§3. Development of Cesium-free Deuterium Negative Ion Source with Grid Bias Method

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Development of hydrogen/deuterium negative-ion source is performed as follows: (1) Control of the electron temperature T_e in the H^- production region is performed by the mesh grid bias method and the magnetic filter method in rf plasmas.[1] (2) The isotope effect on H^- and D^- production is investigated in dc plasmas with the magnetic filter.[2] (3) Surface production of H^+ and H^- on porous catalysts with hydrogen plasma irradiation is tried.[3] We report on the issues of (2) and (3) here.

Experimental setup of a dc arc-discharge negative ion source is shown in Fig. 1. The rectangular chamber with line cusp magnetic fields is 25 cm x 25 cm in cross section and 19 cm in axial length. Four tungsten filaments with 0.7 mm in diameter and 20 cm in length are set in the source region. An external magnetic filter (MF) composed of a pair of permanent magnets in front of a plasma grid (PG) has a role that the electron temperature T_e in the extraction region is decreased for H^- and D^- volume productions. An end-plate is kept at a floating potential and the PG is grounded here. Plasma parameters are measured by Langmuir probes, the negative-ion density is measured by a laser photodetachment method and a magnetic deflection-type ion analyzer.

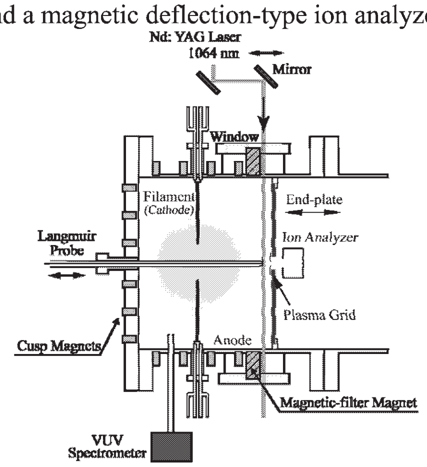

Fig. 1. Experimental setup with negative-ion measuring system of laser photodetachment method and magnetic deflection-type ion analyzer.

The plasma parameters in the extraction region in H_2/D_2 plasmas are obtained from the probe measurement, T_e come to decrease below 1 eV suitable for the H^- and D^- volume production due to the MF effects. D_2 plasmas with higher n_e and T_e compared with H_2 plasmas are generated under the same discharge conditions, and the properties of the plasma production and transport are different in those plasma. Thus, the stronger MF fields are required to control of T_e in D_2 plasmas. Maximum photodetached electron currents, which are measured by the Langmuir probe, are normalized by the steady electron saturation currents. The normalized currents $\Delta I/I_{dc}$ mean the existence ratios of negative ions, and $\Delta I/I_{dc} = 1$ and 0.5 denote $n_-/n_+ = 0.5$ and 0.33 ($n_e/n_+ = 1 - n_-/n_+$), respectively, where n_+ is the plasma density. Figure 2 (a) and (b) show $\Delta I/I_{dc}$ depending on the gas pressure and the MF intensity in H_2 plasmas and D_2 plasmas, respectively. As is clear from the results, the efficiencies of the negative-ion production in the H_2 and D_2 plasmas are different under the same discharge condition and the optimum control of the plasma parameters by external parameters needs to reveal.

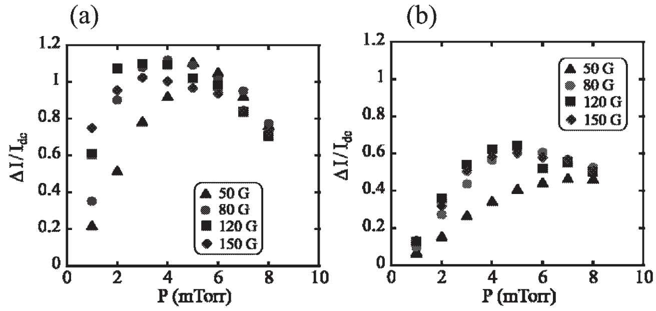

Fig. 2. Photodetached electron currents normalized by steady electron currents depending on gas pressure and MF intensity in (a) H_2 plasmas and (b) D_2 plasmas.

The new development of surface production method is tried using nickel porous catalysts. Hydrogen plasma produced by PIG discharge is irradiated to the porous plate, and the positive and negative ions are produced from the backside of the porous plate. The probe saturation currents I_+ and I_- are almost the same and the ionic plasma without electrons is generated downstream from the porous catalyst. I_+ and I_- depending on the discharged current I_a and the porous temperature T are shown in Fig. 3, where the porous catalyst is additionally heated by a sheath heater and the temperature can be controlled even though I_a is fixed and the irradiation condition is unchanged. The quantity of the ion production becomes larger as the irradiation density and the porous temperature are higher.

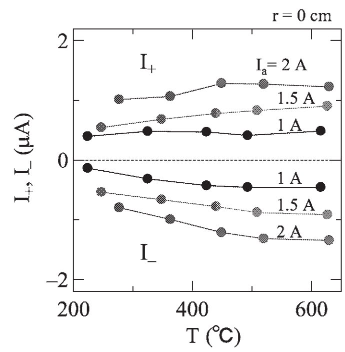

Fig. 3. Probe saturation currents of positive and negative ions depending on PIG-discharge currents I_a and porous-catalyst temperature T.

1) Fukumasa, O. et al.: AIP Conf. Proc. **1097** (2009) 109.
2) Fukumasa, O. et al.: AIP Conf. Proc. **1097** (2009) 118.
3) Oohara, W. et al.: Proc. PSS2009 & 26th SPP (2009) 328.