

Synthesis and characterization of stoichiometric BCN films by radiofrequency plasma enhanced chemical vapor deposition on highly oriented pyrolytic graphite

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Introduction

Much effort has been devoted to the synthesis of hexagonal $B_xC_yN_x$ compounds since they are attractive as the semi-conducting materials with adjustable band-gap energy due to the isoelectronic structure of graphite. In our previous study, we reported $B_xC_yN_x$ hybrid films synthesized on Si (100) [1]. However, the C contents in those films were low (≤ 18 at.%) compared with B and N. In this work, almost stoichiometric $B_1C_1N_1$ hybrid films have been synthesized on the highly oriented pyrolytic graphite (HOPG) as the substrate.

Experimental

The films were deposited on HOPG (001) at the RF power of 400 ~ 800 W, at the working pressure of 0.2 ~ 0.4 Torr and at the substrate temperature of 600 ~ 1050 °C, using tris(dimethylamino) borane as a precursor. The chemical bonds of the films were studied by Raman spectroscopy. The chemical composition and the atomic configuration were studied by XPS and NEXAFS, using the linearly polarized synchrotron radiation at the Beam Line 11A and Beam Line 27A, PF, KEK.

Results and Discussion

The films synthesized at the substrate temperature below 800 °C (at the RF power ≤ 600 W) were found to contain more C. The compositions of the films as determined from the XPS are almost stoichiometric close to $B_1C_1N_1$. At the substrate temperature above 900 °C (at the RF power ≥ 700 W), the films were composed of only C.

The B1s, C1s and N1s XPS spectra for the stoichiometric films were analyzed by means of Gaussian deconvolution. It was suggested that the films are composed of different B–N, B–C, C–N chemical environments to form the graphite-like sp^2 -B–C–N atomic hybrid configurations. The Raman spectra also suggested the presence of the graphite-like sp^2 -B–C–N atomic hybrid bonds. The formation of separate binary phases such as BN/graphite/carbon nitride (CN_x)/boron carbide (BC_x) was not perceptible.

The B K-edge NEXAFS spectrum of a stoichiometric film $B_{37}C_{31}N_{30}O_2$ (O; a minor contaminant) is shown in Fig.1, together with those of the heat-treated film and the reference samples; h-BN and B_4C . Compared with the h-BN, a broad π^* resonance peak has been predominantly

observed and been ascribed to the π^* resonance of sp^2 -B–C–N bonds similar to the BN_3 -like configuration in h-BN. Wider broadening of NEXAFS spectra was observed for the heat-treated samples. The broadening indicates the formation of various atomic configurations around B atoms besides the BN_3 -like configuration. Formation of the different configurations was also confirmed by the polarization dependence of NEXAFS.

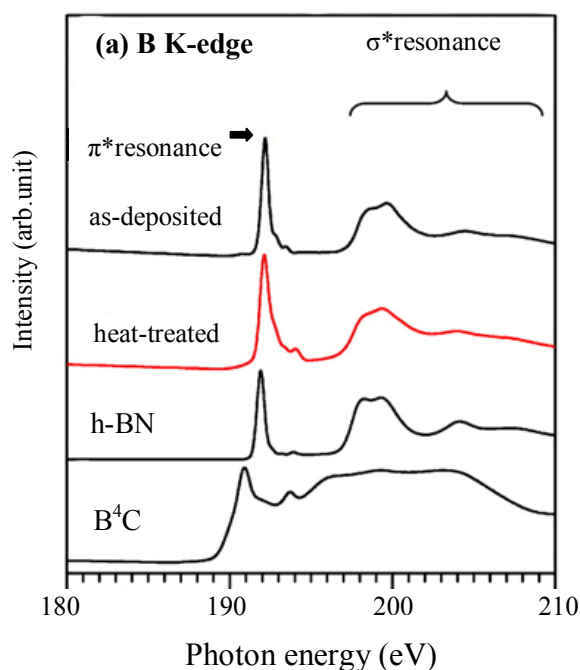


Fig.1 B K-edge NEXAFS spectra of the as-deposited film $B_{37}C_{31}N_{30}O_2$ and the heat-treated film. The spectra of h-BN and B_4C are also shown for comparison.

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References

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