEXT (blue)
■ Organizations that evaluate next-generation power devices under development (orange)

NIMS Open Facility

Contact us if you want to:

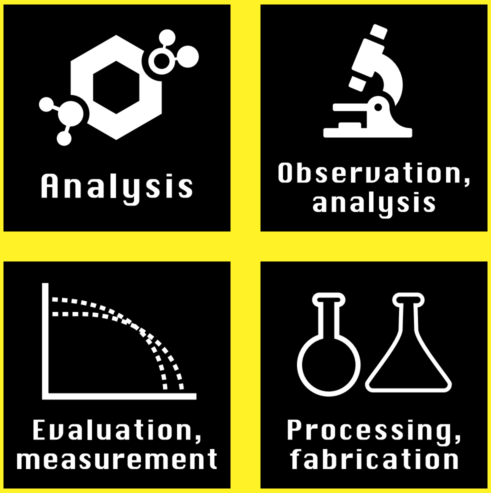
- Use cutting-edge equipment
- Consult with experts on research equipment
- Participate in workshops and other events
- Know how to use NIMS facilities

The RNFS provides a range of helpful research support.

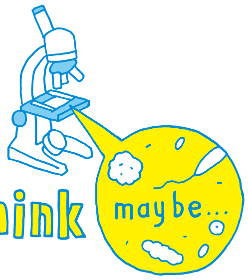
http://www.nims.go.jp/rnfs/

English website under construction

You can search for equipment by category or using keywords (device names, model numbers, etc.)



Science is even more amazing than you think



SPring-8

Text by Akio Etori
Illustration by Joe Okada (vision track)

Frequent readers of this column probably have a good idea of how small a nanoscale world would be. It is now feasible to visualize sub-nanometer atoms and molecules at certain levels. By “certain levels,” I mean that scientists can observe the shadows and movement of atoms and molecules rather than the atoms and molecules themselves.

Observing extremely small, distant and fast-moving objects is difficult and requires specialized equipment. Because such equipment is often very large and expensive, making it available to many researchers, rather than restricting it to individual research groups, increases overall research efficiency and reduces overall research costs. RIKEN’s SPring-8 is one of those research facilities that are open to a range of researchers.

SPring-8 is a facility that produces high-energy X-rays. Because X-rays have very short wavelengths, they are a very effective means of exploring a nanoscale world composed of atoms and molecules. X-rays generated at SPring-8 can be extracted from 62 beamlines. Individual users of the facility from private companies, universities and other organizations are assigned specific beamlines. NIMS also has a designated beamline for its advanced materials analysis.

This massive facility has contributed to industrial development and the convenience of everyday life by enabling the development of new pharmaceutical products, new battery technologies and high-density electronic devices. In addition, the facility has been used to pursue answers to astronomical questions, such as the origin of the universe and the history of Earth.

I’d like to offer some specific examples of achievements made using SPring-8.

The facility played a vital role in the analysis of protein structures for the Protein 3000 Project I featured in the last NIMS NOW issue. SPring-8 was used in the structural analysis of many newly discovered proteins after the structure of rhodopsin, a light-sensitive protein found in the retina of the human eye, was successfully analyzed using it.

The development of innovative storage batteries will be critical in solving imminent energy issues. Automobile manufacturers are using SPring-8 to develop high-performance catalysts, next-generation fuel cells and high-quality tires.

Many of you are likely to remember the miraculous return of the unmanned spacecraft Hayabusa from the asteroid Itokawa several years ago. A sample of the fine particles brought back in a capsule by the spacecraft was analyzed using SPring-8, which confirmed that the sample in fact originated from the surface of Itokawa.

These are only a few of the amazing achievements that have been made by using SPring-8 to analyze various materials and phenomena.

The enhancement of scientific tools has made enabled dramatic scientific and technological progress. The development of more advanced tools might enable new scientific explorations—such as investigating the nature of dark matter and dark energy and pursuing a more detailed understanding of atoms and atomic nuclei—which could not have been undertaken before.

Shared-use facilities are expected to play a wide range of roles in the future, such as increasing the quality of Japanese products, thereby improving the reputation of Japanese industry and creating new industries.

These facilities are putting the “Tools will create the future” concept into practice.

Akio Etori: Born in 1934. Science journalist. After graduating from College of Arts and Sciences, the University of Tokyo, he produced mainly science programs as a television producer and director at Nihon Educational Television (current TV Asahi) and TV Tokyo, after which he became the editor in chief of the science magazine Nikkei Science. Successively he held posts including director of Nikkei Science Inc., executive director of Mita Press Inc., visiting professor of the Research Center for Advanced Science and Technology, the University of Tokyo, and director of the Japan Science Foundation.

NIMS NEWS

1 Deputy Prime Minister, Federal Democratic Republic of Ethiopia, H.E. Mr. Demeke Mekonnen Hassen Visits NIMS

On June 14, H.E. Mr. Demeke Mekonnen Hassen, Deputy Prime Minister, Federal Democratic Republic of Ethiopia visited NIMS accompanied by H.E. Dr. -Ing. Getahun Mekuria Kuma, Minister of Science and Technology, H.E. Dr. Samuel Kifle Kidane, State Minister of Education, H.E. Mr. Cham Ugala Uriat, Ambassador Extraordinary and Plenipotentiary to Japan and some government officials.

H.E. Mr. Demeke and the delegation with President Hashimoto.

Ethiopia is one of the most active countries in Africa improving education, and the delegation took a special interest in the supporting system to foster students and young researchers at NIMS. NIMS could be of assistance to the development of materials research in Ethiopia in the future.

2 NIMS Researcher Wins a 2017 Japan National Fellowship from the “L'Oréal-UNESCO For Women in Science” Program

Yukiko Ogawa, a researcher at the NIMS Research Center for Structural Materials, was one of the five scientists to be honored for winning the 12th Japan National Fellowship from the L'Oréal-UNESCO For Women in Science program on July 5, 2017. This award was jointly established by L'Oréal Japan and the Japanese National Commission for UNESCO in November 2005 to encourage young female scientists in Japan to continue to pursue research at domestic educational or research institutions. Eligible applicants must be female scientists who are currently or are expected to be in doctoral programs in materials or life sciences. Ogawa received the award for her work in changing the structures of magnesium alloys to develop novel, highly functional magnesium alloys. She engaged in this research while attending the Tohoku University Graduate School of Engineering.

NIMS researcher Yukiko Ogawa (second from the left) at the award ceremony (photo provided by L'Oréal Japan).

Hello From NIMS

Hello! My name is Dai-Ming Tang, a researcher in MANA since 2010. The past 7 years in Japan and NIMS has been a wonderful time for my work and for my family. NIMS is special place to do research, with a supportive working environment especially for the foreigners. There are many advanced common facilities maintained by professional and kind engineers, including the super computers, aberration corrected TEMs, and nanofabrication clean rooms. I have successfully worked in collaboration with the TEM station on the modification of the carbon nanotubes and the correlations of the atomic structures with the transport properties. In particular, I am grateful for the unique NIMS ICYS system, where we enjoyed the strong support along with the complete freedom to choose our own topics to focus on. Besides work, I enjoy the life in Tsukuba and Japan with my family. It is modern, even futuristic, needless to say, since it is the science city. It is also natural, with the rice fields, forests and rivers within the walking distance. It is peaceful, with beautiful parks everywhere. It is also energetic, with such a crowd in the summer festival (Matsuri). This is the “Tsukuba style”, a highly diversified harmony.

I like hiking, including this snow walk in Nagano, on 2011.11.25.

Dai-Ming Tang (China)
7 years (2010.09 to present)
Researcher, MANA

NIMS NOW International 2017. Vol.15 No.4
National Institute for Materials Science
http://www.nims.go.jp/eng/publicity/nimsnow/

photo by Michito Ishikawa
editorial design by Barbazio Inc.
on the cover: Akio Iwanade (Engineer), Glow Discharge Mass Spectrometry

To subscribe, contact:
Dr. Yasufumi Nakamichi, Publisher
Public Relations Office, NIMS
1-2-1 Sengen, Tsukuba, Ibaraki, 305-0047 JAPAN
Phone: +81-29-859-2026, Fax: +81-29-859-2017
Email: inquiry@nims.go.jp

R70 Percentage of Waste Paper pulp 70%
VEGETABLE OIL INK