§20. Cs-free Negative Ion Production inside the Extraction Aperture of Plasma Grid

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As development of fundamental technology of hydrogen negative-ion source without a Cs admixture, negative ions are produced in an extraction aperture of a plasma grid. A hydrogen plasma is generated by a dc arc discharge between filament cathodes and a wall anode in a cuboidal chamber.[1)] The plasma is irradiated to a plasma grid made of aluminum (Al-PG) and positive ions in the plasma are brought in the extraction aperture of Al-PG. Al-PG is biased at V_{PG} and the incident energy of positive ions is controlled in the sheath formed in front of Al-PG. Positive ions are negatively ionized and become negative ions when they collide to the inner wall of the aperture and leave reflection with electron resonance transition from the metal surface. A control grid (CG), we call, controls the electric field for extraction of the charged particles in between Al-PG and CG by the biased voltage, $V_{CG} = \Delta V + V_{PG}$. Electrons are mostly removed by a magnetic field applied by permanent magnets embedded in CG. The negatively charged particles passing through the CG aperture are analyzed by a magnetic sector mass spectrometer. The charged particles 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 of the particle orbit and collected by segmented wire electrodes biased at V_c.

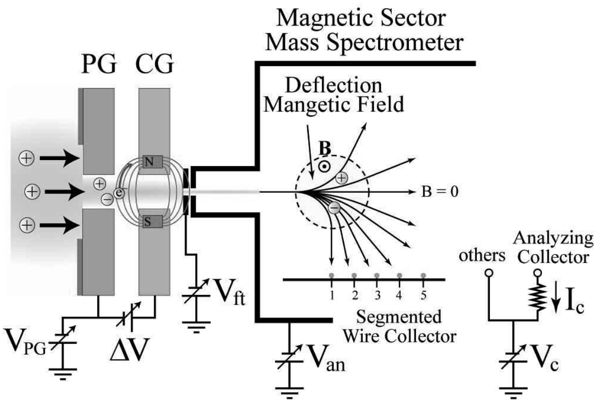

Fig. 1. Plasma grid, control grid, and magnetic sector mass spectrometer.

The negative currents I_{c-} of the collector 1 as function of B_d, i.e., the mass spectra of the negatively charged particles depending on V_{PG} are shown in Fig. 2, where the charged particles are not accelerated or decelerated in between Al-PG and CG at $\Delta V = 0$ V. There are a sharp negative peak at $B_d \sim 10$ mT and a negative peak at $B_d = -80 \sim -100$ mT, which denote e^- and H^-, respectively. There is also a very broad component at $B_d = -300 \sim 0$ mT. The H^- peak is disappeared and the broad component is only left at $V_{PG} < -4$ V. In the voltage condition of $V_{PG} = -10$ V that the broad component only appears, the negatively charged particles are extracted at $\Delta V > 0$ V. The mass spectra of them depending on ΔV are shown in Fig. 3, where V_{PG} is fixed at -10 V. The broad component is only extracted at $\Delta V < +40$ V, but H^- are also extracted at $\Delta V > +40$ V. It is found that H^- are detected as the broad component when there is a decrease in the relative energy of positive and negative ions. The component with a broad spectrum is usually considered to have a broad energy range. But it is unlikely that the component has a higher energy than the acceleration energy. At this present stage, the reason is not clear.

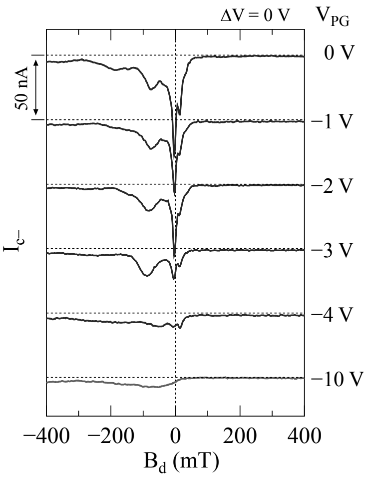

Fig. 2. Mass spectra of negatively charged particles depending on plasma-grid voltage.

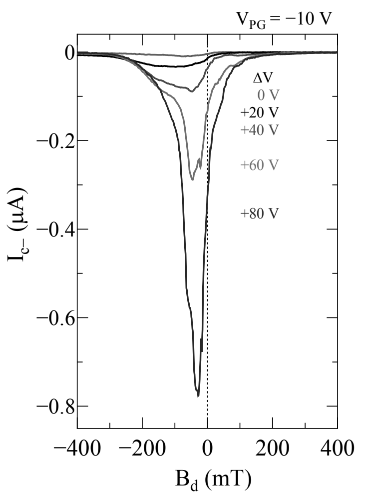

Fig. 3. Mass spectra depending on extraction voltage.

1) Oohara, W. et al. : Phys. Plasmas **22** (2015) 033507.