§30. 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 of no usage of filaments which 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 new bare metal antenna system, and compared with the conventional insulated antenna system. The influence of the magnetic filter on the plasma parameter is also examined.

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 conventioanl insulated antenna or a metal antenna electrically isolated by series-connected blocking capacitors. The discharge is turned on during 200 ms with the priod of 10 s. Negative ions extracted from the plasma through a magnetic filter are accelerated up to 10 keV in energy. Plasma parameters such as electron density and electron temperature are measured by Langmuir probe. The extracted negative ion current is also measured by a collecting electrode which is negatively biased to suppress the secondary electron current.

Figure 1 shows a density dependence of the extracted negative ion current. For the both antenna systems, the negative ion current increases with the electron density. However the slope of the line shows that the bare metal system gives more significant increase in the extraction current proportionally to the square of the electron density. This result suggests the negative ion production via a two-electron process such as $H_2 \rightarrow H_2^* \rightarrow H^- + H$. Figure 2 shows a time evolution of the electron density as well as the electron temperature in the discharge period for the insulated antenna. The electron density gradually increases up to ~100 ms, however, after that, the density abruptly decreases by a factor of ~5. Since the removal of the magnetic filter results in disappearance of the drastic change in the plasma parameters, it may be caused by a wave excitation in the leakage field from the magnetic filter.

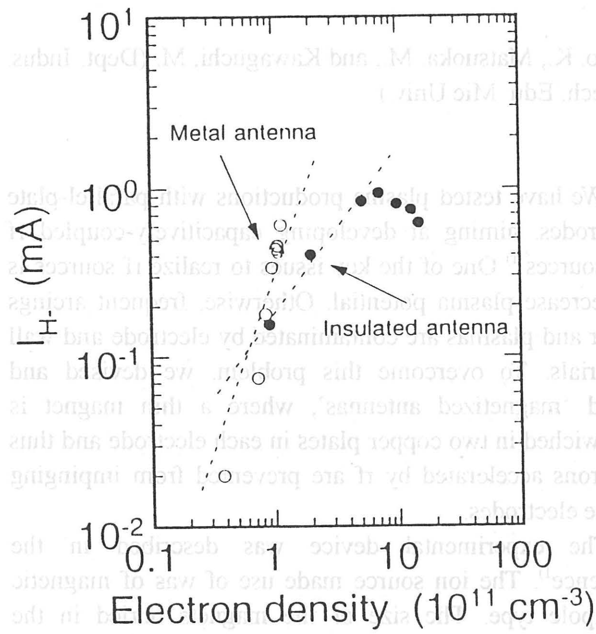

Fig. 1. Negative ion current I_{H^-} as a function of electron density

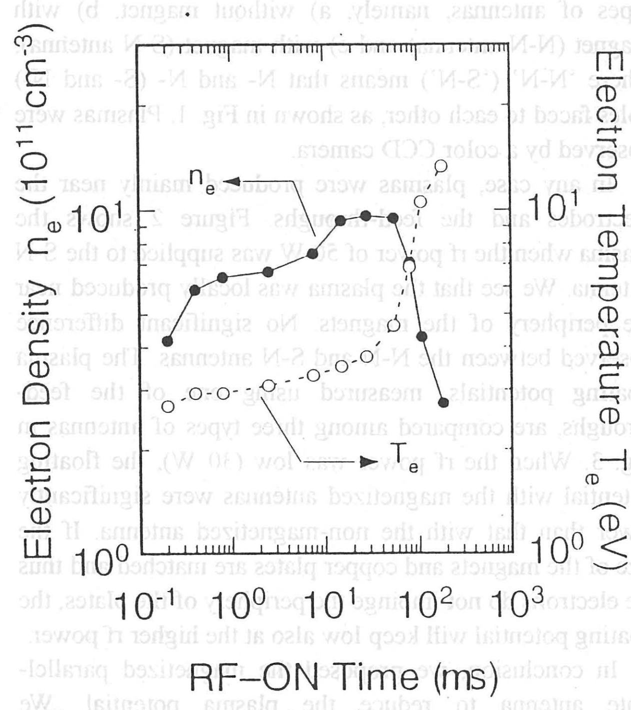

Fig. 2. Time evolution of plasma parameters