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F82H鋼 におけるヘリウム照射効果による水素保持特性への影響評価
Effects of helium bombardment on hydrogen retention properties in F82H steel

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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 [2]. In this study, samples exposed to hydrogen and helium plasmas and demonstrated effects of helium bombardment by helium ash 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 X-ray photoelectron spectroscopy (XPS), Transmission electron microscope (TEM) and Thermal desorption spectrometry (TDS).

Different types of discharges are operated to compare with pure Hydrogen, pure helium, and helium plasma pre-irradiation. Helium bubbles are observed from TEM images of cross-section by focus ion beam (FIB) milling process on F82H of (a) helium plasma pre-irradiation (200eV) and (b) helium plasma pre-irradiation (100eV) as shown in Figs.1. A depth distribution of helium bubbles by 200eV helium plasmas is approximately until 150 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.

Depth profiles of stopped helium ions with 200 eV were calculated about 50nm by TRIM code. In Fig.1, cross-section images by TEM are shown many helium bubble and typical diameters are about 5nm. These bubbles are observed until 200 nm from the top surface. Two kinds of binding energies of hydrogen in alpha iron are reported [4]. The case of intrinsic defects is 24-50 kJ/mol. and the case of helium bubble is 67-86 kJ/mol. Then temperature peaks in helium bubbles are higher than in intrinsic defects by thermal desorption spectrums in alpha iron. Higher thermal desorption spectrums of hydrogen to helium irradiated target are observed in F82H samples as shown in Fig.2. Total amounts of retained hydrogen in F82H targets exposed to pre-helium plasma are also higher than exposed to pure hydrogen plasmas. This work is supported by NIFS budget UFFF028.

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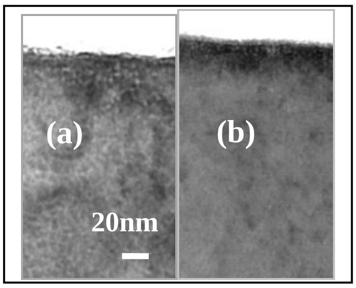

Figue.1

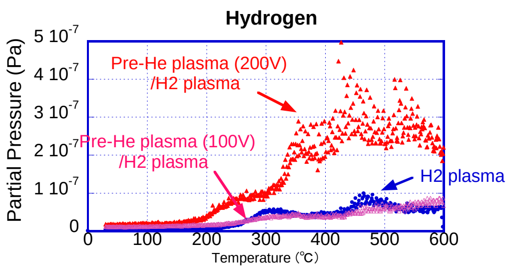

Figure.2