§4. Characterization of High-Density Helicon Plasma Source with Large Diameter and Short Axial Length for Negative Ion NBI

Shinohara, S., Tanaka, K., Motomura T.
(Interdis. Grad. Sch. Eng. Sci., Kyushu Univ.),
Kaneko, O., Tsumori, K.

In NIFS, high power neutral beam injection (NBI) heating utilizing negative ions has been actively executing Concerning the advanced, future plasma source in NBI, key issues are easier plasma production with a good stability, higher plasma density and higher ionization, and also developments of a large area plasma source with a short axial length. In addition, a low magnetic field operation is desirable due to the small effect on the ion source as well as from the viewpoints of the small necessary power supply and light weight. Here, the present objective is to develop and characterize a large area, high-density, low-field plasma source [1,2] with a small aspect ratio A, using a helicon wave scheme [3] in the range of radio frequency. Here, A is the ratio of the axial length to the diameter.

Experiments are carried out in the following conditions: The device diameter and axial length are 40 cm and 126 cm, respectively. With a fill pressure P (argon) of 3-10 mTorr using the modified device [2,3], as shown in Fig. 1, plasmas are produced by a RF wave of 7 MHz. The axial plasma size L is limited by the movable metal end plate. Plasma parameters (rf wave structures) are measured by Langmuir probes (magnetic probes). Typical plasma density and electron temperature were $10^{12} \sim 10^{13}$ cm^{-3} and 3 - 5 eV, respectively. Plasma light is monitored by the high speed (up to 1,200 fps) digital camera（CASIO EX-F1）.

Figure 2 shows the axial profiles of the electron density n_e, changing the axial length L. Here, the rf output power P_{rf} is 2 kW with a fill pressure P of 10 mTorr and the low magnetic field B of 50 G. In the case of L = 30 -125 cm, n_e does not change very much except for the region near the termination plate. However, with the decrease in L from L = 30 cm, n_e gradually decreases. A further reduction of L from L = 9.5 cm causes no high-density stable discharges. Note that even with L = 10 cm, which corresponds to A = 0.25, we have a high-density plasma of $n_e \sim 10^{13}$ cm^{-3}, and the obtained data are consistent with the predicted scaling of the plasma production efficiency [6] with the low A case that $N_e \propto P_{rf} L$, (in another expression $n_e \propto P_{rf}/a^2$). Here, N_e and a are total number of electrons and plasma radius, respectively.

In conclusion, we have successfully produced the large diameter (40 cm), high-density (~ 10^{13} cm^{-3}) helicon plasma with a short axial length down to 10 cm. The good plasma production efficiency is obtained, which is consistent with the expectation. These studies must be continued to have the optimum conditions to meet the real ion source requirements.

1) K. Tanaka, T. Motomura, K. Murakami and S. Shinohara: Int,. Cong. Plasma Phys., Fukuoka, 2008, FA.P2-004.
2) S. Shinohara, K. Tanaka, T. Motomura and K. Murakami: Bull. Am. Phys. Soc. **53** (2008) 174.
3) S. Shinohara: J. Plasma Fus. Res. **78** (2002) 5 (Review Paper, in Japanese).
4) S. Shinohara, S. Takechi, and Y. Kawai: Jpn. J. Appl. Phys. **35** (1996) 4503.
5) S. Shinohara, S. Takechi, N. Kaneda and Y. Kawai: Plasma Phys. Control. Fusion **39** (1997) 1479.
6) T. Tanikawa and S. Shinohara: Proc. 12th Int. Cong. on Plasma Phys., Nice, 2004, p.179, http://hal.archives-ouvertes.fr/hal-00002013/en/.

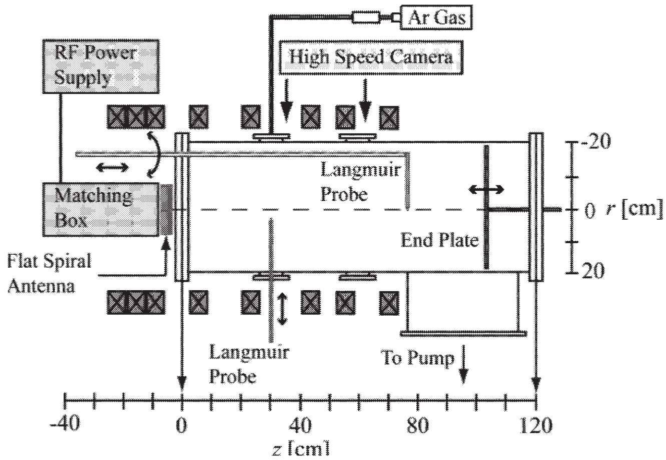

Fig. 1. Experimental setup.

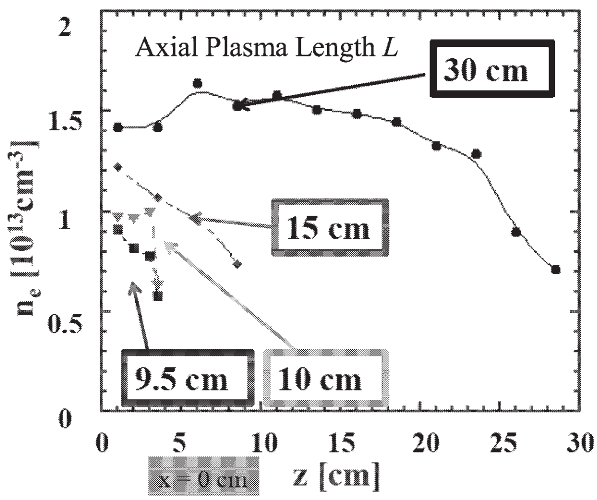

Fig. 2. Axial electron density profiles, changing the axial plasma length.