§13. Cs-free Negative Ion Production Inside the Extraction Aperture of Plasma Grid

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A plasma-assisted catalytic ionization method for the production of positive and negative hydrogen ions using catalyst has been proposed for generating a hydrogen pair-ion plasma and developing a highly efficient hydrogen negative-ion source without a Cs admixture.[1,2] Negative ions H^- are produced using a plasma grid and a control grid. The composition of charged particles is analyzed by a magnetic sector mass spectrometer.

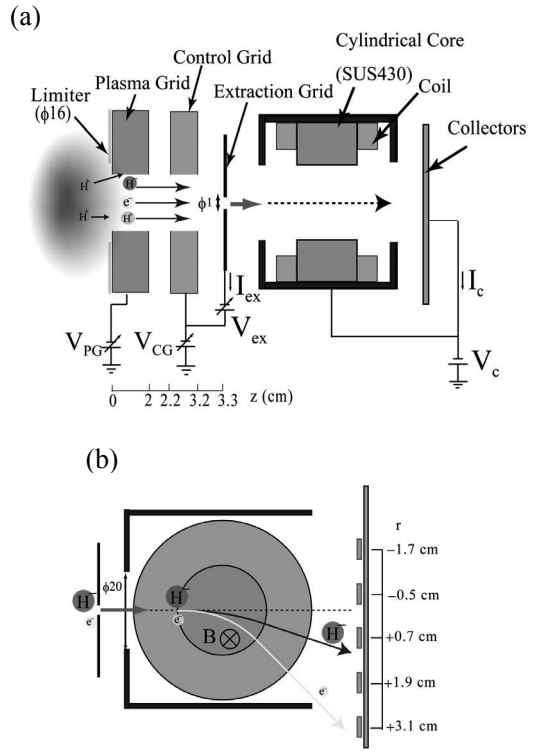

Fig. 1. Magnetic sector mass spectrometer, (a) side view, (b) top view.

A hydrogen plasma is generated by a dc arc discharge between filament cathodes and a wall anode in a cuboidal chamber with a cross section of 25 cm×25 cm, i.e., a bucket plasma source. Positive ions in the plasma are irradiated onto a plasma grid under controlled irradiation current density and energy. The plasma grid has a single aperture of 13 mm-diameter, which is made of aluminum (Al-PG). The grid is negatively biased at a dc voltage of V_{PG} and the irradiation energy is controlled by V_{PG} and the plasma potential ϕ_s. The irradiation current density J_{ir} is controlled by the discharge power. The control grid plays a role in the control of the electric field inside the aperture of the Al-PG for the negative-ion production. The charged particles are extracted by an electrode biased at V_{ex}, and pass through the pinhole of 1 mm-diameter and enter the mass spectrometer. They are deflected by the magnetic field B_d applied in a vertical direction and collected by segmented electrodes. The segmented electrodes biased at V_c are 0.6 cm in width and 3 cm in length, and attached to each 1.2 cm. Figure 1 shows a schematic view of the magnetic sector mass spectrometer.

The extraction-current characteristics are measured as functions of the bias voltage of the control grid V_{CG} and V_{ex}. The mass analysis of the negative and positive extraction current are found to be appropriate at $V_{ex} = V_{CG} \pm 200$ V, respectively. The collector current at $V_{CG} = -300$ V as a function of B_d is measured at the peripheral electrode of $r = 3.1$ cm, where the position of the pinhole is at $r = 0$ cm, as shown in Fig. 2. There are two positive peaks at $V_c = -700$ V, which denote H_3^+ and H^+. There are two negative peaks at $V_c = +400$ V, which denote e^- and H^-. The peak currents depend on V_{PG}, i.e., the irradiation energy of positive ions. It has become possible to measure the negative-ion current which is separated from the secondary-electron current that could not be ever.

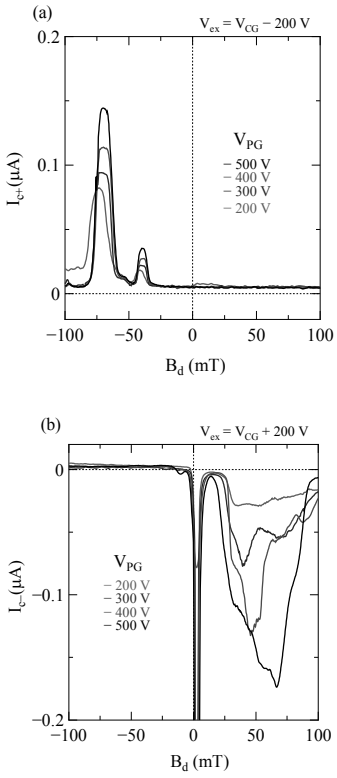

Fig. 2. Mass spectra of (a) positive ions and (b) negatively charged particles.

1) W. Oohara, H. Yokoyama, Toshiaki Takeda, Y. Maetani, Takashi Takeda, and K. Kawata, Phys. Plasmas **21** (2014) 063514.
2) W. Oohara, Y. Maetani, Takashi Takeda, Toshiaki Takeda, H. Yokoyama, and K. Kawata, Phys. Plasmas **22** (2015) 033507.