§10. Deuterium and Helium Retentions of V-4Cr-4Ti Alloy for First Wall of Breeding Blanket

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Vanadium alloy is an attractive structural material for fusion reactor, because of its low induced radioactivity and the good thermal and mechanical properties at high temperatures. In this study, the deuterium and the helium retention properties of V-4Cr-4Ti alloy were investigated by using thermal desorption spectroscopy and an ECR ion source. The sample with low impurity contents[1], NIFS HEAT1 and 2, were prepared by National Institute for Fusion Science (NIFS). Before ion irradiation, the samples were annealed in a vacuum at 1273 K (D^+ irradiation) and 1373K (He^+ ion irradiation) for 1 hr. Ion energies of deuterium and helium were taken 1.7 keV and 5 keV, respectively. Deuterium retained in the sample desorbed mainly as D_2 at 650~800K when the irradiation temperature was changed from 380 to 773K at the heating rate of 0.5 K/s. Fig.1 shows the retained amount of deuterium as a function of ion fluence. The retained amount of deuterium in the sample irradiated at 380 K increased with the ion fluence, and did not saturate to the fluence up to 1×10^{19} D/cm^2. For the irradiation at 773 K, 0.1% of implanted amount was retained at the highest fluence which was almost the same as those of tungsten and graphite irradiated with deuterium ion energy of 1.5 keV at 773 K[2]. This result indicate that hydrogen embrittlement of the V-alloy due to both hydrogen gas absorption and hydrogen ion irradiation does not occur at operational temperatures for V-alloy blankets (>673 K). No blister was observed on the sample after deuterium ion irradiation, while a number of blisters with a diameter of 0.1~0.5 μm was observed after helium irradiation at room temperature (RT). The fluence of helium ion was $(0.5\sim10)\times10^{21}$ He/m^2, which corresponds to 4.5 ~91 dpa, comparable fluence with the operating condition of DEMO reactor. A number of blisters with a diameter of 0.1~0.5 μm were observed on the surface. The density of the blister was in the order of $10^8\sim10^9$ cm^{-2} in the case of helium ion fluence of 5×10^{21}He /cm^2. After the irradiation, the sample was heated up to 1600 K with a heating rate of 1 K/s. Figure 2 shows TDS spectra of the V-alloy after helium ion irradiation at RT. In the thermal desorption spectra, three groups of desorption peaks appeared at around 500 (Peak I) , 850 (Peak II) and 1200 K (Peak III) which correspond to the desorption from He_nV(vacancy)X(impurity) type defect cluster or weak trap sites formed in an amorphous region, He_nV_5X cluster and the blisters and/or internal bubbles, respectively. In the lower fluence region, the retained helium desorbed mainly at around 1200 K. With the increase in the fluence, the amount of desorption at 500 K increased. A similar trend of increasing the desorption rate in low temperate region with increasing fluence has also been observed in V-4Ti alloy irradiated with 5 keV He ion [3], 316L stainless steel with 3 keV He ion [4].

The present result shows that the amount of retained helium in V-alloys might largely decrease in the case of high flux and fluence, at operational temperatures for V-alloy blankets (>673 K).

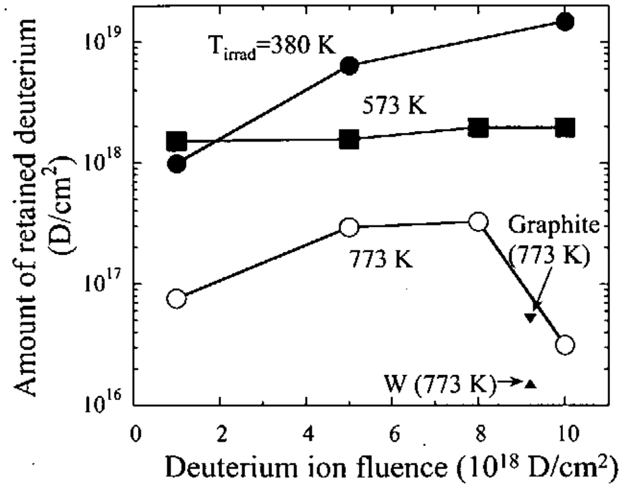

Fig.1 Amount of retained deuterium vs ion fluence with different irradiation temperature.

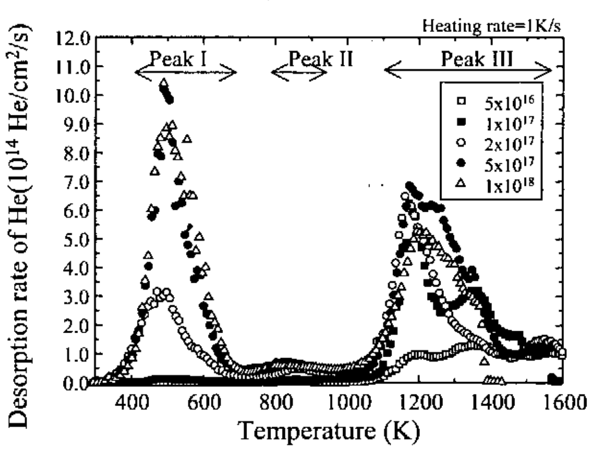

Fig.2 Thermal desorption spectra of helium in the V-alloy after helium ion irradiation at room temperate.

Reference

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4) Nobuta Y.et.al., J.Nucl.Mater. to be submitted