§ 19. Development of Deuterium Negative Ion Sources and its Database Construction

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In a tandem volume source, H^- ions are generated by the dissociative attachment of slow plasma electrons e_S (T_e〜1eV) to highly vibrationally excited hydrogen molecules $H_2(v")$ (effective vibrational level $v" \geqq 5$〜6). These $H_2(v")$ are mainly produced by collisional excitation of fast electrons e_f with optimum energy of about 40 eV. Namely, H^- ions are produced by the following two step process, i.e. $H_2(v")$ production and H^- formation:

$$H_2(X^1\Sigma g, v"=0) + e_f \rightarrow H_2^*(B^1\Sigma u, C^1\Sigma u) + e_f' \quad (1a)$$

$$H_2^*(B^1\Sigma u, C^1\Sigma u) \rightarrow H_2(X^1\Sigma g, v") + h\nu \quad (1b)$$

$$H_2(v") + e_S \rightarrow H^- + H \quad (2)$$

Production process of D^- ions is believed to be the same as that of H^- ions described above. To develop efficient D^- ion sources applying for the NBI system, namely to extract D^- ions with high current density, it is important to clarify production and control of H_2 and D_2 plasmas, and to understand difference in the two step process of negative ion production between H_2 plasmas and D_2 plasmas.

For this purpose, we are interested in estimating densities of highly vibrationally excited molecules and negative ions in the source. The production process for $H_2(v")/D_2(v")$ is discussed[1] by observing the photon emission, i.e. VUV emission associated with process (1b). H^- or D^- ions in the source are measured by the laser photodetachment method.

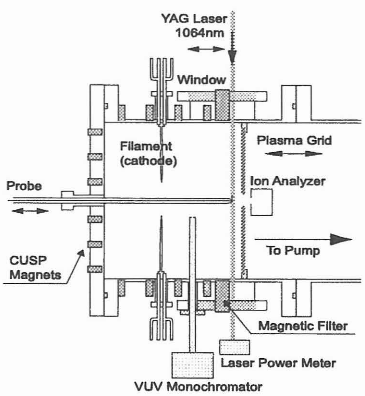

Fig. 1. A schematic diagram of the ion source.

In this paper, we present the preliminary results[2] concerning production and control of H^- ions in the source, and extraction of H^- ions from the source.

Figure 1 shows a schematic diagram of a rectangular ion source. The arc chamber (plasma generator) is 25×25 cm in cross-section and 19 cm in height. Four tungsten filaments of 1.0 mm in diameter are installed from the side walls of the chamber. The line cusp magnetic field consists of permanent magnets which surround the arc chamber. The external magnetic filter (dipole magnetic field) is produced by a pair of permanent magnets and the field separates extraction region from a high temperature bulk plasma produced by arc discharge between filament cathodes and the chamber anode.

Plasma parameters are measured by Langmuir probes. Negative ions in the source are measured by the laser photodetachment method. A magnetic deflection-type ion analyzer is used for relative measurements of the extracted H^- or D^- currents.

Figure 2 shows H^- ion densities in the source for two different magnetic filter fields (150G and 80G on the axis). Axial distributions of plasma parameters (n_e and T_e) were controlled by these two different magnetic filters. H^- ion densities have the different spatial distributions with each other.

Corresponding to those plasma conditions, extracted H^- currents are shown in Fig. 3 as a function of discharge power. Details concerning relationship between H^- ion density in the source and the extracted H^- current is under study. Production and control of D^- ions is also under study.

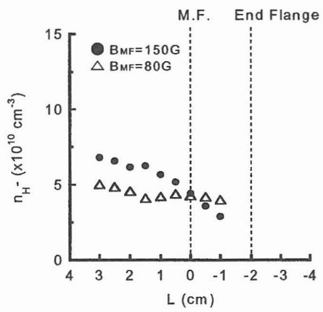

Fig. 2. Axial distributions of H^- ion densities. (350W, 1.5 mTorr)

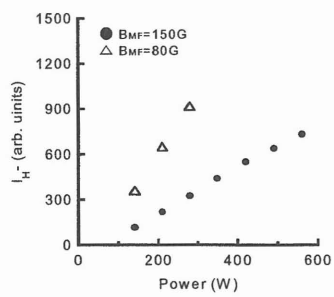

Fig. 3. Extracted H^- current. (1.5 mTorr)

References

1) Fukumasa, O. et al., 9th Inter. Symp. Pro. Neutral. Negative Ions and Beams (May 30-31, 2002).
2) Mori, S. et al., 30th IEEE Conf. Plasma Science (June 2-5, 2003).