7A/2011G539

In situ NEXAFS Study on Carbon Nanotube Formation Process by Surface Decomposition of SiC

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1 Introduction

Carbon nanotube (CNT) growth by surface decomposition of SiC is a unique growth technique, because zigzag-type CNTs are selectively formed only by heating SiC crystals in a vacuum without any catalysts. At the initial stage of CNT formation, nanosized hemispherical structures composed of carbon atoms are formed on SiC surface [1]. These "carbon nanocaps" determined the structure of CNTs, such as the number of walls, diameter and chirality [2]. Therefore, clarifying the formation process of carbon nanocaps would lead to control of the CNT structure. In this study, we carried out *in situ* NEXAFS measurements at high temperature to investigate the formation process of carbon nanocaps.

2 Experiment

After HF etching, 6H-SiC(000-1) substrates were placed in a high vacuum chamber. Then, the samples were gradually heated to an intended temperature, followed by annealing under a H_2 ambient for 30 min. The sample temperature was monitored with a pyrometer, and the H_2 pressure was kept between $1\text{-}0.5\times10^{-4}$ Pa. After exhausting the H_2 gas, C K edge NEXAFS spectra were measured at BL-7A in Auger electron yield mode, keeping the sample at the heating temperature. For all temperature, the NEXAFS measurements were carried out with two different incident angles, θ, i. e. 30º and 90º, to investigate the orientation of the C-C bond.

3 Results and Discussion

Fig. 1(a) shows NEXAFS difference spectra of SiC(000-1) at 960ºC, where the spectral component of SiC was subtracted. By the subtraction of SiC component, π* resonance peak of C-C bond was clearly observed for the two incident angles. This indicates that the sublimation of Si atoms occurred and the formation of C-C bond began to start at this temperature. The relative intensity of π* resonance peak at normal incidence was weaker than that measured at θ =30º, suggesting that the C-C bond was inclined from the surface normal. NEXAFS spectra measured at 1380ºC are shown in Fig. 1(b). Both π* resonance peak and σ*bound exciton peak were clearly observed for the two incident angles. It should be noted that, in contrast to the spectra at 960ºC, the π* resonance peak at normal incidence was stronger than that for θ =30º at 1380 ºC. This indicates that the orientation of C-C bond changed as temperature rose. Taking into account the results of the QM/MD calculation

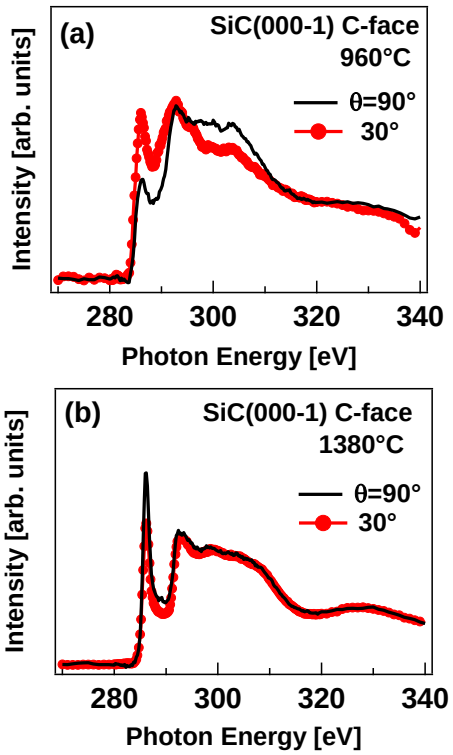

Fig. 1: *In situ* NEXAFS spectra for &H-SiC(000-1) at 960 and 1380 ºC.

[3], we consider that the graphene flakes formed on the surface were curved by the dangling-bonds on SiC(000-1) face, leading to the orientation change of the C-C bond and that this induced the formation of carbon nanocaps.

Acknowledgement

A part of this work was supported by the Japan Society for the Promotion of Science (JSPS), a grant-in-Aid for Scientific Research (c) 21510119. The NEXAFS measurements were performed under the approval of Photon Factory Program Advisory Committee (Proposal No. 2011G539).

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