Alcohol CVD Growth of Vertically-Aligned Single-Walled Carbon Nanotubes

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The growth mechanism of vertically aligned single-walled carbon nanotubes (VA-SWNTs) [1-3] is discussed based on the in-situ growth monitoring by laser absorption [4,5] during CVD. The growth curves are characterized by an exponential decay of the growth rate γ, from the initial value γ_0 and decay time constant τ. The initial growth rate γ_0 is linearly proportional to pressure up to the critical value which is determined by CVD temperature. This result indicates the first order reaction below the critical pressure [5]. Beyond this critical pressure, the growth decay time drastically decreases probably due to the carbon over-coat on metal catalysts.

When CVD flow rate is very small, the growth curve is obviously different because of the contribution of gas-phase thermal decomposition of ethanol. In fact, a sudden increase of growth rate can be observed by adding a small amount of acetylene during ACCVD. However, the deactivation rate of catalysts is also larger with acetylene. Nevertheless, the carbon conversion rate from ethanol to VA-SWNTs can be as high as 40 % in no-flow ACCVD. Hence, isotopically modified ethanol can be employed to study the growth process [6]. The detailed chemical reaction process in gas-phase and on metal catalysts will be discussed based on CVD results using isotope labeled ethanol and acetylene as carbon source.

Finally, optical characterization of the VA-SWNT film using polarized absorption, polarized Raman, and photoluminescence spectroscopy will be discussed. Laser-excitation of a vertically aligned film from top means that each nanotube is excited perpendicular to its axis. Because of this predominant perpendicular excitation, interesting cross-polarized absorption [7] and confusing and practically important Raman features are observed.

References:

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