§10. Electron Density Measurement of Large Scale Negative Ion Source

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In hydrogen negative ion sources for fusion researches, the negative hydrogen beam of several tens ampere is successfully produced with small fraction of co-extracted electrons by seeding a cesium. The enhancement of H^- production in the cesium seeded negative ion source is widely understood as the result that the production region changes from the plasma to the metallic surface, but the mechanism of reduction in the co-extracted electron current is not sufficiently clarified. One of the reasons to keep from accessing to study of the electron behavior is a strong magnetic field produced in negative ion sources. Recently, we confirmed that a surface wave probe (SWP), which is based on the resonant spectroscopy, is highly available for study of the electrons in the negative ion source using the small test cell.

To study the electron behavior near the extraction region, the SWP was installed into a 1/3-size negative ion source for LHD-NBI. Fig. 1(a) shows the schematic illustration of the experimental setup. The SWP is composed of a dielectric tube and a semi-rigid cable. In this study, the aluminum tube was selected because of its high resistance to heat. A network analyzer applies a radiofrequency power to the cable and detects the ratio of the reflected power to the applied power. The SWP is set over the aperture of a plasma grid (PG) and the distance between the central axis of the SWP and the PG is 10 mm.

The typical absorption spectrum is shown in Fig. 2. An electrostatic wave is excited at the interface between the aluminum tube and the plasma in the resonant condition and the incident RF power is strongly absorbed. In H^- ion sources, a bias voltage is applied between the PG and the arc chamber in order to suppress the co-extracted electrons. To investigate the effect of the bias voltage on the electrons near the PG, the electron density was measured at various bias voltages. Fig. 3 shows the variation of the electron density and the H^- ion density as a function of the bias voltage. The electron density is reduced by applying the bias voltage while the H^- ion density is almost constant. H^- ions become the dominant negatives at the bias voltage of more than 6 V.

The electron density in the large scale negative ion source was obtained with the SWP. However, the measurable range of the electron density was limited up to 10^{17} m^{-3} due to the constraint of the accessible frequency of the network analyzer. As the resonant frequency decreases with increase in the dielectric constant of the tube, the higher power experiment will be carried out with the zirconium tube whose dielectric constant is 4 times higher than that of the aluminum.

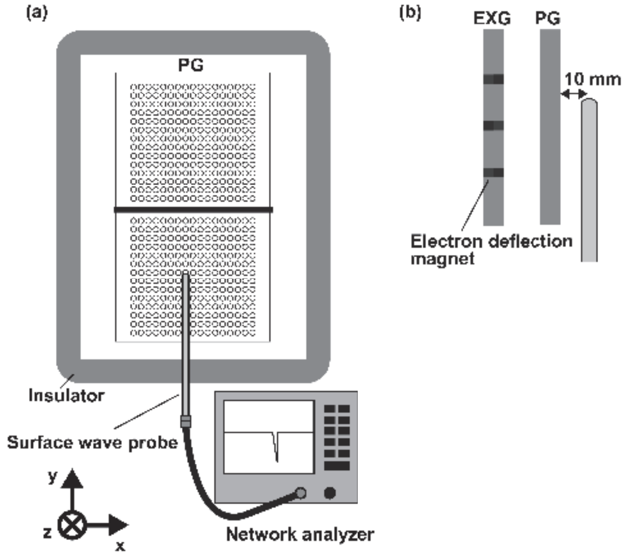

Fig. 1. (1) Schematic illustration of experimental setup, (b) positional relation of surface wave probe with PG,

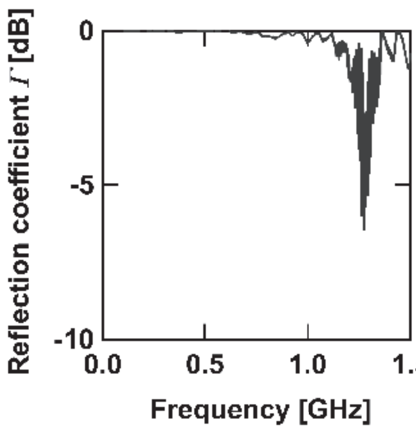

Fig. 2. Typical absorption spectrum.

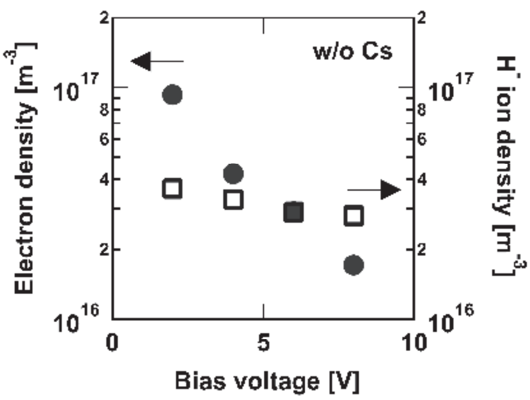

Fig. 3. Dependence of electron density and H^- ion density on bias voltage.