

Alcohol Catalytic CVD Growth of Randomly-Oriented and Vertical-Aligned Single-Walled Carbon Nanotubes with Sub-nanometer Diameter

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We grow random network and vertical-aligned arrays of single-walled carbon nanotubes (SWNTs) with sub-nanometer diameter on Si/SiO₂ substrates by chemical vapor deposition (CVD) using Co/Cu bimetallic catalysts [1]. The random network of SWNTs is formed at 650 °C. The major absorption peak for the E_{11} transition is located at 980 nm (1.27 eV), demonstrating the highly (6,5)-enriched characteristics of the random-oriented SWNT films. Raman spectroscopy also confirmed the sub-nanometer diameter distribution. When the CVD temperature increased to 750 °C, vertical alignment of the SWNTs was observed, with the E_{11} transition peak slightly shifted to ~ 1120 nm (1.10 eV). The as-synthesized SWNT films have the band-gap comparable or larger than silicon, which is realized for the first time to the author's knowledge. TEM observation indicated that the diameter of Co nanoparticles in bimetallic Co/Cu system is much smaller than that in mono-Co system. The diameter of SWNTs was further reduced by loading Co/Cu catalysts on zeolite support at low CVD temperature of 420 °C. The chirality specific growth of SWNTs using W/Co catalysts from molecular precursors and from sputtered metals are also discussed. Finally, recent molecular dynamics simulation results of defect free SWNTs growth will be presented. Growth processes of (14,1), (15,2), (9,0) SWNTs will be discussed.

Reference

[1] Cui, K; Xiang, R; An, H; Chiashi, S; Maruyama, S; Anchoring Catalysts on Substrates for the Direct Synthesis of Random-Oriented and Vertical-Aligned Single-Walled Carbon Nanotubes with Subnanometer Diameter, to be submitted