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

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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 depth profiles of helium as well as hydrogen atoms 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].

Figure 1 shows schematic view of ion beam analysis systems for helium and hydrogen retained in the SiC materials. The 6H-SiC 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 2.8×10^{18} ions/cm^2 with 10 keV He^+ ions at room temperature. After He^+ ion irradiation, 3.0 MeV O^{3+} ions were irradiated at an incident angle of 75° to the surface normal of the He^+ ion-irradiated SiC samples to investigate the concentration of He retained in the near surface of the samples. The forward-recoiled hydrogen and helium ions (H^+ and He^+) 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 2 shows typical ERD spectra of recoiled H^+ and He^+ ions from 10 keV He^+ ion-irradiated 6H-SiC after irradiations at several fluences of 4.0×10^{16}, 1.2×10^{17}, 6.1×10^{17}, and 2.8×10^{18} ions/cm^2 and room temperature, measured using 3.0 MeV O^{3+} ion probe beams. In Fig. 2, the horizontal axis (Channel Number) corresponds to several energies of recoiled H^+ and He^+ ions and represents the distance from the surface. The vertical axis (Counts) corresponds to the hydrogen and helium concentration. Each sharp and broad peak near 190 and 330 channel numbers is associated with recoiled H^+ and He^+ ions, respectively, from the 6H-SiC, indicating the residual hydrogen and implanted helium at approximately 60-90 nm in depth. From the ERD spectrum, measured after the irradiation up to the He^+ ion fluence of 2.8×10^{18} ions/cm^2, the saturation concentration of helium atoms trapped in the near surface of approximately 75 nm in depth for the SiC specimens was estimated to be approximately 4.5×10^{22} atoms/cm^3, where the He counts averaged over 30 channels at the broad peaks of 330 channel numbers in Fig. 2, O^{3+} ion fluence, the elastic recoil cross-sections of O^+ ion for trapped He, the stopping cross-sections for He^+ and O^+ ions in SiC specimens the solid angle of the detection used were taken into account [2].

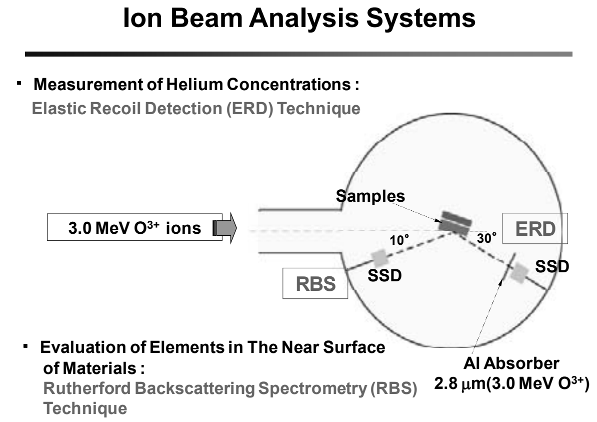

Fig. 1. Schematic view of ion beam analysis systems for helium and hydrogen retained in the SiC materials.

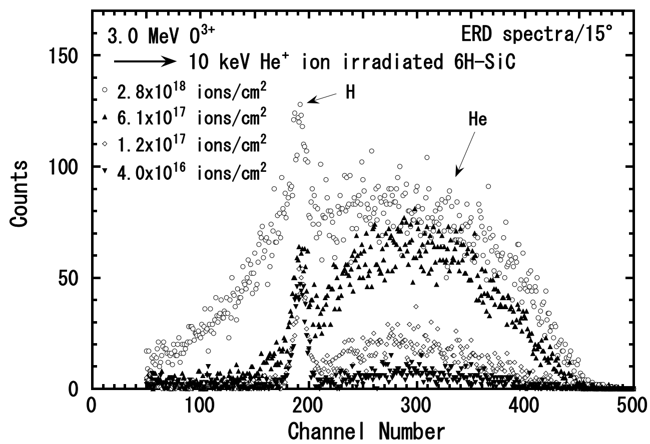

Fig. 2. Typical ERD spectra of helium and hydrogen recoiled from 6H-SiC samples after 10 keV He^+ ion irradiation at several fluences of 4.0×10^{16}, 1.2×10^{17}, 6.1×10^{17}, and 2.8×10^{18} ions/cm^2 and room temperature.

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).