Characteristics of Hydrogen Traps in Ion-irradiated F82H Steel

T. Komura[a,*], I. Takagi[a], M. Akiyoshi[a], T. Sasaki[a], K. Moritani[a], H. Moriyama[b]

[a]*Graduate School of Engineering, Kyoto University, Yoshida Sakyo-ku, Kyoto 606-8501 Japan*

[b]*Research Reactor Institute, Kyoto University, Kumatori-cho, Osaka590-0494 Japan*

F82H (8Cr-2W-Fe) is a low-activation ferritic steel and can be used as structural material for blanket and divertor in fusion reactors. As these components are heavily irradiated by fast neutrons, interactions between radiation damages and hydrogen isotopes should be known for quantitative evaluation of tritium retention. In the present work, deuterium retention in ion-irradiated F82H is observed by a nuclear reaction analysis (NRA) and some characteristics of hydrogen traps will be investigated.

In an experiment, one side of a sample disk of F82H with thickness of 2.0 mm was exposed to a deuterium rf plasma so that deuterium was charged into the sample. The plasma-exposing side was irradiated with 0.8-MeV ^{4}He or 0.3-MeV H ion at 370 K and deuterium concentration profiles near the surface were observed by the NRA with a 1.7-MeV ^{3}He beam. During the irradiation and the NRA, the sample was continuously exposed to the plasma and deuterium permeation through the sample was monitored.

In the He irradiation with a dose of $1.5\text{x}10^{21}$ m^{-2}, a significant amount of traps was produced and the deuterium concentration increased by 5 orders of magnitude larger than that before the irradiation. The shape of the deuterium depth profile was very similar to that of displaced atoms, indicating that the trap was related to radiation-induced defects. Analysis of temperature dependence of the concentration and the permeation flux resulted that a trapping energy, an enthalpy difference between solution and trapping sites, was 0.62 eV and a trap production rate, a ratio of traps to displaced atoms, was 0.0040. Some traps were annihilated at 670 K.

In the H irradiation with a dose of $1.0\text{x}10^{22}$ m^{-2}, the trapping energy was almost the same, the production rate was lower and the annihilation temperature was lower compared to the He irradiation. These suggested that the trap was a cluster of the point defects which can be stabilized by He atoms. Difference in the trap production rate would be attributed to a size of collision cascade and stabilization by He.