14.94 Å, respectively. Here, the integers in parentheses (*n*,*m*) allow a topographical characterization of the chirality of the nanotube in comparison with the lattice vectors that span the graphite lattice. Wilson deems the fact that IINTs with very similar diameters but different morphologies can form in the same SWNT as indicative of significant kinetic control of IINT morphology. Wilson said that his simulations show "that a class of IINT structures, analogous to those formed by elemental carbon itself, may exist and that an experimental pathway to such structures may lie in the filling of [SWNTs] from the liquid phase."

Two alternate IINT morphologies investigated by Wilson are related to hexagonal or square-net sheets. Energies of geometry-optimized (5,0) IINTs plotted as a function of ion density show double minima, which Wilson attributes to the two morphologies, with the square-net minimum occurring at a higher density than the hexagonal. For (5,2) IINTs formed in small-diameter SWCNTs, the square-net structure is the stable morphology.

Wilson said that the presence of multiple energy minima suggests that a pressure-driven pathway may exist between the square-net and hexagonal IINT morphologies. Indeed, the application of pressure in a simulation of a (14,14) SWNT (diameter, 19.01 Å) filled with bulk molten ions led to the formation of nested, double-walled IINTs—one IINT with morphology (3,2) inside a (9,2) IINT. Wilson said that "this demonstrates that both the [SWCNT] pore diameter and the external pressure have the potential to effectively control both the IINT morphology and the degree of nesting."

STEVEN TROHALAKI

Tungsten Electrodes Reduce Parasitic Source/Drain Resistance of Poly-Si TFT

Polycrystalline silicon thin-film transistors (TFTs) are of potential interest for applications in peripheral circuits for active-matrix liquid-crystal displays, but device dimensions must be scaled down in order to improve speed and circuit densities. In the February issue of *Electrochemical and Solid-State Letters*, H.-W. Zan of the National Chiao Tung University, T.-C. Chang of the National Sun Yat-Sen University, P.T. Liu of the National Nano Device Laboratory, and their colleagues have proposed a method for decreasing parasitic resistance of TFTs by the use of tungsten electrodes.

The research team from Taiwan created TFTs by conventional methods in which a 30 nm a-Si layer is deposited by low-pressure chemical vapor deposition (LPCVD) on oxidized silicon wafers. After active region patterning, a 60 nm tetraethylorthosilicate (TEOS) oxide layer and subsequently a 300 nm a-Si layer were deposited by LPCVD. The a-Si layer was then recrystallized by solid-phase crystallization at 600°C for 24 h. After defining the gate by reactive ion etching (RIE) and removing the oxide on source/drain (S/D) regions by HF dip, a lightly doped drain implant was performed using phosphorus ions at a dose of 3×10^{13} cm^{-2}. Then, a 200 nm oxide side-wall spacer was formed abutting the gate by conformal deposition of a TEOS oxide layer and subsequent RIE. Next, phosphorus ions at a dose of 5×10^{15} cm^{-2} were implanted to form the S/D region. Dopants were activated by a rapid thermal anneal at 750°C for 20 s. After removal of the oxide from the S/D

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regions, W was deposited on the exposed gate, source, and drain regions. After the formation of an initial thin W film, a SiH_4 reduction reaction took place with a deposition rate of ~240 nm/min. The WF_6/SiH_4 gas flow rate was kept at 40/12 and the process temperature was 300°C. Conventional devices without W film deposition were also fabricated to serve as controls. A 500 nm Al film was deposited, patterned, and sintered at 400°C for 30 min to form metal pads. To reduce trap density and improve interface quality, wafers were also immersed in a NH_3 plasma. The poly-Si gate was 10 μm in length and 3 μm in width. The oxide gate thickness was ~30 nm.

The researchers observed that the W-TFTs have a larger driving current then conventional TFTs, especially under high gate bias. The parasitic resistance of the W-TFTs is ~4 kΩ, which is three times smaller than that of conventional TFTs. In addition, the researchers found that a NH_3 plasma treatment before the deposition of W contacts achieves a better interface quality and junction integrity of W-TFTs than for NH_3 plasma treatment after deposition of the W contacts. The researchers said this happens because the W blocks the plasma passivation from reaching the active regions under the contacts in the latter case.

MAXIM NIKIFOROV

In Situ TEM Observations Reveal Growth Mechanisms for Carbon Nanofibers

The synthesis of carbon nanotubes and nanofibers with specific structures and functionality is very important for nanotechnology applications. Carbon nanofibers are grown from the vapor phase in the presence of a catalyst. The atomic-scale growth mechanisms for forming nanofibers have not been understood thus far. This understanding is crucial for manufacturing carbon nanofibers with tailored properties and characteristics. Now, S. Helveg at the Danish company Haldor Topsøe, F. Abild-Pedersen at the Technical University of Denmark, and their colleagues have used time-resolved, high-resolution *in situ* transmission electron microscopy (TEM) to elucidate the growth mechanisms of carbon nanofibers.

As the researchers reported in the January 29 issue of *Nature*, carbon nanofibers are formed by the decomposition of methane vapor at 500°C over a catalyst consisting of Ni nanoclusters with diameters of 5–20 nm supported on $MgAl_2O_4$. The growth experiments were performed in an *in situ* TEM, and a large number of consecutive real-time TEM images were obtained and stitched into a TEM movie. The nanofibers formed through a reaction-induced reshaping of the Ni nanocrystals into highly elongated shapes. The reshaping of the nanoclusters helped align the graphene sheets into tubular structures forming the nanofibers. The researchers said that this reshaping is abrupt, oscillating between spherical and elongated, but is critical for the formation of the fibers. The Ni nanoparticles were found to remain crystalline throughout the growth process. The nucleation and growth of the

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