BL-5

XPS study on the boron-doped amorphous carbon films

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Heavily boron (B)-doped amorphous carbon, which is called as B-doped Q-carbon, shows the superconductivity with a superconducting transition temperature of 55K [1,2]. Since B-doped Q carbon is the first example of amorphous semiconductor showing the superconductivity, much efforts have been devoted to preparing this material. However, preparation of this material is quite difficult because of its metastable form achieved by the nano-second pulsed laser annealing to the B-doped amorphous carbon precursors. So far, B-doped Q-carbon has not yet been reproduced. One of important studies related to the preparation of B-doped Q-carbon is to characterize the B-doped amorphous carbon precursors. Especially, the chemical states of B-doped amorphous carbon may affect the formation of the B-doped Q-carbon. In this study, we investigate the chemical states of carbon and boron atoms in the B-doped amorphous carbon precursors with different nominal boron content by means of an X-ray photoemission spectroscopy.

The B-doped amorphous carbon precursors were fabricated by a pulsed laser deposition method with a KrF excimer laser ($\lambda = 248$nm). Single crystal $Al_2O_3(0001)$ substates were used for the film deposition. The deposition was performed under the vacuum condition of 3.0×10^{-6} Pa. Nominal boron content in the films was varied by changing the B/C ration in the target materials. The film thickness of the obtained precursor films was 200 to 300 nm. X-ray photoemission spectroscopy (XPS) measurements were carried out on the beamline BL-5, at the Hiroshima Synchrotron Radiation Center in Hiroshima University with non-monochromatic Mg Kα X-ray source ($h\nu = 1253.6$ eV). C 1*s* and B 1s core-level spectra were measured under an ultrahigh vacuum of ~10^{-7} Pa using a VSW hemispherical analyzer. The total energy resolution was about 1.8 eV. The binding energy of the films was corrected using the peak position of molybdenum spectra. Before measurements, the films were annealed at 100 °C under ultrahigh vacuum (~10^{-6} Pa) for 1 h to clean the film surface.

Figure 1 shows the C 1*s* core-level spectra of B-doped amorphous carbon films with different B content. The peak at 285 eV is observed for the non-doped films. This peak position shifts toward lower binding energy side with increasing boron content. Figure 2 shows the B 1*s* core-level spectra of B-doped amorphous carbon films with different B content. The peak structure appears as the nominal boron content is increased, indicating that boron atoms are present in the films. The B/C ratio of the films is estimated from the peak area ratio of C 1*s* and B 1*s* spectra to be 0-0.27. The peak position is located at 189 eV, which originates from B^0 states [3]. This indicates that most of boron atoms exist as an elemental state in the films. The reason for the shit of the C 1*s* spectra with increasing B content is probably due to the surface bending effect. It will be interesting to see how the chemical states of carbon and boron atoms change after pulsed laser annealing. Our present results provide an important starting point for obtaining the B-doped Q-carbon.

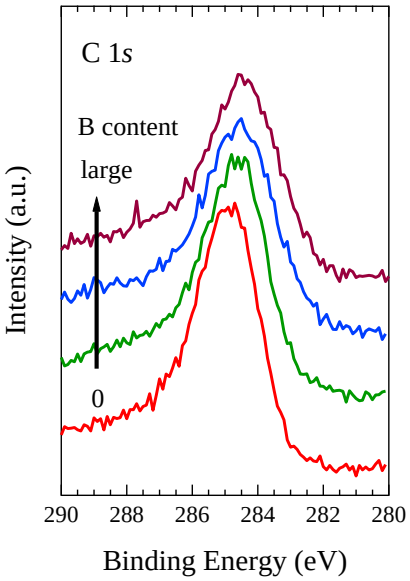

FIGURE 1. C 1*s* core-level spectra of boron-doped amorphous carbon films with different boron content.

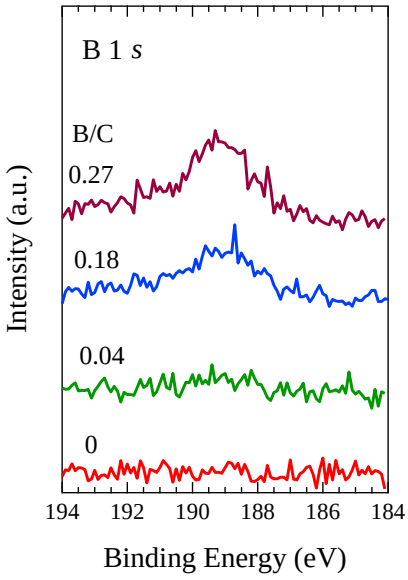

FIGURE 2. B 1*s* core-level spectra of boron-doped amorphous carbon films with different boron content.

REFERENCES

1. A. Bhaumik, R. Sachan, and J. Narayan, *ACS Nano*. **11**, 5351-5357 (2017).
2. A. Bhaumik, R. Sachan, S. Gupta, and J. Narayan, *ACS Nano*. **11**, 11915-11922 (2017).
3. W. G. Shin, H. J. Jung, H. G. Sung, H. S. Hyun, and Y. Sohn, *Ceram. Int.* **40**, 11511-11517 (2014).