

Parametric Studies towards Controlled Floating Catalyst CVD Synthesis of SWCNTs

Prof. Dr. Esko I. Kauppinen

Department of Applied Physics, Aalto University School of Science, Puumiehenkuja 2
P.O. Box 16100, FI-00076 Aalto, FINLAND
esko.kauppinen@tkk.fi

日時: 2013年2月4日(月) 14:00-15:30

会場: 東京大学工学部2号館2F 222号講義室

要旨

We review our current understanding of floating catalyst CVD synthesis of SWCNTs from CO using Fe catalyst clusters made via direct evaporation using hot wire generator as well as via thermal decomposition of ferrocene, and with the addition of trace amounts for CO₂ and water vapor. Here both the tube diameter as well as length can be tailored by changing the reactor temperature profile as well as CO₂ concentration. (n,m) distribution is biased towards large chiral angles with the maximum population at about 23 degrees. Then we proceed to explore the effect of carbon source gas, by adding C₂H₄ together with CO and looking at the effect of temperature when producing catalysts via ferrocene decomposition. Also, we present results when using C₂H₂ alone as a carbon source with H₂ carrier gas, and look at the effect of CO₂ addition.

To study the effect of Fe catalyst cluster size and concentration in the floating catalyst synthesis, we have developed a novel catalyst particle production method via physical vapor deposition, based on arc discharge between two electrodes i.e. the spark generator. This method allows to control both the catalyst particle size and concentration when fed into the floating catalyst SWCNT synthesis reactor. Here we use the aerosol methods i.e. gas phase particle size measurements to observe in real time the changes of the produced tubes. Preliminary results show that when reducing catalyst particle gas phase number concentration, the bundle size of the produced tubes also is reduced.

To further understand the growth mechanisms, we have carried out parallel 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 (when deposited into MgO via impregnation) in CO enables to grow SWCNTs 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 SWCNT 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 °C, with the Co catalyst nanoparticle shape as well as the tube growth direction fluctuating during the growth process. Also, then we have broader (n,m) distribution at ambient pressure growth conditions.



主催: 東京大学グローバルCOEプログラム「機械システム・イノベーション国際拠点」
本件連絡先: 東京大学大学院工学系研究科機械工学専攻 教授 丸山 茂夫
E-mail: maruyama@photon.t.u-tokyo.ac.jp Phone: 03-5841-6421
GCOE事務局 E-mail: gmsi-office@mechasys.jp Phone: 03-5841-7437