§21. Inductive RF Negative Ion Sources with Internal Metal Antenna

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In a negative ion source for neutral beam injection (NBI) of experimental nuclear fusion devices, a hot cathode discharge has been widely used. Instead of that discharge, a RF inductive discharge has been recently studied because no filaments are used. Filaments limit the lifetime of the ion source due to erosion and fatigue. However, even in the RF-driven source, degradation of insulation materials covering the plasma-immersed RF antenna makes the lifetime short. In the present study, we have developed a internal bare metal antenna system, and applied it to an RF negative ion source.

In a stainless steel vacuum vessel, 30 cm x 30 cm in crosssection and 20 cm in depth, a hydrogen plasma is generated by coupling 2 MHz RF power through a metal antenna electrically isolated by series-connected blocking capacitors. Negative ions extracted from the plasma through a magnetic filter are accelerated up to 10 keV in energy. Plasma parameters such as electron density, electron temperature and plasma potential are measured by Langmuir probe. At the same time, the extracted negative ion current is also measure by a collecting electrode which is negatively biased to suppress the secondary electron current.

Figure 1 shows a power dependence of electron density and electron temperature. Similarly to a conventional insulated antenna system, a stable plasma having a potential as low as ~20 V were obtained by the metal antenna system for the measured power up to ~10 kW. The electron density increases linearly with the RF power, however the absolute density is half that of an insulated antenna system. The electron temperature is approximately constant as ~4 eV. As shown in Fig. 2, the negative ion current is proportional to the square of the electron density, suggesting that the negative ion is produced via a two-electron process such as $H_2 \rightarrow H_2^* \rightarrow H^- + H$.

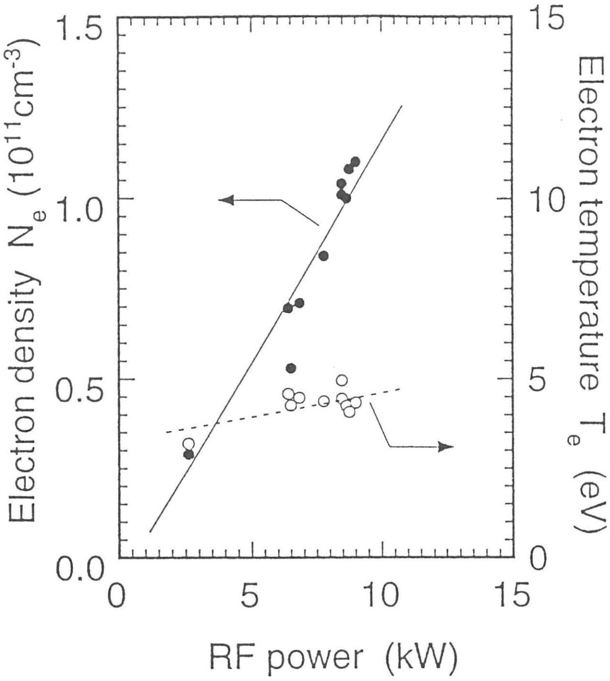

Fig. 1. Power dependece of electron density and electron temperature

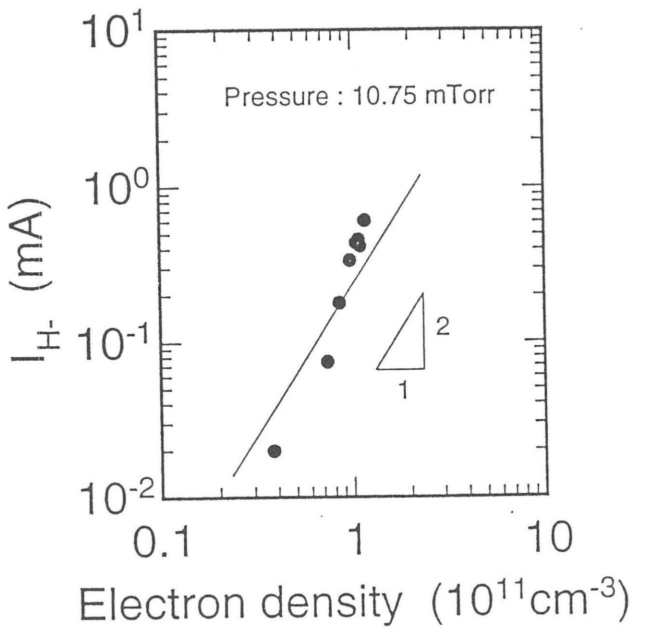

Fig. 2. Negative ion current I_{H^-} as a function of electron density