§47. Hydrogen Retention of Low-activation Ferritic Steel Alloys Irradiated by Plasma

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Reduced Activation Ferritic/Martensitic (RAFM) steels, such as F82H and EUROFER, are candidate materials for fusion DEMO reactor. To understand bulk fuel retention and tritium inventories of plasma-facing materials in DEMO, analyses of samples exposed to deuterium plasmas are essential. In this study, RAFM steel samples are exposed to low energy deuterium plasmas and the effects of surface modifications on deuterium retention is elucidated.

RAFM steels, F82H (8Cr-2W) and EUROFER (9Cr-1W), are bombarded with steady-state deuterium plasmas under conditions relevant to the first wall environment using the PlaQ facility [1]. The surface temperature of the samples during plasma exposure was measured by thermocouples and an infrared camera. It was set at 450 K. Target steels were exposed to helium pre-irradiation applied a DC-bias voltage of 200V and deuterium plasma bombardment applied a DC-bias voltage of 100V. Applied deuterium and helium fluences are 1 x 10^{24} D/m^2 and of the order of 10^{24} He/m^2, respectively. After the plasma exposures the samples were analyzed with nuclear reaction analysis (NRA), microbalance, Rutherford backscattering spectroscopy (RBS), field emission scanning electron microscopy (FE-SEM), X-ray photoelectron spectroscopy (XPS).

Deuterium retention in the steels determined by NRA is shown in Fig.1. NRA was done using D (He^3, p) ^{4}He reaction at different energies, 690 keV, 1200 keV, 1800 keV, 2400 keV, 3200keV and 4000 keV, respectively. Amounts of deuterium retention are of the order of 10^{18} to 10^{19} D/m^2 at the near top surface region using an energy of 690 keV. Target samples with helium pre-irradiation show higher deuterium retentions to compare with without helium pre-irradiations. The difference between F82H and EUROFER is almost negligible.

Figure 2 shows surface morphologies analyzed by FE-SEM. After deuterium plasma bombardment, a smooth plane shown. From microbalance measurement, weight loss of 10 μg per 1 cm^2 was observed. But a surface on the target after helium pre-irradiation shows pinholder-like un-uniform structures as shown in Fig.2 (b). A weight loss after helium irradiation is about 60 μg per 1 cm^2 and then an erosion rate by helium irradiation is higher than that after deuterium irradiation.

Two kinds of damages by helium irradiations, such as a changing of surface morphologies and helium bubbles, are known on RAFMs. Such surface damages have an influence on increasing hydrogen/deuterium retentions on RAFMs.

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1) A. Manhard, et al., Plasma Sources Sci. Technol. (2011) 20 015010.

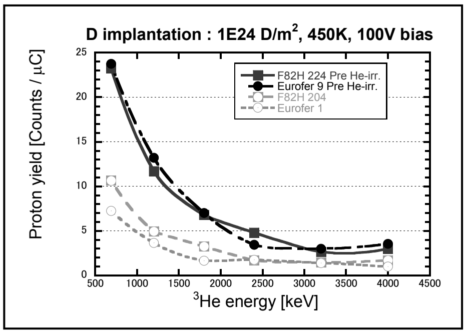

Figure 1 Deuterium retentions in F82H and EUROFER targets exposed to helium pre-irradiation and deuterium-plasma bombardments in the Pla-Q dacility. Target temperatures are 450 K.

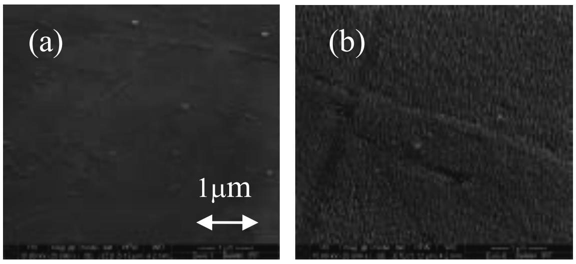

Figure 2 Surface morphologies of F82H measured by FE-SEM. (a) deuterium bombardment and (b) helium pre-irradiation and deuterium bombardment.