7A/2011G539

NEXAFS Investigation of Order in Vertically Aligned Carbon Nanotubes formed by Surface Decomposition of SiC

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1 Introduction

Carbon nanotube (CNT) growth by surface decomposition of SiC can produce high-density, vertically aligned CNTs with fairly uniform tube diameters simply by heating SiC in a vacuum. Previous TEM studies showed that, compared to those grown by CVD method, the alignment of CNTs formed by the surface decomposition of SiC was fairly high [1]. However, the quantitative characterization has never been attempted.

In this study, we carried out NEXAFS measurements to evaluate the degree of vertical alignment of CNTs grown by the surface decomposition of SiC.

2 Experiment

The CNTs were prepared by heating an n-type 6H-SiC(000-1) C-face (CREE) in a vacuum electric furnace. Most of the CNTs were 2-5 walled and the diameters were between 3 and 6 nm. The average length of the CNTs was about 400 nm.

C K-edge NEXAFS spectra were obtained for both the total electron yield (TEY) and the partial electron yield (PEY) modes under ultrahigh vacuum (UHV) at BL2 in the SR Center, Ritsumeikan University.

3 Results and Discussion

Fig. 1 shows TEY C K-edge NEXAFS spectra for the CNTs grown by the surface decomposition of SiC. The spectra were measured at different incident angles and all spectra were pre- and post-edge normalized. The C K-edge NEXAFS spectra of the CNTs were quite similar to those of graphite [2], which were characterized by a sharp C-C π* transition near 286 eV and a sharp σ* bound exciton near 293 eV. Fig. 1 shows that the intensity of the π* resonance increased with the temperature, while, for the σ* resonances, there does not appear to be a systematic variation in intensity with the incidence angle.

Fig. 2 shows the variation in intensity of the π* and σ* resonances with the angle of incidence from the TEY NEXAFS spectra. The π* and σ* intensities were determined by subtracting an arctan function from the pre- and post- edge normalized spectra to simulate the edge jump followed by fitting the π* and σ* peaks with a Gaussian function. It is clear in the TEY spectra that, as the incidence angle increased, the π* intensity was enhanced, while the σ* intensity decreases. This tendency confirms that the CNTs are formed perpendicular to the substrate surface. Taking into account that the π* intensity

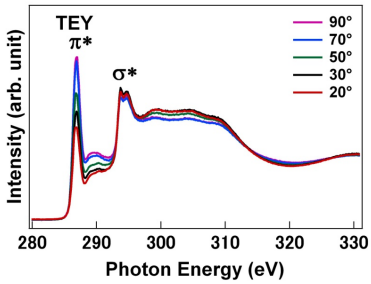

Fig. 1 TEY C K-edge NEXAFS spectra of the CNTs grown by the surface decomposition of SiC obtained at different incidence angles.

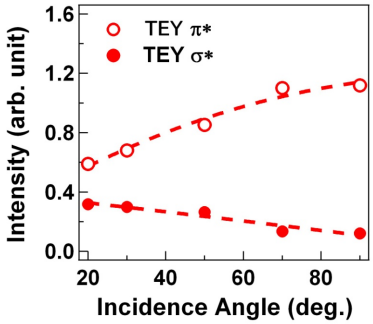

Fig. 2 Intensities of the π* and σ* resonances in the TEY NEXAFS spectra at different angles of incidence.

for the vertical CNTs show sine-squared dependence, we estimated the orientation parameter to be 0.38. This value is larger than those reported for vertically aligned CNTs grown by CVD, 0.08-0.145. These results clearly indicate that the order of vertical alignment of CNTs grown by the surface decomposition of SiC is fairly high.

Acknowledgement

A part of this work was supported by the JSPS, a grant-in-Aid for Scientific Research (c) 21510119 and the Nanotechnology Support Project (the Synchrotron Radiation Research Group).

References

[1] M. Kusunoki et al. Appl. Phys. Lett. **77** (2000) 531.
[2] S. Banerjee et al. J. Phys. Chem. B **109** (2005) 8489.
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