New process makes nanofibers in complex shapes and unlimited lengths

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The continuous fabrication of complex, three-dimensional nanoscale structures and the ability to grow individual nanowires of unlimited length are now possible with a process developed by researchers at the University of Illinois.

Based on the rapid evaporation of solvent from simple “inks,” the process has been used to fabricate freestanding nanofibers, stacked arrays of nanofibers and continuously wound spools of nanowires. Potential applications include electronic interconnects, biocompatible scaffolds and nanofluidic networks.

“The process is like drawing with a fountain pen – the ink comes out and quickly dries or ‘solidifies,’ ” said Min-Feng Yu, a professor of mechanical science and engineering, and an affiliate of the Beckman Institute. “But, unlike drawing with a fountain pen, we can draw objects in three dimensions.”

Yu and graduate students Abhijit Suryavanshi and Jie Hu describe the drawing process in a paper accepted for publication in the journal *Advanced Materials*.

To use the new process, the researchers begin with a reservoir of ink connected to a glass micropipette that has an aperture as small as 100 nanometers. The micropipette is brought close to a substrate until a liquid meniscus forms between the two. As the micropipette is then smoothly pulled away, ink is drawn from the reservoir. Within the tiny

meniscus, the solute nucleates and precipitates as the solvent quickly evaporates.

So far, the scientists have fabricated freestanding nanofibers approximately 25 nanometers in diameter and 20 microns long, and straight nanofibers approximately 100 nanometers in diameter and 16 millimeters long (limited only by the travel range of the device that moves the micropipette).

To draw longer nanowires, the researchers developed a precision spinning process that simultaneously draws and winds a nanofiber on a spool that is millimeters in diameter. Using this technique, Yu and his students wound a coil of microfiber. The microfiber was approximately 850 nanometers in diameter and 40 centimeters long.

To further demonstrate the versatility of the drawing process, for which the U. of I. has applied for a patent, the researchers drew nanofibers out of sugar, out of potassium hydroxide (a major industrial chemical) and out of densely packed quantum dots. While the nanofibers are currently fabricated from water-based inks, the process is readily extendable to inks made with volatile organic solvents, Yu said.

“Our procedure offers an economically viable alternative for the direct-write manufacture of nanofibers made from many materials,” Yu said. “In addition, the process can be used to integrate nanoscale and microscale components.”

Source: University of Illinois at Urbana-Champaign

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