NIST laser-based method cleans up grubby nanotubes

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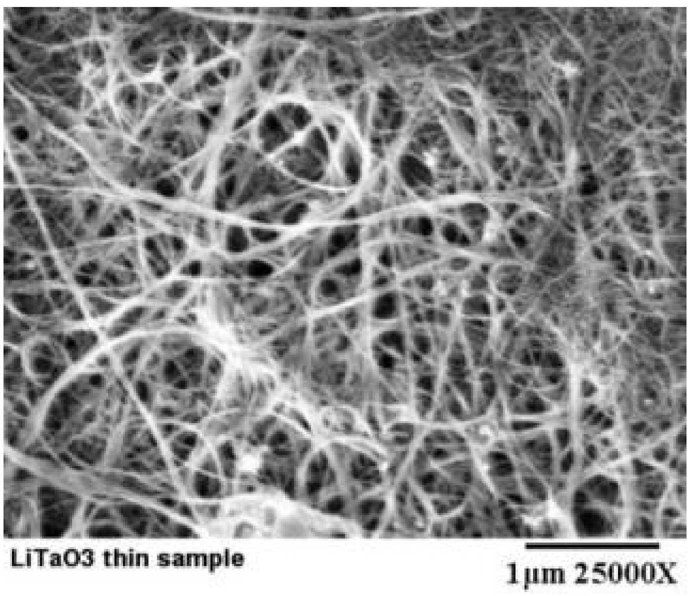
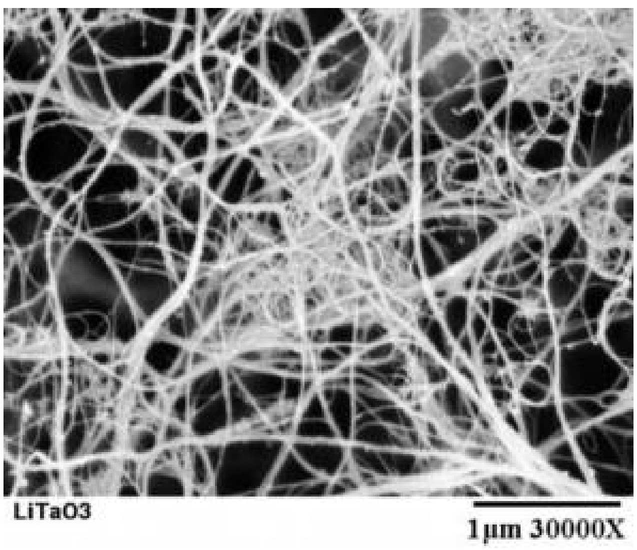


Before and after electron microscope images of a pyroelectric detector coated with single-walled nanotubes (SWNTs) visually demonstrate the effect of the laser cleaning process. In addition, the SWNTs look visibly blacker after laser treatment, suggesting less graphitic material and increased porosity. Credit: NIST

Before carbon nanotubes can fulfill their promise as ultrastrong fibers, electrical wires in molecular devices, or hydrogen storage components for fuel cells, better methods are needed for purifying raw nanotube materials. Researchers at the National Institute of Standards and Technology (NIST) and the National Renewable Energy Laboratory (NREL, Golden, Colo.), have taken a step toward this goal by demonstrating a simple method of cleaning nanotubes by zapping them with carefully calibrated laser pulses.

When carbon nanotubes--the cylindrical form of the fullerene family--are synthesized by any of several processes, a significant amount of contaminants such as soot, graphite and other impurities also is formed. Purifying the product is an important issue for commercial application of nanotubes.



Before and after electron microscope images of a pyroelectric detector coated with single-walled nanotubes (SWNTs) visually demonstrate the effect of the laser cleaning process. In addition, the SWNTs look visibly blacker after laser treatment, suggesting less graphitic material and increased porosity. Credit: NIST

In a forthcoming issue of *Chemical Physics Letters*, the NIST/NREL team describes how pulses from an excimer laser greatly reduce the amount of carbon impurities in a sample of bulk carbon single-walled nanotubes, without destroying tubes. Both visual examination and quantitative measurements of material structure and composition verify that the resulting sample is "cleaner." The exact cleaning process may need to be slightly modified depending on how the nanotubes are made, the authors note. But the general approach is simpler and less costly than conventional "wet chemistry" processes, which can damage the tubes and also require removal of solvents afterwards.

"Controlling and determining tube type is sort of the holy grail right now with carbon nanotubes. Purity is a key variable," says NIST physicist John Lehman, who leads the research. "Over the last 15 years there's been lots of promise, but when you buy some material you realize that a good percentage of it is not quite what you hoped. Anyone who thinks they're going into business with nanotubes will realize that purification is an important--and expensive--step. There is a lot of work to be done."

The new method is believed to work because, if properly tuned, the laser light transfers energy to the vibrations and rotations in carbon molecules in both the nanotubes and contaminants. The nanotubes, however, are more stable, so most of the energy is transferred to the impurities, which then react readily with oxygen or ozone in the surrounding air and are eliminated. Success was measured by examining the energy profiles of the light scattered by the bulk nanotube sample after exposure to different excimer laser conditions. Each form of carbon produces a different signature.

Changes in the light energy as the sample was exposed to higher laser power indicated a reduction in impurities. Before-and-after electron micrographs visually confirmed the initial presence of impurities (i.e., material that did not appear rope-like) as well as a darkening of the nanotubes post-treatment, suggesting less soot and increased porosity.

The researchers developed the new method while looking for quantitative methods for evaluating laser damage to nanotube coatings for next-generation NIST standards for optical power measurements (see www.physorg.com/news2821.html). The responsivity of a prototype NIST standard increased 5 percent after the nanotube coating was cleaned.

Citation: K.E. Hurst, A.C. Dillon, D.A. Keenan and J.H. Lehman. Cleaning of carbon nanotubes near the [pi]-plasmon resonance. *Chemical Physics Letters*, In Press, Corrected Proof. Available online 15 November 2006.

Source: National Institute of Standards and Technology

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