Modeling of the plasma electrode bias in the negative ion sources with 1D PIC method

[1]D. Matsushita, [1]S. Kuppel, [1]A. Hatayama and [2]M. Bacal
[1]*Graduate School of Science and Technology, Keio University, Japan*
[2]*Laboratoire de Physique et Technologie des Plasmas, Ecole Polytechnique, UMR 7648 du CNRS, France*

The effect of a DC bias voltage in negative hydrogen ion sources has been modeled in this study. Negative ion sources have been developed to produce intense beams for efficient heating of fusion plasma. For the optimization of negative ion extraction, a DC bias voltage is positively applied to the plasma electrode (PE) with respect to the ion source chamber [1]. However, the effect of a DC bias on negative ion extraction has not been theoretically understood until now. This bias voltage is thought to modify the plasma potential profile near the PE and consequently improve the negative ion extraction efficiency. Thus, it is necessary to model the effect of such a bias in the negative ion sources.

In this study, 1D3V particle-in-cell (PIC) method is applied to model the effect of the bias. Hydrogen plasma (H^-, H^+, and electrons) is modeled from the PE to plasma bulk boundary. At the PE, the potential is fixed, while the electric field is fixed at the plasma bulk boundary. Plasma parameters (density, temperature) are given based on the experimental data. All the particles are loaded randomly in the system and their velocities are picked up from Maxwellian distribution. The particles pass through the plasma bulk boundary are re-injected immediately. The particles hitting the PE are removed from the calculation. To simulate the bias voltage, plasma current in the system is specified. The calculation is repeated until the system reaches the steady state.

The dependence of electron current on the bias voltage is calculated to verify the PE bias. The result shows the model well reproduces the V-I characteristics of Langmuir Probe. The detail comparison of these numerical results with the experimental results will be discussed and presented. In order to simulate more realistic conditions, the collision with neutrals and charged particles will be introduced using Monte Carlo method. Some different models of particle sources (e.g. volume H^- / surface H^- production) will be used to clarify how it influences the potential structure near the PE.

Based on these experiences, 2D3V PIC modeling of the bias and analysis of its effect upon the H^- ion extraction yield is now under way [2].

References

[1] P. Svarnas, J. Breton, M. Bacal and R. Faulkner., IEEE Trans on Plasma Sci., vol. 35, no. 4, pp. 1156-1162, (2007).
[2] S. Kuppel, D. Matsushita, A. Hatayama and M. Bacal., 1st Int. Conf. on NIBS 2008 (to be presented.)