Synthesis of Sub-nanometer diameter SWCNT by Alcohol catalytic CVD

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Single walled carbon nanotube (SWCNT) comprised of fore frontier application due to its superior chemical, electrical and optical properties (1). Chirality controlled SWCNT synthesis is progressing very rapidly to surpass the post growth treatment process (2). So synthesized SWCNTs had more than 1nm diameter and with very low yield. The band gap of semiconducting SWCNTs increases on decreasing diameter. Narrow diameter distributed SWCNTs possesses fewer chirality and synthesis of such tubes could be an alternative technique to solve the aforementioned problem. Here we challenge to address this issue by utilizing simultaneously deposited Co and W onto SiO_2 as a catalyst.

An ultrahigh vacuum (UHV) chemical vapor deposition (CVD) system with nozzle in the proximity of substrate though which ethanol is supplied as a chemical vapor was used as a growth chamber as reported elsewhere (3). 0.2nm Co and simultaneously deposited 0.2nm Co and 0.4nm W onto SiO_2/Si (referred as Method-A and method-B respectively) were utilized as growth substrates. 10^{-1}Pa ethanol vapor over the 10^{-6} Pa base pressure was utilized for 60min at elevated temperatures. As synthesized SWCNTs under our optimized condition were analyzed by Raman spectroscopy, FESEM, and XPS.

Figure 1 (a) and Figure 1 (b) show the Raman spectra of SWCNTs grown for 60 min at 600ºC onto Method A and at 800ºC onto to Method B substrates respectively by keeping other conditions unchanged and were the optimal growth conditions. It is clearly observable in Figure 1 (b) that, from 250-500 cm^{-1} range, RBM peaks were observed indicating sub nanometer distributed SWCNT. Inset to Figure 1 (a) and (b) show the corresponding FESEM images.

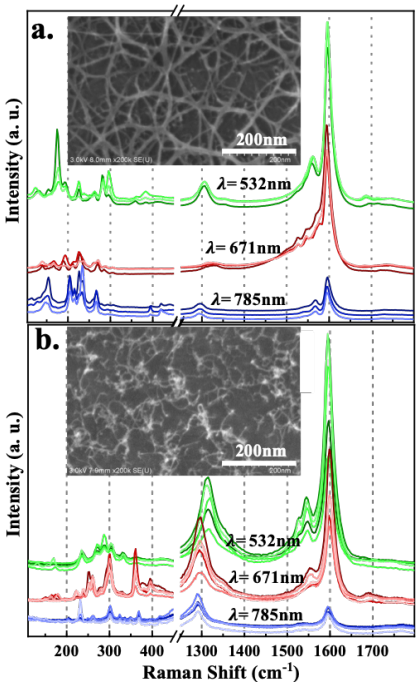

Figure 1. Raman spectrum of SWCNT grown onto SiO_2/Si by ACCVD technique at **(a)** 600ºC by utilizing 0.2 nm Co and **(b)** 800ºC using 0.2nm Co/0.4nm W. Inset show the corresponding FESEM images.

References

[1] R. H. Baughman, et al. Science, 297, 787 (2002).
[2] F. Yang et al., Nature, 510, 522 (2014).
[3] T. Maruyama et al. Carbon 116, 128 (2017).