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Polarization-dependent NEXAFS spectra of monolayered SiC synthesized by ion-beam deposition and post-annealing

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Introduction

The discovery of carbon nanotube has stimulated the search for new low-dimensional materials composed of carbon atoms. The versatility of carbon allotrope originates from the stability of both sp^2 and sp^3 configurations in C-C bonds. Recently some of new hetero-atomic low-dimensional materials of which configurations are similar to those of graphite, fullerene and carbon nanotube were synthesized such as B-N nanotubes, B-C-N nanotubes, Si and SiC nanowires, and SiO_x nanoflowers. Among them, SiC-based low-dimensional materials have attracted particular attention as a wide-gap electronic and optoelectronic material, because it has excellent properties such as high thermal conductivity and chemical stability. In this report, we present the electronic and geometrical structures of monolayered SiC films synthesized by ion-beam deposition and post-annealing using organic silicon compounds as source materials.

Experimental

The experiments were performed at the BL-27A station. The X-ray beam was linearly polarized in the horizontal direction. The ultrahigh vacuum system (base pressure 1 x 10^{-8} Pa) consisted of a five-axis manipulator, a hemispherical electron-energy analyzer, and a cold-cathode ion-gun. An HOPG single crystal of 12 mm×12 mm was used as a substrate. High-purity tetramethylsilane (TMS) was used as a source gas. The ions were bombarded on HOPG from normal direction without accelerating voltage. The monolayered SiC was synthesized by 1) ion-beam deposition at 1.1x10^{15} ions/cm^2, and 2) annealing at 850°C by YAG laser. The NEXAFS spectra were taken by total electron yields (TEY's) obtained by the sample drain current. For the measurements of the polarization dependencies, the sample was rotated around the vertical axis.

Results and discussion

Figure 1 shows the polarization dependence of the NEXAFS spectra for monolayerd SiC film. For comparison, NEXAFS spectra for bulk Si(100) and β-SiC are shown in the upper figure. Sharp peaks (marked A) are clearly seen at 1840 eV in the spectra at 10°and 30°incidences. It is noteworthy that the energy of this new peak is lower than those for SiC. To our knowledge, such low-energy peak has never been reported for any silicon-containing materials. Inferred from the C K-edge NEXAFS for carbon-containing compounds, the low-energy and sharp features of the peak A suggests the existence of π^*-like orbitals around Si atom. A remarkable polarization dependence is observed; The intensity of the peak A decreases with the increase in the incident angles, and it almost disappears at nearly normal incidence (θ=80°) From this polarization dependence, we can suppose that the final state orbitals represented by the peak A is perpendicular to the surface. The result suggests that Si atoms are located as one of the six-membered aromatic ring in graphite-like configuration. The result suggests that the obtained monolayered SiC film has flat-lying two-dimensional structure of which configuration is similar to a single sheet of graphite.

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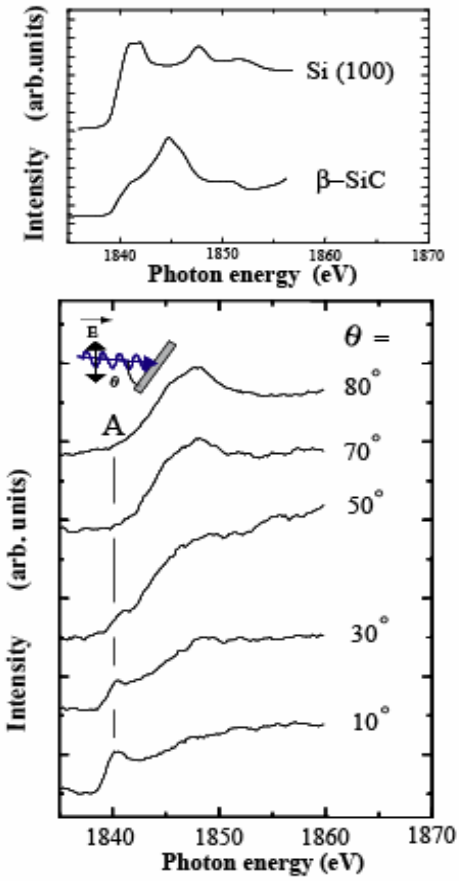

Fig.1 Polarization dependence of NEXAFS spectra at the silicon *K*-edge for monolayered SiC. For comparison, NEXAFS spectra for standard materials of Si(100) and β-SiC are shown in the upper figure.