§5. Relation of H^- Extraction and Plasma Potential Structure in a Hydrogen Negative Ion Source

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i) Introduction

Hydrogen negative ion (H^-) sources have been sophisticated to obtain higher reliability and heating ability of neutral beam injection (NBI) systems. Additional knowledge of H^- physics in an ion source plasma is needed as fundamental information to their improvements. Especially, we should make clear H^- extraction physics for improvement of H^- extraction.

We have been studied H^- transport and extraction with two kinds of photo detachment techniques, PD-LP(photo detachment with Langmuir probe) and PD-FC(photo detachment with Faraday cup). Especially, we devised, and have been sophisticated PD-FC to measure H^- extraction probability from ion sources.[1] It gives information of H^- transport toward an extraction hole. Besides, we have been compared the experimental data to calculation one to obtain proper model of H^- transport and extraction. In the study, we focus influence of spatial structure of plasma potential on H^- extraction. [2]

ii) Experimental and calculation results

Fig.1 is spatial distribution of H^- extraction probability estimated by two kinds of photo detachment. It is about 3% at 3mm from plasma electrode(PE) surface. The value drastically decreases with the distance from PE. Fig.2 is spatial distribution of plasma potential in a direction of perpendicular to an ion beam axis. The figure shows a very interesting phenomenon. It includes experimental results in two conditions, namely with and without beam extraction voltage. We can confirm that the high extraction voltage gives slightly high plasma potential in front of the beam extraction hole. The potential hill leads to high H^- extraction probability; An electric field exists near the PE surface, even if there is no applying extraction voltage. It directs parallel to the ion beam axis. H^- extraction suffers from the field, in other words, it is a potential barrier. When the extraction voltage is applied to the ion source, the potential is locally changed like Fig.2. The potential change makes arise transverse electric field, which directs perpendicular to the ion beam axis, in front of the extraction hole. The field pulls H^- ions toward the extraction hole. In the process, the field will give H^- ions kinetic energy to overcome the potential barrier. As a result, the field helps the ions to reach the extraction hole, and H^- extraction is improved. Thus, the effect will drastically change H^- extraction probability from the ion source.

We confirm the potential effect with numerical calculation, which is H^- trajectory calculation by motion equation. The calculation takes into account the small potential hill referred from the experimental results in the Fig.2. As a result, H^- extraction probability drastically increases with potential hill case (Fig.1).

We experimentally confirm the potential change by extraction field, and make clear that the potential structure is key issue for H^- extraction from ion sources.

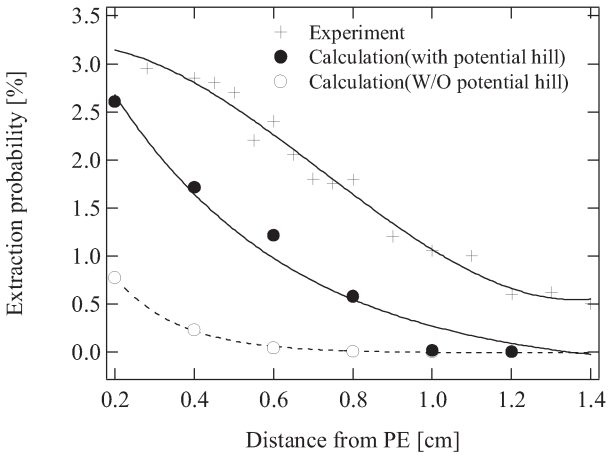

Fig.1 Experimental results and calculational results of extraction probability.

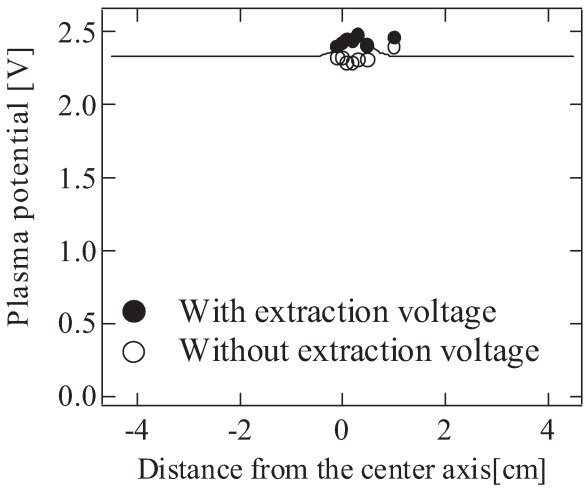

Fig.2 Influence of extraction voltage on spatial distribution of plasma potential.

1) Y. Matsumoto, M. Nishiura, K. Matsuoka, M. Sasao, M. Wada, and H. Yamaoka, "*Dependence of H⁻ Extraction Probability on Filter Magnetic Field and Gas Pressure of a Volume-Type Negative Ion Source*", Thin Solid Films Vol.506-507, 522-526 (2006)

2) Y. Matsumoto, M. Nishiura, M. Sasao, H. Yamaoka, K. Shinto and M. Wada, "*Importance of electric field for H⁻ extraction in a volume-type hydrogen negative ion source*", Rev. Sci. Instrum. **79**, 02B909 (2008)