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炭化珪素中にイオン注入された水素およびヘリウム挙動
Behavior of ion-implanted deuterium and helium in SiC

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Silicon carbide (SiC) is one of the most attractive candidates for components in fusion reactors such as the first wall, tritium breeding blankets, and insulating materials, owing to its inherent properties, such as low activation, good thermal conductivity, and stability at high temperatures. As a first wall material, SiC is subjected to severe condition with high-energy neutron and energetic helium (He) bombardment. These environment cause deterioration of the materials due to induced defects and introduced transmutation products. In addition, in case of using SiC as insert between structural materials and tritium breeding materials, the produced hydrogen isotopes, including tritium, are retained in the SiC and interact closely with He. The retention of tritium in SiC is a critical issue from the viewpoint of the tritium breeding ratio. Therefore, it is important to establish a fundamental understanding of the interactions between hydrogen isotopes and He. In this study, the retained concentration depth profiles of deuterium (D) and He in SiC were measured using ion beam analysis techniques to examine the influence of He pre-implantation on the retention/release behavior of D. The depth profiles of damaged Si sub-lattices were analyzed simultaneously to elucidate the correlation between release behavior and damage recovery.

The samples used in this study were single crystal plates of α-SiC with <0001> orientation. 10 keV He^+ and D_2^+ were implanted into the sample at an ion fluence of 1.0×10^{21} ions/m^2 at room temperature (RT) and 770 K. The depth profiles of implanted D and He were measured by the elastic recoil detection (ERD) analysis technique. To examine the correlation between D and He in the sample, 10 keV He^+ ions were implanted into the sample prior to the D ion implantation. After irradiation, the sample was annealed isochronally for 10 min from RT up to 1370 K. Rutherford backscattering (RBS) analysis in a channeling condition was also performed to calculate the amount of Si atoms displaced from the <0001> axis.

The depth profiling during isochronal annealing experiments showed that the D retention in He^+ implanted sample at 1370 K was much smaller than that for D implanted into the non-irradiated sample. The reduction of D retention can be explained by He implantation-induced damage, which disturb the C–D bonds forming. In addition, He release temperature increased in the D_2^+ implanted sample as shown in Fig.1, which may be attributed to suppression of He bubble formation by D remaining in the sample at high temperature. A correlation was not found between the release behavior of implanted ions by ERDA and the annealing behavior of damage observed by RBS/C analysis during the heat treatment. For implantation at 770 K, the D retention and D-ion-induced disorder were decreased considerably compared with 300 K implantation, while the He retention and He-ion-induced disorder did not change.

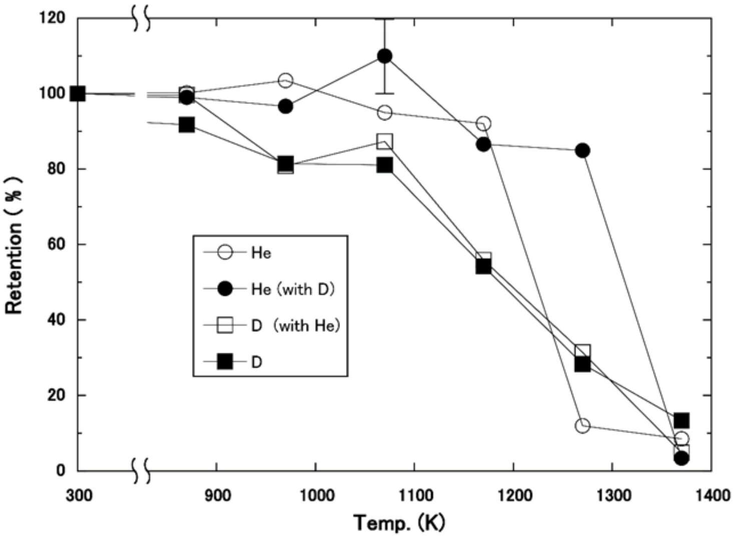

Fig.1. D and He retention as a function of annealing temperature