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

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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 a number of existing fusion devices. Low activated ferrtic steel, F82H, is a candidate structural material for test blanket module in ITER. Plasma-facing materials are exposed to fuel hydrogen during plasma operation and part of implanted hydrogen is accumulated in the materials. In fusion reactor, neutron and helium (He) produced by D-T reaction are implanted into plasma-facing materials, which produce irradiation damages in the materials, such as vacancy clusters, voids and He bubbles, and should influence the hydrogen retention properties. In terms of estimation of tritium inventory and fuel hydrogen recycling, hydrogen retention behavior of neutron- and 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.

Early in FY 2013, disk-shaped samples of ITER grade tungsten and F82H with 5 mm in diameter and 0.2 mm in thickness were prepared and these samples were sent to Belgium for neutron irradiation. These samples will be sent back to Japan in May 2015 after the neutron irradiation, and be used for deuterium (D) irradiation experiments in Tohoku University where D and He ions irradiation for neutron-irradiated materials can be performed using a ion/plasma irradiation apparatus in the controlled area (Fig.1). This apparatus equips not only a normal QMS but also a high resolution QMS (HRQMS), which allows to separately detect D_2 and He released from samples during thermal desorption measurement.

In FY 2014, in order to investigate the effect of He irradiation on deuterium retention behavior in W and F82H, 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 $1x10^{18}$ 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). In the TDS analysis, samples were heated with a heating rate of 0.5 K/s from room temperature to 1273 K. During the heating, D_2 desorption was monitored with HRQMS.

Thermal desorption spectra of D_2 is shown in Fig. 2. In the case of no He pre-irradiation, D_2 spectra had a major desorption peak at around 140 ^oC and D_2 desorption continued up to 400 ^oC. For W pre-irradiated with He, major desorption peak was seen around 170 ^oC and desorption rate between 200 and 400 ^oC largely evolved compared to no He case. This would be owing to release of D detrapped from defects produced by He pre-irradiation. In addition, a desorption peak around 600 ^oC appeared for He pre-irradiated W. A major desorption peak of He was also seen in the same temperature. Thus, the D_2 desorption at 600 ^oC might be related with He release. 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 the He fluence.

D irradiation experiment is being performed for F82H. The results of these irradiation experiments will be compared with that of neutron- and He-irradiated W and F82H.

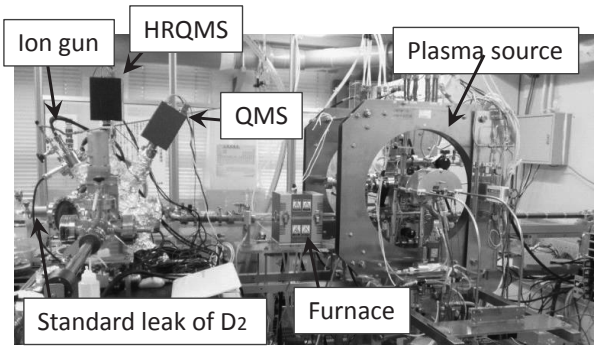

Figure 1 Photo of ion/plasma irradiation apparatus with a normal and high resolution (HR) quadrupole mass spectrometers (QMS) used for thermal desorption spectrometry.

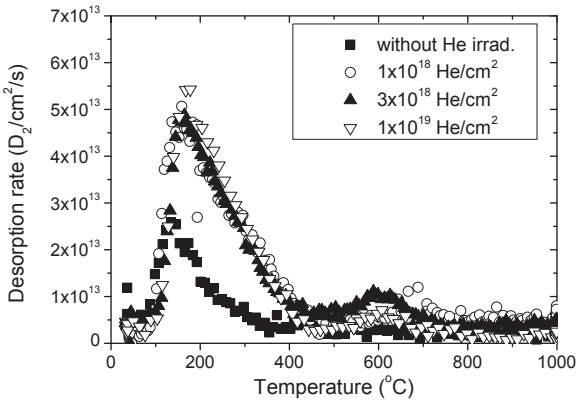

Figure 2 Thermal desorption spectra of D_2 in He pre-irradiated W.