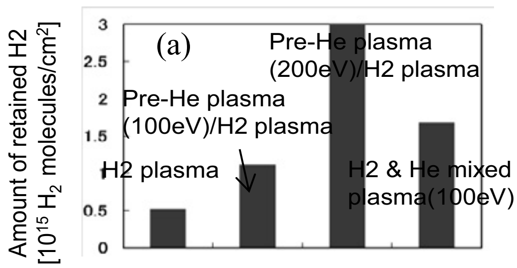
§6. Effects of Helium Bombardment on Hydrogen Retention in F82H Steel

Ashikawa, N., Hirooka, Y., Zhou, H., Muroga, T., Konishi, A., Yamauchi, Y., Nobuta, Y. (Hokkaido Univ.), Yoshida, N. (Kyushu Univ.)

Ferritic steel alloys are candidates as a low activation material in a fusion DEMO reactor such as FFHR [1]. Helium ash produces in D-T fusion reactions and hydrogen isotopes mix in the vacuum vessel of DEMO reactors. To understand bulk fueling retentions and tritium inventories of plasma facing materials in DEMO reactors, analyzed data of samples exposed to plasmas with hydrogen and helium mixed gasses are important. But investigations of bulk retention after plasma exposures in F82H are not sufficient yet. In the previous work, F82H samples exposed to hydrogen plasma and these amounts of retained hydrogen has been measured. Two kinds of hydrogen trapping sites were observed and considered to be inner defects and damage of plasma bombardment on the surface [2]. In this study, samples exposed to hydrogen and helium mixed gas plasmas and demonstrated effects of helium bombardment on hydrogen retention.

A low-activation ferritic steel alloy, F82H (8Cr-2W), has been bombarded with steady-state hydrogen and helium plasmas under some of the conditions relevant to the first wall environment, using the VEHICLE-1 facility [3]. The plasma density is the order of 10^{10} cm^{-3} and the electron temperature is a few electron volts, resulting in the ion fluencies of the order of 10^{16} - 10^{19} ions cm^{-2}. The ion bombarding energy is set at 100-200 eV by applying a negative DC-bias onto the target assembly. F82H samples are analyzed with SEM, EPMA, XPS, TEM and TDS.

Different types of discharges are operated to compare with pure Hydrogen, pure helium, hydrogen/helium mixed plasmas and helium plasma pre-irradiation. An amount of retained hydrogen in a sample exposed to mixed gas plasma is 1.5 times larger than in a sample with helium plasma pre-irradiation as shown in Fig.1. Helium bubbles are observed from TEM images of cross-section by focus ion beam (FIB) milling process on F82H as shown in Figs.2. A depth distribution of helium bubbles by 200eV helium plasmas is approximately until 200 nm. These results suggest low energy helium plasmas are also effective to produce helium bubbles and it contributed as additional hydrogen trapping sites in F82H. Then total amounts of trapped hydrogen in F82H targets exposed to plasma mixed helium are higher than exposed to pure hydrogen plasmas. This work is supported by NIFS budget UFFF028.



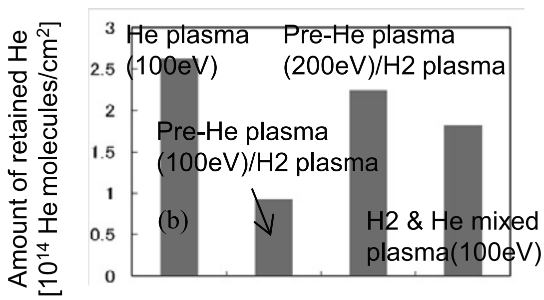


Fig.1 Amount of retained (a) hydrogen and (b) helium.

1) A. Sagara et al., Fusion Engineering and Design 83 (2008) 1690-1695.
2) N. Ashikawa et al., 22nd International Toki conference (2012).
3) Y. Hirooka et al., J. Nucl. Mater. 363-365 (2007) 775-780.

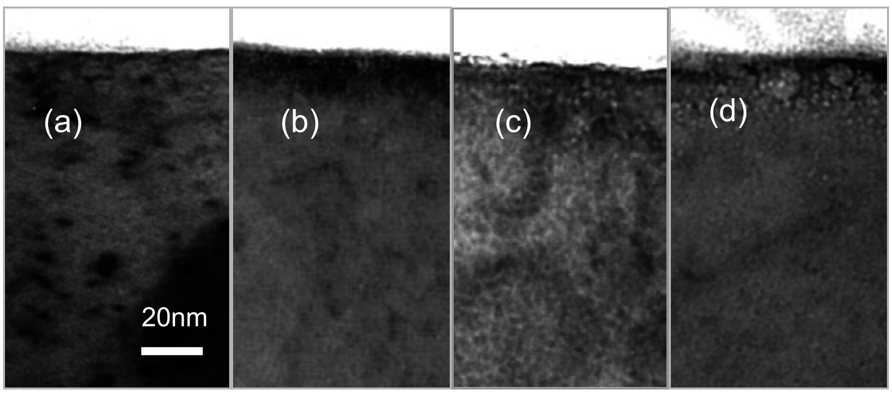


Fig.2 TEM observation with Focused Ion beam (FIB) milling process for cross-section images of F82H exposed to plasmas. (a) Pure helium (100eV), (b) helium plasma pre-irradiation (100eV) , (c) helium plasma pre-irradiation (200eV) and hydrogen/helium mixed plasmas (100eV).