Growth control of vertically aligned SWNTs by ACCVD method

Shigeo Maruyama

Department of Mechanical Engineering, The University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, JAPAN

The growth mechanism of vertically aligned single-walled carbon nanotubes (VA-SWNTs) [1, 2, 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.

The non-flow CVD [6] turned out to be very efficient, resulting a thicker film up to 100 μm. The growth curve is obviously different probably because of the contribution of small amount of acetylene thermally decomposed from 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 [7]. 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.

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Corresponding Author: Shigeo Maruyama, maruyama@photon.t.u-tokyo.ac.jp, Tel&Fax: 03-5800-6983