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Georgia Tech Study Targets Nanomanufacturing

We found many important stories for this issue's Technology Report on materials research. We chose to present this research news from the Georgia Institute of Technology (www.gatech.edu) because it addresses an important technique for continued miniaturization of devices in the future. The report has been edited from the press release provided by the Gerogia Tech Research News & Publications Office.

Researchers have taken an important step toward high-volume production of new nanometer-scale structures with the first systematic study of growth conditions that affect production of one-dimensional nanostructures from the optoelectronic material cadmium selenide (CdSe).

Using the results from more than 150 different experiments in which temperature and pressure conditions were systematically varied, nanotechnology researchers at the Georgia Institute of Technology created a "road map" to guide future nanomanufacturing using the vapor-liquid-solid (VLS) technique.

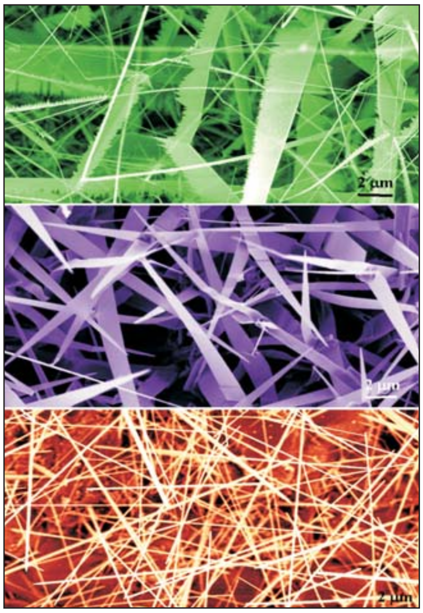
The results join earlier Georgia Tech work that similarly mapped production conditions for nanostructures made from zinc oxide. Together, the two studies provide a foundation for large-scale, controlled synthesis of nanostructures that could play important roles in future sensors, displays and other devices.

The research was supported by the National Science Foundation (NSF), the NASA Vehicle Systems Program, the Department of Defense Research and Engineering (DDR&E) and the Defense Advanced Research Projects Agency (DARPA).

"For the future of nanomanufacturing, we needed a systematic map to show the best conditions for producing these structures reproducibly with high yield," explained Zhong Lin Wang, director of Georgia Tech's Center for Nanoscience and Nanotechnology.

In work that required more than a year to complete, Wang and collaborator Christopher Ma collected information on more than 45 separate combinations of growth conditions governing the production of cadmium selenide nanostructures. In their experimental set-up, powdered cadmium selenide was heated in a simple horizontal tube furnace under the flow of nitrogen gas, using gold as a catalyst. The technique produced three different types of nanostructures:

- "Nanosaws/nanocombs"—unusual structures that form with "teeth" on one side and a smooth surface on the other.
- "Nanobelts"—ribbon-like structures.
- "Nanowires"—resemble grass and grow vertically from the substrate.



Scanning electron microscope images show nanosaws, nanobelts and nanowires of cadmium selenide grown using the vapor-liquid-solid process.

"These three different structures are all produced using the same general experimental conditions, but somehow you get different percentages of each," Wang said. "Our goal was to determine how to control the conditions to learn how to get close to 100 percent yield of each structure."

Based on their experimental work, Wang and Ma found that growth of the nanostructures is primarily controlled by the nitrogen gas pressure inside the chamber and the temperature of the substrate where the structures are deposited. They also learned where each type of structure was likely to be deposited on the substrate under each set of conditions.

Cadmium selenide nanosaws and nanocombs are the most finicky to grow. At the other end of the scale, nanowires can be produced from cadmium selenide over a broad range of temperature and pressure conditions.

Cadmium selenide has been studied for applications in optoelectronics, luminescent materials, lasing materials and biomedical imaging. It is perhaps best known as the basis for quantum dots that have applications in biomedical imaging.

Zinc oxide is a semiconducting, piezoelectric and optical material with potential applications in sensors, resonators and other nanoelectronic structures.

"Now that we have determined the optimal requirements for growth, it should be straightforward to scale up the production of these structures," Wang concluded. "We have a lot of ideas for potential applications."