§39. Hydrogen and Helium Ion induced Effects of Chemical Vapor Deposited Silicon Carbides

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Silicon carbides (SiCs) are potential candidates as separators between tritium breeding and neutron multiplier materials composing Li-Pb blanket modules. Therefore, it is significantly important to understand the transportation processes such as migration, trapping, detrapping, recombination of hydrogen isotopes (H^+, D^+, and T^+) and helium (He^+) ions retained in SiCs.

The sample used in present study was a silicon carbide (6H-SiC) material having a single crystal structure with high purity and density. The 6H-SiC sample was placed on a manipulator in a vacuum chamber evacuated to pressure of 1.3×10^{-5} Pa and was irradiated up to fluences of 3.0×10^{18} ions/cm^2 with 10 keV D_2^+ ions at room temperature. After the D^+ ion irradiation, some surface analyses such as nanoindentation hardness test, FE-SEM (field emission-scanning electron microscope) observation, ERD (elastic recoil detection) [1], AFM (atomic force microscope), and XPS (X-ray photoelectron spectroscopy) measurements have been examined, in order to investigate the radiation-induced modifications in mechanical property, surface morphology, crystalline structure of β phase SiC, and electronic structure of Si-C bond.

Figure 1 shows change in nanoindentation hardnesses, H_{IT}, of the unirradiated and 10 keV D_2^+ ion-irradiated 6H-SiC samples at several fluences of 1.6×10^{16}, 5.4×10^{17}, 1.2×10^{18}, and 3.0×10^{18} ions/cm^2 and room temperature, measured using a nanoindenter with a maximum stress of approximately 6 N and an injection depth of approximately 100 nm. The nanoindentation hardness values quickly reduce at more than approximately 1.0×10^{18} ions/cm^2. It is speculated to change in the bonding between Si-C due to D occupying at some trapping sits.

Figures 2(a)-(d) show AFM images of unirradiated and 10 keV D_2^+ ion-irradiated 6H-SiC samples at several fluences of 5.4×10^{17}, 1.2×10^{18}, and 3.0×10^{18} ions/cm^2 and room temperature. The roughness of the surface modification occurs with an increase in the fluence and the height of the projections reaches to be more than approximately 50 nm for the fluence of 3.0×10^{18} ions/cm^2. The result corresponds to the projected range of implanted D^+ ions, resulting in the ERD spectra. In addition, XPS analysis reveals annihilation of isolated C on the top-most surface, presences of Si-C and Si-deuteride (Si-D).

Figure 3 shows FE-SEM (SEI: secondary electron image) micrograph of 10 keV D_2^+ ion-irradiated 6H-SiC sample at approximately 3.0×10^{18} ions/cm^2. The radiation damage due to atomic displacements as well as ionizing effects may be caused on the top-most surface in the 5 keV D^+ ion projected range, Therefore, the implanted D^+ ions may be occupied at the trapping sites of the defects produced by atomic displacements as well as ionizing effects.

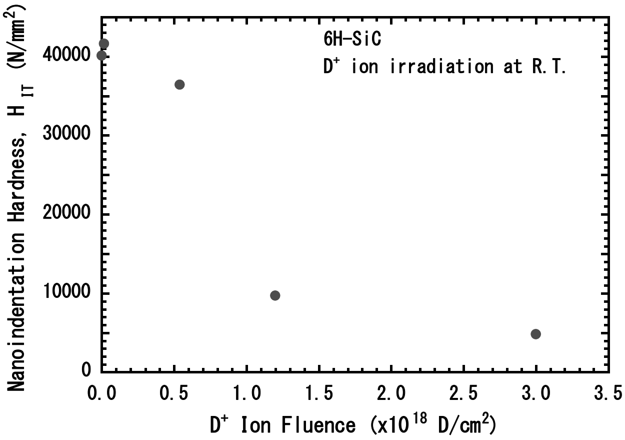

Fig. 1. D^+ ion fluence dependence of nanoindentation hardness of 10 keV D_2^+ ion irradiated 6H-SiC samples.

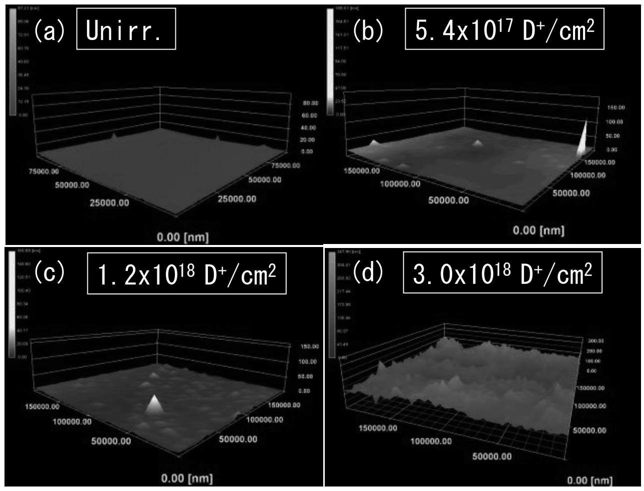

Fig. 2. AMF images of (a) unirradiated and 10 keV D_2^+ ion-irradiated CVD-SiC samples at approximately (b) 5.4×10^{17}, (c) 1.2×10^{18}, and (d) 3.0×10^{18} ions/cm^2.

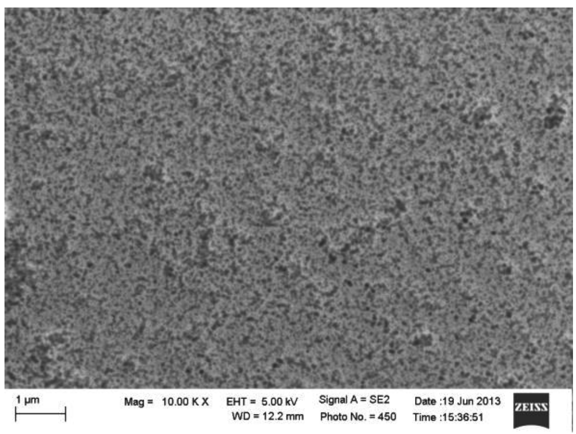

Fig. 3. FE-SEM (SEI: secondary electron image) micrograph of 10 keV D_2^+ ion-irradiated 6H-SiC sample at approximately 3.0×10^{18} ions/cm^2.

1) Tsuchiya B., Nagata S., Shikama T.: Nucl. Instr. and Meth. in Phys. Res. **B 212** (2003) 426.