§14. Influence of Electron Suppression Magnetic Field on H⁻ Extraction in Hydrogen Negative Ion Source

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Hydrogen negative ion (H^-) sources have been utilized as beam sources of Neutral Beam Injection (NBI) systems. More efficient sources have been required to obtain higher heating ability for plasma with NBI. Tandem type negative ion source is generally adapted to this application, whose ion source plasma has two kinds of electron temperature regions separated by filter magnetic field to improve H^- yield. In high power sources, another magnetic field is utilized to reduce heat load of extraction electrodes by irradiation of electron beams extracted together with H^- ions. The electron suppression magnets embedded into plasma electrodes realize lower electron beam current by reduction of electron density near the extraction hole. However, it also changes H^- extraction performance due to influence on spatial distribution of plasma parameters and H^- ions near the hole. To understand the influence for development of higher efficient sources, we study role of magnetic field on H^- extractions changing conditions of two kinds of magnets with experimental and numerical approaches.

In experiment, we use a test stand having a small ion source whose apparatus is shown in Fig. 1. The ion source chamber is cylindrical shape with 9 cm diameter and 11 cm height. H^- ions are extracted from a single aperture located at center of a plasma electrode. Filter magnetic field is formed in perpendicular direction to a center axis of the source by a pair of permanent magnets attached on sidewall of the chamber. Strength of the filter field is about 95 Gauss at a beam extraction hole. Meanwhile, our current experimental system does not have electron suppression magnets. We will install permanent magnets onto surface of an extraction electrode, which is located downstream of the plasma electrode, to reasonably simulate effect of the magnets, because our plasma electrode is too thin to embed it. Measurements of two kinds of photodetachment methods whose detectors are a Langmuir probe and a Faraday cup are used to estimate local H^- extraction probability from the ion source[1)] changing these magnetic field conditions. The experimental results are analyzed by 2D3V Particle-In-Cell (PIC) simulation. Collisions between particles and cesiated effect are not taken into account in the present code.

In this year, we carry out PIC calculation to obtain favorable layout of the electron suppression magnet as preparation of experiments in next year. Vector field in Fig. 2 shows influence of the suppression magnets in the *x-z* directions, whose strength at the plasma electrode surface is about 300 Gauss as maximum value. A contour plot of electron density is superimposed to the field in the figure. We can see that electrons concentrate along the magnetic field lines. Meanwhile, lower electron density is observed in weak magnetic field region includes front of the extraction hole. We confirmed the magnets in this layout enable to reduce electron density due to effectively work as the suppression field. We will carry out experiments with the magnetic layout in next year to understand influence of the suppression magnets on H^- extraction.

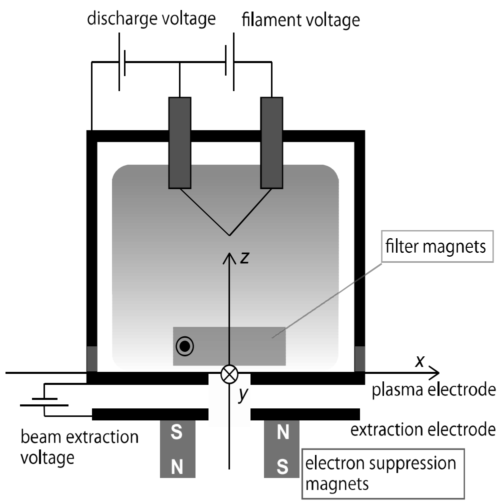

Fig. 1 Experimental setup

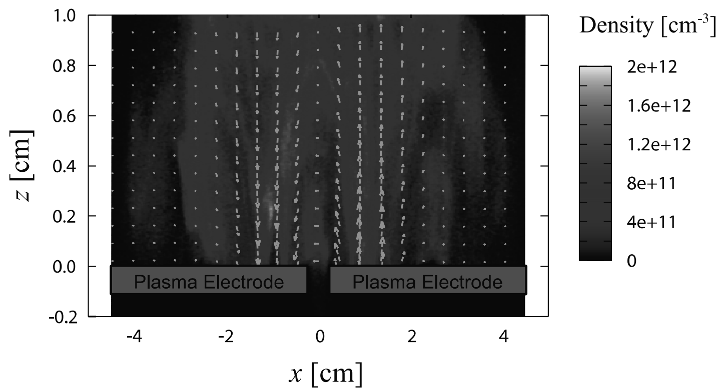

Fig.2 Magnetic field represented with vector field and a contour plot of electron density in *x-z* plane

1) Matsumoto, Y., Nishiura M., Yamaoka H., Sasao M., and Wada, M. : Rev. Sci. Instrum. 85, (2014), 02A720