

charge through the tube, causing electrons to be transported through it. By measuring the charge field at several points on the tube with an atomic force microscope, they viewed local charge differences. Dekker said, "The charge seems to be concentrated in small islands at intervals of approximately 40 nm. We had not expected this. The electrons apparently jump from one point to another, and this provides the conductive capacities of the nanotube."

**Crystalline Selenium Nanowires Produced**

The fabrication and properties of nanostructures, including dots and wire, has elicited much interest. A method has been introduced in the July 2000 issue of *Chemistry of Materials* that allows the fabrication of selenium nanowires in one chemical reaction in aqueous solution at room temperature. This technique was developed through a collaborative effort by researchers at the University of New Mexico, Sandia National Laboratories, and the Universidade Nova de Lisboa.

The first step in the nanowire fabrication was the reduction of the selenate ion

( $\text{SeO}_4^{2-}$ ) to elemental selenium ( $\text{Se}^0$ ) by the enzyme cytochrome  $c_3$ , with sodium dithionite ( $\text{Na}_2\text{S}_2\text{O}_4$ ) serving as the electron donor. Cytochrome  $c_3$ , which is well known for its ability to catalyze the reduction of metals, was extracted from the sulfate-reducing bacteria *Desulfovibrio vulgaris* (strain Hindenborough). In the second step of the fabrication process, the colorless selenium solution was allowed to stand until it turned red (1 week), indicating the precipitation of red selenium.

Transmission electron microscope characterization of the product showed the presence of nanowires roughly 60 nm in diameter and 1  $\mu\text{m}$  long, consisting of a single strand of stacked nanoparticles with visible grain boundaries between them. Larger diameter wires with several nanoparticles in parallel were also present, along with isolated spherical nanoparticles roughly 50 nm in diameter. Electron-diffraction studies showed that the nanowires were crystalline, with a monoclinic structure that is consistent with red selenium. The wires were stored in water solution for at least 10 weeks with no degradation; the aging resulted in the

formation of longer but not thicker wires.

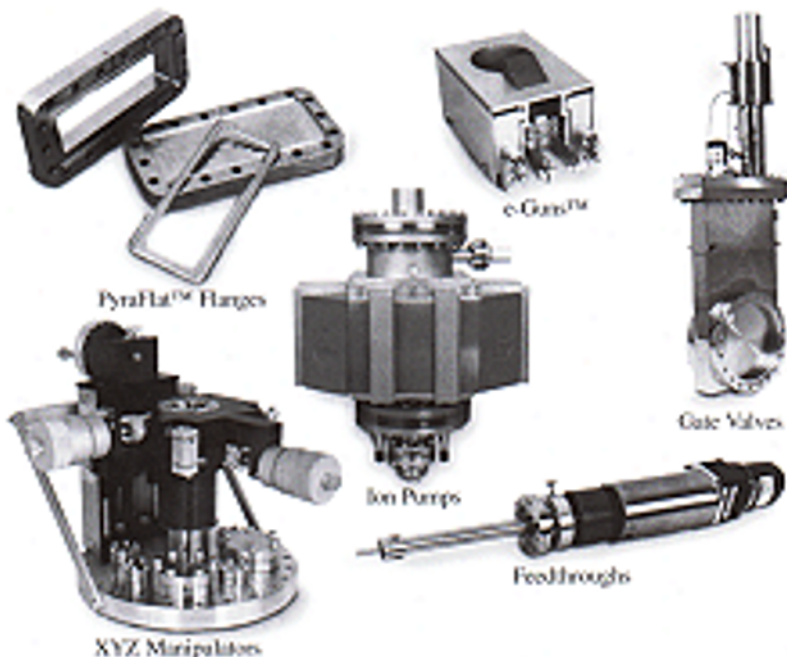
The mechanism of selenium nanoparticle assembly into nanowires is not known, but the researchers speculate that "the stacking of nanocrystals in the same [crystallographic] direction provides an energetically favorable link between them." Similar stacking was previously observed for silver nanocrystals.

GREG KHITROV

**Magnetic Actuation Folds Microparts into 3D Structures**

Researchers at the University of Illinois—Urbana-Champaign have utilized a magnetic field to assemble large arrays of three-dimensional microstructures, ~100  $\mu\text{m}$  on a side. To fabricate arrays of 3D structures, individual components are first cast in place on sacrificial layers using planar deposition. A small amount of magnetic material is electroplated onto each of the parts, which are then freed from the substrate by a highly selective etchant consisting of 49% hydrofluoric acid. The etchant attacks the oxide sacrificial layer but not the structure materials, which are made of polysilicon. When a magnetic field is

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