§25. Behavior of Negative Ions in Inductive RF Negative Ion Sources

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In a negative ion source for neutral beam injection (NBI) of nuclear fusion devices, a hot cathode DC discharge has been widely used. Instead of the DC discharge, a RF inductive discharge has been recently studied because of no usage of filaments which limit the lifetime of the ion source. In the inductive discharge, the plasma is mainly produced with electromagnetic (inductive) coupling, however, there are simultaneously capacitive coupling, and negative self bias appears on the insulated discharge antenna. Therefore, in the RF negative ion source, such a capacitive coupling may affect a production of negative ions. In this study, we measure a negative ion density based on laser-photo-detachment technique, and investigate a mechanism of negative ion production in the RF negative ion source of NIFS.

In a stainless steel vacuum vessel, 30 cm x 30 cm in crosssection and 20 cm in depth, a hydrogen plasma is generated by supplying 2 MHz RF powers through an insulated antenna. As shown in Fig. 1, the antenna conductor is electrically floated by two series-connected blocking capacitors. Laser-photodetachment technique is used to detect the hydrogen negative ions. In the center of the chamber, a Langmuir probe is located, and a flash-lamp-excited pulse YAG laser is irradiated onto the probe tip. From an increment of electron saturation current induced by the laser irradiation, density and fraction of the negative ions are obtained.

Figure 2 shows the electron saturation current and its laser-induced incremen (photodeteched electron current) as a function of net discharge power. The electron saturation current monotonically increases with the discharge power up to ~15 kW, whereas the photodetached electron current has a maximum at the discharge power of ~10 kW. A simultaneous probe measurements revealed that an electron temperature increases with the discharge power, thus density of high-energy electrons proportional to the electron temperature increases with the discharge power. The high-energy electrons contribute to a prodution of highly-excited hydrogen molecules required for the negative ion production, however enhance destruction of negative ions by electron impact. Therefore such a peak of negative ion density appears due to a competition between the production and destruction processes of the negative ions.

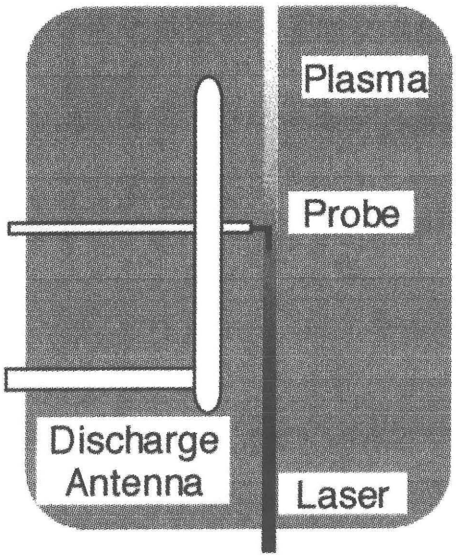

Fig. 1 Experimental Apparatus

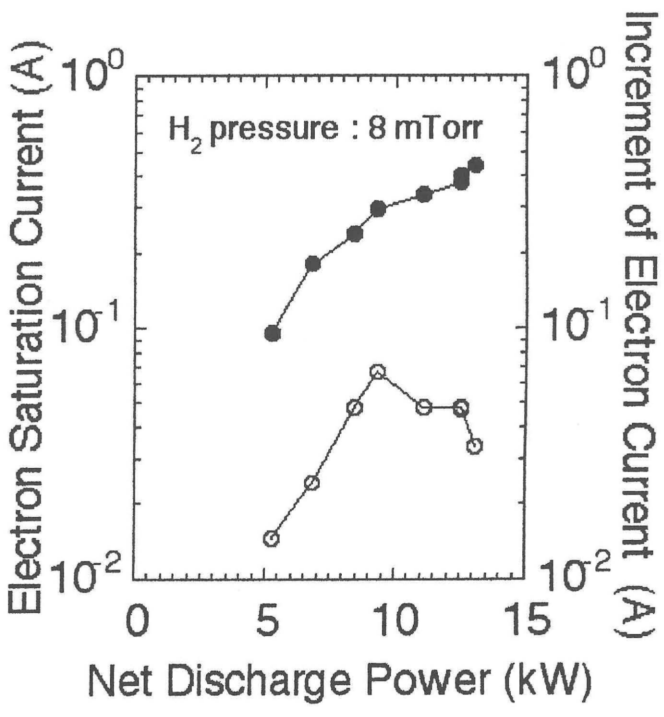

Fig. 2 Electron saturation current and laser-induced increment of electron current as a function of net discharge power