§7. Effects of Helium Bombardment on Hydrogen Retention Properties of a Ferritic Steel Alloy F82H

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Reduced Activation Ferritic/Martensitic (RAFM) steels are candidate materials for fusion DEMO reactors such as FFHR. Helium ash produced by D-T fusion reactions and hydrogen isotopes mix with each other in the vacuum vessel of DEMO reactors. To understand bulk fueling retentions and tritium inventories of plasma facing materials in DEMO reactors, analyses of samples exposed to plasmas of both hydrogen and helium are essential. However, investigations of bulk retention after exposures to plasmas of the two elements are still limited for RAFM steels. In this study, RAFM steel samples are exposed to hydrogen and helium plasmas and the effects of helium bombardment on hydrogen retention is elucidated.

A RAFM steel, F82H (8Cr-2W), has been bombarded with steady-state hydrogen and helium plasmas under conditions relevant to the first wall environment, using the VEHICLE-1 facility [1]. The size of the F82H target samples was 15 mm x 15 mm x 1 mm. The plasma density is the order of 10^{10} cm-3 and the electron temperature is in a few electron volts, resulting in the ion fluencies of the order of 10^{19} - 10^{20} atoms cm-2. The ion bombarding energy is set at 100-200 eV by applying a negative DC-bias onto the target assembly. After the plasma exposure, the samples are analyzed with TDS, XPS, TEM and the optical microscope.

A ceramic heater is located on the sample holder, and this ceramic heater possesses a thermocouple. The temperature on the rear side of the target sample is measured by the thermocouple on the ceramic heater. The radiation heating caused by the plasmas and the heating provided by the ceramic heater are balanced during plasma exposure, and the temperatures are controlled by a heat regulator. The temperature of the target samples was maintained from 473 K to 823 K..

Figure 1shows the hydrogen retention of the samples after hydrogen-plasma exposure. The net amount of hydrogen retention was determined by subtracting the background hydrogen from the raw data. The temperature of the target samples was maintained at 823 K. In Fig. 1, it is evident that the hydrogen retention saturated at over 6 x 10^{19} atoms/cm^2.

The hydrogen retention of F82H samples exposed to hydrogen plasma after helium bombardment was recorded and is presented in Fig. 2. For the experiments represented in Fig. 2, all helium bombardment was performed using the same fluence and bias voltage, and the hydrogen fluence was varied. At a hydrogen fluence of 3x10^{19} atoms/cm^2, the hydrogen retention was identical with and without helium pre-irradiation. For hydrogen fluences over 6x10^{19} atoms/cm^2, the hydrogen retention after helium irradiation was higher than that without helium irradiation. This result suggests that helium bombardment creates additional hydrogen-trapping sites in the F82H alloy [2].

Helium-plasma bombardment at incident energy of 200 eV causes changes in the surface morphologies of the targets and the formation of helium bubbles. The hydrogen retention of a sample exposed to hydrogen plasma after helium-plasma bombardment is higher than that of a sample that has not been subjected to helium bombardment. The damage to the F82H alloy caused by helium irradiation affects the total hydrogen retention.

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1) Y. Hirooka et al., J. Nucl. Mater. 363-365 (2007) 775..
2) N. Ashikawa et al., 21th PSI conference (2014).

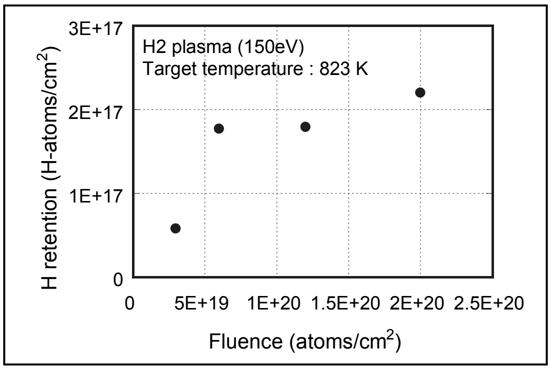

Figure 1 Fluence dependence of hydrogen retention in F82H targets after hydrogen-plasma bombardment. The temperature on the rear side of the target was 823 K.

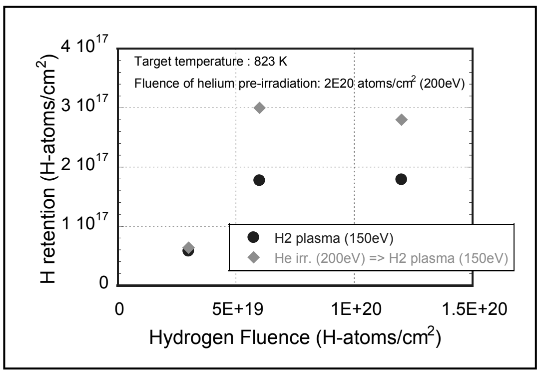

Figure 2 Hydrogen retention after hydrogen-plasma bombardment with and without pre-irradiation with helium plasma.