

March Meeting of the APS in Montreal, March 22-24, 2004  
MAR04 -7.9.5 Carbon Nanotubes and Related Materials (DMP)

## Compositional-Spread Discovery of Catalysts for the Growth of Long-Length Dense Forests of Vertically Aligned Carbon Nanotubes

H. M. Christen, A. A. Puretzky<sup>a)</sup>, H. Cui, D. H. Lowndes, K. G. Belay<sup>b)</sup> D. B. Geohegan

Condensed Matter Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831

<sup>a)</sup>Department of Materials Science and Engineering, University of Tennessee,  
Knoxville, TN 37996

<sup>b)</sup>Florida A&M University

### Abstract

The growth of dense forests of vertically aligned arrays of multi-walled carbon nanotubes (VAA-MWNTs) by chemical vapor deposition [CVD] from a single metallic catalyst layer typically self-terminates after only a few hundred microns of tube length. In order to obtain maximal growth to long lengths, a *systematic simultaneous* study of catalyst composition *and* thickness is needed – performed here by a compositional-spread approach. Using Pulsed-Laser Deposition (PLD), metallic layers with a wedge-shaped thickness profile are deposited onto Al-coated silicon substrates. High temperature annealing of the metal catalyst films in flowing Ar/H<sub>2</sub> gas followed by the one-hour growth of VA-MWNTs by CVD using acetylene gas yields VAA-MWNTs. Tube height (and thus the catalytic activity) is determined as function of position and can be analyzed as a function of catalyst thickness and composition. A dependence of tube height as function of catalyst composition (Mo/Fe ratio) demonstrates that a specific catalyst *composition* exhibits a local maximum in catalytic activity, permitting the extension of nanotube growth up to 4 millimeters in height. Other combinations of catalysts and the growth of single-walled tubes will be discussed.

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

Presenting (and contact) author:  
Hans M. Christen  
MS-6056, Bldg. 3150, ORNL  
P.O. Box 2008  
Oak Ridge, TN 37831-6056  
Phone: 865-574-5965  
FAX: 865-576-3676  
Email: christenhm@ornl.gov