NIMS NOW

NATIONAL INSTITUTE FOR MATERIALS SCIENCE

2023 No.3 INTERNATIONAL

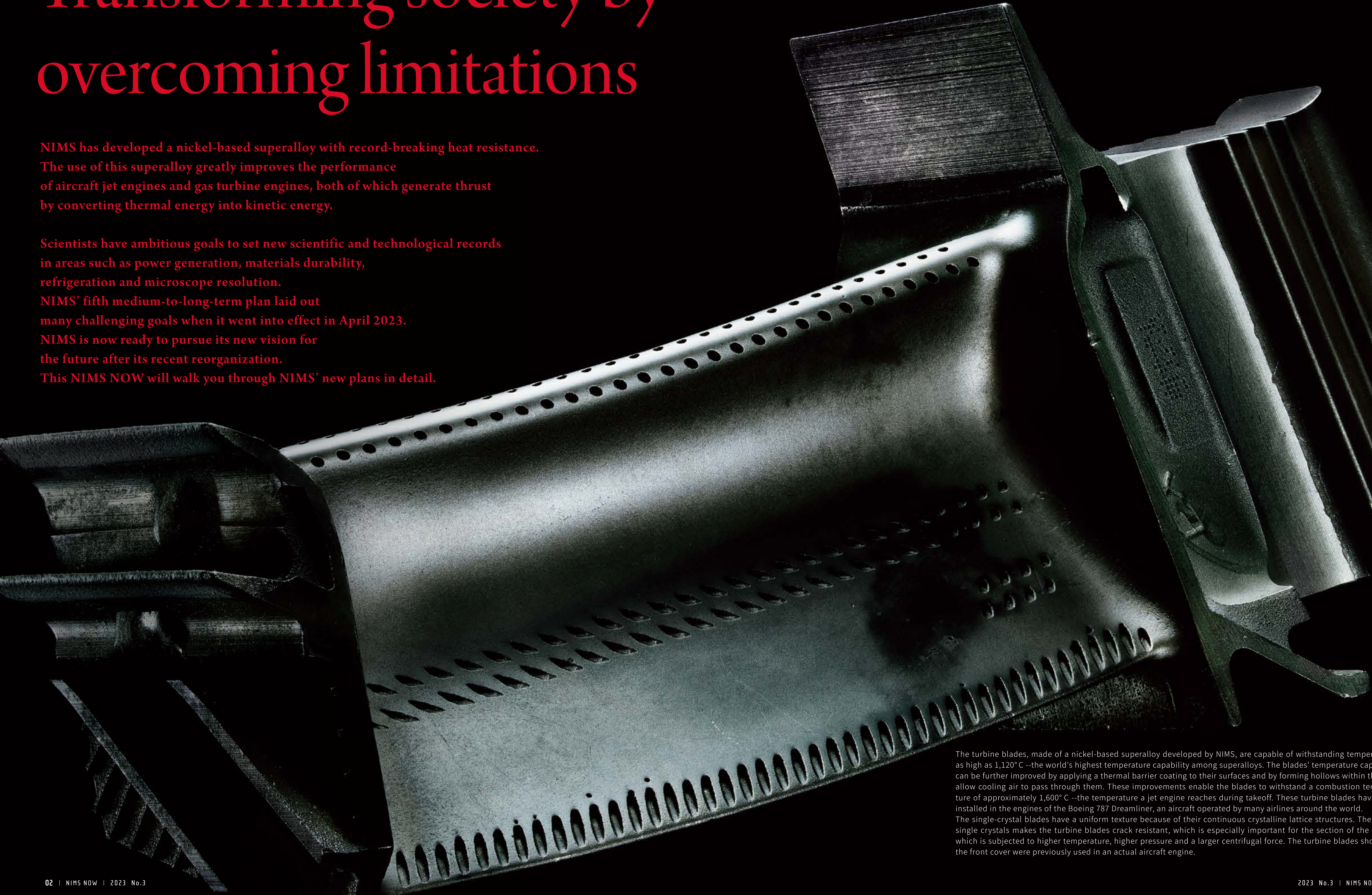
Making Breakthroughs in Materials Science

NIMS Launches Its Fifth Medium-to-Long-Term Plan

Transforming society by overcoming limitations

NIMS has developed a nickel-based superalloy with record-breaking heat resistance. The use of this superalloy greatly improves the performance of aircraft jet engines and gas turbine engines, both of which generate thrust by converting thermal energy into kinetic energy.

Scientists have ambitious goals to set new scientific and technological records in areas such as power generation, materials durability, refrigeration and microscope resolution. NIMS' fifth medium-to-long-term plan laid out many challenging goals when it went into effect in April 2023. NIMS is now ready to pursue its new vision for the future after its recent reorganization. This NIMS NOW will walk you through NIMS' new plans in detail.



The turbine blades, made of a nickel-based superalloy developed by NIMS, are capable of withstanding temperatures as high as 1,120° C --the world's highest temperature capability among superalloys. The blades' temperature capability can be further improved by applying a thermal barrier coating to their surfaces and by forming hollows within them to allow cooling air to pass through them. These improvements enable the blades to withstand a combustion temperature of approximately 1,600° C --the temperature a jet engine reaches during takeoff. These turbine blades have been installed in the engines of the Boeing 787 Dreamliner, an aircraft operated by many airlines around the world.
The single-crystal blades have a uniform texture because of their continuous crystalline lattice structures. The use of single crystals makes the turbine blades crack resistant, which is especially important for the section of the blades which is subjected to higher temperature, higher pressure and a larger centrifugal force. The turbine blades shown on the front cover were previously used in an actual aircraft engine.

VISION
Interview with President Hono

The fifth medium-to-long-term plan started in April 2023.
What are the points of change from the fourth phase?
What is the strategy envisioned by NIMS?
We asked President Kazuhiro Hono.

Kazuhiro Hono

President,
National Institute for Materials Science (NIMS)

He received his Ph.D. from Pennsylvania State University in 1988. After conducting research at the Institute for Materials Research, Tohoku University, he joined the National Research Institute for Metals, the predecessor of NIMS, in 1995. He has been involved in research on metallic materials, especially magnetic materials, and has held leadership positions; he has been a NIMS Fellow since 2004 and Executive Vice President since 2018; he was appointed President of NIMS in April 2022.

Q1 How has the research system changed?

A. We will continue to achieve world-class results in materials science while actively contributing to the basic research needed by industry. To this end, we have reorganized our existing six-center system and established **seven research centers**. Each center supports a total of 12 research projects (see next issue for details). One of the most significant changes is the creation of **the Research Center for Macromolecules and Biomaterials**. This center will bring together polymer and biomaterials experts who have been scattered in various centers and organize researchers who can understand each other's terminology to develop materials needed for a super-aging society. In addition, **the Center for Basic Research on Materials** will bring together experts in cutting-edge analytical technologies and data-driven materials development methods to advance the basic and fundamental research often required for materials development in other centers.

Seven research centers P.8

- Research Center for Energy and Environmental Materials
  - Center for Advanced Battery Collaboration 【Project commissioned by the Japan Science and Technology Agency (JST)】
- Research Center for Electronic and Optical Materials
- Research Center for Magnetic and Spintronic Materials
  - Digital Transformation Initiative Center for Magnetic Materials 【Project commissioned by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)】
- Research Center for Structural Materials
- Research Center for Materials Nanoarchitectonics
- Research Center for Macromolecules and Biomaterials
- Center for Basic Research on Materials

Q2 What research topics do you particularly focus on?

A. The mission of NIMS is to address societal challenges through the "power of materials". To fulfill this mission, we have selected materials research projects that contribute to solving global problems as **priority projects** and are working across the organization to solve these problems. In the current fiscal year, we have launched four projects: **Carbon Neutrality, Biomaterials, Quantum Materials, and Material Circulation.** In the Carbon Neutral project, we are working on materials issues that contribute to the reduction of greenhouse gas emissions, such as storage batteries and hydrogen energy, while in the Biomaterials project, we are promoting research into biomaterials that will extend healthy life spans in a super-aging society. In addition, as fundamental research that will revolutionize the times, we will explore "quantum materials" that express new functions by controlling quantum phenomena. The "Material Circulation" project, which will be launched in fiscal 2024, will contribute to the achievement of the SDGs by creating materials that lead to resource recycling.

Priority research projects P.11

Q3 How to proceed with data-driven materials development?

A. Starting with the national projects "Cross-Ministerial Strategic Innovation Promotion Program (SIP)" (Phase 1, FY2014-2019) and "Material Research by Information Integration Initiative (MI^{2}I)" (FY2015-2019), NIMS has been working on "data-driven" materials development utilizing AI and machine learning. We have been a pioneer in Japan in "data-driven" materials development utilizing AI and machine learning. As a result of these efforts we have discovered new materials with the highest level of properties actively promoted the construction of a smart laboratory that combines automated experimental equipment and AI to conduct fully automated searches and begun to achieve numerous results including the discovery of new electrolytes for storage batteries.

To expand the data-driven approach to materials development throughout Japan NIMS is playing the role of a **"materials data platform"** and making efforts to consolidate data that contribute to materials development. In particular data generated by the nationally shared facilities established under the Advanced Research Infrastructure for Materials and Nanotechnology (ARIM) project and data generated by the Data Generation and Application-oriented Materials Development (DxMT) project will be collected and stored in the NIMS data platform (DPF). The DxMT will establish a mechanism to efficiently collect and accumulate data generated by institutions sponsoring the five materials development projects and NIMS will be responsible for data collection and management for the entire project through the DPF. As one of the DxMT centers NIMS has established the "Digital Transformation Initiative Center for Magnetic Materials (DXMag)". In addition to these projects commissioned by the Ministry of Education Culture Sports Science and Technology (MEXT), NIMS will also promote research on the development of data-driven materials development methods at the Center for Basic Research on Materials.

Materials data platform P.12

VISION
Interview with President Hono

Q4 What is your strategy for connecting your research results to society?

A. NIMS has strengthened its ties with the industry through Collaboration Centers and the Materials Open Platform (MOP) in which several companies in the same industry work together to conduct basic research.

On the other hand in the case of emerging technologies that cannot be realized by existing companies it is necessary for researchers to make their own efforts to implement them in society. In the case of the materials industry since large capital investment is required from the sample shipment stage public support for start-ups is also said to be necessary.

NIMS will further improve the **"NIMS Venture Support Program*"** a unique support measure it has implemented to date and will also support **the third phase of SIP "Innovation in materials business start-ups by constructing a business support ecosystem"** (Program Representative Director, Shosuke Kiba) as a research support organization. This is a challenging initiative to create unicorn companies in the field of materials by providing customized data-driven tools for researchers at various research institutes and universities to use the NIMS Materials Data Platform. By supporting this SIP program NIMS expects to gain expertise in start-up support.

*NIMS Venture Support Program: A support program for companies established by NIMS researchers for the purpose of disseminating research results. Management support is provided for five years from the start of the venture (extendable by three years after screening, up to eight years), including reduced fees for the use of research facilities and management guidance by advisors.

The third phase of SIP P.14

Q5 What do you emphasize in the management of the Organization?

A. In order to enhance NIMS' research capabilities, it is necessary to attract **talented people**. It is the responsibility of the management team to create an environment in which excellent researchers can devote themselves to research and fully demonstrate their abilities. We ask each researcher to participate in "mission research" supported by operating grants based on national strategies while strongly supporting free research in which researchers can pursue their own research based on their individual ideas.

In addition, we have revised our recruitment system for researchers and engineers so that we can hire excellent human resources quickly. In addition to the regular recruitment of researchers twice a year, we have introduced a system that allows us to recruit personnel recommended by our employees at any time. This makes the hiring system more flexible as mid-career hires can be offered treatment that does not put them at a disadvantage. In addition, the standard salary for temporary administrative staff has been revised for the first time in about 20 years and efforts are being made to create a sustainable and attractive work environment by improving the treatment of young researchers and DXing their work.

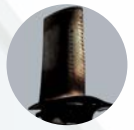
Column "Onward, NIMS:Upgrading programs" P.15

Q6 Once again, what is your message for the launch of the 5th term?

A. Leveraging the expertise gained through the operation of the International Center for Young Scientists (ICYS) a unique training program for researchers within 10 years of completing their Ph.D., NIMS provides a place where young researchers can concentrate on their research in an international and interdisciplinary environment without being overwhelmed by other administrative and educational duties. In addition they will receive international standard treatment regardless of their age. A flexible organizational structure allows a group of talented leaders to grow significantly. We hope that researchers who can take on new challenges and develop future-oriented materials research will choose NIMS as a place to build their careers.

Seven research centers reorganized

NIMS is committed to developing materials that can be used to help solve social issues. It recently underwent organizational reform to better prepare for new challenges—achieving carbon neutrality and meeting Japan' s Society 5.0 goals—resulting in the establishment of seven research centers. The new directors of these research centers outline their respective visions below.

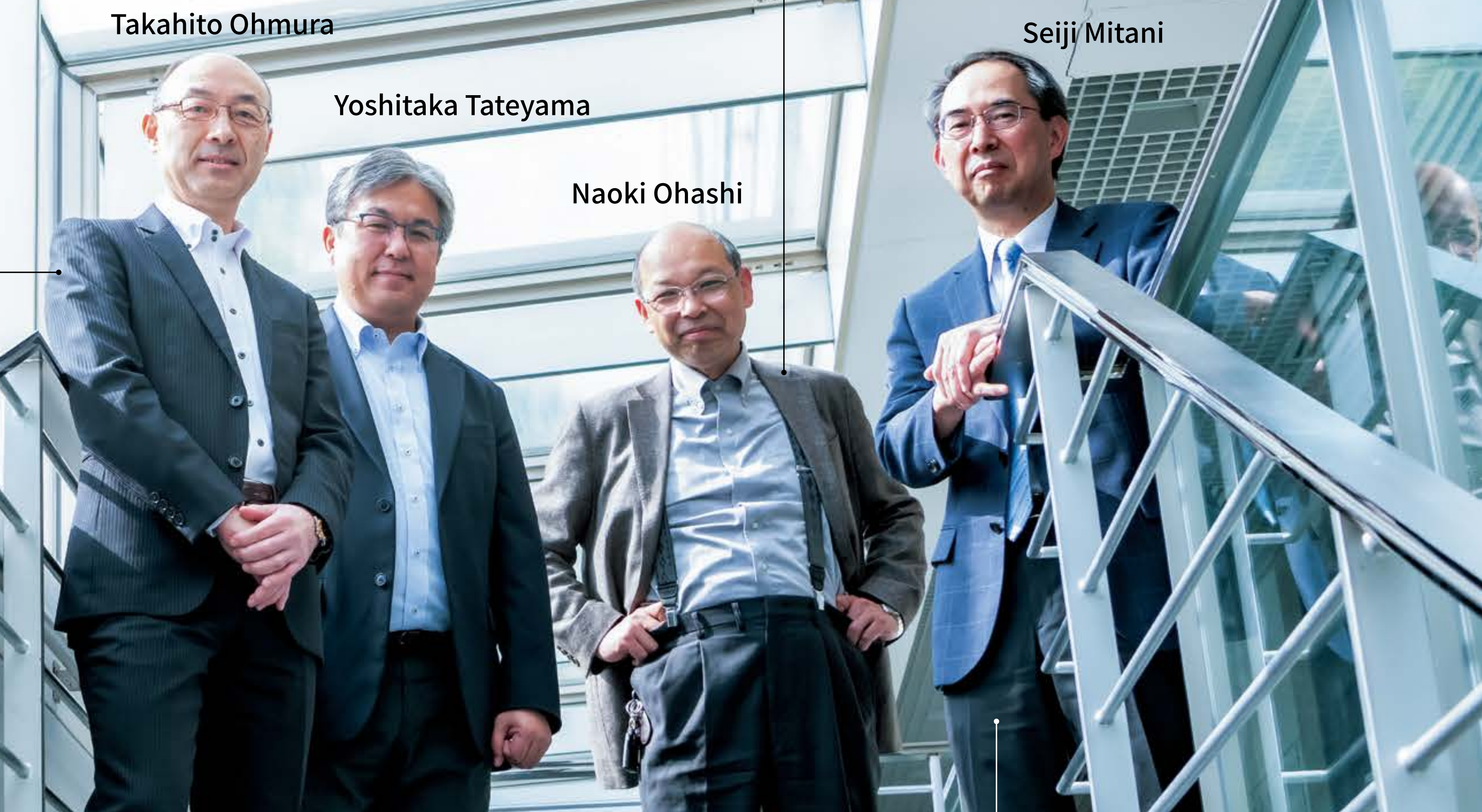


Making society safer
Research Center for Structural Materials

Structural materials physically support various types of social infrastructure that need to function stably for decades. RCSM develops high-performance structural materials and related technologies vital to civil infrastructure, transportation equipment and energy creation plant. These include antiseismic materials used to protect buildings, bridges and other structures from huge earthquakes, high specific strength materials essential to the development of lightweight transport equipment and super heat resistant materials needed to improve jet engine efficiency. In addition, RCSM contributes to the development of cryogenic materials for hydrogen infrastructure and makes society safer and more secure by improving the techniques used to evaluate materials' physical properties and estimate their service lives.

Revolutionizing electronics
Research Center for Electronic and Optical Materials

Electronic and optical materials have played a major role in the development of modern society. Continued social development will require more innovative materials. This center will develop a wide range of materials with the potential to enhance social systems. They include semiconductors vital to next-generation communications technologies which need to operate under severe conditions, such as high voltage, high temperature and high speed; phosphors needed in the development of image display devices used to connect cyberspace and real space; and single crystals for use in laser emitters. The center also aims to develop materials for more sensitive and reliable sensors intended to make society safer and more secure and more recyclable and reusable materials for circular economy. The data generated during these materials development processes will be added to the NIMS data platform, facilitating its construction.



Overcoming energy issues
Research Center for Energy and Environmental Materials (GREEN)

GREEN will conduct world-leading research and development of energy and environmental materials for the realization of a carbon neutral society and Society 5.0, especially focusing on battery/cell and hydrogen technology materials. In the battery/cell materials field, we will extensively investigate the materials for advanced Li-ion batteries, solid-state batteries, photovoltaic cells and so on, toward the next-generation energy devices. In the hydrogen technology materials field, we will intensively study the development of materials and systems for magnetic refrigeration, which is crucial for efficient liquid hydrogen production, and catalytic materials for hydrogen production. In addition, we actively advance the cutting-edge techniques of characterization, automated experiments, and computational/data science approaches. Furthermore, GREEN is serving as a hub for the JST-funded "Center for Advanced Battery Collaboration" conducted jointly by the industrial and academic sectors across Japan.

Developing next-generation magnetic materials
Research Center for Magnetic and Spintronic Materials

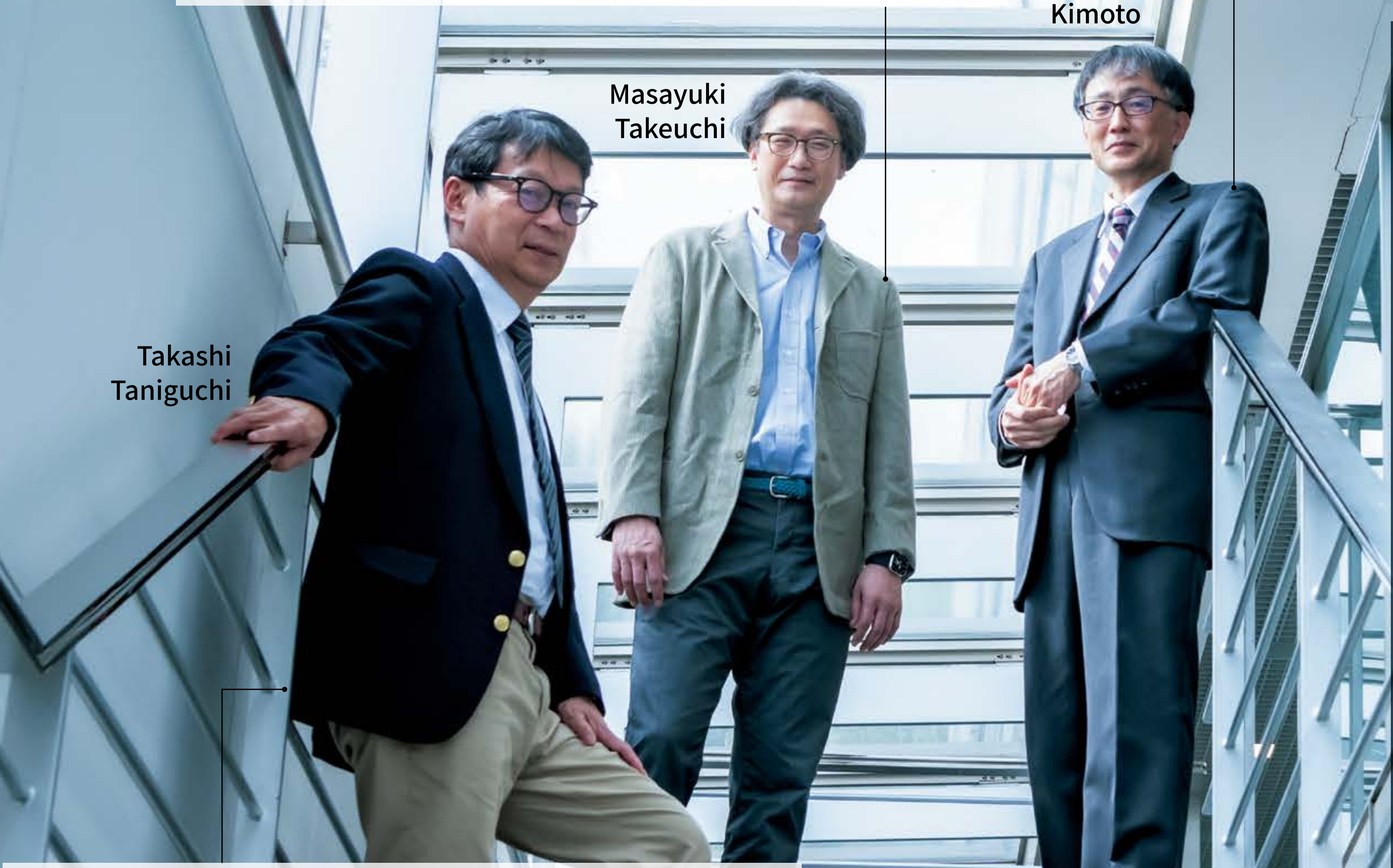
Magnetic materials and spintronic devices are indispensable in making society more sustainable through their use in energy-related fields and information and communications technology. Well-known examples include permanent magnets used in motors and hybrid vehicles, magnetic recording media in storage devices and magnetoresistive materials for non-volatile memory. CMSM has been conducting a wide variety of basic research with the aim of dramatically improving the performance of these materials/devices. Our recent research activities include how magnetism interacts with heat and light, respectively. Based on these researches, we will develop green magnetic materials (e.g., permanent magnets free from heavy rare earth elements and magnetic refrigeration materials) and new materials/devices vital for the practical application of next-generation data storage devices and magnetic memory devices. In addition, CMSM will serve as a hub for MEXT-funded DXMag (Digital Transformation Initiative Center for Magnetic Materials) aiming to develop new data-driven research methodologies.

Creating groundbreaking polymeric materials and materials adaptive to biological activities

Research Center for Macromolecules and Biomaterials

This center has been newly organized by a group of researchers with expertise in organic/polymeric materials and biomaterials, with the goal of developing soft/polymeric materials for a materials revolution and developing biomaterials useful for improving the well-being* of society. We will create these materials using advanced synthetic techniques for organic materials, techniques for controlling the response of materials to external stimuli, and techniques for evaluating the physical properties of materials. We will also develop the fundamental technologies needed to create polymeric materials with desired properties. NIMS has already developed technologies for designing organic, inorganic, bio, and hybrid materials. We will improve and apply them to create materials for next-generation medical technologies that can perform their intended functions in response to targeted biological phenomena.

* According to the World Health Organization, "well-being" is a contented state in which a person is physically, mentally and socially happy and healthy.



Developing materials with novel properties

Research Center for Materials Nanoarchitectonics (MANA)

Nanoarchitectonics—nano-sized architectural technology—enables the creation of new materials with novel functions through precision synthesis and integration of nano-scale components. MANA—established as a result of the WPI*—will continue to pursue bottom-up type fundamental research approach to finding effective nanoarchitectonic materials. Our current projects include the creation of new materials by controlling nano-interfaces and crystalline defects within them, the development of nanomaterials with new physical properties by controlling their dimensions and the identification of new mechanisms in materials. In addition, MANA has been working to develop quantum materials—one of NIMS' priority research areas (see p. 11)—to meet growing demand for quantum technologies. Through these activities, we aim to create new materials with novel working principles.

* MANA was founded in 2007 as a consequence of the MEXT-led World Premier International Research Center Initiative (WPI). Since the completion of the 10-year WPI program, MANA has continued to serve as an international research center in its capacity as a WPI academy center.

Dramatically accelerating materials R&D

Center for Basic Research on Materials

This new organization consists of experts in advanced characterization and data-driven materials design. The center carries out basic research applicable to a wide range of materials as a way of significantly increasing R&D efficiency. We are developing advanced analytical techniques capable of characterizing materials from many different angles (e.g., multiscale measurement techniques and operando measurement techniques, which enable the measurement of materials' behavior under device operating conditions). In materials design-related activities, we will develop advanced data-driven analysis techniques and high-throughput data collection techniques. We will also build the knowledge base of material-related information needed to interconnect different types of databases.

Priority research projects

NIMS has laid out the priority research projects listed below to help resolve urgent global issues using materials. NIMS researchers are collaborating across various fields to carry out these projects.

Project for Carbon Neutrality

To dramatically reduce CO_2 emissions, it is urgent that we efficiently utilize renewable energy and construct hydrogen-related infrastructure. To this end, we have three research focuses: rechargeable batteries, photovoltaic cells and hydrogen-related materials/technologies. Our data-driven rechargeable battery and photovoltaic cell R&D includes the development of solid electrolytes with high ionic conductivity for use in oxide all-solid-state batteries and the identification of effective electrode materials and liquid electrolytes for use in high energy density rechargeable batteries. In addition, we are working to substantially improve the power generation efficiency of perovskite solar cells by addressing interrelated issues that occur during their fabrication.

Our multifaceted hydrogen-related R&D includes the development of a magnetic refrigeration system capable of efficient hydrogen cooling and liquefaction using optimum materials, data-driven exploration of electrode catalysts needed in hydrolytic chemical reactions and theoretical research on hydrogen embrittlement in structural metal materials. In addition, we are developing a data-driven computer program capable of designing highly heat-resistant hydrogen-related materials and predicting their physical properties.

Project for Biomaterials

Japan is facing a super-aging society, therefore it is desirable to increase the options of medical treatment and health promotion to ensure the well-being of patients as well as elderly people. To this end, NIMS is pursuing to integrate biomaterials research with engineering technologies. Five projects are currently underway on sensors and therapeutic materials.

The former group develops membrane-type surface stress sensors (MSS) capable of detecting biogases, such as breath, and sensory systems for bodily hydration levels and specific biomarkers in the human body. By analyzing these data using AI, we aim to improve the prediction accuracy to detect pre-symptomatic disease states or diseases as early as possible. The latter group develops several materials such as "materials for physical treatment at various hierarchical structures of living systems at molecules to tissue", "anti-cancer materials with multiple functions, such as drug-release, heating, adhesion and tissue regeneration", "optical materials for analyzing biological particles and diagnosing diseased tissues" and so on.

Project for Quantum Materials

Materials subjected to high-precision quantum state manipulation may exhibit useful quantum effects. NIMS conducts quantum materials research from various angles through materials development, measurement and evaluation, and theoretical studies, with the goal of bringing about breakthroughs that can solve social issues by using the novel functions of quantum materials/technologies.

In one project, we are working to improve a diamond synthesis technique capable of precisely control NV centers—a type of point defect consisting of a nitrogen atom and an adjacent carbon lattice vacancy that exhibits quantum states—in a diamond lattice. This technique is expected to facilitate the development of practical quantum sensors and quantum memory. In another project, we are attempting to discover novel quantum physical properties from a stack of two-dimensional materials composed of layers of high-purity hexagonal boron nitride—a wide band gap semiconductor—graphene and other materials using advanced evaluation technologies. Through these and other efforts, we aim to develop fundamental quantum technologies and theories, including core quantum materials, associated substrate materials and peripheral technologies.

New priority research project added in FY2024

Project for Material Circulation

NIMS will promote the recycling of natural resources by developing recyclable materials based on its many years of experience in materials science research. Examples include adhesive materials that bond reliably with other materials during use and can be easily separated at the time of disposal.

NIMS compiles data generated across Japan

State-of-the-art equipment that measures the properties of materials and the high-quality data it generates through research activities are important Japanese assets that could lead to breakthroughs. Three interrelated national projects are currently underway to promote innovation in materials R&D by constructing nationwide data infrastructure as a means of integrating equipment and data generated all over Japan.

NIMS has been leading these efforts by integrating and streamlining the three data platform functions: data generation, data aggregation and making data available for use by researchers. We're covering the initiatives that NIMS has taken in the fifth medium-to-long-term plan.

Topic1 // Materials Research Data

Enhancing Japan's innovation in materials through a NIMS-led data strategy

DICE: a vital resource in data-driven materials development

The adoption of data-driven materials research techniques enables speedy and efficient development of new materials. Compilation of large amounts of high-quality data is crucial for these data-driven approaches to be effective. To achieve this, NIMS has been constructing a materials data platform called DICE[*1]. DICE is a user-friendly data ecosystem capable of performing a series of functions: efficient data collection, data aggregation in formats appropriate for data reuse, graphic representation of data and data analysis using advanced AI methods.

In the mid-2010s—the dawn of data-driven materials development in Japan—NIMS was one of the first organizations to begin experimentally incorporating data science into materials research. NIMS has since developed and improved its materials data platform by developing its own databases and creating methods of collecting materials data generated at research labs. This platform performs a succession of functions related to generating and aggregating data and making it available for use by researchers. A major effort to expand this platform began in 2022 in collaboration with universities and other research organizations across Japan. This new project is funded by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Materials DX platform vision: NIMS-led nationwide data utilization strategies

MEXT envisions developing a materials DX platform via three interrelated projects: the ARIM Japan (Advanced Research Infrastructure for Materials and Nanotechnology in Japan) program (see the next page for details) to generate materials data, DICE to aggregate it and finally the DxMT (Data Generation and Application-oriented Materials Development) project to use the aggregated data for materials research. In these projects, NIMS serves as a "core data center," contributing to the progress of individual projects and leading efforts to develop infrastructure capable of efficient and secure collection and sharing of data generated by universities and other research organizations. As part of this effort, NIMS has added various features to DICE.

The Research Data Express (RDE) system is one of the new DICE features rolled out in January 2023. This innovative system is able to aggregate data generated by lab equipment located anywhere. Data is submitted to the system online together with the necessary metadata. The system then extracts the metadata and translates the data into a format appropriate for its reuse automatically. This is a groundbreaking achievement—materials data was previously collected in inconsistent formats, making it difficult for others to reuse. Other DICE features are being developed, including an AI system capable of analyzing data aggregated in DICE in many different ways.

Promoting innovation by introducing DX into materials research

As with materials, the true value of data is in its use. The objective of the DxMT project, which fully launched in FY2022, is to popularize data-driven materials research across Japan by promoting digital transformation (DX)[*2] in five areas of materials research through full utilization of DICE. The data-driven research is promoted by five core organizations selected for each area—including universities. A collaboration committee was established to coordinate the DX activities of the five research organizations and NIMS was appointed to lead it. NIMS will contribute to achieving the common goal of the DxMT project: creating successful examples of cross-area data utilization. To achieve this, we will identify features common to different types of materials—a challenging effort.

NIMS leads the development of a materials DX platform—a potential source of breakthroughs and innovations—through the mutually complementary DxMT, DICE and ARIM Japan projects.

*1 DICE (Digital Innovative Collaborative Ecosystem for materials) was developed by the Materials Data Platform Center (DPFC), part of the Research and Services Division of the Materials Data and Integrated System (MaDIS), during the implementation of NIMS' fourth medium-to-ling-term (MLTC) plan from FY2017 to FY2022. DICE was named and released to the public in June 2020. Since the launch of the fifth MLTC, DPFC was transferred to the Research Network and Facility Services Division (RNFS) and reorganized under the name "Materials Data Platform" (DPF). It continues to operate and update DICE.

*2 Digital transformation (DX) is the adoption of digital technology by an organization to digitize non-digital products or operations. The goal of implementing DX is to increase value through innovation, invention and efficiency.

DICE

Topic2 // Shared lab equipment

NIMS' cutting-edge equipment widely available
Growing importance of shared lab equipment

NIMS shares its rich array of equipment to meet researchers' needs

NIMS makes its lab equipment available for use by external researchers and engineers to support their R&D. About 250 types of equipment are available for shared use. Some are general-purpose equipment while others are state-of-the-art equipment found only at NIMS. This equipment enables materials fabrication through metal/glass machining, welding, nanofabrication and analysis via electron microscopy and nuclear magnetic resonance (NMR) spectroscopy. While these instruments are available to NIMS researchers, they are also accessible to external researchers/engineers via two types of services: the NIMS Open Facility service, which allows users to maintain the confidentiality of their research results, and the NIMS-ARIM[*3] service, which requires them to publish their results. Users who register with either service can select one of three ways of using the equipment (see the lower right figure) to meet their various needs.

In addition, RNFS offers training programs for external researchers and engineers interested in using NIMS equipment in seminar events and workshops. These training programs also aim to cultivate next-generation engineers and promote the use of advanced scientific equipment.

Amassing data: a new mission

Many of the lab equipment available at NIMS for shared use were procured through the large research equipment acquisition projects led by the Japanese government and the Nanotechnology Platform Japan program (2012–2021) funded by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT). NIMS has been promoting the use of its lab equipment—especially its advanced nanotechnology systems and large equipment that are difficult for many laboratories to acquire and maintain—to the wider research community.

MEXT's ARIM Japan (Advanced Research Infrastructure for Materials and Nanotechnology in Japan) program was launched in 2021 to succeed MEXT's Nanotechnology Platform Japan program. The objective of the ARIM Japan program is to aggregate high-quality data needed for data-driven materials development using high-performance equipment and advanced engineering skills available. NIMS serves as a central hub for the 25 research organizations participating in the ARIM Japan program. Its role is to collect data generated using ARIM participating organization lab equipment and aggregate it into the DICE (featured in the previous page) being developed by NIMS. As mentioned earlier, external researchers have access to NIMS' lab equipment via two types of services: the NIMS Open Facility service and the NIMS-ARIM service newly launched specifically for ARIM participants. NIMS-ARIM service users have access to NIMS' lab equipment at lower fees than NIMS Open Facility service users in exchange for an agreement to supply their data to DICE and publicize their research results.

The array of equipment available at NIMS for shared use had been managed by RNFS during the implementation of NIMS' fourth medium-to-long-term (MTLT) plan. This management scheme will remain unchanged during the fifth MTLT plan implementation period. In line with its fourth MTLT plan, NIMS established the Research and Services Division of the Materials Data and Integrated System (MaDIS), which took charge of developing the materials data platform. MEXT has since drawn up the materials DX platform vision to enhance coordination between data producers, aggregators and users. This prompted NIMS to reorganize its RNFS when its fifth MTLT plan went into effect. RNFS is now ready to put NIMS' data utilization strategies into action since welcoming Masahiko Demura, the former director of MaDIS, as its new director and acquiring new engineers to strengthen its capability to carry out the three interrelated projects. NIMS has made the necessary organizational arrangements to fulfill its role as a central hub in the ARIM Japan program.

Three ways in which external researchers can use NIMS' shared lab equipment

No assistance	Users operate equipment without assistance. They are required to obtain a license in advance by taking equipment operation training.
Partial assistance	Users operate equipment with assistance from NIMS staff members.
Full assistance	NIMS staff members operate equipment on behalf of the user.

*3 NIMS-ARIM

Masahiko Demura
Director,
Research Network and Facility Services Division

FOCUS

Novel strategies to support startups using custom-made research tools

—SIP enters its third phase—

Shosuke Kiba
Representative Director, Managing Partner
Universal Materials Incubator Co., Ltd. (UMI)

Starting new businesses in the materials industry has long been a daunting prospect, requiring enormous investments in time and capital before profitability. The Cross-ministerial Strategic Innovation Promotion Program (SIP) led by Japan's Cabinet Office has just entered its third phase. One of the new SIP programs will take an innovative approach to promoting the growth of materials businesses using customized data-driven research tools. We asked the director of this SIP program how this strategy is expected to work.

Private companies in the materials industry aiming to develop and commercialize new materials/technologies usually require huge financial investments over periods of 20 to 40 years before becoming profitable. For this reason, it is extremely rare for the materials industry to produce so-called “unicorn companies.”* The third phase of the SIP program was designed to address this issue. Its director, Shosuke Kiba (Representative Director, Managing Partner, Universal Materials Incubator Co., Ltd.), has considerable experience investing in the materials industry as a representative of a venture capital company. Masahiko Demura (Director, Research Network and Facility Services Division, NIMS) has been appointed as this program's subdirector and NIMS is serving as a “research promotion agency” for the program.

“Startups in the materials industry need to be provided with generous support until they become self-sustaining. This is absolutely necessary,” Program Director Kiba said. “Our mission during this three-year SIP program is to ensure that these startups develop sufficient credibility and attention to attract investments from private companies. Until then, we will provide active support.”

This SIP program will support startups in a unique way. Business start-up support is generally provided in the form of financing, but the program will provide “tools” instead.

Data-driven R&D has become more mainstream in recent years as a way of expediting materials development. Various organizations across Japan (i.e., universities and other research organizations) have built data platforms needed to perform data-driven techniques. These include the Materials Integration by Network Technology (MInt) system developed by NIMS and the Materials Process Innovation (MPI) Platform created by the National Institute of Advanced Industrial Science and Technology (AIST) during the first and second SIP periods. The objective of the third-phase of the SIP program is to integrate these data platforms and make them available for use by startups. However, this is not the only benefit the program plans to offer to startups.

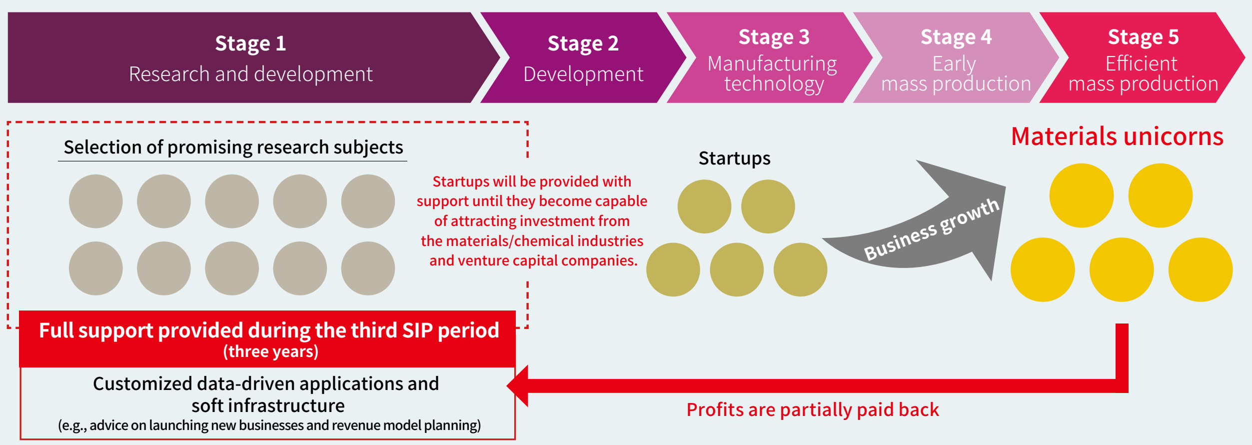
“We will design customized business models able to effectively enhance the competitiveness of individual researchers and companies with differing needs,” Kiba said. “To achieve this, we will identify the social issues and take a backcasting approach to formulating customized business models. Based on the differing characteristics of the models, we will then develop and provide applications—a combination of custom-designed datasets and analytical tools. The cost of this program will be covered by the SIP R&D budget. Universities and other research organizations will manage these custom-made applications and startups will be licensed to use them.”

If startups successfully grow into unicorns, they will be obliged to share their profits with the supporting universities and other research organizations by issuing these organizations shares and share acquisition rights. The capital gained by the research organizations will support other startups planning to launch businesses. This business support ecosystem will give startups access to all necessary research resources and advice on business management—a truly pioneering initiative to develop unicorns.

(by Kumi Yamada)

* A unicorn is a privately held technological startup company which has achieved a market capitalization of 100 billion yen or more within 10 years of its establishment.

Concept of the SIP program, “Innovation in materials business start-ups by constructing a business support ecosystem”



Onward, NIMS: Upgrading programs

In addition to addressing on the new challenges outlined in its fifth medium-to-long term plan, NIMS has made vigorous efforts to enhance and revise its existing programs to help its researchers more fully concentrate on their projects and actively engage one another. NIMS continues to update its programs, as shown below.

Stipend for NIMS junior researchers*

2.45 million yen annually
(2.54 million yen for outstanding students)

Students admitted to the NIMS Joint Graduate School Program in principle conduct research as “NIMS junior researchers” and are paid monthly. Their stipend was increased for new students admitted in April 2023.

*Doctoral students who have already earned a master's degree.

International Center for Young Scientists (ICYS)

Maximum length of contract for an ICYS Research Fellow 5 years

ICYS provides an environment for young researchers who have completed their Ph.D. within the last 10 years to pursue their own original research topic. The maximum contract period has been extended from 3 to 5 years from April 2023 so that young researchers can dedicate themselves to research while still having enough time to look for their next position. In order to maintain international competitiveness, the annual salary has also been increased to 6 million yen and above. To date, 51% of ICYS Research Fellows who applied for NIMS tenured research positions have been hired (FY 2016-2022). Currently, about 50 ICYS alumni are engaged in research as NIMS tenured researchers.

ICYS

Influence of research papers published by NIMS scientists

Average impact factor: 9.32

The average impact factor of the journals in which NIMS scientists publish their research has steadily increased over the years, reaching a record high of 9.32 in FY2022.

This figure is based on March 2023 citation data published by Clarivate Plc.

NIMS Joint Graduate School Program

NIMS Joint Graduate School Program

6 universities that have collaborated for the program

University of Tsukuba	Hokkaido University
Waseda University	Kyushu University
Osaka University	Yokohama National University

This program allows qualified graduate students to conduct research as “NIMS junior researchers” under the guidance of NIMS researchers while pursuing graduate degrees at their respective universities. The program was launched jointly by NIMS and the University of Tsukuba in 2004 and the number of participating universities and students has steadily increased since then. As of FY2022, a total of 560 students have recieved their graduate degrees through this program.

Two new Materials Open Platforms (MOPs) launched

Structural Materials DX-MOP

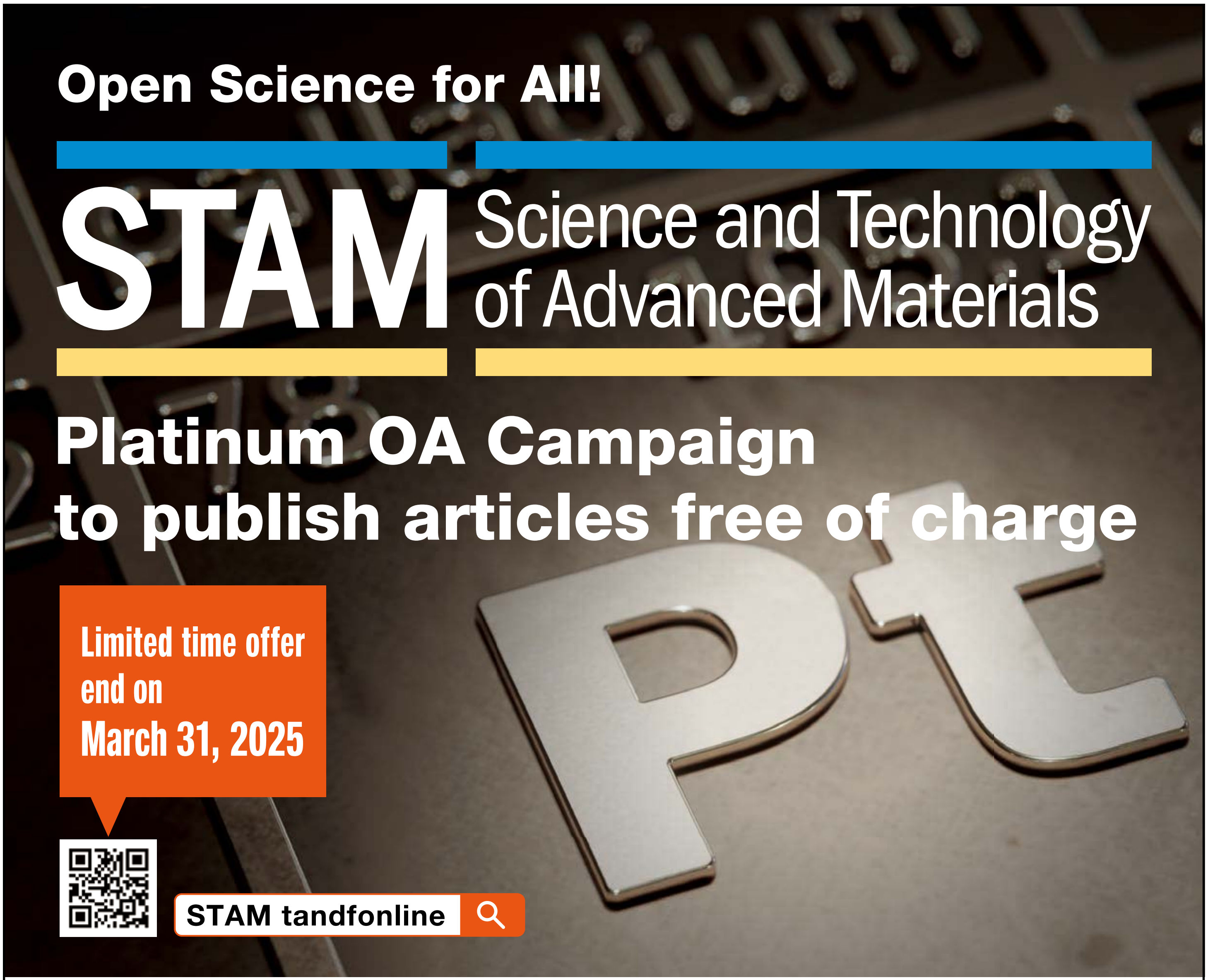
Phosphor MOP

MOP is a NIMS-mediated framework designed to promote basic research collaboration between competing companies in the same industry. Two new MOPs were established in FY2023 following the establishment of the Pharmaceutical, All-Solid-State Battery and Permanent Magnet MOPs. The Structural Materials DX-MOP will research and develop design tools for structural materials while the Phosphor MOP will conduct R&D on next-generation phosphor materials.

Financing NIMS-derived venture companies

First Investment to a NIMS startup

Legislative changes have allowed NIMS to invest directly in startup companies to implement NIMS intellectual property into society. In 2022, NIMS made its first investment in Thermalytica Inc., a company specializing in thermal insulation materials and technologies. NIMS plans to actively fund promising NIMS-derived start-ups.



With rising article processing charges (APCs) becoming a global issue, the National Institute for Materials Science (NIMS) has decided to collaborate with Empa in supporting an APC-free campaign by "Science and Technology of Advanced Materials (STAM) (IF=5.5)," an international journal specializing in materials science. Authors will be exempted from STAM's usual APC (US$1200 / £ 925 / €1060 / ¥131,000) and will be able to publish open access papers (platinum OA) for free until March 31, 2025, the 25th anniversary of STAM's first issue. NIMS will contribute to the expansion of open science through STAM's APC-free publishing campaign.

STAM Advisory Member
Institute Professor / Honorary Professor, Tokyo Institute of Technology
Distinguished Fellow, NIMS

Hideo Hosono

I have published a number of review articles and original research papers in STAM. I was pleased to learn that our 2010 review article on amorphous IGZO-TFTs has been cited 1,600 times. When we published our efforts to explore new superconducting materials in another review, I was even allowed to enlist unsuccessful materials thanks to STAM's unique policy. I find STAM to be a valuable resource for materials scientists.

国立研究開発法人物質・材料研究機構
National Institute for Materials Science

Empa

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photo by Naohiro Tsukada(STASH) (H1,p2-3) Michihito Ishikawa(p4-13)
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on the cover: Turbine blades previously used in an actual aircraft engine (see their description on p. 3)

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