Growth Mechanism and Structure Control of Vertically Aligned SWNT Arrays in Alcohol CCVD

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In this work, we present our new understandings on the growth mechanism and some progress on the structure control of single-walled carbon nanotubes (SWNTs) from alcohol catalytic chemical vapor deposition (ACCVD).

The growth of vertically aligned SWNTs has an exponential decay, as discovered by *in situ* optical absorption.[1] By isotope labeling, it is clearly confirmed that all SWNTs in an array form by a root growth mechanism.[2] Calculation of the diffusivity of hydrocarbons inside such an array predicts the height at which diffusion resistance will become significant.[3] It has also recently been shown that ethanol undergoes complicated decomposition before forming SWNTs. This decomposition is found to be critical to the quality of the product. Only when alcohol is directly utilized as the carbon source can clean SWNTs be obtained.[4] These new understandings on the formation process of SWNTs will be briefly reviewed.

We also demonstrate that the diameter of aligned SWNTs synthesized by ACCVD can be tailored over a wide range by modifying the catalyst recipe. SWNT arrays with an average diameter as small as 1.2 nm were obtained by this method. Additionally, owing to the vertical alignment of the array, the continuous change of the SWNT diameter during one CVD process can be also clearly observed and easily characterized by Raman spectroscopy and UV-vis-NIR optical absorption. This diameter change indicates catalyst aggregation/ripening may be occurring during synthesis.

Finally, we present a versatile wet chemistry method using surface modification to localize the growth of SWNTs to desired regions. By functionalizing the silicon surface by classic self assembled monolayer, the catalyst can be selectively dip-coated onto the hydrophilic area. This technique allows us to pattern our SWNTs for future device applications.

[1] E. Einarsson, et al., *Carbon* **2008**, 46, 923

[2] R. Xiang, et al., *Jpn J Appl Phys* **2008**, 47, 1971

[3] R. Xiang, et al., *J Phys Chem C* **2008**, 112, 4892

[4] R. Xiang, et al., submitted

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