# §19. Clarification of Mechanism on Radiation-induced Defect Formations of Chemical Vapor Deposited Silicon Carbides by Hydrogen Isotope Ion Irradiations

Tsuchiya, B., Ozawa, M., Bandow, S., Fujita, N., Matsunami, N. (Faculty of Science and Technology, Meijo Univ.),
Tanaka, T., Muroga, T.

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 depth profiles of deuterium atoms (D) near the surface of 6H-SiC were analyzed by means of high-energy ERD, combined with RBS, using 3.0 MeV $O^{3+}$ ion probe beams from Tandem accelerator, installed at Institute for Materials Research, Tohoku University [1].

After 6H-SiC was irradiated up to fluences of $2.8\times10^{18}$ ions/cm$^2$ with 10 keV $D_2^+$ ions at room temperature and in a vacuum chamber evacuated to pressure of $1.3\times10^{-5}$ Pa, 3.0 MeV $O^{3+}$ ions were irradiated at an incident angle of 75° to the surface normal of the $D_2^+$ ion-irradiated SiC samples to investigate the concentration of D retained in the near surface of the samples. The forward-recoiled deuterium ions ($D^+$) by elastic collisions with $O^{3+}$ ions were detected at a scattering angle of 30° to the incident $O^{3+}$ ion direction by a solid state detection (SSD) for ERD, mounted an absorber comprising 2.8 μm-thick Al film. Simultaneously, the back-scattered $O^{3+}$ ions by elastic collisions with Si atoms were detected at an angle of 170° to the incident $O^{3+}$ ion direction by a SSD for RBS.

Figure 1 shows typical ERD spectra of recoiled $D^+$ ions from 10 keV $D_2^+$ ion-irradiated 6H-SiC after irradiations at several fluences of $1.6\times10^{16}$, $5.4\times10^{17}$, $1.2\times10^{18}$, and $3.0\times10^{18}$ ions/cm$^2$ and room temperature, measured using 3.0 MeV $O^{3+}$ ion probe beams. In Fig. 1, the horizontal axis (Channel Number) corresponds to several energies of recoiled $D^+$ ions and represents the distance from the surface. The vertical axis (Counts) corresponds to the hydrogen (H) and D concentration. The sharp peak around 260 channel number is associated with recoiled $D^+$ ions from the 6H-SiC. There is no presence of residual H and implanted H in the 6H-SiC, resulting in no peaks around 190 channel number. From the ERD spectra after the irradiation up to the $D^+$ ion fluences of 1.2 and $3.0\times10^{18}$ ions/cm$^2$, the saturation concentration of D atoms trapped in the near surface of approximately 50 nm in depth for the SiC specimens was estimated to be approximately $4.0\times10^{22}$ atoms/cm$^3$, where the D counts averaged over 30 channels at the sharp peak of 260 channel number in Fig. 1, $O^{3+}$ ion fluence, the elastic recoil cross-sections of $O^+$ ion for trapped D, the stopping cross-sections for $D^+$ and $O^+$ ions in SiC specimens the solid angle of the detection used were taken into account [2].

Figures 2(a)-(d) show SEM (SEI: secondary electron image) micrographs of unirradiated and 10 keV $D_2^+$ ion-irradiated CVD-SiC samples. For the irradiations at the $D^+$ ion fluences of less than $1.2\times10^{18}$ ions/cm$^2$, it seemed that some scratches on the surface by polishing were removed out by ion sputtering effects. On contrary, for the irradiation up to more than $1.2\times10^{18}$ 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, resulting in the XRD patterns and SEM photographs. In addition, XPS analysis revealed annihilation of isolated C on the top-most surface, presences of Si-carbide (Si-C) and Si-hydride (Si-D).

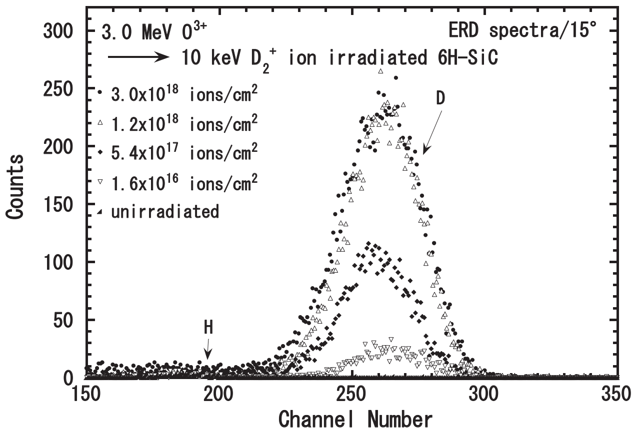


Fig. 1. Typical ERD spectra of deuterium recoiled from 6H-SiC samples after 10 keV $D_2^+$ ion irradiation at several fluences of $1.6\times10^{16}$, $5.4\times10^{17}$, $1.2\times10^{18}$, and $3.0\times10^{18}$ ions/cm$^2$ and room temperature.

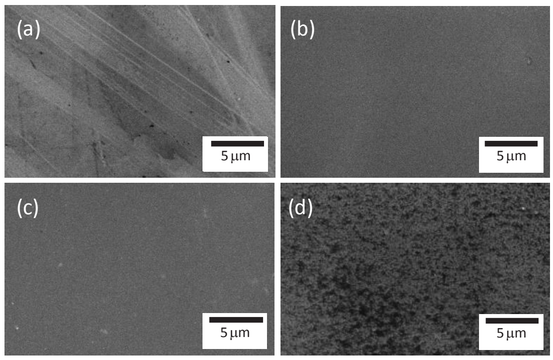


Fig. 2. SEM (SEI: secondary electron image) micrographs of (a) unirradiated and 10 keV $D_2^+$ ion-irradiated CVD-SiC samples at approximately (b) $5.4\times10^{17}$, (c) $1.2\times10^{18}$, and (d) $3.0\times10^{18}$ ions/cm$^2$.

1) Tsuchiya B., Nagata S., Shikama T.: Nucl. Instr. and Meth. in Phys. Res. **B 212** (2003) 426.
2) Ziegler J.F., Biersack J.P., Littmark U.: The Stopping and Range of Ions in Solids, Pergamon Press, New York, (1985).