§21. Development of a High Frequency Negative Ion Source for the NBI System

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In the present negative ion sources of NBI systems, the source plasma is generated by dc arc discharge where a hot filament act as a cathode. The lifetime of the ion source is limited to several hundred hours due to erosion and fatigue of the cathode filaments and damage to the filaments by anomalous arc discharge. Thus, a long-lifetime ion source is required for future NBI systems. Electron cyclotron resonance(ECR) - discharge plasmas and radio frequency(RF) - discharge plasmas are promising as long-lifetime ion sources because they have no filaments.

In this project, mainly following two articles are studied experimentally:

①Production and control of both ECR plasmas (2.45 GHz) and RF plasmas (13.56 MHz).

②Application of these high frequency plasmas to negative ion sources for the NBI systems.

According to the present study, we have obtained and confirmed the following results.

(1) ECR discharge plasmas

We test the two types of magnetic field structure for the ECR field[1)], i.e. the line-cusp and the ring-cusp. The line cusp of permanent magnets provide both the resonance magnetic flux density of 875 G for 2.45 GHz inside the chamber (i.e., the annular region 10-15 mm from the chamber wall) and confinement of the produced plasmas. The ring-cusp samarium-cobalt permanent magnets are located just outside the chamber with facing same polarities at a separation of 4 mm. These permanent magnets provide the resonance magnetic flux density of 875 G for 2.45 GHz inside the chamber i.e., the annular region 15-20 mm from the chamber wall.

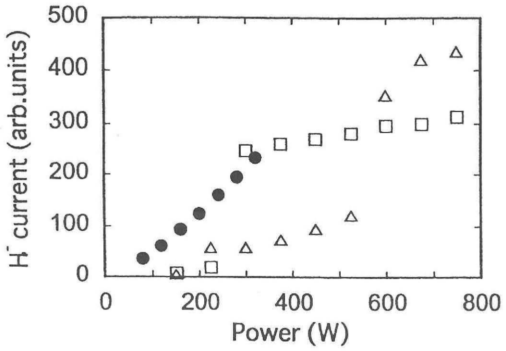

Fig. 1. Extracted H^- currents, vs P_μ, ●: dc plasmas (3mTorr), △: the line-cusp (3mTorr), □: the ring-cusp (1.5 mTorr).

Figure 1 shows the dependence of extracted H^- currents on P_μ, where extraction voltage $V_{ex} = 600$ V, For reference, the H^- currents in dc plasma is also plotted. The H^- currents in dc plasma is higher than those in ECR plasmas. For H^- production, *Te* and *Ne* of ECR plasmas in the second chamber are not controlled well by the magnetic filter. In addition, plasma production effiency, and also production of fast electrons, are not necessarily high compared with dc plasma production. Therefore, the optimization of plasma parameters for the H^- production is under study.

(2) RF discharge plasmas

Production and control of a capacitively coupled RF(13.56 MHz) plasma have been investigated. The RF plasmas are produced uniformly in the vessel by using the circular plane antenna. Typical example of axial distribution of plasma parameters are shown in Fig. 2. *Ne* is increased with the diameter of the RF antenna. Control of electron energy distribution by the magnetic filter is not well compared with the case of ECR plasmas although *Te* is reduced in the extraction region. High density plasma production and control of *Te* are under study.

References

1) Fukumasa, O. and Matsumori, M., Rev. Sci. Instrum. **71**, (2000) 935

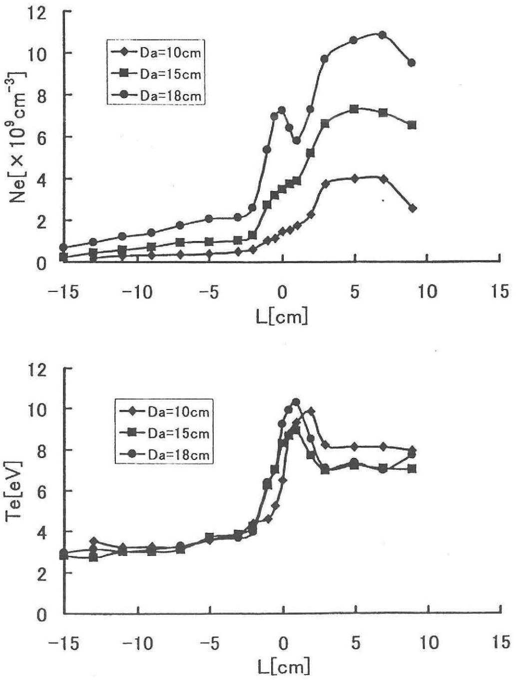

Fig. 2. Axial distributions of *Ne* and *Te* for three different RF antennas. The magnetic filter is set at L= 0 cm.