

Synthesis of vertically aligned single-walled carbon nanotubes with sub-nanometer-diameter using cobalt-copper binary catalyst

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Single-walled carbon nanotubes (SWNTs) have been regarded as one of the most attractive materials for electronic devices because of their unique electronic structures and fascinating properties. Since the band gap of a semiconducting SWNT inversely depends on its diameter, small-diameter SWNTs are highly desired in the application. In this study, we used a novel combination of Co/Cu as catalyst to grow small-diameter SWNTs on silicon substrate by alcohol catalytic chemical vapor deposition (ACCVD) [1]. We characterized the as-grown SWNTs by scanning electron microscopy (SEM), Raman spectroscopy, optical absorption spectroscopy and transmission electron microscopy (TEM). Compared with the conventional catalyst Co/Mo [2] and Co/Fe, the combination of Co/Cu can grow sub-nanometer vertically-aligned SWNTs. The diameter and yield of SWNTs can be further tuned by parametric modulation of the growth condition. The possible mechanism through detailed TEM analysis will also be discussed. We also discuss the preliminary result of SWNT growth from sputtered W/Co binary metal catalysts for chirality controlled synthesis [3].

[1] S. Maruyama *et al.*, Chem. Phys. Lett. **360**, 229 (2002).

[2] R. Xiang *et al.*, ACS Nano **6**, 7472 (2012).

[3] F. Yang *et al.*, Nature **510**, 522 (2014).