§8. Response of Electron to Bias Voltage in Large Negative Ion Source

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In negative ion sources for fusion researches, the electron is extracted along with the negative ion and the co-extracted electron causes the heat loading on acceleration grids. To suppress the co-extracted electron current the plasma grid is positively biased with respect to the plasma chamber and it has been experimentally observed that the co-extracted electron current gradually decreases with increasing the bias voltage, while the negative ion current remains constant at the low bias voltage. However, we have used the Langmuir probe for diagnostic of the ion source plasma and it has difficulty in obtaining the electron density precisely due to the weak magnetic field in the plasma chamber. Then, it has not been well understood how the electron near the PG responses to the bias voltage.

To obtain the electron density precisely, the surface wave probe (SWP), which is based on the resonant spectroscopy, was utilized and the response of the electrons in the NIFS 1/3-scaled negative ion source for LHD to the bias voltage was investigated with and without Cs seeding. Figure 1 shows the spatial profile of the electron density along the axis perpendicular to the PG in pure-volume plasma. In negative ion sources, the plasma is generated in the driver region and the electron seems to be diffused to the extraction region by the ion-driven ambipolar diffusion because these two regions are separated by the transverse magnetic field and the positive ion can traverse this field due to its larger Larmor radius and the electron follows it to keep the charge neutrality. Hence, the electron density monotonically decreases toward the PG in Fig.1. As can be seen in Fig. 1, the electron density in the pure-volume plasma significantly decreases with increasing the bias voltage. The plasma potential, which was measured with the Langmuir probe, is smaller than the bias voltage and it rises with increasing the bias voltage. This implies that the ion diffusion is reduced by applying the bias voltage and it results in the reduction in the electron diffusion to the extraction region.

When the surface production becomes a dominant process for the negative ion production, the response of the electron to the bias voltage shows the different property in Figure 2. In the Cs-seeded plasma, the electron density near the PG becomes lower than that in the pure-volume plasma, because the negative ion is mainly produced from the PG surface and the electron diffusion to the extraction region is reduced in order to maintain the charge neutrality. The negative ions near the PG surface also mitigate the effect of the grid bias on the electron and the electron density depends on the bias voltage weakly in the Cs-seeded plasma.

For the further work, the behavior of the electron will be investigated during beam extraction by the SWP to understand the mechanism of charged particle extraction from the ion-ion plasma where the fraction of the electron is significantly small.

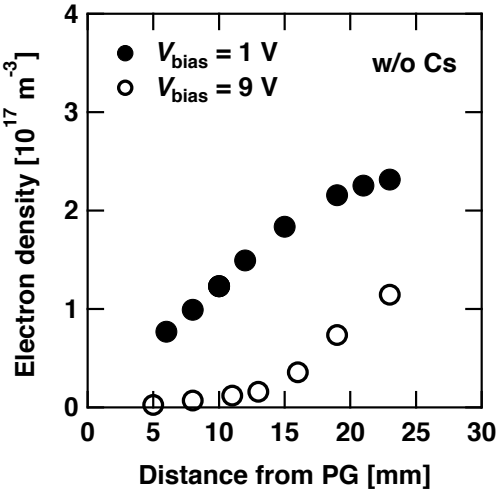

Fig. 1. Spatial profile of electron density along axis perpendicular to PG in pure hydrogen

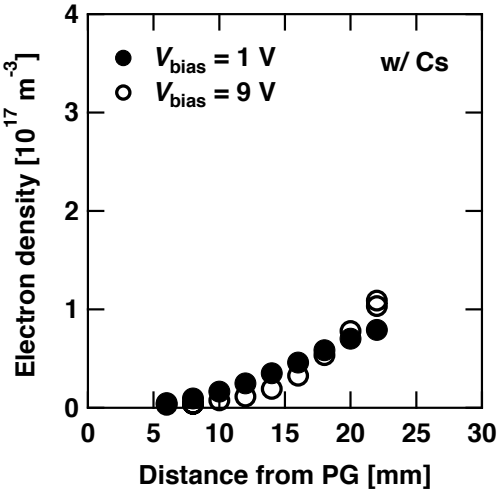

Fig. 2. Spatial profile of electron density along axis perpendicular to PG in Cs-seeded plasma.