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

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In-situ measurement of hydrogen retention in plasma-facing materials under plasma exposure, so called dynamic retention has been one of the most important topics in plasma-wall interaction because the dynamic retention has a strong effect on a particle balance in fusion devices, associated with fueling. However, because of the difficulty of the in-situ measurement of hydrogen retention under plasma exposure, only static hydrogen retention was measured after plasma exposure termination. In this study, we have investigated deuterium retention in graphite under and after plasma exposure by using a device of PS-DIBA (Plasma Surface Dynamics with Ion Beam Analysis) as shown in Fig. 1, which makes it possible to carry out in-situ ion beam analysis of deuterium retention[1].

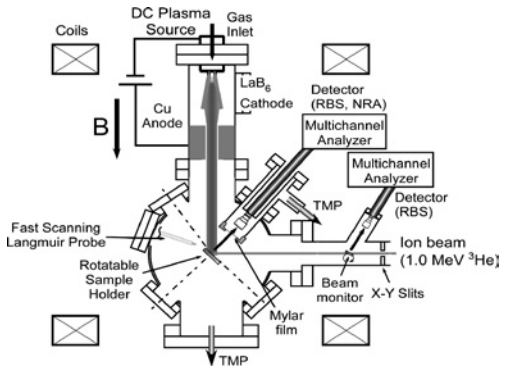

Fig. 1: Schematic top view of PS-DIBA device.

The steady state deuterium plasma was produced with a DC arc discharge using a zigzag-shaped LaB6 cathode. Electron density n_e was above $1 \times 10^{18}\mathrm{m}^{-3}$. The incident ion energy can be controlled by electrically biasing the sample. D(^{3}He, p)α nuclear reaction analysis (NRA) was used to measure retained deuterium. A primary energy of a mass-separated ^{3}He ion beam generated by a Van de Graaff accelerator was 1.0 MeV.

Deuterium retention in isotropic graphite (ETU-10) sample was investigated by using PS-DIBA device[2]. Figure 2 shows the time evolution of deuterium retention measured with NRA. The sample temperature was controlled from 350 K to 550 K with a step of 50K by using air cooling and electron heating. The sample was irradiated to deuterium plasma at three different fluxes up to $1.0 \times 10^{18}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ with the incident ion energy of 33 eV. Dynamic deuterium retention were clearly observed. The dynamic retention decreased with the sample temperature and increased with the plasma flux. However, fraction of the dynamic retention normalized by total retention on each sample temperature was almost constant.

Figure 3 shows dependence of the dynamic deuterium retention on deuterium ion flux. It shows that the dynamic retention was proportional to the ion flux and the release time τ was estimated. Therefore, we found the sample temperature dependence of the release time τ (84 ms at 350 K, 59 ms at 400 K and 48 ms at 450 K, respectively) and it is needed to control fuel particles with a time scale of τ to maintain stable plasma in future fusion devices.

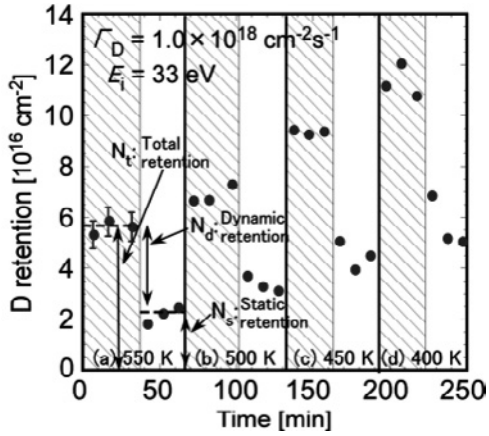

Fig. 2: Time evolution of deuterium retention in isotropic graphite measured by NRA under plasma exposure.

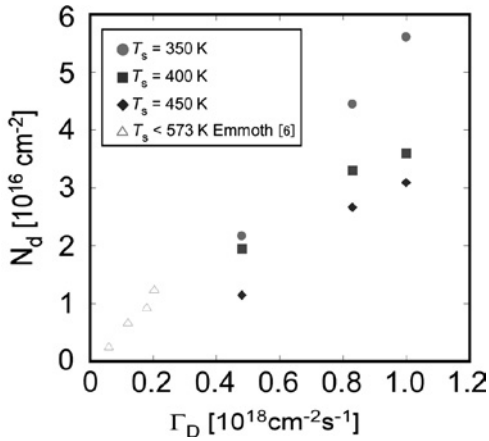

Fig. 3: Dependence of dynamic retention N_d on deuterium ion flux Γ_D .

1) M. Yamagiwa, Y. Nakamura, N. Matsunami, N. Ohno, *et.al.*, Physica Scripta T145 (2011) 010432.

2) Y. Nakamura, M. Yamagiwa, T. Kaneko, *et.al.*, to be published in J. Nucl. Mater.