§16. H^- Extraction Study for a Practical Beam Extraction System in a H^- Ion Source

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More improvement of hydrogen negative ion source is needed in order to obtain higher performance of neutral beam injection(NBI) systems. The extractable current density is mainly determined by H^- density and extraction efficiency from ion sources. It is well known that spatial distribution of plasma potential near the extraction hole is a key factor for H^- extraction efficiency. Extraction electric field induced by beam extraction high voltage between a plasma electrode(PE) and an extraction electrode(EE) affects plasma inside an ion source through an extraction hole. It changes plasma potential geometry near the extraction hole, and improve H^- extraction probability. In order to avoid complexity of model for calculational analysis, we have used a simple beam extraction system that is constructed with two electrodes, only a PE and an EE to study dependence of H^- extraction on plasma potential. We confirmed that plasma potential is changed by the influence, and it crucially helps H^- extraction from an ion source. However, multi-electrode system constructed with more than three electrodes is generally used for H^- beam extraction of ion sources. Vacuum potential induced by the multi-electrode system downstream of ion source might show different influence on ion source plasma against our simple extraction system. To accumulate more practical knowledge in general use of ion source, we should research H^- extraction and influence of the multi electrode systems on plasma potential.

Schematic diagram of our experimental setup is shown in Fig.1. Ion source chamber is 9cm diameter and 11cm height. Discharge is maintained with electron emission from filaments installed in an end plate. In this year, one more electrode is added into the present beam extraction system. The new extraction system is constructed with three electrodes, plasma, acceleration and deceleration electrodes. All of these extraction holes are 4mm diameter. A Langmuir probe installed from an end plate can measure plasma parameters even applying beam extraction high voltage.

As an operation test, we measure beam current dependence on deceleration voltage(V_2) with acceleration voltage(V_1) set to 1kV. Here, discharge voltage, discharge current and extraction voltage are 70V, 0.5A and 1kV, respectively. H_2 gas pressure in the ion source is 1.8Pa. Experimental result is shown in Fig.2. Now, our electrode has not been optimized, so that beam focusing is not observed by V_2. We will continuously optimize the electrode setting mainly adjusting gap length of extraction electrodes in next year.

Though we cannot realize desirable beam focusing property at present electrode setting, it is no doubt that high voltage is properly applied to each extraction electrodes. Therefore, as a preliminary experiment, we can at least confirm whether deceleration voltage affects plasma potential inside the ion source even under existence of beam extraction voltage. Langmuir probe measurement is carried out varying applied voltage V_2 under setting V_1 is 1kV. Experimental result is shown in Fig.2. Dependence of V_2 on plasma potential is not observed in this discharge condition. Meanwhile, in order to check influence of only acceleration voltage V_1 on plasma potential, we also carry out Langmuir probe measurement with two kinds of V_1 voltage 0kV and 1kV, under V_2=0kV condition. We can confirm increment of plasma potential about 0.1V due to the change of V_1 voltage. In this discharge condition, variation of plasma potential is mainly determined by acceleration voltage V_1. Deeper research will be carried out with various discharge parameters in next year.

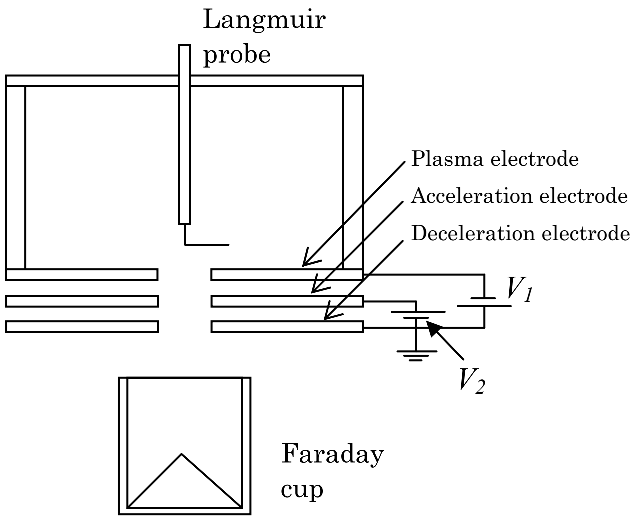

Fig. 1 Experimental setup

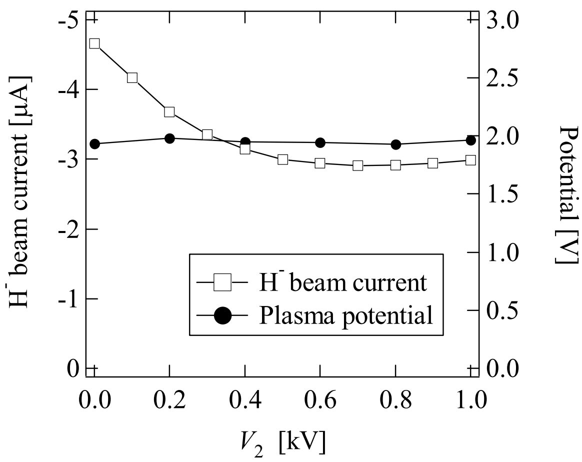

Fig. 2 Dependence of H^- beam current and plasma potential on deceleration voltage V_2