§6. Optimization of Magnetic Filter Field in a Large RF Negative Ion Source

Takanashi, T. (The Graduate University for Advanced Studies)
Takeiri, Y., Kaneko, O., Oka, Y., Ando, A., Tsumori, K., Kuroda, T.

A negative ion source is required for the neutral beam injection (NBI) system in the future nuclear fusion experimental devices, because the neutralization efficiency in high energy region (>100keV/nucleon) of negative ion is high. Moreover, the negative ion source should be operated with a long lifetime due to the limitation of accessibility to the radio-activated device.

We have constructed a large RF negative hydrogen ion source with a possibility of longer lifetime, which has no erosive electrodes. The ion source has an immersed induction coil antenna shielded from the RF plasma by quartz tubing. The dimensions of the RF plasma chamber are 30cm × 30cm in cross section and 19cm in depth[1]. Multi-cusp magnetic field is produced on the plasma chamber wall for the RF plasma confinement. A pair of permanent magnet rows facing to each other is attached to the chamber wall, which produce the magnetic filter field dividing the RF plasma into two regions - the driver region and the extraction region.

In the RF negative ion source, the electron temperature in the extraction region is higher than that in the filament - arc type source at the same filter strength. Figure 1 shows the dependence of the electron temperature in the extraction region on the filter strength. The electron temperature is decreased with increasing in the filter strength, and about 1eV at 1030Gauss.cm of the filter strength, where the peak filter field strength is about 100Gauss. Compared with the filament-arc type source, the required filter strength is almost double for reduction of the electron temperature of 1eV, which is suitable for an efficient negative ion production.

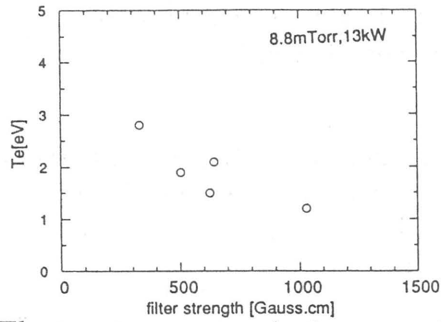

Fig.1. Electron temperature in the extraction region vs. magnetic filter field strength.

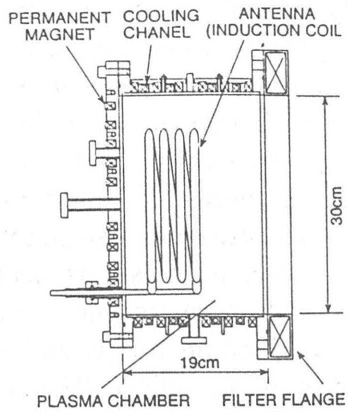

Fig.2. A schematic diagram of the RF source.

Figure 2 shows a schematic diagram of the RF negative ion source. From the above result, a filter flange, which contains a pair of strong permanent magnet rows, is attached to the RF plasma chamber for the strong filter field, as shown in Fig.2. The obtained plasma parameters in this RF source are: $1.5 \times 10^{12} cm^{-3}$ of the electron density and 5eV of the electron temperature in the driver region, and $4 \times 10^{11} cm^{-3}$ of the electron density and 1.5eV of the electron temperature in the extraction region, at 13.1mTorr of the gas pressure and 28W of the RF power. In the H^- extraction from a single aperture of 13mm in diameter, 5.5mA of the negative ion current was obtained at 13.1mTorr of gas pressure, 15kW of the RF power and 8.8kV of the extraction voltage.

From these results, it is considered that for the efficient negative ion production it is important to make the filter field stronger in the RF negative ion source.

References

1)Takanashi,T.,et al. :Ann.Rep.NIFS (1993-1994)66.