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Abstract Details

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Abstract

TITLE: Crucial role of ethylene pyrolysis in millimeter growth of single-walled carbon nanotubes as evidenced by separate optimization of gas and catalyst temperatures.

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ABSTRACT BODY:

Millimeter growth of single-walled carbon nanotubes (SWNTs) in minutes by water-assisted chemical vapor deposition (CVD) [1] has attracted great interests from nanotube community. We recently reproduced such growth with C2H4/H2/H2O/Ar reactant gas and Fe/Al2O3 catalyst [2]. Al2O3 supported layer was essential for such rapid growth, and such growth was sustained under a quite narrow window among C2H4/H2/H2O partial pressures, temperature, and catalyst Fe thickness. To understand the underlying mechanism in detail, we carried out experiments using a cold-wall CVD reactor, in which substrates were heated while the gas-phase was kept unheated.

Surprisingly, SWNTs grew up to only tens micrometer height even after careful adjustment of the reaction and catalyst conditions. Then, we combined the cold-wall reactor with the hot-wall tubular reactor so that we can examine the effect of preheating of the reactant gas. Millimeter growth was then realized not only when heated gas was supplied to the substrates, but also when the heated gas was once cooled and then supplied to the substrates. Not the gas-phase temperature itself but the gas-phase pyrolysis of ethylene proved crucial.

This reaction scheme of gas-phase pyrolysis followed by the catalytic reaction would be rather common not only for thermal CVD but also for plasma-enhanced CVD and hot-wire CVD. We are now conducting separate optimization of gas-phase and catalyst temperatures, which will lead us to further understanding of SWNTs growth mechanisms as well as to further development of SWNTs growth methods.

[1] K. Hata, et al., Science 306, 1362 (2004).
[2] S. Noda, et al., Jpn. J. Appl. Phys. 46, L399 (2007).