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Effect of irradiation damages and He existence on hydrogen isotope plasma driven permeation for W

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For the establishment of fusion reactor, it is essential to elucidate the physical parameters related to hydrogen isotope transport through plasma-facing materials under the consideration of hydrogen isotopes (H/D/T). To accurately predict hydrogen isotope behavior, damage by neutrons and energetic charged particles, combined with He ash effects, should be extensively studied at fusion-relevant higher temperatures. In our previous study, D retention has increased by introduction of irradiation damages in W, but D permeation was reduced. However, the contamination of the plasma with less than 1% He clearly reduced hydrogen isotope retention by a factor of 10 below 813 K. In addition, H and D permeation behavior in W showed that the permeation flux was also controlled by the square root of mass. In this study, the plasma driven permeation (PDP) with mixed plasma (H and D) with various ratios were performed using newly developed PDP device (Fig. 1) in the radiation controlled area at Shizuoka University, and their isotope effect was evaluated. In addition, He effect on H/D PDP was also performed for undamaged W and Fe^+ damaged W with damage level of ~1 dpa was also studied.

It was found that the D permeation flux was almost 1/3 under the co-existence of H and D with the ration of 1:1 for undamaged W at the temperature between 700-900 K. This indicates that the H has a higher permeation flux compared with D under the co-existence of H and D. Figure 2 shows the H/D permeation fluxes during H/D/He mixed plasma exposure. At lower temperature, clear H/D isotope effect was found, and D permeation flux was clearly reduced. However at higher temperature, H and D permeation fluxes were almost the same. In addition, as He concentration increased, the H and D permeation fluxes were largely reduced, which can be explained by the formation of He bubbles.

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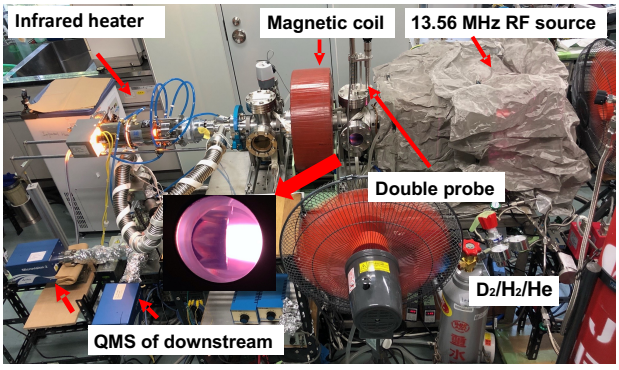

Figure 1. Plasma driven permeation device in radiation controlled area at Shizuoka University.

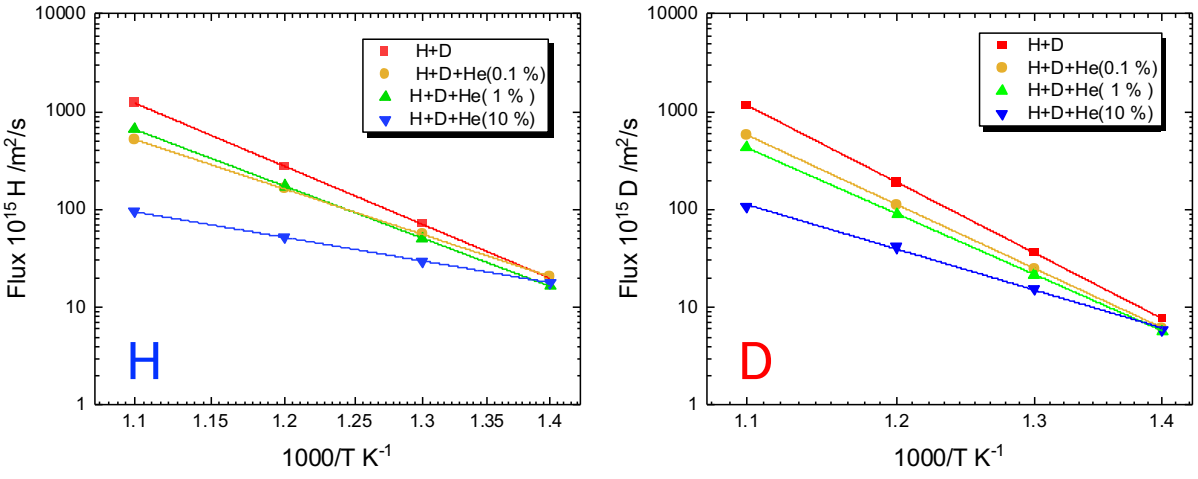

Figure 2. H and D permeation fluxes by plasma driven permeation experiment with coexistence of H, D and He.