§5. Negative Ion Extraction from a Large RF Negative Ion Source

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Currently, typical ion sources in the neutral beam injection (NBI) system for nuclear fusion application are positive ion sources with cathode-filaments. The neutralization efficiency of the positive ion beam is extremely low at the high beam energy (> 100 keV/nucleon). On the other hand, neutralization efficiency of the negative ion beam remains high (60%) at more than several hundred keV. Thus, the negative ion source is essential for the next step NBI system. Moreover, the future NBI system requires a long maintenance period, because the next step fusion experimental devices will be operated in the D-T burning. Cathode-filament ion sources have short lifetime due to electrode erosion. An RF driven negative ion source is prospective to the long lifetime operation because of no cathode.

We have constructed an RF negative ion source[1], which has dimensions of 30 x 30 cm^2 in cross section and 19 cm in depth. This is a metal-walled bucket type source with the multicusp magnetic field for plasma confinement and the tent-filter field for separation of the negative ion production region (extraction region) from a plasma production region (driver region). An RF antenna as an induction coil which is immersed in plasma, is used for coupling the RF power to the plasma. An accelerator consists of plasma gird, extraction grid and grounded grid, and each grid has permanent magnets for the electron suppression. An extraction aperture of the plasma grid is 13 mm in diameter. An extraction voltage up to 4 kV is applied and, however, an acceleration power supply has not been available. An RF power supply provides 30 kW with the frequency of 2 MHz for 1 second (duty 1/30). The RF generated plasma parameters are 5-10 eV of the electron temperature and 370 mA/cm^2 of the ion saturation current density at the antenna vicinity (driver region). The ion saturation current density as a function of the RF power for various gas pressure is shown in Fig.1. The negative ion current was measured using a calorimeter array 83 cm downstream from the plasma grid. Fig.2 shows the RF power dependence of the negative hydrogen ion current. The negative hydrogen ion beam of 3.1 mA was extracted from the single aperture at the gas pressure of 13.1 mTorr.

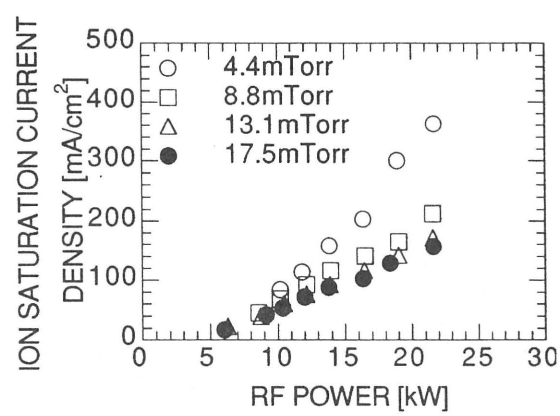

Fig. 1. Ion saturation current density at driver region.

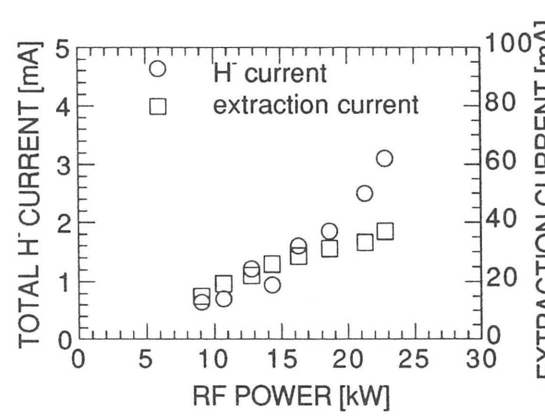

Fig. 2. Total H^- current and extraction current at 13.1 mTorr

References
1) Takeiri,Y.,*et al.* :Ann.Rep.NIFS(1992-1993) 60.