Studies on CVD growth and oxidation of SWCNTs

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We review our recent results on SWCNT direct, dry deposition from the floating catalyst reactor, called Direct Dry printing (DPP), to manufacture transparent thin film conductors and field effect transistors (TFT). Also, we discuss the (n,m) maps of our tubes produced from CO using Fe nanoparticle catalysts as determined by ED/TEM method.

To further control the tube properties, we have carried out studies on SWCNT growth from carbon monoxide (CO) using supported CVD methods, both at ambient CO pressure in the in-situ Raman microscope as well as at 7 mbar pressure inside the dedicated, Cs-corrected environmental TEM (ETEM). When using supported bimetallic Fe-Cu catalysts, narrow chiral distribution SWCNTs were produced at ambient pressure growth. In addition, epitaxial formation of cobalt (Co) nanoparticles from $Co_xMg_{1-x}O$ solid solution reduction (deposited into MgO via impregnation) in CO enables to grow SWNTs also with a narrow diameter distribution. (ETEM) studies at reduced pressure reveal that the Co nanoparticles remain in metallic state and their epitaxial contact with MgO support remains coherent during SWNT root growth process. Interestingly, when depositing Co via atomic layer deposition (ALD) onto MgO surface, we observe tip growth of SWCNTs inside the ETEM at 700 ^{o}C, with the Co catalyst nanoparticle shape as well as the tube growth direction fluctuating during the growth process. We compare the observed growth dynamics to the state-of-the-art Monte Carlo modeling results (1). In order to understand the role of oxidation reaction during the synthesis (as trace amount of CO_2 is needed for successful synthesis in our floating catalyst method), we have carried out studies on individual SWCNT oxidation at ambient air vs. temperature via ex-situ ED/TEM method.

References

1. Importance of carbon solubility and wetting properties of nickel nanoparticles for single wall nanotube growth. Diarra, M., A. Zappelli, H. Amara, H., F. Ducastelle and C. Bichara. ***Phys. Rev. Lett.*** **(2012)** (accepted).