Effect of an Al underlayer on the Growth of mm-long Thin Multi-walled Carbon Nanotubes in Water-Assisted Thermal CVD

Choi In Sung, Jeon Hong Jun, Lee Han Sung, and Lee Naesung
Faculty of Nanotechnology and Advanced Materials Engineering,
Sejong University, Seoul143-747,Korea
TEL: 82-2-3408-3786, e-mail: nslee@sejong.ac.kr

Abstract : Vertically aligned arrays of mm-long multi-walled carbon nanotubes (MWCNTs) on Si substrates have been synthesized by water-assisted thermal chemical vapor deposition (CVD). The growth of CNTs was investigated by changing the experimental parameters such as growth temperature, growth time, gas composition, annealing time, catalyst thickness, and Al underlayer thickness. The 0.5-nm-thick Fe served as catalyst, underneath which Al was coated as a catalyst support as well as a diffusion barrier on the Si substrate. We grew CNTs by adding a little amount of water vapor to enhance the activity and the lifetime of the catalyst. Al was very good at producing the nm-size catalyst particles by preventing "Ostwald ripening". The Al underlayer was varied over the range of 15~40 nm in thickness. The optimum conditions for the synthesis parameters were as follows: pressure of 95 torr, growth temperature of 815 °C, growth for 30 min, 60 sccm Ar + 60 sccm H_2 + 20 sccm C_2H_2. The water vapor also had a great effect on the growth of CNTs. CNTs grew 5.03 mm long for 30 min with the water vapor added while CNTs were 1.73 mm long without water vapor at the same condition. As-grown CNTs were characterized by using scanning electron microscopy (SEM), high resolution transmission electron microscopy (HRTEM), and Raman spectroscopy. High-resolution transmission electron microscopy showed that the as-grown CNTs were of ~3 graphitic walls and ~ 6.6 nm in diameter.

Key Words : multi-walled carbon nanotubes, mm long, water vapor, Al underlayer