Thin films of silicon nanoparticles roll into flexible nanotubes

June 14 2005

By depositing nanoparticles onto a charged surface, researchers at the University of Illinois at Urbana-Champaign have crafted nanotubes from silicon that are flexible and nearly as soft as rubber.
"Resembling miniature scrolls, the nanotubes could prove useful as catalysts, guided laser cavities and nanorobots," said Sahraoui Chaieb, a professor of mechanical and industrial engineering at Illinois and a researcher at the Beckman Institute for Advanced Science and Technology.

To create their flexible nanotubes, Chaieb and his colleagues – physics professor Munir Nayfeh and graduate research assistant Adam Smith – start with a colloidal suspension of silicon nanoparticles (each particle is about 1 nanometer in diameter) in alcohol. By applying an electric field, the researchers drive the nanoparticles to the surface of a positively charged substrate, where they form a thin film.

Upon drying, the film spontaneously detaches from the substrate and rolls into a nanotube. Nanotubes with diameters ranging from 2 to 5 microns and up to 100 microns long have been achieved.

Using an atomic force microscope, the researchers found that the Young’s modulus (a measure of a material’s elasticity) of the film was about 5,000 times smaller than that of bulk silicon, but just 30 times larger than that of rubber.

“We suspect that the nanotubes consist of silicon nanoparticles held together by oxygen atoms to form a three-dimensional network," Chaieb said. "The nanotubes are soft and flexible because of the presence of the oxygen atoms. This simple bottom-up approach will give other researchers ideas how to build inexpensive active structures for lab-on-chip applications."

"Because the silicon nanoparticles – which are made using a basic electrochemical procedure – have properties such as photoluminescence, photostability and stimulated emission, the resulting nanotubes might serve as nanodiodes and flexible lasers that could be controlled with an electric field," Nayfeh said.

The results will be reported in an upcoming issue of the journal Applied Physics Letters. The work was funded by the National Science Foundation and the state of Illinois.

Source: University of Illinois at Urbana-Champaign