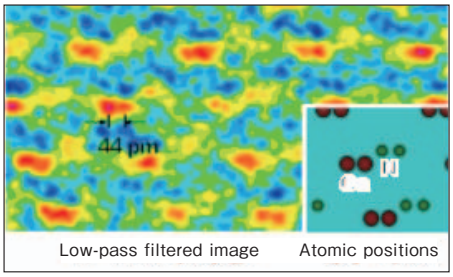
The World's Most Powerful Electron Microscope Supports the Development of Future Technologies

Atomic-resolution holography electron microscope



Crystals of gallium nitride (GaN), used in blue light-emitting diodes, as seen through the electron microscope. Pairs of red gallium atoms were observed 44 picometers apart, showing how structures and electromagnetic fields can be observed and measured at an atomic level.

A model of the electron microscope. The entire microscope, including the special casing, is housed in a large facility 18 meters in height.

An Electron Microscope Designed to Beat World Standards

With support from the government-sponsored Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST), in 2010 Hitachi Ltd. set out to develop an atomic-resolution holography electron microscope with an accelerated voltage of 1.2 megavolts, and managed to achieve a new world record resolution※ of 43 picometers (one picometer is one trillionth of a meter).

The microscope's greatest merit was its spherical aberration corrector, something that had never been installed in an ultra-high-voltage electron microscope before. Spherical aberration occurs when light passing through the lens some distance from the lens center doesn't match the electron focal distance, causing the focus to blur. In optical microscopes this problem is solved by using a combination of concave and convex lenses to correct the aberration, but this requires a stability which seemed difficult to achieve in large, ultra-high-voltage electron microscopes. To overcome this obstacle, an electron gun emitting 1.2 megavolt electron beams with stable long-term suppressed energy dispersion and an ultra-high-voltage power supply system were developed. A special structure was built to house the electron microscope in order to reduce as much as possible the external factors that can affect point resolution, such as vibration, noise and ambient magnetic fields.

Analysis at the Atomic Level is Applied to the Development of New Materials

"Our development process is nothing radical," said Hiroyuki Shinada of the Basic Research Center. "We brought together all the technology that the company possessed, and thoroughly got to grips with the fundamental and most difficult aspects of it. We procured the necessary parts from about six hundred companies, both domestic and overseas. There are many small and medium size companies in regional areas manufacturing world-class products."

During the four years it took to develop the microscope, the team endured more than just development-related difficulties. One parts factory, which was located in the city of Hitachi, Ibaraki Prefecture, was damaged by a tsunami caused by the Great East Japan Earthquake in 2011. In 2012, Dr. Akira Tonomura, the central researcher for the project, and also considered a strong candidate for a Nobel Prize, unfortunately passed away. Veteran engineer Isao Matsui also died during the same year.

"There was talk of abandoning the project entirely, but we continued out of respect for Dr. Tonomura's wishes, so it was a very emotional time when we finished in March 2014."

In the future, it is planned that the analyses made using this electron microscope will be used to develop energy-conserving products, such as lightweight high-capacity batteries for electric cars, and also contribute to the creation of resource-efficient new materials. Other fields, such as the life sciences, should also benefit from this new microscope.

※ Point resolution is the degree of resolution that can be identified or measured by a piece of equipment.