

Expert Insights

Expectations for Atomic-resolution Holography Electron Microscope



Prof. Daisuke Shindo, Dr. Eng.

Institute of Multidisciplinary Research for Advanced Materials, Tohoku University
Head of Center for Advanced Microscopy and Spectroscopy

Graduated in nuclear engineering from the School of Engineering at Tohoku University in 1977 and completed a doctoral program at Graduate School of Engineering at Tohoku University in 1982. Appointed as Research Associate at Institute for Materials Research, Tohoku University in 1982, Associate Professor at Institute for Advanced Materials Processing, Tohoku University (previously Research Institute of Mineral Dressing and Metallurgy) in 1992, and Professor at Institute for Advanced Materials Processing, Tohoku University (since renamed Institute of Multidisciplinary Research for Advanced Materials) in 1994. He has also served as Team Leader of Emergent Phenomena Observation Technology Research Team at RIKEN since 2012.

Doctor of Engineering. His specialty is the measurement of electromagnetic fields using electron interference.

The atomic-resolution holography electron microscope project, launched in March 2010 by the late Akira Tonomura under the Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program), was completed last year. Overcoming numerous difficulties, not least of which was the Great East Japan Earthquake, Dr. Tonomura was, in accordance with his own wishes, succeeded within Hitachi by Nobuyuki Osakabe and Hiroyuki Shinada, and the project culminated in a 1.2-MV ultra-high-voltage electron microscope that combines atomic resolution with the ability to image electromagnetic fields. Although a number of ultra-high-voltage electron microscopes have been constructed in the past, mainly in Japan, I offer my sincere congratulations for achieving the world's first ever ultra-high-voltage holography electron microscope with an electron interference function, and featuring extremely high voltage stability and an aberration corrector. Of the four fundamental forces of the natural world (strong force, weak force, electromagnetism, and gravity), it is electromagnetism that accounts for most of the phenomena with which we are familiar, particularly interactions on the nano- to micro-scales. Electromagnetism has its origins in electromagnetic fields, and the public announcement of the ability to image electromagnetic fields with world-leading resolution is highly significant in terms of Japan maintaining its role as a world leader in the field of science and technology.

The FIRST Program has also actively promoted applied research into the observation of electromagnetic fields using holography electron microscopes. I myself have received FIRST funding for applied research into such subjects as advanced materials and biological samples using the 300-kV holography electron microscope at the National Research and Development Institute, RIKEN. While charge buildup due to the discharge of secondary electrons is known to occur when non-conductive samples such as biological material are viewed under an electron microscope, it has recently been discovered that when this buildup of charge becomes large, the previously discharged secondary electrons are attracted back to the sample, and that the formation of stable orbital configurations in the vicinity of the sample surface can be imaged by detecting the

disturbance in the electric field due to the movement of electrons. Moreover, the late Shinji Aizawa of Hitachi High-Technologies Corporation joined my team at RIKEN to engage in further research, where he undertook numerous precise and delicate experiments and succeeded in obtaining sharp and dynamic images of the collective motion of electrons that had progressively built up on the surface of a biological sample. This reinforced my strong impression of the very high technical capabilities of Hitachi researchers.

Underpinned by the high level of technical capabilities passed on from one Hitachi researcher to another and shared between them, the atomic-resolution holography electron microscope is recognized for how, in the future, it will continue to uncover information on electromagnetic fields at the atomic level that is important for understanding the electromagnetic characteristics of various types of advanced devices. In addition to this information on electromagnetic fields, I look forward to the microscope also being utilized in the near future for the analysis of complex quantum phenomena that have to date remained unexplained through the tracking of interactions between atomic lattices imaged with world-leading resolution and electrons detected as disturbances in electric fields.