§12. 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. We have studied relationship between negative ion (i.e. H^- and D^- ions) productions [1, 2,3] and plasma parameters across the magnetic filter (MF).

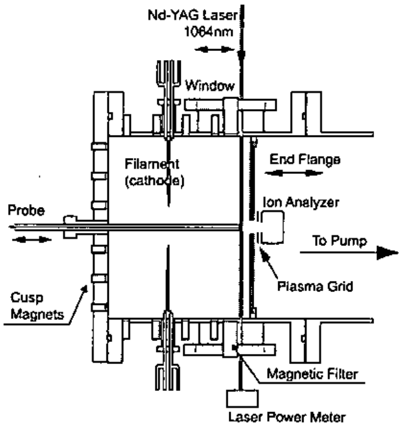

Fig. 1. Schematic diagram of the ion source.

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. 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]. Both patterns of T_e and n_e distributions are strongly dependent on the MF intensity.

D^- density distributions are compared to H^- density distributions in the same discharge conditions. Figure 2 shows axial distributions of photodetached electron signals and obtained negative ion densities, where B_{MF} = 80 G, $p(H_2) = p(D_2)$ = 1.5 mTorr, respectively. Axial distribution of D^- density is lower than that of H^- density. From viewpoint of plasma production, T_e in D_2 plasma is higher than that in H_2 plasma.

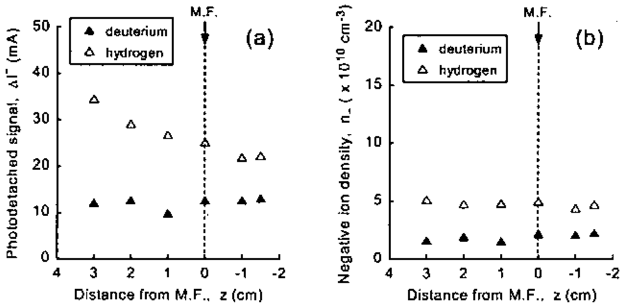

Fig. 2. Axial distributions of (a) photodetached electron signals from H^- and D^- ions and (b) obtained H^- and D^- ion densities. Experimental conditions are as follows: Vd = 70V, Id = 5A, $p(H_2 \text{ or } D_2)$ = 1.5 mTorr.

Variation of H^- and D^- production due to changes in plasma parameter distributions across the MF are discussed by taking into account main collision processes for production and destruction, 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.

It is reconfirmed [2,3] 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 H^- and D^- production.

References

1) Mori, S. et al., 30th IEEE Conf. Plasma Science (2003).
2) Fukumasa, O., 26th ICPIG (2003) Vol. 1, pp.13-14.
3) Mori, S. and Fukumasa, O., 7th APCPST (2004).