§14. Study of H⁻ Extraction Mechanism from a Hydrogen Negative Ion Source with a Practical Extraction System

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Improvement of hydrogen negative ion (H^-) source contributes enhancement for heating ability of neutral beam injection (NBI) systems to fusion plasmas. However, basic knowledge concerned to performance of H^- sources including H^- extraction mechanism has not been enough understood. Our aim is contribution to development of higher efficient H^- source through revealing more advanced information of the H^- extraction mechanism. So far, we have used an ion source test stand having simple beam extraction system in experiments, which has only two electrodes, plasma and extraction ones. The simple system was specified for an H^- extraction study, because it allows us to use a simple numerical model in a simulation to save computation time. However, typical H^- sources in practical uses have more complex extraction systems, which is ordinary constructed with more than three electrodes. Purpose of our study here is to accumulate basic knowledge for H^- extraction mechanism under more practical and complex extraction systems.

Fig. 1 shows our experimental setup. The ion source chamber is 9 cm diameter and 11 cm height, and generates hydrogen plasma by hot electron emission from a pair of W filaments. H^- beam is extracted with 1 kV beam energy through the beam extraction hole located at center of the electrodes, whose diameters are 4 mm. Around the hole, filter magnetic field produced by a pair of permanent magnets exists to improve H^- yield by reduction of electron temperature in the plasma, whose strength is about 95 Gauss. H^- extraction characteristics is measured by two kinds of photodetachment methods, which use a Langmuir probe and a Faraday cup as detectors of photodetachment signals[1]. Especially, they give us averaged H^- extraction probability from a local region illuminated by a pulse laser light.

In last year, though we designed and installed new beam extraction system constructed with three kinds of electrodes, plasma, extraction and earth ones. However, the extraction system did not correctly work for beam focusing. We mainly adjust the electrode gaps to obtain their proper work as our first task in this year. As a result, H^- beam obtains good focusing and -2.7 μA at V_2 = 0.8 kV as a peak current.

Fig. 2 shows a dependence of H^- extraction probability on lens voltage V_2 when extraction voltage V_1 is fixed with 1 kV. We can see that the extraction probability largely decreases at V_1=0.2 kV. Spatial structure of plasma potential near the extraction hole critically affects H^- transport inside plasma. Thus, we expect that the drop of H^- extraction probability is caused by change of H^- transport trend due to variation of plasma potential structures near the extraction hole by influence of strong electric field induced by V_2. We measured space potential of the ion source plasma with a Langmuir probe varying V_2 voltage from 0 to 1 kV. However, the potential change is not clearly observed such as Fig. 2. Thus, the changes of the extraction probability in Fig. 2 may be caused by another reason: some H^- ions are destructed just after their extraction from the source by collisions with the extraction electrode. The V_2 may change the destruction ratio, because it probably affects beam trajectory due to remap of vacuum potential geometry downstream the ion source chamber. We will carry out numerical simulation to evaluate the H^- beam loss on the extraction electrode to understand the experimental result.

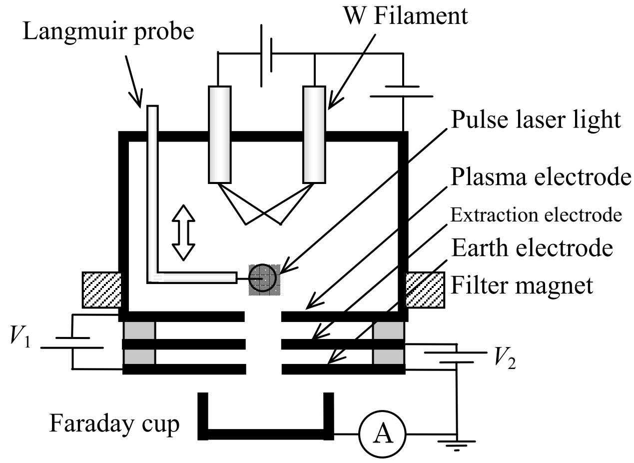

Fig. 1 Experimental setup

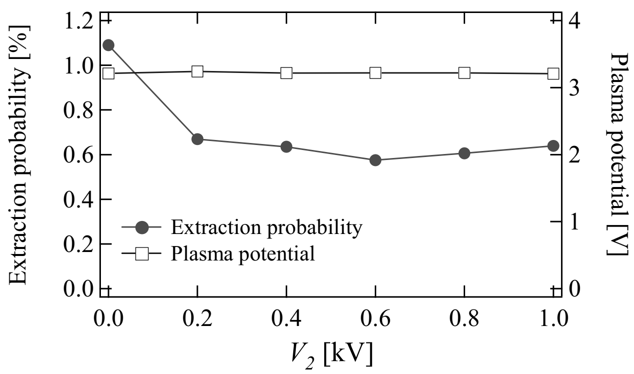

Fig. 2 Dependence of H^- extraction probability and plasma potential on the lens voltage V_2

1)Matsumoto, Y., Nishiura M., Matsuoka, K., Sasao M., Yamaoka H. and Wada, M.: Thin Solid Films Vol.506-507, 522-526 (2006)