Growth and Production of Single-Wall Carbon Nanotubes

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The goals of the Growth and Production team at JSC are to provide a reliable source of quality single-wall carbon nanotubes (SWCNTs) for research in applications associated with human spaceflight, and to provide carbon nanotubes for research at other NASA centers, academic institutions, and research entities. The group produces nanotubes using a well-established laser ablation technique, and also engages in flow characterization research into improved techniques and numerical modeling and simulations to understand the process—with an aim of improving production rates and purity. It also is investigating the possibility of producing unique forms of SWCNTs in collaboration with Rice University for continued growth of nanotubes for use in quantum conductors; i.e., lightweight, high electrical conductivity electrical cables.

JSC has been producing SWCNTs since 1997, using the laser-ablation-oven technique. High-power lasers vaporize carbon and metal catalysts in a 1200ºC oven; and the carbon condenses into SWCNTs with the aid of catalysts. The facility produces about 1g/day of very pure SWCNTs, and the production rate is expected to increase to 5 g/day in 2006. In addition, the laser facility was the first to carry out in-situ diagnostics of the ablation process for SWCNT growth to improve understanding of formation conditions and mechanisms. In 2005, a Chemical Vapor Deposition (CVD) reactor was assembled to produce nanotubes by CVD process on patterned substrates for controlled growth of specific types of SWCNTs.

NASA-JSC and The Center for Nanoscale Science and Technology at Rice University sponsored workshops in 2003 and 2005 on nucleation and growth of SWCNTs. World experts in carbon nanotube growth were invited to present reviews and new original work on how nanotubes form and grow in various types of production facilities. Proceedings of the 2003 workshop were published in a special issue of the Journal of Nanoscience and Nanotechnology; and the 2005 workshop proceedings, consisting of abut 14 articles, will be published soon.

The team members developed chemical reaction models involving carbon and metal atoms and clusters to simulate nanotube growth and applied these models to various configurations, including pulsed laser ablation, continuous wave laser ablation, and arc plasma SWCNT production. Results of these calculations have been published or have been submitted for publication.

Laser production facility at NASA-JSC showing open oven and laser beam optics.