Growth mechanism of vertically aligned single-walled carbon nanotubes

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Following the first realization of VA-SWNTs [1] by alcohol catalytic CVD (ACCVD) method, various techniques are reported for the vertical aligned growth such as control of water, point-arc microwave plasma CVD, molecular-beam CVD, hot-filament control of atomic hydrogen, hydrogen/oxygen ratio control by oxygen-assisted CVD. Recently, it was revealed that VA-SWNTs by ACCVD method is composed of high-purity SWNTs with small bundles about 5 nanotubes through the cross-sectional TEM scan. The small-bundle morphology and nearly isolated electronic properties [2] of each nanotube is suited for various applications of VA-SWNTs. In this study, the growth mechanism of VA-SWNTs film is studied through the in-situ measurement of film thickness by laser absorbance [3]. The measured growth curves for various CVD temperature, ethanol pressure and ethanol flow rate in the alcohol CCVD technique are all described by a simple function with the exponential decay of growth rate, where initial growth rate and decay life time are parameters. The decay of growth rate was almost linearly proportional to the film thickness. This result implies that the catalyst metal is over-coated by carbon as the CVD reaction proceeds. Because the initial growth rate was almost proportional to ethanol pressure, the first order reaction can be assumed for the growth process. As the ethanol pressure increase, the decay time suddenly decreased. This phenomenon is explained by the excess rate of decomposition of ethanol beyond the possible over-all growth rate of the tangled film.

References [1] Y. Murakami et al., Chem. Phys. Lett. 385 (2004) 298. [2] E. Einarsson et al., submitted to J. Phys. Chem. B, (cond-mat/0702630). [3] S. Maruyama et al., Chem. Phys. Lett. 403 (2005) 320.