§101. Effects of Neutron and Helium Irradiation on Deuterium Retention Behavior in ITER Grade Tungsten and Ferritic Steel (F82H)

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Tungsten (W) material is a primary candidate for plasma-facing material because of its low sputtering rate and high melting point, and is widely used in existing fusion devices. Low activated ferrtic steel, F82H, is a candidate structural material for test blanket module in ITER. In terms of estimation of tritium inventory and fuel hydrogen recycling, hydrogen retention behavior of neutron- and helium(He)-irradiated materials needs to be investigated. The purpose of this study is to understand the mixing effects of neutron and He irradiations on hydrogen retention behavior in W and F82H.

In FY 2015, the effect of He irradiation on deuterium retention behavior in W and F82H was mainly investigated. For this purpose, He^+ ion irradiation followed by D_2^+ ion irradiation were performed. In He^+ ion irradiation, the incident ion energy was 5 keV and ion fluence was varied from $1x10^{17}$ to $1x10^{19}$ He/cm^2. D_2^+ ion irradiation was succeedingly performed. The incident energy of D_2^+ ion was 2 keV (corresponding to 1 keV for sole D atom) and the ion fluence was $1x10^{18}$ D/cm^2. All the irradiation experiments were done with substrate temperature at room temperature. After the He and D ion irradiation, desorption behavior of retained D in the samples were evaluated with thermal desorption spectrometry (TDS) with high resolution quadrupole mass spectroscope, which allows to individually detect He and D_2. In the TDS analysis, samples were heated with a heating rate of 0.5 K/s from room temperature to 1273 K.

Thermal desorption spectra of D_2 in only He pre-irradiated W and in both neutron and He pre-irradiated W are shown in fig. 1. In the case of no He pre-irradiation, D_2 spectra had a major desorption peak at 420 K and D_2 desorption continued up to 670 K. For W pre-irradiated with He, major desorption peak was seen around 440 K and desorption rate between 470 and 670 K increased by a factor of 2 to 3 compared to no He case. This would be owing to release of D trapped in defects produced by He pre-irradiation. The D_2 spectra in W pre-irradiated with He showed little difference in the fluence range used in this study. This suggests that the effect of He irradiation on D_2 desorption is almost the same within this He fluence rage. For neutron-irradiated W, the desorption rate at a peak of 420 K became smaller than that in no neutron irradiation case. The reason for that is not clear for now. The reproducibility of the results for the neutron-irradiated W will be confirmed in the near future.

Thermal desorption spectra of D_2 in He-irradiated F82H is shown in fig.2. For F82H with no He pre-irradiation, main peaks were seen at 420 and 940 K. The desorption peak at higher temperature (940K) was not observed for F82H with He pre-irradiation. The depth profile of atomic composition in F82H before ion irradiations is shown in fig.3. At the top surface, an impurity layer containing carbon and oxygen was observed. The sputtering erosion of the impurity layer by He pre-irradiation might be the reason for the reduction of higher temperature peak[1)].

In the next fiscal year, the ion irradiation experiments against neutron-irradiated W and F82H will be performed.

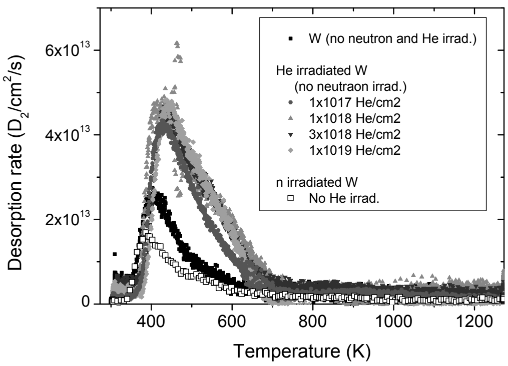

Figure 1 Thermal desorption spectra of D_2 in only He pre-irradiated W and in both neutron and He pre-irradiated W.

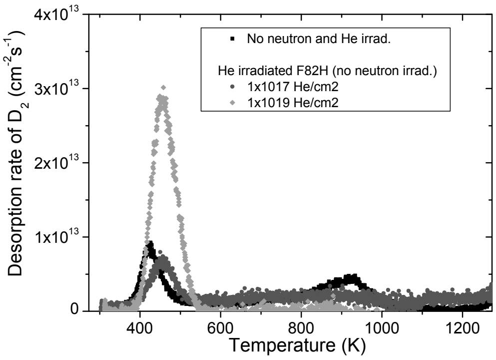

Figure 2 Thermal desorption spectra of D_2 in He pre-irradiated F82H.

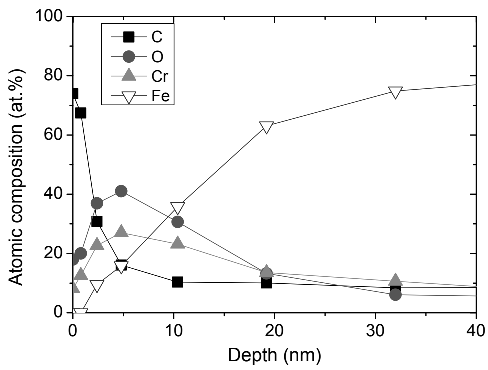

Figure 3 Depth profile of atomic composition in F82H before ion irradiation.

1) Hino, T. et al.: J. Nucl. Mater., 386-388 (2009) 736.