## §6. Polar Distribution of Ion and Electron Saturation Currents of Electro-Negative Plasma in Caesium-Seeded Negative Ion Source

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Electrons co-extracted with hydrogen negative ions ($H^-$ ions) contaminate the beam in negative ion sources dedicated for NBI. The electron current is blocked with the extraction electrode grid (EG), and the current causes a damage on the EG in the high-power and long-pulse beam extraction more than 10 sec duration. Reduction of the electron current is an important issue in the future NBI ion sources.

We have reported ion-ion plasmas including quite little electron density are produced in the beam extraction region of caesium (Cs) seeded hydrogen negative ion ($H^-$ ion) source for NBI[1)]. Although the result suggests the possibility of ideal negative ion source without the co-extracted electrons, the experimental result also shows the electron density increases to compensate the extracted $H^-$ charge density with applying electrostatic field for beam extraction[1,2)]. The electrons increased with the compensation can be extracted with $H^-$ ions, and it could be possible to reduce the electron current by controlling the electrons to diffuse to the extraction region. In order to investigate the diffusion path, we start to measure the electron flow in the extraction field by means of directional Langmuir probe, whose schematic view is shown in Fig. 1.

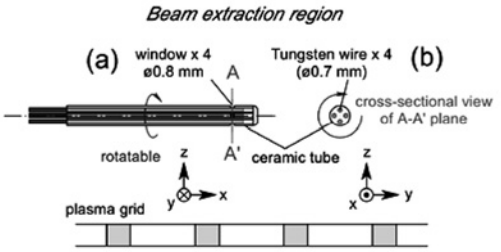


Fig. 1. Schematic view of the directional Langmuir probe in the directions parallel to the long axis (a) of the probe stem and the cross sectional view of the probe at A-A' line (b).

The probe made of ceramic stem with four parallel channels, where a tungsten wire is inserted in each channel. Four circular windows with 0.8 mm diameters are opened near the end of the probe stem. The probe stem is rotatable in the long direction of the stem, and movable in the directions of normal and parallel to the plasma grid (PG).

By applying an electrostatic field extracting $H^-$ ions, electron saturation current changes as shown in Fig. 2, whose shaded region indicates the beam-on duration. Though the ion saturation current changes slightly with the extraction field, the increasing ratio with and without the field is less comparing to that in the electron saturation current.

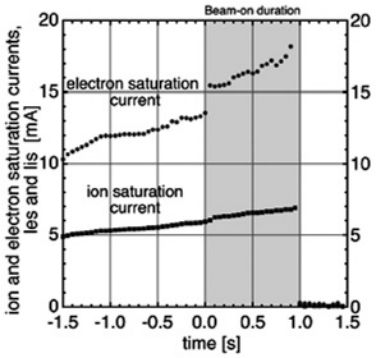


Fig. 2. Change of the electron saturation currents by applying the extracting electrostatic field.

Typical polar distribution of electron saturation current at the probe tip locating on the axis of PG aperture and on the center of neighboring apertures, on the PG metal, is shown in Fig. 3 (a) and (b), respectively. In both plots, the distance of the probe tip and the PG surface is the same value of 6 mm. The polar distribution on the PG metal indicates a sharper peak on the side of so-called driver (filament side), while the distribution is similar on the PG side. On the axis of the PG aperture, the magnetic file is almost parallel to the PG surface and the magnetic field forms a closed loop with the legs landing on the PG. On

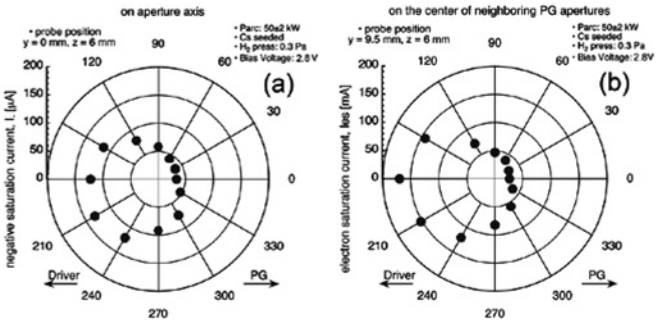


Fig. 3. Polar distribution of electron saturation current (a) at the probe-tip locating on the axis of PG aperture and (b) on the center of neighboring PG apertures. The probe tip locates at a distance of 6 mm apart from the PG surface.

the other hand, at the center of neighboring PG apertures, magnetic field intersects the PG surface normal and the magnetic field line links to the external magnetic filter separating the driver and extraction region. The difference of the polar peak in Fig. 3 suggests electrons access to the extraction region along the linkage magnetic field.

In this experiment, polar distribution of electron saturation current is obtained at a fixed distance from the PG surface. However, 2D scanning of the PG parallel and normal is necessary for further study.

1) Tsumori, K. et al: Rev. Sci. Instrum. **83** (2012) 02B116.
2) Nakano, H. et al.: AIP Conf. Proc. **1390** (2010) 359.