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Diagnostics of Oriented Multiwall Carbon Nanotube Growth by CVD from Evaporated Metal Catalyst Films

D. B. Geohegan, A. A. Puretzky[a], J. Y. Howe, I. N. Ivanov, G. Eres, and S. Jesse

Oak Ridge National Laboratory, Oak Ridge, TN 37831-6056
[a]Dept. of Materials Science and Engineering, University of Tennessee

The CVD growth of vertically-aligned multiwall nanotubes (VA-MWNT) (as well as disoriented single-wall nanotubes) from evaporated metal multilayer catalyst films were investigated at different temperatures using a variable-pressure thermal CVD system which permitted rapid evacuation. Long, vertically-oriented MWNT (~ 10 nm in diameter, some exceeding 700 microns in length) grow within a narrow temperature range from acetylene precursors on evaporated iron-containing multilayer films of nanometers thickness (e.g. Al/Fe/Mo). In situ reflectivity and other optical diagnostics were employed in timed growth experiments to observe surface roughening and initial MWNT growth rates, as correlated with ex situ AFM, TEM, SEM, EDX, and Raman characterization of the films. Linearity in the VA-MWNT growth rate was demonstrated for the first time over a large range in film thickness, with the initial growth rate determining subsequent growth. High-resolution TEM and EDX measurements were performed for short nanotubes grown directly from TEM grids in order to investigate the base vs. tip growth mechanisms. In addition to the oriented MWNT arrays, single-wall carbon nanotubes are simultaneously grown, and will be discussed.

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Presenting (and contact) author:
David B. Geohegan
MS-6056, Bldg. 3150, ORNL
P.O. Box 2008
Oak Ridge, TN 37831-6056
Phone: 865-576-5097
FAX: 865-576-3676
Email: odg@ornl.gov