LA13
Nanotech Science using Laser Solid Interactions

In situ imaging and spectroscopy of carbon nanotube synthesis by laser ablation

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Laser vaporization of carbon targets which contain metal catalysts is one of the most versatile techniques for the synthesis of single wall carbon nanotubes (SWNT) for electronic and structural applications. Unfortunately, there is very little agreement on the mechanisms or rates for SWNT growth, which are key elements for the production of SWNT with controlled properties or approaches to scale their production.

In our study several different time-resolved spectroscopic techniques are applied in situ to form a comprehensive picture of the SWNT growth process by laser vaporization, including intensified CCD-array imaging of Rayleigh scattered laser light and laser-induced luminescence, plasma and laser-induced emission spectroscopy, absorption spectroscopy, and pyrometry. The imaging diagnostics are applied, along with ex situ TEM and FESEM analysis of collected deposits, to estimate the SWNT growth rate by limiting the growth time at elevated temperature. Two different cases of laser vaporization (LV) were investigated: a nanosecond-pulse LV at 1000^{o}C (8 ns, 1.06 μm), and a long-pulse LV at 1000^{o}C (a train of ~80, 200ns-pulses, total length 200 μs, 1.06 μm). Raw material collected from different locations in the chamber (indicated by the in situ diagnostics) was characterized by Raman spectroscopy, TEM, and FESEM, and thermogravimetric analysis (before and following various chemical etches and oxidative purification treatments) to investigate the SWNT growth mechanism and to optimize the processing conditions of SWNT.

This research was sponsored by the U.S. Department of Energy and the Laboratory-Directed Research and Development Program at ORNL under contract DE-AC05-00OR22725 with the Oak Ridge National Laboratory, managed by UT-Battelle, LLC.