§3. Plasma Potential Simulation for Improvement of Beam Extraction Efficiency from a Negative Ion Source

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Higher efficient sources of hydrogen negative ion (H^-) beam for neutral beam injection(NBI) systems should be developed to obtain higher heating power and stability requested by ITER and future fusion reactors. One of approaches for the development is enhancement of H^- extraction probability from ion sources. The goal of our study is to make clear the H^- extraction mechanism as a fundamental knowledge for ion source improvements. Especially, we note a relation between a plasma potential structure and H^- extraction, since we concluded that the relation is most important for H^- extraction, in previous work[1): Strong beam extraction electric field penetrates into an ion source plasma though an beam extraction hole. It changes the plasma edge and affects H^- transport in the plasma and extraction. A potential hill just in front of the extraction hole induced by the field penetration effect is most important for H^- extraction. To understand H^- extraction physics, construction mechanism of the plasma potential geometry near an extraction hole is indispensable. Besides, when we design ion sources, optimizing H^- extraction efficiency, we will need a calculational tool to expect a potential structure in ion sources. Thus, we construct and sophisticate two dimensional Particle-In-Cell(PIC) code as plasma potential calculation tool in an ion source.

A small negative ion source which is set up in NIFS is our calculation target.[2)] The ion source is a cylindrical shape with 9cm diameter and 11cm height. It has two type movable Langmuir probes for a parallel and perpendicular direction to a beam axis. We can obtain plasma potential profiles for the two directions with them. The probe system can be used with the high beam extraction voltage applied, to observe influence of strong electric field on the ion source plasma. These experimental data is used for code check and sophistication processes to make reliable PIC code.

A calculational result of plasma potential geometry near the extraction hole is shown in Fig. 1. Now, we are in code test phase, therefore, the program runs with simple calculation condition whose beam extraction voltage is 0kV. In this figure, the x and z axis are defined as perpendicular and parallel direction to H^- beam axis, respectively. A line of x=0cm is an ion source center axis. A plasma electrode(PE) is located on z=0cm line. Besides, the extraction hole exists at x=0cm and z=0cm. The calculation result has similar geometry to an experimental one measured by Langmuir probe experiment. For more detail research, we compare the calculation result to experiment directly. Fig. 2 shows ratio of plasma potential of calculation to experiment along the ion source center axis. This is below 0.3 for all positions, and we can not obtain correct absolute value of plasma potential with our current code. The discrepancy increases toward the PE surface. Therefore, we consider that assumption of boundary condition causes the error. We continue correction processes to sophisticate the code.

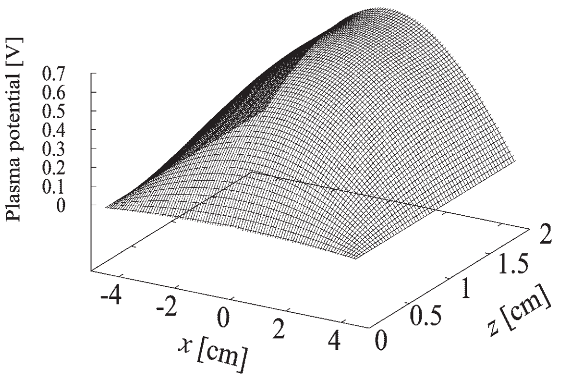

Fig. 1. Plasma potential geometry calculated by PIC. Beam extraction voltage is 0kV.

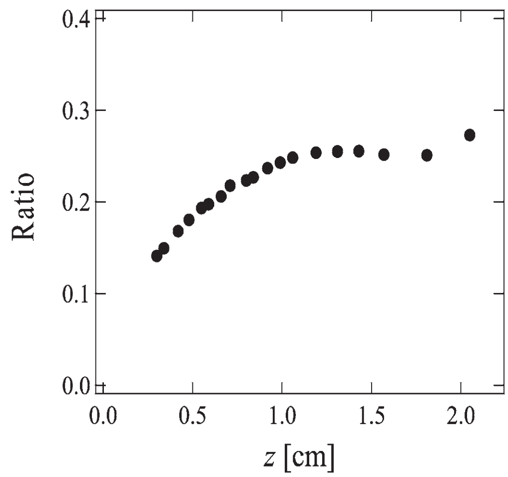

Fig. 2. Ratio of calculation to experimental result in plasma potential

1) Y. Matsumoto et.al., Rev.Sci.Instrum., **79** (2008) 02B909.
2) Y. Matsumoto et.al., Thin Solid Films **506-507** (2006) 522-526.