NIMS Award 2024 goes to Prof. Yuichi Ikuhara and Prof. Franz J. Giessibl

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NIMS(National Institute for Materials Science)

Summary

The National Institute for Materials Science (NIMS) has selected **Prof. Yuichi Ikuhara** of the University of Tokyo and **Prof. Franz J. Giessibl** of the University of Regensburg, Germany as the winners of NIMS Award 2024.

This year's NIMS Award has been granted to two researchers for their research in the field of Basic Materials Science, the results of which have initiated practical applications and made a significant impact on society. **Prof. Yuichi Ikuhara from the University of Tokyo was recognized for his contribution to material interface research through innovations in transmission electron microscopy**, and **Prof. Franz J. Giessibl from the University of Regensburg was honored for his contribution to nanomaterial research through innovations in non-contact atomic force microscopy**.

The NIMS Award Ceremony and Commemorative Lectures will be held on Wednesday, November 6th at the Tsukuba International Congress Center as part of **NIMS Award Symposium 2024**.

Prof. Yuichi Ikuhara
Distinguished Research Professor
Institute of Engineering Innovation, School of Engineering,
The University of Tokyo

Prof. Franz J. Giessibl
Chair for Quantum Nanoscience
Institute of Experimental and Applied Physics,
University of Regensburg

[NIMS Award]

Since 2007, NIMS has awarded the international NIMS Award to researchers who have made outstanding achievements in the science and technology of materials, in recognition of their contributions. NIMS broadly divides materials science topics into four fields*, and selects the winners from a different field each year. This year, leading scientists from around the world were asked to nominate candidates in the field of Basic Materials Science that has initiated practical applications and made a significant impact on society. NIMS Award Selection Committee, composed of impartial experts then conducted a rigorous selection process.

*The four fields are: 1. Materials for Environmental and Energy, 2. Functional Materials, 3. Structural Materials, and 4. Basic Materials Science.

[NIMS Award Symposium]

NIMS Award Symposium is an event to honor the achievements of NIMS Award winners and to promote academic exchange in the field of the NIMS Award by bringing together researchers from around the world who are conducting cutting-edge research in the field and by presenting their research results in Tsukuba. Following last year's format, this year's symposium will be held at the Tsukuba International Congress Center and will feature NIMS Award ceremony, commemorative lectures, invited lectures and academic presentations by NIMS researchers. There will also be poster presentations by symposium participants.

Please visit NIMS Award Symposium 2024 official website. The details will be updated soon.
https://www.nims.go.jp/nims-award-symposium/

* The National Institute for Materials Science has unified its abbreviation to "NIMS."

NIMS Award 2024 Winners (1)

[Winner]

Prof. Yuichi Ikuhara (Distinguished Research Professor, Institute of Engineering Innovation, School of Engineering, The University of Tokyo)

[Research Field]

Electron microscopy, grain boundaries/interfaces

[Research achievement title]

Contribution to material interface research through innovations in transmission electron microscopy

[Research summary]

Prof. Yuichi Ikuhara has led the development of high-resolution measurement techniques for atomic structures, electronic states, and dopant elements at grain boundaries and interfaces for many years by developing instruments and methods that expand the potential of material analysis and evaluation methods using transmission electron microscopy (TEM)(1). Also, by combining chemical composition/chemical bonding state measurements through energy dispersive x-ray spectroscopy and electron energy loss spectroscopy(2), and theoretical analysis by first-principles calculations, he established quantitative evaluation methods for grain boundaries, interfaces, and dislocations in materials. Additionally, collaborating with electron microscope manufacturers, he developed a 300kV electron microscope with a new spherical aberration corrector and achieved the world's highest spatial resolution in scanning transmission electron microscopy (STEM)(3) using annular dark-field imaging(4). He also developed annular bright-field STEM(5), which allows to observe light elements that are difficult to observe by conventional imaging, enabling the observation of hydrogen and lithium. These innovations in electron microscopy techniques and equipment, as well as their application to the analysis of grain boundaries and interfaces, have led to the elucidation of various mechanisms of functional expression in materials such as ceramics, thereby contributing greatly to materials science.

[Impact on the academic and industrial sectors]

Prof. Yuichi Ikuhara's achievements have had significant impacts on materials science from two perspectives: the development of innovative material measurement techniques and equipment using transmission electron microscopy, and the elucidation of grain boundary and interface atomic structures.

STEM instruments with the world's highest spatial resolution and annular bright-field STEM detectors have been commercialized and are used worldwide as innovative electron microscopes and related equipment. Additionally, research applying these innovative electron microscopy techniques to a wide range of materials such as ceramics, batteries, catalysts, semiconductors, and magnetic materials have revealed many new findings into grain boundaries and interfaces, leading to the establishment of design guidelines for new materials and the creation of novel materials.

(Glossary)

(1) Transmission Electron Microscopy (TEM): A microscopy technique where electrons accelerated by high-voltage are irradiated to a thin sample, and then the electrons passing through it form a magnified image. This method provides information on the internal structure and composition of the sample.

(2) Electron Energy Loss Spectroscopy: A measurement technique where the energy loss by electrons as they interact with atoms in a sample during passing through the sample is measured. This provides information on the elemental composition, chemical bonding states, and electronic structure of the sample.

(3) Scanning Transmission Electron Microscopy (STEM): A microscopy technique where a finely focused electron beam is scanned across a thin sample, and the electrons passing through it are detected to form a magnified image synchronized with the beam scan. Like TEM, this provides information on the internal structure and composition of the sample.

(4) Annular Dark-Field Imaging: A technique in STEM where an annular detector is used to collect electrons scattered at high angles and form a magnified image. The contrast is generally proportional to the square of the atomic number of the sample.

(5) Annular Bright-Field STEM: A technique in STEM that collect electrons scattered at low (rather than high) angles with an annular detector, forming a magnified image. Unlike annular dark-field imaging, it enables clear observation of light elements.

NIMS Award 2024 Winners (2)

[Winner]

Prof. Dr. Franz Josef Giessibl (Chair for Quantum Nanoscience, Institute of Experimental and Applied Physics, University of Regensburg, Germany)

[Research Field]

Atomic force microscopy

[Research achievement title]

Contribution to nanomaterial research through innovations in non-contact atomic force microscopy

[Research summary]

Prof. Dr. Franz J. Giessibl achieved atomic resolution with non-contact atomic force microscopy (AFM) for the first time in the world in 1995. He then developed the qPlus sensor(1), a self-sensing force sensor originally based on a quartz tuning fork, significantly enhancing the capabilities of non-contact AFM. In non-contact AFM, the probe oscillates near the sample surface and the minute forces between the sample surface and the probe are detected. Compared to the previously-used cantilever sensors, the qPlus sensor has a very high spring constant, enabling it to detect short-range forces with high sensitivity at amplitudes as small as tens of picometers, which was unattainable with cantilever sensors. This has dramatically improved the contrast at the atomic level. Using the self-sensing qPlus sensor, he also developed a scanning probe microscope capable of operating at extremely low temperatures, which is challenging with cantilever sensors, and proposed the necessary theories for high-resolution measurements. He has demonstrated the significance of these developments through numerous studies on nanomaterials.

[Impact on the academic and industrial sectors]

Atomic force microscopes utilizing the qPlus sensor developed by Prof. Dr. Franz J. Giessibl have been commercialized and over 500 units have been sold worldwide. The qPlus sensor is incorporated in nearly all atomic force microscopes operating at extremely low temperatures and ultra-high vacuum. The use of these instruments has significantly advanced academic fields of surface science, surface physics, surface chemistry, and the like. Notably, the use of the qPlus sensor has enabled the observation of the internal structure of molecules for the first time, making low-temperature atomic force microscopes equipped with the qPlus sensor essential tools in surface chemistry.

(Glossary: Supplemental explanation)

(1) qPlus sensor:

In conventional AFM, a cantilever is vibrated, and the changes in its resonance characteristics due to interaction with the sample surface are detected using a laser or similar method to obtain information about the sample surface. On the other hand, the qPlus sensor is a force sensor modified from a watch quartz oscillator (in other words, a force sensor based on a tuning fork quartz oscillator), which unlike a cantilever, enables it to detect changes by itself. It is therefore called a self-sensing force sensor.

The spring constant of a cantilever ranges from 0.1 to 100 N/m, whereas the qPlus sensor has a spring constant of 1000 N/m, making it much stiffer. This stiffness allows for smaller amplitudes and makes the qPlus sensor suitable for detecting short-range interaction changes. For example, it can improve the measurement accuracy of interactions that are highly distance-dependent, such as the simultaneous measurement of tunneling currents.

<Reference>

NIMS Award laureate of the past five years and their achievements (Affiliation is at the time of the award)

2019 **Prof. Gerbrand Ceder** (University of California Berkeley, USA)
"Pioneering data-driven materials research based on the first-principles calculations"
Dr. Pierre Villars (Materials Phases Data System (MPDS), Switzerland)
"Development of Pauling File, inorganic materials database"

2020 **Prof. Hiroshi Julian Goldsmid** (The University of New South Wales, Australia)
"Pioneer work on bismuth telluride thermoelectric material and its application for large-capacity optical communication systems using the Peltier cooling phenomenon"
Prof. Kunihito Koumoto (Nagoya University, Japan)
"Development of environmental-friendly inorganic thermoelectric materials"

2021 **Prof. Tsuneya Ando** (Tokyo Institute of Technology, Japan, University of Tokyo, Japan)
"Fundamental theoretical studies on quantum states of low-dimensional materials"
Prof. Allan H. MacDonald (University of Texas at Austin, USA)
Prof. Pablo Jarillo-Herrero (Massachusetts Institute of Technology, USA)
"Pioneering work of new quantum physics by twistronics"

2022 **Prof. Teruo Okano** (Tokyo Women's Medical University, Japan)
"Development of cell sheet engineering using temperature-responsive polymers and its application to regenerative medicine"
Prof. Kazuhiko Ishihara (Osaka University, Japan)
"Pioneering work in the development of biomimetic polymer biomaterials and their medical applications"
Prof. Donald E. Ingber (Wyss Institute for Biologically Inspired Engineering at Harvard University, USA)
"Proposal of the cellular tensegrity model and the invention of organ-on-a-chip technology"

2023 **Prof. Dierk Raabe** (Max-Planck-Institut für Eisenforschung GmbH, Germany)
"Pioneering research on the sustainability and microstructure-based design of advanced metallic alloys"

<Past winners> Past winners since 2007 can be seen below.
https://www.nims.go.jp/nims-award/en/award.html

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