§24. Fuel Hydrogen Retention of SiC/SiC Composite after Helium Ion Irradiation

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SiC fiber reinforced SiC matrix (SiC/SiC) composite is a promising material as plasma-facing material in a fusion reactor, because of their low induced activation, low atomic number, high thermal shock resistance, good thermal conductivity. In this study, a suitability to use SiC/SiC composite for blanket and divertor is investigated. In addition, in order to investigate the hydrogen isotope retention behavior, deuterium ion irradiation was conducted for the SiC/SiC material.

For the use of SiC/SiC as blanket material in a fusion reactor, a feasibility of the SiC/SiC material with Li-Pb cooling/breeding system was discussed. In this advanced blanket, a temperature of structural material, ferritic stainless steel, is limited below 773 K. If the SiC/SiC material is used as flow channel insert material, a temperature of ferritic stainless steel can be reduced. In this case, a SiC/SiC material with a low thermal conductivity is appropriate. On the other hand, it is found that for the use of SiC/SiC materials as a divertor target, a SiC/SiC material with a high thermal conductivity is needed. The above results suggest that the characteristics required for the SiC/SiC material depend on the in-vessel component.

In a fusion reactor, helium produced by DT fusion reaction is implanted into the plasma-facing materials. In order to investigate the effect of helium ion irradiation on the deuterium retention behavior, helium ion irradiation followed by deuterium ion irradiation was conducted for SiC/SiC material, by using an ECR ion apparatus at Hokkaido University. After the deuterium ion irradiation, the deuterium retention behavior was examined by using a thermal desorption spectroscopy. Figure 1 shows thermal desorption spectra of D_2 after helium ion irradiation at various fluences followed by the deuterium ion irradiation. The desorption spectra of D_2 had two main peaks at around 950 K and 1230 K which can be regarded as detrapping from Si-D and C-D bonds, respectively[1)]. The peak temperatures of these desrption spectra decreased with an increase of helium ion fluence. Figure 2 shows the total amount of desorbed deuterium and amount of D_2 desorbed from Si-D and C-D bonds. The total desorbed amount increased by approximately 25 %, compared to the case without helium ion irradiation. This increase is owing to an increase of trapping site, such as dangling bond created by helium ion irradiation. The amount of desorbed deuterium from Si-D bonds increased approximately by a factor of two at a helium ion fluence of 1.0×10^{18} cm^{-2} while the amount of desorbed deuterium from C-D bond increased slightly with helium ion fluence. From an analysis of surface atomic composition by means of Auger electron spectrometry, it was found that the atomic composition of silicon increased after helium ion irradiation. This corresponds to the increase in the amount of deuterium desorbed from Si-D bonds. The present data is useful to understand the change of fuel hydrogen retention after the helium ion irradiation in a fusion reactor.

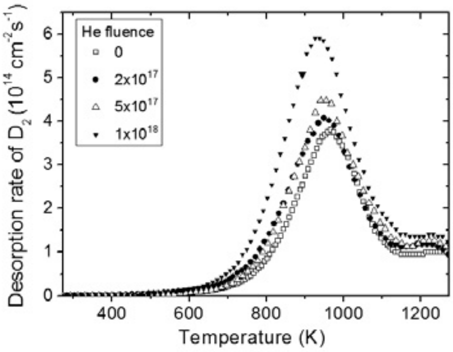

Fig.1 Thermal desorption spectra of D_2 after deuterium ion irradiation following helium ion irradiation at various fluences.

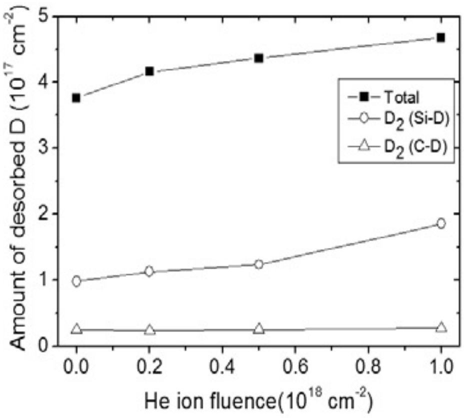

Fig.2 Total amount of desorbed deuterium and amount of desorbed D_2 due to Si-D and C-D bonds.

1) Yamauchi Y., Hirohata Y., Hino T.: Fus. Eng. Des., 39-40 (1998) 427.