§6. Electrostatic Response of Ionic Plasma in a Negative Ion Source for NBI

Tsumori, K., Nakano, H., Kisaki, M., Ikeda, K., Takeiri, Y., Osakabe, M., Nagaoka, K., Kaneko, O., Shibuya, M., Asano, E., Kondo, T., Sato, M., Sekiguchi, H., Komada, S.

Lower current ratio of the hydrogen negative ion (H^-) to electron is more suitable to negative ion sources to reduce damages of the beam accelerators in long pulse and high power beam injections. The current ratio changes with bias voltage and H_2 gas pressure to produce ion-source plasmas. The plasmas at so-called beam extraction region respond sensitively to the bias voltage and H_2 pressure. Ionic plasmas of quite low electron density are observed in the extraction region by seeding caesium (Cs) vapor to enhance H^- ions in the plasmas. In order to investigate how electrons, positive and negative ions behave with respect to bias voltage, a Langmuir probe and cavity ring-down (CRD) system has been combined to measure the ratios in the extraction region.

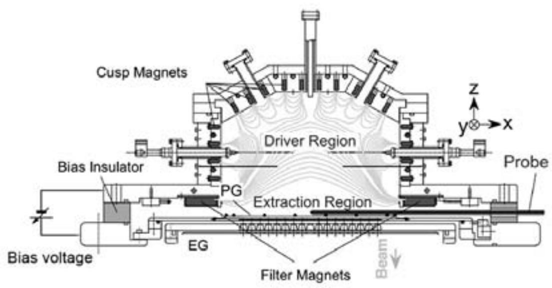

Fig. 1. Extraction and driver regions in the R&D ion source in NIFS NBI teststand. Connection of the bias power supply is shown on the left hand side.

A cross-sectional view of the R&D negative ion source in NIFS NBI teststand is shown in Fig. 1. The bias voltage is applied to plasma grid with respect to the arc chamber as indicated in this figure. The experiment has been carried out with the input arc power and H_2 gas pressure of 50 kW and 0.3 Pa, respectively. Positive and negative saturation currents is shown in Fig. 2 with respect to bias voltage, whose positive sign indicates a positive voltage is applied to the arc chamber. There is a lack of saturation currents and bias power supply cannot control the voltage there due to the internal resistance. The bias voltage is normally applied on the positive voltage side, and negative saturation current is gradually suppressed. In this source plasma, the plasma potential at driver region is about 4.6 eV and negative and positive saturation currents becomes equally at any bias voltage higher than the potential; i.e. ionic plasma is formed in the condition. On the other hand, increment of the negative saturation current becomes higher below the bias voltage less than the plasma potential. Electrons are included in the negative saturation current, and H^- density is measured with CRD to separate

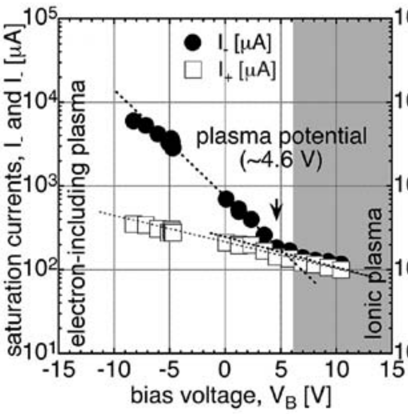

Fig. 2. Negative and positive saturation currents (closed circles and open squares, respectively) with respect to bias voltage.

the electron from the saturation current. The H^- density as a function of bias voltage is shown in Fig. 3. Electron density cannot be derived from the saturation current, because it is not clear the sheath formation of the ionic plasma. However, the monotonous decreasing character of the density to the bias voltage is the similar except for the range of ionic plasma. The H^- density goes down by increasing the bias voltage as well as negative and positive saturation currents. Although the saturation currents goes up monotonously by decreasing the bias voltage lower than the plasma potential, the H^- density increases and saturates

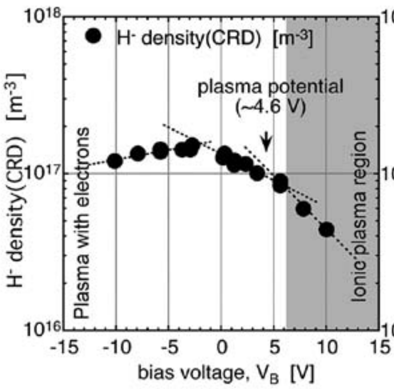

Fig. 3. Negative and positive saturation currents (closed circles and open squares, respectively) with respect to bias voltage.

at ~ -2 V. This shows the electrons increase when negative bias voltage is applied to the plasma grid with respect to the arc chamber. This feature suggests that the bias voltage affect to positive ions not to electrons magnetized with relatively strong magnetic field in the vicinity of plasma grid. Typical electron energy and magnetic strength at the extraction region are respectively 1 eV and 6 mT, and the radius is about 0.5 mm. On the other hand, gyro radius of proton is about 20 mm, and the electric field possibly affects to the ions, and electron reaches to the extraction region due to ambipolar diffusion.