

§3. In-situ Measurement of Hydrogen Isotope Exchange under Plasma Exposure

Ohno, N., Yamagiwa, M., Nakamura, Y., Kaneko, T., Matsunami, N., Takagi, M., Kajita, S. (Nagoya Univ.), Masuzaki, S., Tokitani, M., Sagara, A.

Hydrogen isotope exchange is considered one of the most effective methods for reducing the tritium inventory in plasma-facing components. Ion-beam experiments have revealed the fundamental features of hydrogen isotope exchange phenomena. However, no studies on hydrogen isotope exchange have attempted to investigate the dynamic behavior of deuterium retention under hydrogen plasma exposure relevant to the edge plasma condition in fusion devices. The time evolution of deuterium retention in isotropic graphite under successive deuterium and hydrogen plasma exposure has been investigated using a Plasma Surface Dynamics with Ion Beam Analysis (PS-DIBA) device¹⁾, which makes it possible to perform the in-situ ion beam analysis of deuterium retention under high flux plasma exposure. Deuterium and hydrogen plasma were exposed to an isotropic graphite sample (ETP-10: IBIDEN CO., LTD). D(³He, p) α nuclear reaction analysis (NRA) was used to measure retained deuterium. A primary energy of a mass-separated ³He ion beam generated by a Van de Graaff accelerator was 1.0 MeV.

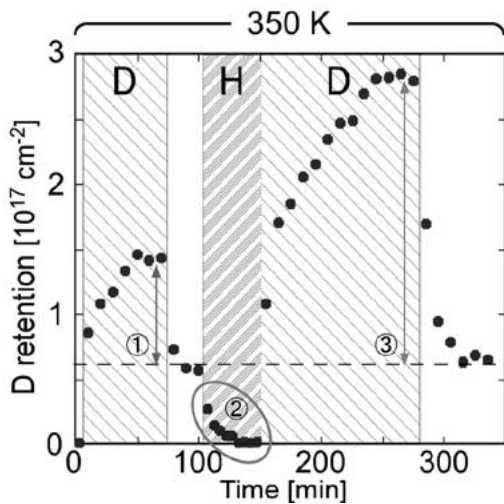


Fig. 1: Time evolution of D retention measured by NRA analysis. The temperature of the graphite sample is kept at 350 K both with and without plasma exposure. In the hatched region.

Figure 1 shows the time evolution of the deuterium retention in the graphite sample. In hatched regions, the sample was irradiated with deuterium (D) or hydrogen (H) plasma, and in other regions, the sample temperature was fixed at 350 K by electron heating. The D

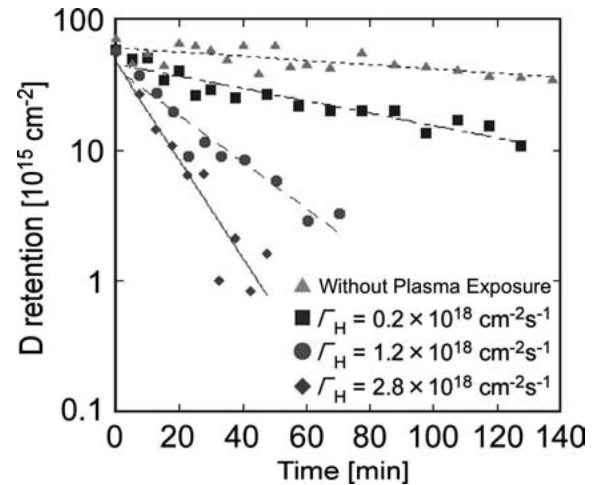


Fig. 2: Semi-logarithmic plots of the D retention in time without and during H plasma exposure.

plasma parameters were fixed: the incident ion energy was 33 eV, and the D ion flux was $8.7 \times 10^{18} \text{cm}^{-2} \text{s}^{-1}$. D retention was saturated in 30 min after D plasma exposure started, and it rapidly dropped after the termination of D plasma exposure. This drop corresponds to the release of dynamically retained solute D from the sample, which is associated with “dynamic retention”. After the release of dynamically retained D, H plasma was irradiated to the sample, and D retention rapidly decreased to almost zero. This result indicates that D retained in trapping sites (static D retention) can be released with hydrogen plasma exposure.

Similar experiments were repeated with different H ion fluxes and without H plasma exposure. Figure 2 shows the semi-logarithmic plots of the D retention in time as a function of the H ion fluxes: D retention decreases exponentially in time, and it drops more rapidly with a higher H ion flux, which corresponds to the hydrogen isotope exchange phenomena²⁾.

After the H plasma exposure, we again irradiated the sample with D plasma. We observed that dynamic D retention under D plasma exposure was more than twice as large as before H plasma exposure as shown in Fig. 1. After D plasma exposure termination, static D retention level was the same as that before H plasma exposure. We have not understood the enhancement mechanism yet. It is necessary to determine the threshold value of hydrogen ion flux and/or hydrogen ion fluence at which the enhancement of dynamic D retention occurs after H plasma irradiation in future experiments.

- 1) M. Yamagiwa, Y. Nakamura, N. Matsunami, N. Ohno, *et.al.*, Physica Scripta T145 (2011) 010432.
- 2) N. Ohno, Y. Nakamura, M. Yamagiwa, T. Kaneko, N. Matsunami, S. Kajita, M. Takagi, Physica Scripta T149 (2014) 014053.