The fascinating world of nanotechnology

Applied nanotechnology: Dr. Arno Nennemann examines a wafer (starting material for microchips) which has been polished with nanoparticles.

Experts believe that our lives will be changed by nanotechnology as fundamentally as they have been by modern telecommunications. Researchers from all parts of Bayer are working in the field of miniaturization, entering worlds which are invisible to the naked eye.

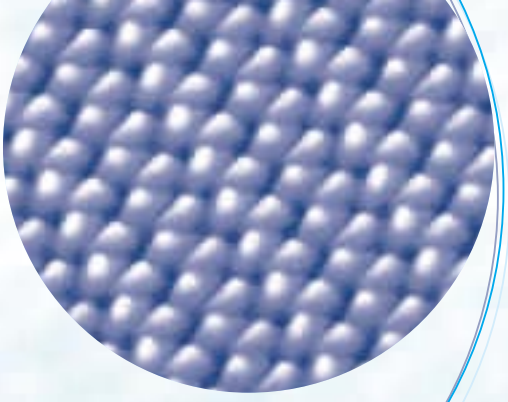
According to the utopias of many visionaries, in the foreseeable future our world will look very different than it does today: our lives will be ruled by nanotechnology. New materials will be produced by armies of tiny machines which renew themselves independently and co-operate with each other. A nanomanipulator in every household will be able to create a juicy steak from a handful of proteins. Doctors will be supported by minirobots which patrol the body, immediately identifying and eliminating pathogens and altered cells.

Nanotechnology is considered to be one of the most important basic and key technologies of the 21st century, involving the miniaturization of materials, tools, machines and production and analytical techniques down to the level of individual atoms.

"But nanotechnology is by no means merely the continuation of miniaturization as we know it from electronics," says Professor Hariolf Grupp of the Fraunhofer Institute for Systems Engineering and Innovation Research in Karlsruhe, Germany. Nanotechnology combines the use of the laws of physics, the chemical characteristics of substances and biological principles. Scientists are selectively intervening in the blueprints of living and non-living matter. "For chemistry in particular, this opens up completely new creative possibilities," says Dr. Udo Oels, Member of the Board of Management of Bayer AG and company spokesman for Technology, Innovation and Environment. "If we learn how to alter materials selectively down to the level of individual atoms, then we can achieve new effects, optimize characteristics and as a result open up completely new opportunities for all our company's business units."

Demand for nanoproducts is increasing. The world market in 2001 was estimated at around €54 billion. The volume is expected to increase about four-fold by 2010. "Bayer has been working in the nanocosmos for several years. Our first nanoproducts are already on the market and many others will follow," explains Oels. "Tailor-made plastics or novel products for diagnostic technology are possibilities, for example."

The prefix nano– comes from the Greek word "nanos" – dwarf. Like the world of mythical creatures, the nano-world is also invisible to the naked eye: the wave-lengths of light are too great for an image of the nanoparticles to be formed. A nanometer corresponds to a millionth of a millimeter; the ratio of a nanoparticle to the size of a soccer ball



The basis of all life
The scanning tunneling microscope makes it possible to see the structure of the smallest elements of life (in this case, guanine, one of the four components of DNA). The peaks of the hilly landscape each represent a molecule of the substance.

is that of the soccer ball to the size of the entire world. In this miniature world, the laws of quantum mechanics prevail. This is the reason why a nanoparticle behaves quite differently from the same material in visible dimensions: ceramic becomes transparent like glass, glass becomes viscous like glue and metals become dyes and their magnetism can be switched on and off.

Previously inconceivable possibilities for the medicine of the future

Scientists are expecting huge progress in the field of medicine: for example, it may be possible one day for cancer treatments to be channeled precisely and directly through the body to the tumor tissue. As with all new technologies, the possible risks to human health and the environment posed by nanotechnology naturally also have to be investigated.

Precise handling of individual atoms and molecules requires new tools. The crucial invention which gave impetus to the nanocosmos was the development of the scanning tunneling microscope and shortly afterwards the atomic force microscope. These devices enabled researchers to visualize individual atoms and molecules for the first time and also manipulate their positions and arrangements on surfaces. Like the needle on a record player, the instrument scans the surface of atomic landscapes. It can not only selectively change surface structures but can also characterize them on the nanoscale, giving us valuable information which helps us to understand the macroscopic properties of materials. In 1986, German physicist Professor Gerd Binnig and his Swiss colleague Professor Heinrich Rohrer were awarded the Nobel prize for physics for inventing the scanning tunneling microscope.

Bayer, too, has been using the technology for a long time, according to Oels: "All subgroups are already carrying out successful research in the field of nanotechnology." Tiny capsules allow materials such as leather to be impregnated with a lasting fragrance (page 30) and fluorescent dyes made of nanophosphors help in the diagnosis of diseases (page 38). Hidden in food packaging, nanoparticles prevent sausage and cheese from drying out (page 34) and X-ray structural analysis makes the structural elucidation of ever smaller crystals possible (page 26). Emphasizes Udo Oels: "In this way, the researchers and developers at Bayer AG are making a considerable practical contribution to this new field of technology. And we are well positioned in international competition, too."

www.nanonet.de
Comprehensive information on nanotechnology can be found at the above website.

The nanocosmos and the macroworld
A length of one millimeter provides enough space for a million particles with a diameter of one nanometer each. These dimensions are only conceivable when compared to specific examples.