In situ optical measurements of the thickness of a vertically aligned single-walled carbon nanotube film during CVD growth

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In this study, we investigate the growth mechanism of vertically aligned single-walled carbon nanotubes (SWNTs) via *in situ* optical absorption measurements. The measurements were performed on vertically aligned SWNT films grown on quartz substrates by the ACCVD (Alcohol catalytic CVD) method [1]. Monodispersed, bimetal catalyst particles were prepared by a liquid-based dip-coat method [2]. A previous study of the samples [3] showed the optical absorption of the vertically aligned film is almost linearly dependent on the film thickness, and an apparent decrease in SWNT film thickness after prolonged CVD reaction times was observed. The goal of the present study is to understand the mechanism of the growth process.

Absorption measurements were performed by passing laser light (488 nm) through the optical-grade quartz glass substrate while inside the CVD chamber. The intensity of the transmitted beam was continually measured, and the absorbance was then calculated relative to the initial intensity (before SWNT growth) as in Fig. 1. Results indicate the growth rate is highly dependent on many factors relating to catalyst activity, as well as a destructive effect of the chamber atmosphere. If the ethanol supply is stopped after growth, but the sample is maintained at the growth temperature of 800 °C, there is a clear decrease in the SWNT film thickness. However, continuing the supply of ethanol for growth times up to 90 minutes resulted in cases where the film thickness decreased, as well as cases where no decrease was observed. This indicates the growth is indeed the net result of the catalyst-driven growth and a destructive influence due to the chamber environment.

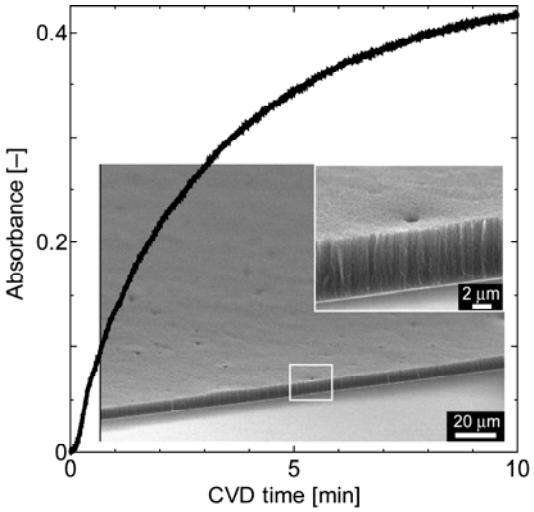

Fig. 1: *In situ* optical measurements of vertically aligned SWNT film thickness. Insert is an SEM image.

[1] Y. Murakami et al., *Chem. Phys. Lett.* **385** (2004) 298.
[2] Y. Murakami et al, *Chem. Phys. Lett.* **377** (2003) 49.
[3] E. Einarsson et al., *Therm. Sci. & Eng.* **12** (2004) 77.

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