Artechnique/CEA

Transmission electron microscope (JEOL 300 keV) installed at CEA/Grenoble. Its point resolution is close to 0.17 nanometre.

III. OBSERVING AND ORGANIZING THE NANOWORLD

There is no technology that does not have its own appropriate tools and resources for analysis, observation and fabrication. This third chapter first describes the microscopes that are the "eyes and fingers" of researchers and engineers, and which enable them to act on the nanoscale world: transmission or scanning electron microscopes and local probe microscopes.

Transmission electron microscopes remain an indispensable tool. They provide data on structure and chemical composition, and can even measure local electrical and magnetic fields with a resolution that sometimes attains the atomic scale. They make it possible to analyse a sample in depth, and have also benefited from progress made in information technology. They are often complementary to local probe microscopes, which sense only the surface.

Scanning microscopes, which are constantly improving, are the prime tools in the top-down approach. Associated with an ion beam they form a complete machine kit for fabricating nano-objects. But the great step forward has been the local probe microscope, which allows both examination and manipulation of the surface, with a resolution that discerns the positions of atoms and detects their movements.

A pioneering instrument was the tunnel-effect microscope, invented in 1981. This instrument has made it possible not only to probe the topology of nanometre-scale surfaces by means of a metal tip, but also to displace atoms and molecules one by one, and thus custom-build nanostructures. A derivative of the tunnel-effect microscope, the atomic force microscope provides a means to explore the surface of all types of materials with a high resolution. It can also be used as a tool to build nano-objects.

The use of synchrotron radiation, which can visualize not only a single object but sets of objects, has proved to be a surprisingly effective way to observe the growth of nanostructures and to deduce their morphological characteristics and their organization. This is possible thanks to the GISAXS method of scattering and diffraction of grazing-incidence X-rays.

Lastly, the omnipresent methods of numerical modelling can predict the atomic assembly of nanostructures and accurately describe their ensuing properties.