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Study of Hydrogen Isotopes Behavior in Graphite with PS-DIBA Device
PS-DIBAを用いた炭素中での水素同位体挙動に関する研究

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The measurement of dynamic behavior of hydrogen isotopes retention under plasma exposure is of importance for the hydrogen recycling in future fusion devices. We investigated deuterium behavior in graphite using PS-DIBA(Plasma Surface Dynamics with Ion Beam Analysis) device. Nuclear Reaction Analysis (NRA) in PS-DIBA was used to measure dynamic behavior of deuterium retention. The results indicated that deuterium retention in graphite was almost constant during plasma exposure. And after the plasma was terminated, deuterium retention decreased by approximately 20%, which was thought to correspond to the dynamic retention.

1. Introduction
Carbon materials have been widely used as plasma facing components and are the candidate material for the vertical targets of the divertor plates of the ITER. However, carbon materials have a disadvantage of accumulating extremely high concentration of hydrogen isotopes and radioactive tritium in the case of D-T experiments. As the result of longtime researches, hydrogen isotopes retention characteristics such as temperature dependence and depth profile in carbon materials have been investigated. However, because of the difficulty of the measurement, hydrogen isotopes were measured after plasma exposure termination except for a few experiments. Thus, only a few experiments have measured so-called 'dynamic retention' observed under plasma exposure until now [1,2]. Dynamic retention is thought to affect major impacts on hydrogen recycling in future fusion devices. In this study, we measured deuterium retention characteristics on graphite under plasma exposure with 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 exposure.

2. Experiments
A schematical experimental set-up is shown in Fig. 1. This device is composed of a compact and powerful DC plasma source using a LaB_6 cathode and a copper anode. $D(^3He,p)\alpha$ nuclear reaction analysis (NRA) using a Van de Graaff accelerator was used to measure retained deuterium. A primary energy of a mass-separated $^3He^+$ ion beam was 1.0 MeV. The retention was determined by integrating the measured deuterium concentration over the entire detection depth. The fluence and flux of $^3He^+$ were 5.6×10^{15} cm^{-2} and 3.1×10^{12} $cm^{-2}s^{-1}$, respectively. The beam was collimated at the sample to a size of about 2×1 mm and the aquisition time was 30 minutes. The sample was isotropic graphite ETP-10 (IBIDEN CO., LTD) .

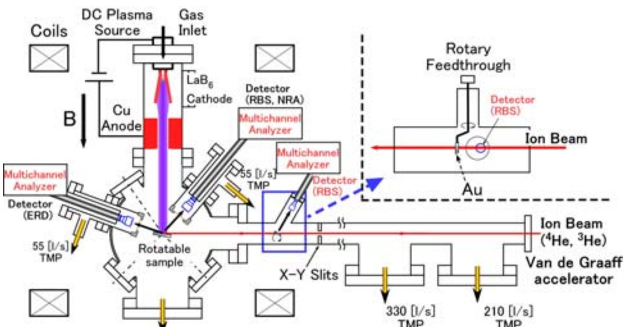

Fig.1 A schematic of the PS-DIBA device.

3. Results&Discussion
Figure 2 shows the time evolution of retained deuterium measured with NRA in ETP-10. Initially, from 0 to 30 minutes, the deuterium retention was measured without plasma exposure. Then, plasma was generated, and the deuterium retention was

saturated soon around the areal density of 6.5×10^{16} cm^{-2}. The plasma parameters were fixed for 3 hours, at the incident ion energy E_i and ion flux Γ_D of 17 eV and 6.8×10^{16} cm^{-2}s^{-1} respectively. After the plasma termination, the deuterium retention in graphite rapidly decreased by approximately 20 %, which was thought to correspond to the dynamic retention, and then slowly decreased with a decay time (half life time) of 22 hours.

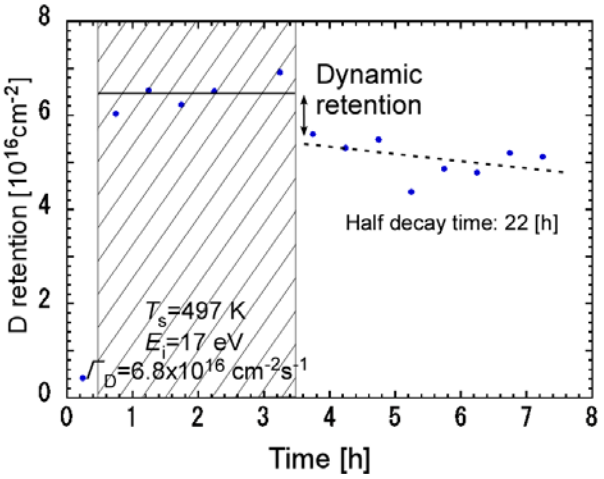

Fig.2 The time evolution of retained deuterium in isotropic graphite ETP-10 measured with NRA

4. Summary

Deuterium retention in isotropic graphite ETP-10 was measured. After producing the plasma, deuterium retention saturated around 6.5×10^{16} cm^{-2} , and decreased by approximately 20 % just after plasma termination. This decrease is thought to correspond to the dynamic retention, and then slowly decreased with a decay time of 22 hours.

In Ref. [3], heavy dependence of deuterium retention in graphite on sample temperature was observed. It indicates that deuterium retention in graphite decreases with increasing temperature in the range of < 1000 K.

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