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On the Preferential Growth of Metallic Single-Walled Carbon Nanotubes Thin Films

AVETIK HARUTYUNYAN, Honda Research Institute USA Inc., 1381 Kinnear Road, Columbus OH 43212, USA

The lack of reasonably homogeneous single walled carbon nanotube (SWCNT) materials hinders their ubiquitous applications. There have been significant achievements in separating SWCNTs according to their conductivity and in enriching the distribution of nanotubes with a specific conductivity. Meanwhile, despite studies regarding direct control over carbon nanotube structure during growth, there is only a limited understanding of exactly what determines carbon nanotube chirality during catalytic growth and, thereby, the electronic structure of grown SWCNT. Here we report the results of the studies of growth of SWCNTs thin films from Fe nanocatalysts deposited onto a SiO_2/Si support and in situ annealed in a He or Ar ambient that contains various ratios of H_2 and H_2O. Our investigations reveal that the variation of the noble gas ambient during thermal conditioning of the catalyst, in combination with oxidative and reductive species, alters the fraction of tubes with metallic conductivity from about 20% of the population to a maximum of 91%. The tubes have been identified based on Raman, photoluminescence and electrical (field effect transistor performance) characterizations by using special prepared reference sample. In situ environmental transmission electron microscopy observations of the SiO_2 supported Fe nanocatalysts in H_2O, H_2/H_2O, Ar/H_2O and He/H_2O gaseous environments reveal that presence of Ar in the ambient leads to significant coarsening of nanocatalysts with rounded surface morphology, while under He ambient the nanocatalyst is more faceted. Various scenarios such as adsorption and roughening induced morphology rearrangements of the catalyst particles and their relationships with grown tubes electronic structures will be presented.