Tuning bimetallic catalysts for controlled CVD growth of single-walled carbon nanotubes

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Bimetallic catalysts such as Fe-Co and Co-Mo have been used for efficient growth of bulk single-walled carbon nanotube (SWNTs) and vertically aligned SWNTs [1]. Recently, bimetallic catalysts such as Co-W [2] or Co-Cu [3] are employed for structure controlled growth of SWNTs. Here, roles of bimetallic catalysts are explored by newly proposed SiO_2 grid based in-plane TEM technique, which enables a direct TEM characterization of catalysts on SiO_2, CVD growth of SWNTs in normal furnace, and TEM characterization of catalysts and grown nanotubes after CVD.

The in-plane TEM results of the traditional Co-Mo bimetallic catalysts were consist with our previous report [1]; metallic Co nanoparticle embedded in Co-Mo oxide is responsible for the nucleation of SWNTs. By using Co-Cu catalysts, we can synthesize vertically aligned SWNTs with subnanometer diameters on quartz (and SiO_2/Si) substrates [3]. EDS-STE and HAADF-STEM imaging of the Co/Cu bimetallic catalyst system showed that small Co catalysts were captured and anchored by adjacent Cu nanoparticles, which grew small diameter of SWNTs. High-melting point W_6Co_7 alloy produced from metalorganic precursors is reported to grow a single chirality (12,6) with over 90 % abundance [2]. Here, we show that a sputtered Co-W catalyst can selectively grow (12,6) SWNTs by CVD at lower reduction and growth temperatures [4]. Statistical Raman mapping analysis and optical absorption spectrum of the as-grown SWNTs reveal that the abundance of (12,6) is over 60 %. The morphology and structure of catalyst is investigated by the in-plane TEM before and after CVD growth. The catalyst alloy we produced was W_6Co_6C and the only metallic Co was left after the CVD of 5 min. It is speculated that the metallic Co precipitated from W_6Co_6C is responsible for chirality selective growth of SWNTs.

References:

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