§25. Photodetachment Diagnostics of H^- Ion Sources and Improvement in H^- Production Efficiency

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High current H^- sources without filaments are desired for the next NBI system of thermonuclear fusion reactors. The most important thing for the efficient H^- production is to realize the three requirements: (1) efficient production of the excited molecules in a high electron temperature (T_e) region, (2) enhanced dissociative attachment to them in a low-T_e region and (3) production of a high electron density (n_e) plasma.

For the purpose of the efficient H^- production, we have produced a high-n_e hydrogen sheet plasma by helicon wave discharge. A high-T_e region and a low-T_e region were formed by the spatial control of applied magnetic field. A helicon plasma was produced in a linear machine with a uniform magnetic field of 220 G. The cusp field was superposed on the longitudinal field and a sheet plasma was formed [1]. The spatial profiles of H^- density (n_-) was measured by laser photo-detachment. The n_e, T_e and space potential (V_s) were measured by a Langmuir probe. This probe was also used to detect photodetached electrons from H^-. In this report, the correlation between the H^- production and the plasma parameters was discussed.

Figure 1. shows the spatial distributions of n_e and T_e. The electron density n_e was $8x10^{11}$ cm^{-3} at the center. A high-n_e plasma was produced. The electron temperature T_e was 7eV at the center and decreased to 1 eV at X=10 mm. The T_e profile was sharp, while the n_e profile was broad. A high-T_e region and a low-T_e region were formed in a high-n_e hydrogen plasma. Favorable condition for H^- production was attained. Figure 2 shows the spatial profile of n_-. The H^- density n_- was peaked at X=30 mm where the low-T_e and high-n_e region was formed. The peak value of n_e was $5x10^{10}$ cm^{-3}. The spatial distribution of V_s was shown in Fig.3. The plasma chamber was grounded. The space potential V_s was -40 V at the center and increased to 0 at X=40 mm. The hollow V_s profile was formed. This may be due to higher-n_e than the positive ion density in the center region. It is considered, therefore, that a high-energy electron component or an electron beam component exists in the high-T_e region, as can be seen in linear DC machine such as TPD. It is favorable for the production of the excited molecules which are produced by impact excitation of energetic electrons.

In conclusion, we have produced the high-n_e hydrogen sheet plasma. The spatial profiles of n_-, n_e, T_e and V_s were measured. By the spatial control of the T_e profile, the high-T_e region and the low-T_e region were realized in the high-n_e plasma. In the high-T_e region, the excited molecules are greatly produced by energetic electrons. The H^- ions were efficiently produced in the low-T_e region.

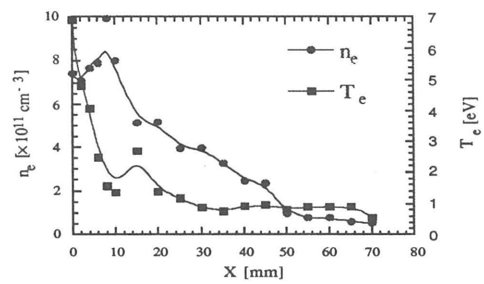

Fig. 1. Spatial distributions of n_e and T_e.

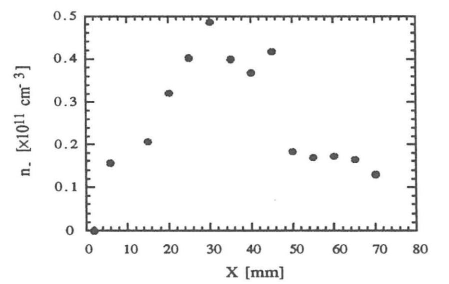

Fig. 2. Spatial distribution of n_-.

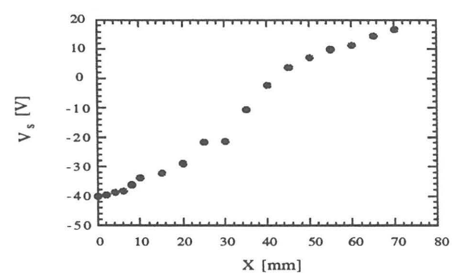

Fig. 3. Spatial Distribution of V_s.

Reference
[1]J. Uramoto, Research report of Institute of Plasma Physics, Nagoya University, Japan, IPPJ-574 (1982)