

Preferential formation of B-C-N hybrids synthesized by high-temperature ion-beam deposition

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Introduction

Hybrid materials of graphite and hexagonal boron nitride (*h*-BN) are known to be B-C-N hybrids which have graphite-like structure and semiconducting property. Since some theoretical reports predicted that the electronic structure can be controlled by both composition and atomic arrangement, these materials are expected to be used for electronic and luminescent devices. Despite of considerable efforts, synthesis method has not been established due to some impediments. One of them is that large amount of graphite and *h*-BN is formed along with various compositions of B-C-N hybrids. We attempted high-temperature ion-beam deposition to synthesize B-C-N hybrids thin films. X-ray photoelectron spectroscopy (XPS) was used for characterization of the products and clarified that B-C-N hybrids were preferentially formed by this method.

Experimental

The experiments were performed at the BL-27A station. Highly oriented pyrolytic graphite (HOPG) was placed as a target in a vacuum chamber. Fragment ions of borazine ($B_3N_3H_6$) were implanted in the HOPG by an ion gun with an acceleration voltage of 3.0 keV. Ion fluences were estimated from time integration of sample current induced by the ion beam. During implantation, the HOPG was heated by irradiation of YAG laser. Sample temperature was measured by an optical pyrometer. Characterization of the products was done XPS with MgK α source which was equipped in the vacuum chamber. Hexagonal boron nitride was also measured as a reference.

Results and discussion

Figure 1 shows B 1s spectra of B-C-N thin films prepared at different fluences and temperatures. Composition ratio and thickness of the films were estimated from intensity ratio of B, C, and N 1s peaks in the XPS spectra. Except *h*-BN, every spectrum consists of multiple components as shown in the figure. Since the B1s binding energy of component 3 matches to that of *h*-BN, this component is assigned to BN_3 coordination at B atoms of *h*-BN. Components 1 and 2 have smaller E_B than component 3, indicating that these components originates from B-C bond formation. Based on previous reports, component 1 is assigned to BC_3 . The coordination of component 2 is not clear. However, considering the electronegativity difference between C and N atoms, we assign this component to some B-C-N hybrids. Relative intensities of components 1, 2, and 3 significantly depend

on both fluence and temperature as shown in Figure 2. At room temperature, component 3 (BN_3) is dominant for all fluences. On the other hand, components 1 and 2 (BC_3 and B-C-N hybrids) are dominant in the low-fluence region at 600 °C. These results mean that, although BN film was formed in high fluence region for both temperature, some B-C-N hybrids were preferentially formed in the interface between BN and HOPG at high temperature. This implies that high-temperature ion-beam deposition can be used for preferential formation of B-C-N hybrids [1, 2].

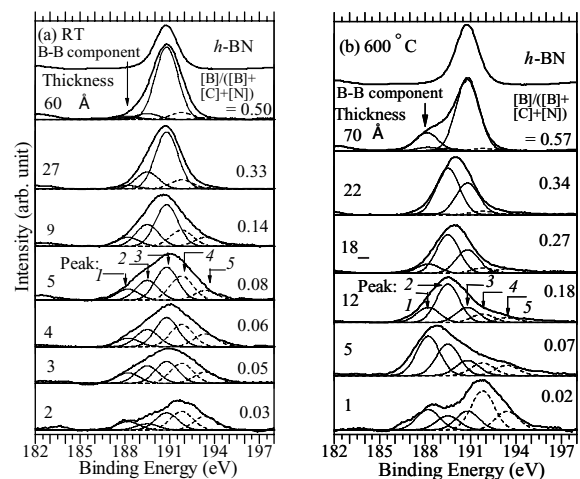


Figure 1. B 1s XPS spectra of B-C-N films prepared at various fluences and temperatures. Figures (a) and (b) show results of room temperature (RT) and 600 °C, respectively. Top curves of (a) and (b) show spectrum of *h*-BN.

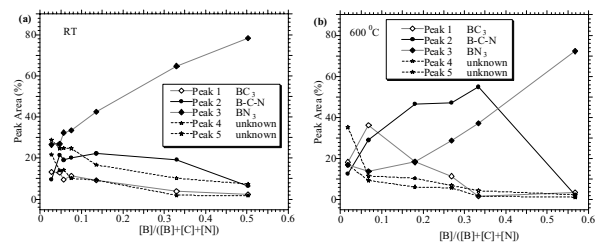


Figure 2. Fluence dependence of relative intensity ratio of components in the B 1s XPS spectra of B-C-N films. Figures (a) and (b) show results of RT and 600 °C, respectively.

References

- [1] M.N. Uddin et al., *Appl. Surf. Sci.*, **241**, 246 (2005).
- [2] M.N. Uddin et al., *J. Vac. Sci. Technol. A*, **23** (2005).

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