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タングステンにおけるH-D混合プラズマ駆動透過に及ぼす水素同位体効果

Permeation characteristics of hydrogen isotope in tungsten under H-D mixed plasma irradiation

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1.Introduction

Tungsten (W) is one of candidate plasma facing materials for future fusion reactors due to its favorable properties such as higher melting point, lower physical sputtering yield and lower solubility for hydrogen (H) isotopes. During the operation of fusion reactor, W will be exposed to high flux deuterium (D), tritium (T) and helium (He) particles in addition to 14 MeV neutron under elevated temperature. The energetic T ions will impinge on W surface and migrate toward the coolant, leading to the loss of T and contamination of coolant. For the evaluation of T permeation, it is quite important to take account of co-existed hydrogen isotopes, namely H and D. In this study, the influence of H or irradiation defects on the plasma driven permeation behavior in tungsten material were studied.

2.Experimental

The H/D mixed plasma driven experiment (PDP) was performed to evaluate the H effect on the D plasma driven permeation behavior. The D^+/H^+ ratio in the plasma during H/D mixed plasma exposure was evaluated by a spectrometer. To understand the effect of irradiation defects on the D plasma driven permeation behavior, 1 dpa Fe2+ damaged W was prepared at TIARA, QST with the maximum damage level of 1 displacement per atom (dpa).

3.Results and discussion

Fig. 1 shows that H/D permeation behavior with the H/D ratio of 0:100, namely only D plasma exposure at the initial 3000 s. Thereafter the gas composition has changed to H/D ration of 100:0, only H plasma exposure. Fig.2 shows that H and D permeation behavior during D plasma between 0 – 5000 s, and thereafter the H/D ratio of 50:50. These results show that the increased HD permeation due to the introduction of H in W.

Increase of HD permeation flux indicated that the permeated D was recombined with residual H at downstream side to form HD. After switching to H plasma, H was reacted with D at backside surface. The generation of HD was also occurred in H/D mixed irradiation. This HD permeation behavior is considered to be the influence of thermal desorption from W and H plasma irradiation.

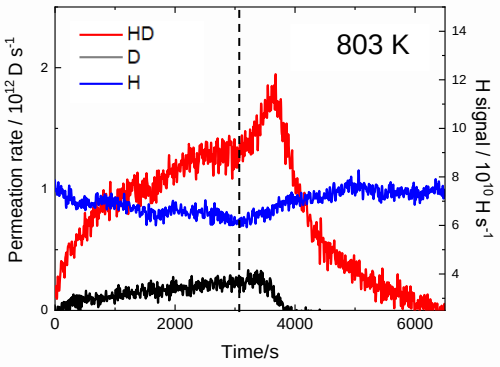

Fig. 1 Permeation behavior of hydrogen isotopes when the H/D ratio in the plasma was changed from 0:100 to 100:0.

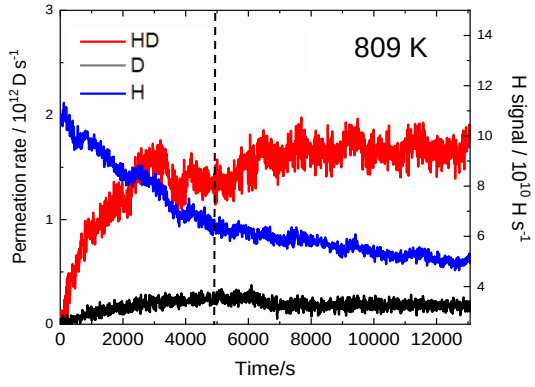

Fig. 2 Permeation behavior of hydrogen isotopes when the H/D ratio in the plasma was changed from 0:100 to 50:50.