reversibly modified the interband transition (S_{11}) intensities in semiconducting SWNTs—by light-induced refilling and depletion of the valence band—and in spiropyran-functionalized SWNTs (SP-SWNTs) by photoinduced changes in the dye's polarity. It is well-known that spiropyran molecules exhibit photochromic effects under UV-excitation, undergoing a transition to the merocyanine form. In this work, the researchers showed that the S_{11} modulation of SP-SWNTs corresponds to the UV-induced, reversible conversion of spiropyran by a ring-opening reaction to its merocyanine form. However, they also observed an absorption band at 440 nm that they indicate is due to the merocyanine aggregation by the functionalized SWNTs. Absorption-band shifts observed for merocyanine-SWNTs indicated to the researchers that the dye's π-electron system strongly interacts with the SWNT. In addition, the researchers interpreted other spectral features as evidence that spiropyrans/merocyanines are either bonded to the sidewalls or to the ends of the SWNTs. They used atomic force microscopy to show that SP-SWNTs exist in solution both as individual nanotubes and bundles of 2–5 nanotubes with lengths in the range of 0.4–2 μm.

The researchers said that discovering the nature of SWNT-substrate interactions will lead to further advances in SWNT-based chemical sensors. Furthermore, they believe that their work "presents an impetus for an exploration of a new type of chemical sensors based on the interaction of an analyte with a host molecule."

STEVEN TROHALAKI

WS_2 Nanotubes Synthesized for Lithium Storage

The discovery of fullerenes and carbon nanotubes has led to extensive research aimed toward the synthesis of similar one-dimensional nanostructures to carbon nanotubes, but based on different materials. These novel nanomaterials could find applications in diverse fields such as quantum computing, sensing and biomedical devices, and energy needs such as hydrogen storage. An example for such one-dimensional nanomaterials is WS_2 nanotubes discovered by R. Tenne and co-workers in the early 1990s.

In the October issue of *Electrochemical and Solid-State Letters* (p. A321), G.X. Wang, S. Bewlay, J. Yao, H.K. Liu, and S.X. Dou from the University of Wollongong, Australia report a major breakthrough in utilizing such WS_2 nanotubes for storing lithium in Li-ion batteries. Li-ion batteries are the most commonly used type of rechargeable batteries in portable electronic devices. Wang's research team has focused on how lithium is stored in WS_2 nanotubes, which represents an important process in using these materials as electrodes or anodes in rechargeable batteries.

The researchers synthesized WS_2 nanotubes from amorphous WS_3 at high temperature in a hydrogen atmosphere. They report a very high yield of ~80%. Characterization of the material by transmission electron microscopy with field emission indicated that the nanotubes have a length of a few hundred nanometers, have open tips, a diameter between 30 nm and 40 nm, with wall thicknesses of ~15 nm. The hollow core measured roughly 4.6 nm. Electrochemical properties were assessed based on coin cell testing.

Wang and co-workers identified electrochemical properties of the WS_2 nanotubes that differ significantly from WS_2 as a powder material. The WS_2 nanotube electrode

delivered a lithium insertion capacity correlating to 8.6 mol lithium per mol WS_2 nanotube whereas the lithium insertion capacity was 0.6 mol lithium per mol crystalline WS_2. The researchers attribute the nanotube capability to its 1D topology and open structure. They further found that the WS_2 nanotubes show stable cyclability over a wide voltage range (0.1–3.1 V vs. Li/Li^+), so that batteries built with these materials will be tolerant for overcharge and overdischarge. Based on their results, the researchers said that WS_2 nanotubes may be an attractive material for usage in electrochemical applications. In particular, they said, the capacity for storing Li is much enhanced in the nanotube modification of the material than the crystalline powder materials.

MARKUS J. BUEHLER

Fabrication of Suspended Micro- and Nanostructures Accomplished by Direct Drawing of Polymer Fibers

In designing and fabricating micro- and nanostructures, ease of fabrication is an important consideration. S. Harfenist, R.W. Cohn, and co-workers at the ElectroOptics Research Institute and Nanotechnology Center in the University of Louisville have demonstrated a simple and versatile method for creating suspended micro- and nanostructures by direct drawing of fibers from liquid polymers. The novelty of this approach is that it offers control and flexibility of forming and simultaneously patterning polymer fibers as suspended bridges and networks of three-dimensional structures.

As reported in the October 13 issue of *Nano Letters* (p. 1931), the researchers used tips attached to an atomic force microscope (AFM) or a computer-controlled micromill to draw fibers from a drop of poly(methyl methacrylate) (PMMA) electron beam resist placed on a substrate. The tip was dipped into the polymer drop several times until a fiber formed between the tip and the drop. The tip end of the fiber was drawn to a second drop of liquid polymer or adhered to a surface to form a polymer fiber that dries and solidifies into a suspended beam. The fibers produced were circular and uniform in diameter ranging from under 50 nanometers to tens of microns and can be made to span lengths from a few microns to several centimeters. This approach can be modified to produce suspended fibers in parallel and to pattern and orient them into three-dimensional geometries. For example, a bead of liquid polymer applied and allowed to dry momentarily on the edge of a stiff sheet of plastic or a microscope glass slide before being quickly dragged over an array of sharp silicon tips results in fibers suspended along each row of tips (see Figure 1). In a different example, polymer fibers several centimeters long can be drawn by hand on the cleaved end of a glass optical fiber and can be repeatedly manipulated and coiled without breaking. Fibers have been formed at draw rates between 10 μm/s and 100 mm/s, depending upon experimental conditions.

According to the researchers, polymer fibers formed and patterned by this approach may be applied as three-dimensional templates for subsequent processing. Capillaries with different functionality can be produced by coating the