Electrochemical Process Makes Ultrasmall Si Nanoparticles

Researchers at the University of Illinois—Urbana-Champaign have developed a process for converting bulk silicon into ultrasmall, nano-sized particles. As reported in the April 3 issue of *Applied Physics Letters*, the nanoparticles—which are about 1 nm in diameter and contain about 30 silicon atoms—can be formed into colloids, crystals, films, and collimated beams for applications in the electronics, optoelectronics, and biomedical industries.

To create the nanoparticles, the researchers begin with a silicon wafer, which they pulverize using a combination of chemistry and electricity. "We use an electrochemical treatment that involves gradually immersing the wafer into an etchant bath while applying an electrical current," said Munir Nayfeh, a professor of physics and a researcher at the university's Beckman Institute for Advanced Science and Technology. "This process erodes the surface layer of the material, leaving behind a delicate network of weakly interconnected nanostructures. The silicon wafer is then removed from the etchant and immersed briefly in an ultrasound bath." The main contents of the etchant bath are hydrogen fluoride (HF) and hydrogen peroxide (H_2O_2).

Under the ultrasound treatment, the fragile nanostructure network crumbles into individual particles of different size groups, Nayfeh said. The slightly larger, heavier particles precipitate out, while the ultrasmall particles remain in suspension, where they can be recovered.

"The assembly of ultrasmall silicon nanoparticles on device-quality silicon crystals provides a direct method of integrating silicon superlattices into existing or future down-scaled microelectronics architectures," Nayfeh said. "This could lead to the construction of single-electron transistors and electric charge-based memory devices, optimized to work at high temperature." The nanoparticles also could form the basis for novel semiconductor lasers. Nayfeh and his colleagues have demonstrated stimulated, directed emission from within the walls of a microcrystallite reconstructed from the nanoparticles. The emission was dominated by a deep-blue color.

"This type of laser could possibly replace the wires used to communicate between components in a circuit," Nayfeh said. "The blue color might also be useful for underwater communications systems."

The benign nature of silicon also makes the nanoparticles useful as fluorescent markers for tagging biologically sensitive materials. The light from a single nanoparticle can be readily detected.

The researchers report that a patent application has been filed.

"Left-Handed" Composite Materials Respond to Electromagnetic Radiation

Physicists at the University of California—San Diego have produced a class of composite materials called "left-handed" because they reverse many of the physical properties observed in ordinary materials in response to electromagnetic radiation. Lead scientists Sheldon Schultz and David Smith described their findings in March at a meeting of the American Physical Society in Minneapolis. The scientists pro-