§11. Production Mechanism of D^- Ions and Evaluation of D^- Ion Current Extraction

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In a tandem volume source, H^- ions are generated by the dissociative attachment of slow plasma electrons e_S ($T_e \backsim$ 1eV) to highly vibrationally excited hydrogen molecules $H_2(v")$ (effective vibrational level $v" \geqq 5 \backsim 6$). 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. We have studied relationship between negative ions (i.e. H^- and D^- ions) production[1, 2, 3] and plasma parameters across the magnetic filter (MF).

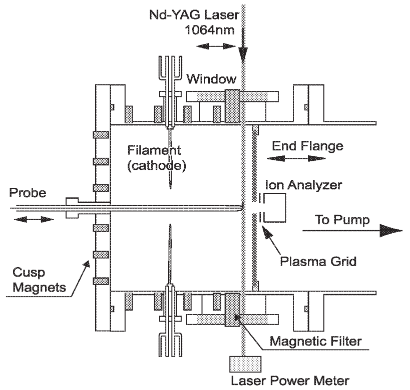

Fig. 1. Schematic diagram of the ion source.

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. Details of experimental procedures are reported elsewhere[3]. By varying the intensity of the MF, axial distributions of T_e and n_e in both H_2 and D_2 plasmas are changed strongly in the downstream region[2, 3].

Variations of H^- and D^- productions due to changes in plasma parameter distributions across the MF are discussed by taking into account main collision processes for production and destruction[4, 5], i.e. dissociative attachment (DA: $H_2(v")+ e \rightarrow H^- + H$) process and collisional electron detachment (ED: $H^- + e \rightarrow H + 2e$) process. Influence of D^- destruction by ED process on D^- density is higher than that of H^- distribution although n_e in D_2 plasma is higher than n_e in H_2 plasmas. Extracted D^- current is also lower than H^- current, and the ratio of H^- to D^- current is almost the same as the ratio of H^- to D^- density in front of the extraction hole. Therefore, extracted D^- current is mainly determined by D^- density in front of the extraction hole.

Figure 2 shows pressure dependence of (a) D^- ion densities in the source and (b) extracted D^- currents, where the intensity of the MF is a parameter. As a whole, the patterns of pressure dependence in D^- ion densities are nearly the same as those in extracted D^- currents. Namely, the extracted D^- currents are proportional to the D^- densities in the source. According to the results shown here and related other results[4, 5], the values of extracted negative ion currents are mainly determined by the negative ion densities in front of the extraction hole.

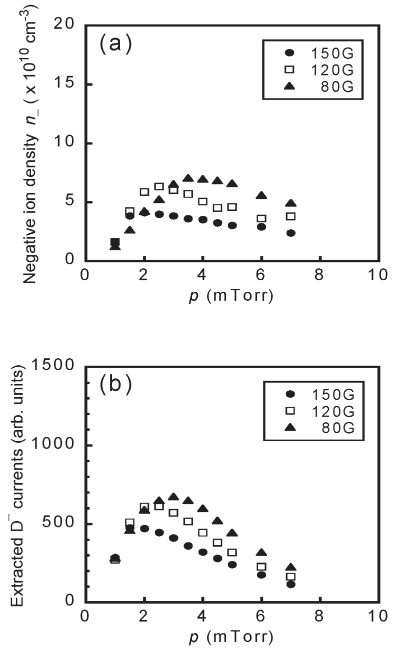

Fig. 2. Pressure dependences of (a) D^- ion densities in the source and (b) extracted D^- currents. Experimental conditions are as follows: V_d = 70 V, I_d = 5 A and V_{ex} = 1.5 kV. D^- ion densities are measured at z = -0.5 cm. Extraction hole is set at z = -1.5 cm. Parameter is the magnetic field intensity of the MF.

It is reconfirmed[4, 5] that T_e in the extraction region should be reduced below 1 eV with keeping n_e higher by using the MF, including good combination of filament position and the MF with a certain intensity. Control of not only T_e but also n_e in the extraction region is very important for enhancement of D^- production.

References

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2) Mori, S. and Fukumasa, O., 7th APCPST (2004).
3) Fukumasa, O. et al., Contrib. Plasma Phys. **44** (2004) 516.
4) Fukumasa, O. and Mori, S., 10th Int. Symp. PNNIB (2004).
5) Fukumasa, O. and Mori, S., 4th IAEA TCM on Negative Ions (2005).