In-situ Raman scattering and temperature measurements during growth of single-walled carbon nanotubes

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Alcohol catalytic CVD generation [1] of high-purity single-walled carbon nanotubes (SWNTs) without the use of an electric furnace or a hot-filament is demonstrated here [2]. Using alcohol as a carbon source, high-purity SWNTs are generated by Joule-heating of a silicon base-plate, upon which sit zeolite-supported Fe/Co catalyst particles. Growth occurs inside a vacuum chamber that is equipped with an SPM/Raman detector. During this CVD process, Raman scattering spectra were taken. The experimental apparatus allowed us to measure the temperature dependence of Raman scattering in SWNTs by carefully eliminating the laser-heating effect and oxidization damage to SWNTs.

Fig. 1 shows the temperature dependence of the G-band and silicon peaks. The temperature dependence of Raman shifts of the G-band for SWNTs generated by various methods is expressed by a single curve; hence the G-band shift can be used as a SWNT thermometer.

Fig. 2 shows time profiles of the intensities and Raman shifts of the G-band and the silicon peak during CVD. The Raman shift and the silicon peak intensity simply changed in accordance with the temperature dependence. However, the intensity of the SWNT G-band showed an initial rapid increase, followed by a nearly linear increase with time before stopping heating of the sample.

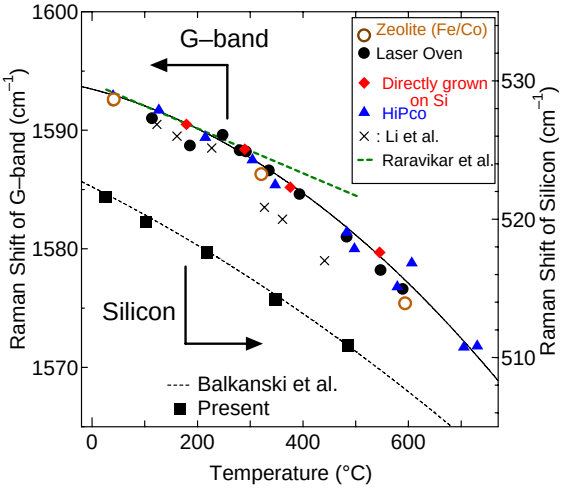

Fig. 1 Temperature dependence of the G-band and silicon peaks.

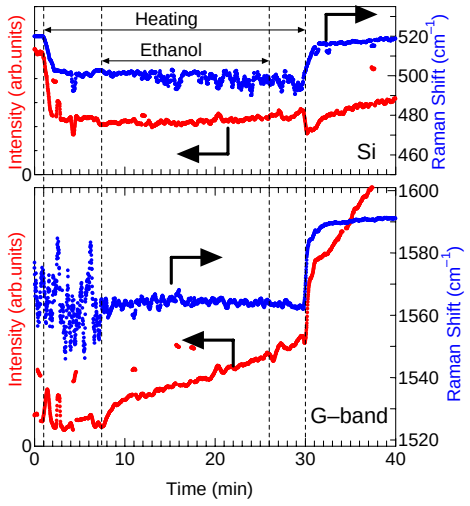

Fig. 2 Time profiles of Raman shifts and the intensity in the G-band and silicon peaks during CVD.

[1] S. Maruyama *et al.*, *Chem. Phys. Lett.*, **360** (2002) 229-234.

[2] S. Chiashi *et al.*, *Chem. Phys. Lett.*, **386** (2004) 89-94.

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