Crucial Role of Gas-Phase Pyrolysis of Ethylene in Rapid Growth of Carbon Nanotubes

○Ryuhei Ito[1], Suguru Noda[1], Toshio Ohsawa[1], Shigeo Maruyama[2], Yukio Yamaguchi[1]

[1]*Department of Chemical System Engineering,*
[2]*Department of Mechanical Engineering,*
The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

Rapid growth of millimeter-thick SWNT forests in a few minutes was realized by water-assisted ethylene CVD [1]. We previously reproduced such growth using $C_2H_4/H_2/H_2O$/Ar reactant gas and Fe/Al_2O_3 catalyst, and found an essential role of Al_2O_3 under layer [2]. In this work, we studied the effect of gas phase and substrate temperatures separately, and found a crucial role of gas phase reaction in forming actual precursor from ethylene.

Figure 1 shows the experimental apparatus used in this study. The reactant gas was once heated by flowing through an externally-heated quartz tube, cooled down, and then fed to a resistively-heated graphite substrate on which the catalyst was supported. The typical condition was 60 Torr C_2H_4/ 200 Torr H_2/ 0.076 Torr H_2O/ Ar for the reactant gas and 1 nm Fe/ 20 nm Al_2O_3 for the catalyst.

Figure 2 shows the side-view images of the graphite substrates after CVD at 800 °C substrate temperature for 10 min. Nanotubes did not grow efficiently at preheating temperatures of 700 °C or below, but they grew efficiently to millimeter-thickness at higher preheating temperatures. CHEMKIN simulation showed the decomposition of C_2H_4 and formation of C_2H_2 in a residence time of a few seconds. Then, we mixed 4 Torr C_2H_2 with 169 Torr H_2/ 0.076 Torr H_2O/ Ar instead of C_2H_4, and found that millimeter-thick nanotube forests actually grew without preheating. C_2H_2 is the actual precursor for the rapid nanotube growth from C_2H_4 feedstock.

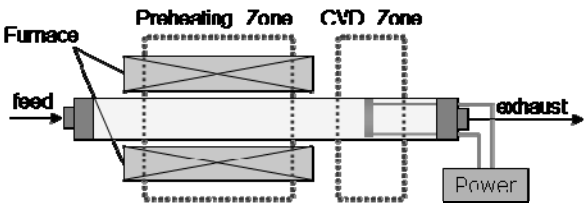

Fig.1 Experimental apparatus

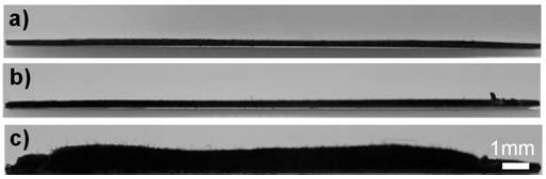

Fig.2 Images of SWNT forests (a) no preheating, (b)preheating: 700 ℃, (c)preheating: 850 ℃

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

Corresponding Author: Suguru Noda, noda@chemsys.t.u-tokyo.ac.jp Tel&Fax: +81-3-5841-7332.