§24. Development of High Heat Plasma Generator with Ion Beam Analysis and In-situ Measurement of Hydrogen Isotope Retention

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In order to establish steady state plasma discharge in fusion devices, particle control in plasma-facing components is a one of the most important issues; therefore, it is necessary to establish the appropriate wall conditioning techniques. In the LHD, wall conditioning by using helium and/or neon glow discharges has been performed regularly, and it is reported that neon glow discharge is particularly useful for wall conditioning. However, underlying physics in the wall conditioning has not been fully understood yet. Especially, it is quite important to understand static and dynamic hydrogen retention in the plasma-facing components.

Therefore, we have developed the high heat flux plasma generator with an ion beam analysis including Rutherford Back Scattering spectroscopy (RBS), Nuclear Reaction Analysis(NRA), Elastic Recoil Deflection (ERD) as shown in Fig. 1[1)]. The novel dc plasma source with a direct heated lanthanum hexaboride (LaB_6) cathode can generate high density deuterium plasma with an electron density of 4.5×10^{18} m^{-3} in steady state (Fig. 2). The solid-state detectors region is sealed by mylar film to maintain high vacuum state and aluminum film is also used to repel plasma photons. Another compound molecular pump was installed for differential pumping of the detectors chamber. The degree of vacuum in detectors chamber was kept less than 10^{-4} Pa by use of the mylar during the plasma exposure. In order to analyze the absolute D retention, ion beam current should be monitored at the samples. However, it is impossible to measure the beam current at the samples during plasma exposure, To monitor the beam current, a gold (Au) plate, which could be rotated, was equipped at the beam line and used as a beam chopper to deflect the beam to the monitor detector, as shown in Fig. 1. By using this monitor system, the absolute D retention at the surface can be measured.

Temporal evolution of deuterium retention on ITER grade W was investigated during and after plasma irradiation by using PS-DIBA device (Fig. 3). The deuterium retention of ITER grade W is mainly determined by sample temperature, not depending on the incident ion energy and ion flux. Decay time of deuterium retention of ITER grade W after plasma disappearance is about 4 hours, which is much shorter than that of powder metallurgy tungsten (40 hours). The result indicates that the decay time could be different depending on manufacturing methods for W.

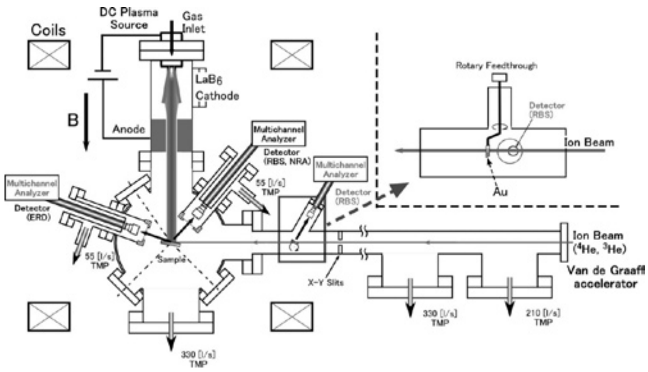

Fig. 1: Schematics of experimental device.

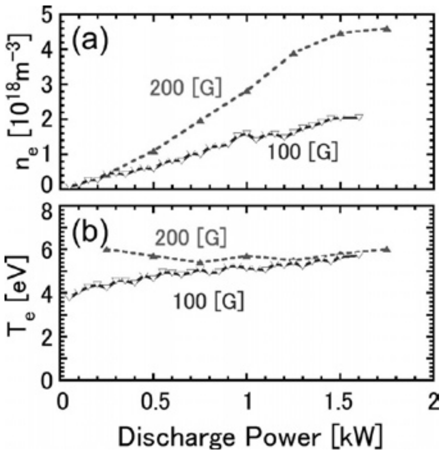

Fig. 2: (a) discharge power dependence of electron density and temperature, (b) profiles of electron density and temperature.

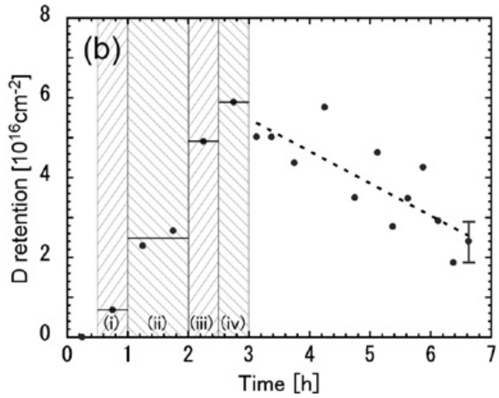

Fig. 3. Deuterium retention in ITER grade W measured with NRA. Hatched regions mean duration of plasma exposure. In the duration of plasma exposure, the sample surface temperature T_s, incident ion energy E_i, and ion flux Γ_i were 497 K, 17 eV, and 6.9×10^{19} m^{-2} s^{-1}, respectively. In (b), (i): T_s = 1000 K, E_i = 28 eV, $\Gamma_i = 2.9\times10^{20}$ m^{-2} s^{-1}, (ii): T_s = 900 K, E_i = 17 eV, $\Gamma_i = 2.9\times10^{20}$ m^{-2} s^{-1}, (iii): T_s = 600 K, E_i = 28 eV, $\Gamma_i = 6.8\times10^{19}$ m^{-2} s^{-1}, (iv) T_s = 568 K, E_i = 17 eV, $\Gamma_i = 6.8\times10^{19}$ m^{-2} s^{-1}.

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