UNIVERSITY OF TEXAS AT DALLAS - DEPARTMENT OF PHYSICS

PHYSICS COLLOQUIUM

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Solid State Assembly of Carbon Nanotubes and Their Applications

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Individual carbon nanotubes (CNTs) are like minute bits of string, and many trillions of these invisible strings must be assembled to make useful macroscopic articles. Though major advances have been made on the fabrication of nanotube sheets and yarns, no one is yet able to assemble carbon nanotubes into sheets and yarns that retain the spectacular properties of the individual nanotubes. For fabricating sheets and yarns having close to single nanotube properties, we have developed a process to assemble CNTs by solid-state fabrication. The production processes involve growth of CNT forests by chemical vapor deposition and then drawing CNTs from the forest. During CVD process, CNTs form small bundles of a few nanotubes each in the forest, with individual nanotubes moving in and out of different bundles. During drawing process, the nanotubes in the forest transition from the highly ordered forest state to a rather disordered intermediate state immediately in front of the forest sidewall, and then to the highly oriented aerogel state. Bundled nanotubes are simultaneously pulled from different elevations in the forest sidewall, so that they join with bundled nanotubes that have reached the top and bottom of the forest, thereby minimizing breaks in the resulting fibrils (containing many bundled CNTs). The assembly at rates about 10 m/min by cooperatively flipping carbon nanotubes in forests and five-centimeter-wide, meter-long transparent sheets have been demonstrated. These self-supporting nanotube sheets, having fundamentally unlimited width and length, comprise a novel state of matter: a highly anisotropic electronically conducting aerogel with a density of ~0.0015 g/cm3 that can be densified into exceptionally strong sheets that are as thin as ~50 nm. Experimental results suggest applications for transparent, highly elastomeric electrodes; low-noise electronic devices; planar sources of polarized broad-band radiation; two-dimensionally reinforced composites; welding agents for microwave bonding of plastics; conducting appliqués; and hole injecting electrodes for flexible organic light-emitting diodes. By introducing twist during spinning of carbon nanotube ribbon to make multi-ply, torque-stabilized yarns, we achieve yarn strengths greater than 700 megapascals. Unlike ordinary fibers and yarns, these nanotube yarns are not degraded in strength by overhand knotting. They also retain their strength and flexibility after heating in air at 450°C for an hour or when immersed in liquid nitrogen. Experimental results also show that CNT sheets and yarns are biocompatible.

About the speaker: Dr. Mei Zhang received her B.S. in Physics from Nanjing University (China) and Ph. D. in materials science from School of Engineering at Osaka Prefecture University (Japan). She was a faculty member in the Department of Physics and Electronics at Osaka Prefecture University for five years (1995-2000). She joined UTD NanoTech Institute in 2003, where she worked on synthesis of CNTs using thermal CVD and successfully discovered the ways to spin CNT yarns and draw CNT sheets from the CNT forests. For these accomplishments Dr. Zhang and her colleagues have been awarded a number of prestigious awards, including Scientific American 50, Nano 50, and NanoVic Prize.