New Materials for Structural Composites and Protective Coatings

2007 Center Director's Discretionary Fund Project

Defect/Damage Location

The objective of this Phase I project was to create novel conductive materials that are lightweight and strong enough for multiple ground support equipment and Exploration applications. The long-term goal is to combine these materials within specially designed devices to create composites or coatings with diagnostic capabilities, increased strength, and tunable properties such as transparency, electroluminescence, and fire resistance. One such technology application is a "smart windows" system. In such a system, the transmission of light through a window is controlled by electrical power. In the future, these materials may also be able to absorb sunlight and convert it into electrical energy to produce light, thereby creating a self-sufficient lighting system.

This experiment, conducted in collaboration with the Georgia Institute of Technology, demonstrated enhancements in fabricating fiber materials from carbon nanotubes (CNT). These nanotubes were grown as forests in an ultra-high-purity chemical vapor deposition (CVD) furnace and then drawn, using novel processing techniques, into fibers and yarns that would be turned into filaments. This work was submitted to the *Journal of Advanced Functional Materials*.

The CNT fibers were initially tested as filament materials at atmospheric pressure; however, even under high current loads, the filaments produced only random sparking. The CNT fibers were also converted into transparent, hydrophobic, and conductive sheets. Filament testing at low vacuum pressures is in progress, and the technology will be enhanced in 2008.

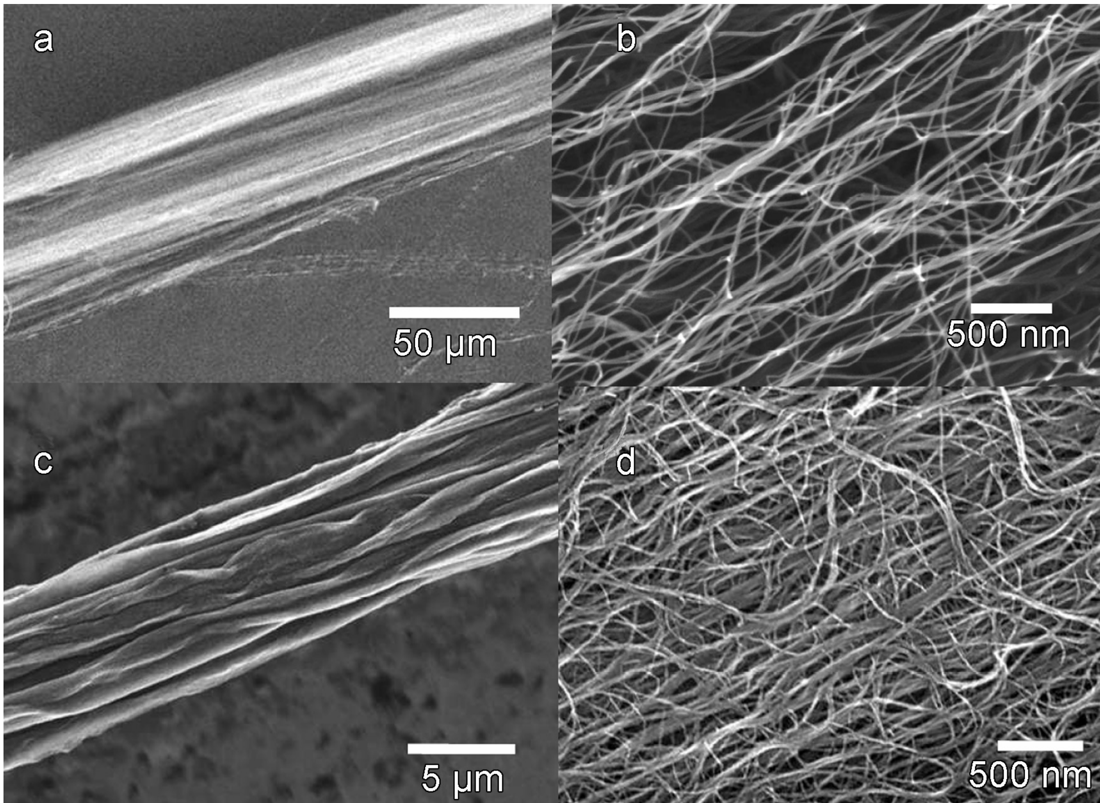
As initial proof of the smart-windows application concept, the use of CNT sheets as composites/protective coatings was demonstrated in collaboration with Nanocomp Technologies of Concord, New Hampshire. CNT sheets were thermally welded between layers of high-performance polymer sheets with high thermal conductivity. The electrical conductivity of the sheets provided an ample flow of current to detect damage.

Enhancements to the fabrication process and performance of this type of system will be addressed in FY 2008. In Phase II, we intend to further address conductive composites, fabrication processes, and various applications. We will apply these next-generation composites and coatings to various hardware systems and analyze their mechanical properties, conductivity for detection, and thermal conductivity for thermal management in Lunar Architecture Team and Exploration applications.

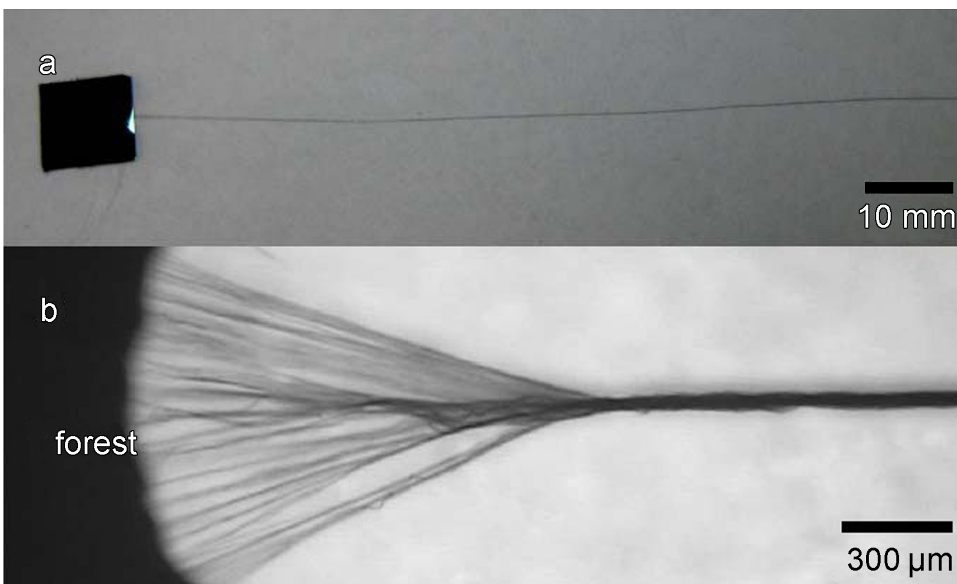
Key accomplishments included fabricating CNT filaments and evaluating them under atmospheric conditions, fabricating CNT sheet fabrication, and fabricating a structural conductive composite with ample current for damage detection.

*Contacts: Dr. Luke B. Roberson <Luke.B.Roberson@nasa.gov>, NASA-KSC, (321) 867-1542;
Dr. LaNetra C. Tate <LaNetra.C.Tate@nasa.gov>, NASA-KSC, (321) 867-3789; and Dr. Martha K. Williams <Martha.K.Williams@nasa.gov>, NASA-KSC, (321) 867-4554*

Participating Organizations: NASA-KSC (Trent M. Smith and Dr. Robert C. Youngquist), Georgia Institute of Technology (Dr. Satish Kumar, Dr. Jud Ready, and Dr. Janusz Kowalik), Nanocomp Technologies, Inc. (Dr. David Lashmore), and ASRC Aerospace (Dr. Barry J. Meneghelli and Dr. Christopher D. Immer)



SEM images of neat MWNT fibers: (a) as-drawn aerogel fiber, (b) nanotube arrangements in the as-drawn fiber, (c) densified fiber, and (d) nanotube arrangement in the densified fiber.



Spinning continuous MWNT fibers from the forest: (a) fiber in the process of being drawn from the 10- by 10-mm^2 wafer scale forest and (b) optical image showing the nanotubes being pulled from the forest wall into a fiber.