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Abstract Details

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Abstract

TITLE: Real-Time Monitoring Coupled with Combinatorial Catalyst Library for Millimeter Growth of Single-Walled Carbon Nanotubes

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ABSTRACT BODY:

The growth rate and the catalyst lifetime govern the yield of single-walled carbon nanotubes (SWNTs) by chemical vapor deposition (CVD) using supported catalysts. However, the large number of process parameters and the relatively poor reproducibility of the SWNTs growth made it difficult to derive these values separately and systematically. Recent progress in the synthesis method realized the millimeter growth of SWNTs [1], which can be monitored even by naked eyes. We also realized the millimeter growth of SWNTs [2] by the aid of our combinatorial method [3]. In this work, we coupled a real-time monitoring with our combinatorial catalyst library and obtained both the growth rate and the catalyst lifetime for a series of catalyst particles in a single experimental run.

We newly designed and made a simple reactor; an externally heated, quartz glass tubular reactor with a window at one end of the tube. Through this window, substrates can be observed by a digital camera in situ during CVD. A combinatorial catalyst library with a gradient thickness profile of catalyst was placed in the reactor, and the growing SWNTs from the whole catalyst thickness region was observed perpendicular to the thickness profile.

By this method, we found that the narrow window of millimeter growth of SWNTs arises from the catalyst lifetime rather than the growth rate. In CVD from C2H4/H2/Ar gas with Fe/Al2O3 catalyst, the catalytic role of Al2O3 support proved essential for the millimeter growth, and a small addition of water proved not to enhance the growth rate but to widen the catalyst window for a long lifetime. Efficient optimization by this method enabled us to realize water-free growth of millimeter tall SWNT forests by a simple reactor which does not have any vacuum pumps. Millimeter growth of SWNTs was achieved also from an ethanol feedstock.

This simple method will accelerate both basics and applications of catalytic growth of SWNTs.

[1] K. Hata, et al., Science 306, 1362 (2004).
[2] S. Noda, et al., Jpn. J. Appl. Phys. 46, L399 (2007).
[3] S. Noda, et al., Carbon 44, 1414 (2006).