§1. In-situ Measurement of Hydrogen Isotope Retention under Plasma Exposure by Using Ion Beam Analysis

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Control of hydrogen isotope retention in plasma-facing components (PFC) is essential to establish steady-state operation. In particular, tritium retention inside the vacuum vessel poses serious problem in the operation of the ITER to give a limit of the number of plasma discharges. Understanding of dynamic behavior of hydrogen isotope retention in PFC is quite important related to optimization of the timing of fueling and flux dependence of chemical sputtering, and so on. However, these phenomena have not been understood yet, primarily due to the lack of proper plasma-surface analyses under plasma exposure.

We developed a new compact divertor plasma simulator PS-DIBA (Plasma Surface Dynamics with Ion Beam Analysis), a device which makes it possible to carry out in-situ ion beam analysis of deuterium retention under high density plasma irradiation, relevant to divertor plasma conditions. Dynamic behavior of deuterium retention in tungsten was investigated during and after plasma exposure by using Nuclear Reaction Analysis (NRA) in PS-DIBA[1)].

Figure 1 shows a schematic of the PS-DIBA device. The steady state plasma was produced with a DC arc discharge using a zigzag-shaped LaB6 cathode, which was heated up to 1500 K by direct-current Joule heating. Anode is made of a copper tube cooled by water. Discharge gases are introduced between the two cathodes, contributing to an efficient usage of the neutral gas for the discharge. Figure 2 shows the discharge power dependences of electron density, n_e, and temperature, T_e, at the center for a plasma column. In helium plasma, n_e reaches $1 \times 10^{19} m^{-3}$ at the discharge power of 2.7 kW. The incident ion energy can be controlled by electrically biasing the sample.

We have investigated reduction of deuterium retention by hydrogen plasma exposure by using PS-DIBA. First, deuterium plasma was exposed to an isotropic graphite sample (ETP-10: IBIDEN CO., LTD). After that, the sample was exposed to hydrogen plasma. Figure 3 shows the time evolution of deuterium retention measured with NRA. The experimental result clearly shows that the deuterium retention dramatically drops due to isotope exchange effect.

1) M. Yamagiwa, Y. Nakamura, N. Matsunami, N. Ohno, S. Kajita, M. Takagi, M. Tokitani, S. Masuzaki, A. Sagara and K. Nishimura, Physica Scripta T145 (2011) 010432.

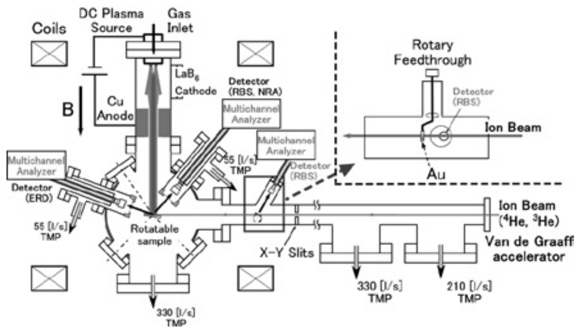

Fig. 1: Schematic top view of PS-DIBA device

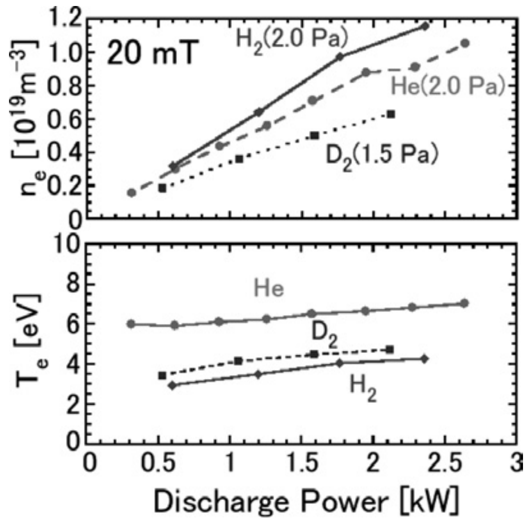

Fig. 2: Discharge power dependence of the electron density n_e and electron temperature T_e.

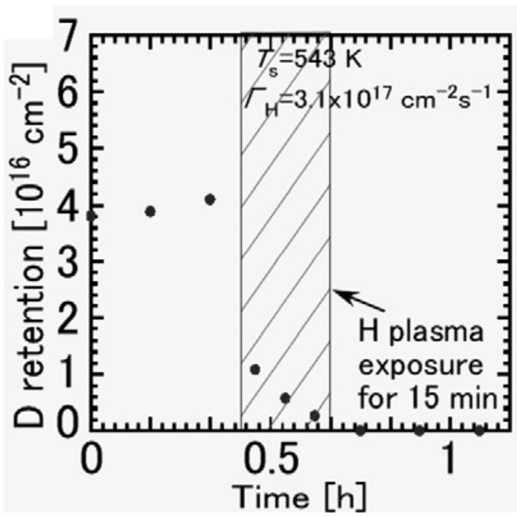

Fig. 3: Temporal evolution of deuterium retention in isotropic graphite(ETP-10: IBIDEN CO., LTD) measured with NRA.