§37. Application of SiC/SiC Composite for First Wall

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SiC/SiC composite is an attractive low activation material, so that the suitability of this material in fusion reactors has to be investigated. We so far investigated the suitability of SiC/SiC composite for the applications as 1) insert plate of Li-Pb blanket, 2) daivertor and first wall, 3) neutron reflector in neutron multiplier region of blanket, and 4) electric conductor used for wall baking. High thermal conductivity is required for the deivetor and first walls, and low thermal conductivity is required for the insert plate of liquid metal blanket. The structure of the SiC/SiC composite has to be porous to reduce the thermal conductivity. On the other hand, use of SiC filament with high thermal conductivity is required to increase the thermal conductivity.

The thermal conductivities of SiC/SiC composites developed so far were surveyed. The highest value is approximately 50 W/m-K, which is only 2-3 times smaller than the graphite with a high thermal conductivity. Thus, the SiC/SiC composite can be employed as the first wall in fusion reactors. The SiC/SiC composite has an advantage on the erosion owing to oxygen impurities. The graphite material is extremely eroded by oxygen impurities, but the erosion of SiC/SiC composite is quite small.

The lowest thermal conductivity is approximately 1 W/m-K. The structure material of L-Pb advanced blanket is RAFS (reduced activated ferritic steel). The operation temperature of the RAFS has to be below approximately 800 K, owing to the swelling limit. If the insert plate of this SiC/SiC composite is employed between Li-Pb flow and the RAFS wall, the temperature of the RAFS can be reduced to below 800 K.

The present study shows that the SiC/SiC composite with a high thermal conductivity can be used for the first wall and contributed for reduction of the erosion due to oxygen impurities. The use of SiC/SiC composite as the insert plate between Li-Pb flow and the ferritic steel enables us to use the RAFS in Li-Pb advanced blanket.

In the followings, the deuterium ion irradiation experiment for the SiC/SiC composite is presented. In order to consider the suitability of SiC/SiC composite as first walls in fusion reactors, the trapping and desorption behavior of fuel hydrogen has to be investigated for understandings of hydrogen recycling and in-vessel tritium inventory.

The small species of SiC/SiC composite was irradiated by D^+ ion with energy of 1.7 keV in an ECR ion irradiation apparatus at Hokkaido University. The irradiation was repeated by changing the deuterium ion fluence. After the irradiation, the sample was extracted from the irradiation chamber, and transferred to the chamber of thermal desorption spectroscopy (TDS). The sample was heated by infrared furnace from room temperature to 1300 K. The deuterium retained in the sample desorbs during the heating and the desorption amount was quantitatively measured using quadruple mass spectrometer (QMS).

Fig. 1 shows the thermal desorption spectra of SiC/SiC composite for the different deuterium ion fluences. The two major peaks appeared at 900 K and 1200 K. The lower and higher peaks correspond to the deuterium trapped by Si and C, respectively. In the case of graphite, the peak appeared at only 1200 K. It is not easy to increase the wall temperature up to 1200 K, but relatively easy to increase the temperature up to 1000 K. If the temperature of the first wall is taken as high as 1000 K, the amount of retained fuel hydrogen is significantly reduced, compared with the graphite. Fig. 2 shows the amounts of gas species containing the deuterium versus the deuterium ion fluence. The fraction of the amounts of CD_4 and C_2D_2 is quite small, only several percent of total amount. This result indicates the chemical erosion of carbon in the SiC/SiC composite by deuterium ion is small.

The deuterium ion irradiation experiment for the SiC/SiC composite showed that the fuel hydrogen retention can be controlled to be low and the chemical erosion of carbon is significantly reduced.

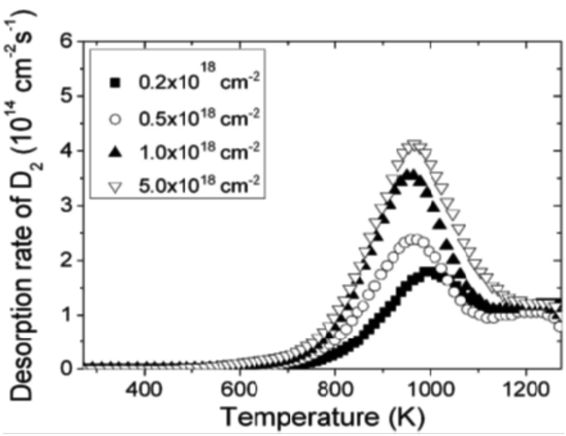

Fig.1 Deuterium desorption spectra after deuterium ion irradiation.

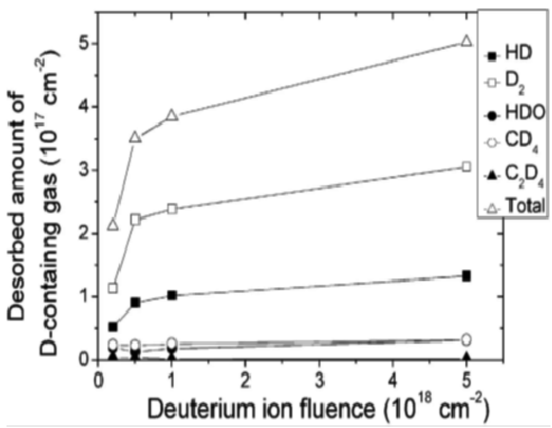

Fig. 2 Amount of retained deuterium vs deuterium ion fluence.