Growth Control of Single-Walled Carbon Nanotubes by High Vacuum CVD Method

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Single-walled carbon nanotubes are one of the attractive materials for nanodevices because of their small diameter (~1 nm), high mechanical strength, high thermal conductivity, and structure-dependent electrical conduction property. Currently the alcohol catalytic chemical vapor deposition (ACCVD) method [1] is widely used to synthesize SWNTs because it can control the position and orientation to some extent. Shiokawa *et al.* [2] have reported that SWNTs can be grown at low temperature for nanodevices by performing CCVD at low pressure (less than 0.1 Pa). The advanced generation method based on the SWNT growth mechanism is necessary for the achievement of device applications in the future.

In this work, our main purpose is the clarification of the growth mechanism of SWNTs by controlling the synthesis reaction in the environment of a high vacuum. We developed an experimental apparatus to control the atmosphere gas accurately while performing ACCVD (Fig. 1), and successfully synthesized SWNTs at various temperatures and pressures. Analysis by resonant Raman spectroscopy (Fig. 2), scanning electron microscopy and atomic force microscopy indicates that SWNTs synthesized under high vacuum have higher purity than the one synthesized with the standard CVD apparatus. Moreover, the results suggest that the flow rate of the ethanol influences the diameter of SWNTs.

[1] S. Maruyama, R. Kojima, Y. Miyauchi, S. Chiashi, M. Kohno, *Chem. Phys. Lett.* **360** (2002) 229.
[2] T. Shiokawa, P. H. Zhang, M. Suzuki, K. Ishibashi, *Jpn. J. Appl. Phys.* **45** (2006) L605.

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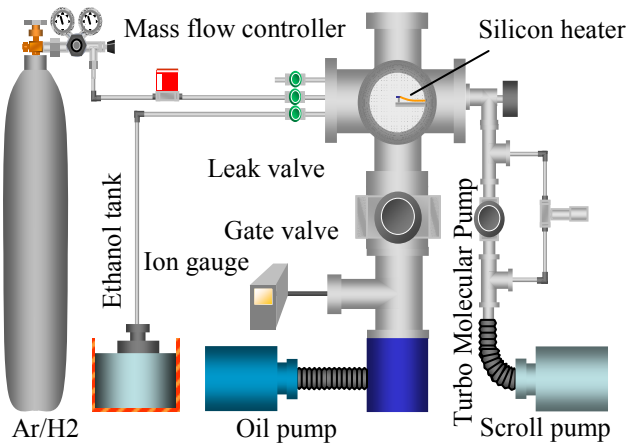

Fig. 1: HV-CVD experimental apparatus

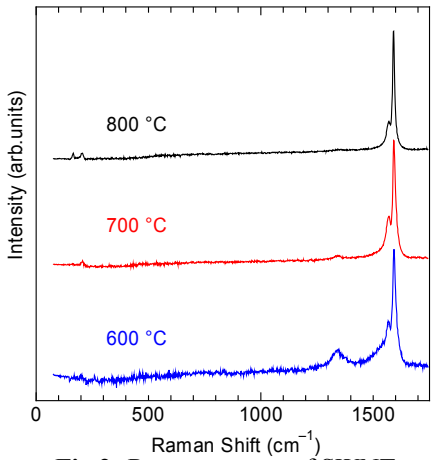

Fig.2: Raman spectra of SWNTs