Körber European Science Prize 1987

Further Development of Electron Holography

Karl-Heinz Herrmann, Friedrich Lenz, Hannes Lichte, Gottfried Möllenstedt

Once a leading force in the field of electron microscopy, Germany has no longer been a location for the production of this important technology for over two decades. Nevertheless, German microscopists number among the vanguard of research in several areas. The Körber Prize in 1987 accelerated the development of a process with which a Tübingen-based research team has advanced to the forefront of the international scene.

Light and electron microscopes have several basic principles in common. When describing them it is noticeable that light or the electron beam must be seen first as a wave phenomenon and then again as the continuous firing of particles:

- The beams collide with the object, alter it, are sent in different directions by lenses and reflected by mirrors – like a game of billiards.
- In order to illustrate the contrast between the object and its background it is necessary to regard the beam as a wave: when it passes through the object, the wave properties change, in particular the intensity, i.e. the amplitude; information about the object is created and made visible by the microscope.

The special electron microscope for atomic electron holography. Built to the specifications of the Tübingen-based scientists at Philips, it currently allows the holographic depiction of structures with a fineness of 0.13 nm. The target is 0.1 nm. (Photo: Peter Allert)

The wave character results in the resolution limit of traditional microscopy: if two points in the object are closer together than 200 or sometimes 100 nanometers (one nm is equivalent to a thousandth millimeter) they can no longer be distinguished from one another. The wavelength of the light is too large for an image of such close neighbors still to be focused sharply. Considerably higher resolutions can be achieved with electron beams. Light microscopy has long arrived at its resolution limit. It cannot be exceeded, but it can be avoided. For this purpose, microscopists are compiling both amplitude information and phase information at the same time: The object can also change the phase of the wave, i.e. shift the point in time at which it hits the peak or trough of a wave in a particular place – and this information can be made visible.

Precisely this can also be accomplished with electrons. Although electron microscopy is still far from reaching the theoretical resolution limit, the unavoidable aberrations of the electron lenses make it more difficult, for example, to examine the atomic structures of crystals. However, if a comparison wave is superimposed on the electron image, the phase changes can be determined from the interference image, a hologram. The Tübingen group captures the electron hologram with a CCD camera; the now digitized data are then processed by a computer whose program simulates the wave optics. It corrects the errors of the electron microscope and thus provides images with a much higher resolution than those taken with commercial electron microscopes. Admittedly, the instruments are extremely expensive; the Körber Prize put the research group in a position to work out ways of raising extensive additional third-party funds – with success.

Contact
Körber Foundation
Körber Prize
Kehrwieder 12
D-20457 Hamburg
Phone +49 40 · 80 81 92 -181
E-Mail koerberprize@koerber-stiftung.de