§12. Clarification of Production and Extraction Mechanisms of High Density Negative Ions

Kojima, A., Hanada, M.,
Yoshida, M., Kashiwagi, M. (JAEA),
Kisaki, M., Tsumori, K., Nakano, H.

In advanced fusion devices such as LHD, JT-60SA and ITER, fusion plasmas are heated by high-power high-energy neutral beam injectors where large-scale negative ion sources are equipped. These negative ion sources have a big advantage of high neutralization efficiency compared to positive ion sources, however, the negative ion current density is much lower than that of the positive ion sources. Therefore, the increase of the current density based on physics understanding is one of the issues for the development of negative ion sources.

In negative ion sources, the negative ions are produced on the surface of the plasma grid whose work function is lowered by cesium coverage. These negative ions are extracted by the extraction voltage between the plasma grid and the extraction grid as shown in Figure 1. By penetration of the extraction electric field to the plasma region, the extraction surface, so-called meniscus, is formed on the plasma grid. Thus, the plasma grid plays an important role for both of the negative ion production and extraction, however, the physics is not fully understood theoretically and experimentally.

This time, the effect of configuration of the plasma grid has been investigated to improve the negative ion production. In this experiment, the aperture shape of a plasma side on the plasma grid was varied from original straight-type to taper-type whose opening angle ranged from 60 to 80 degree as shown in Figure 1, 2(a). The negative ion current extracted from each aperture shape were estimated individually from the temperature profile on the beam target, and the current density at the plasma grid was evaluated. As a result, the aperture shape significantly affected the current density which varied from 0.8 to 1.1 on the normalized values by that of the original shape. Among these variation, the opening angle of the aperture shape was found to have optimum value around 60 degree where 1.1 times larger current density was obtained. The increase of the current density is caused by the improvement of the extraction efficiency and increase of the negative ion density on the plasma grid. In order to separate these effects, the direct measurement of the negative ion density near the aperture should be tried in future.

The beam width from each type of the aperture shape has been also investigated as shown in Figure 2(b). In this experiment, only the arc power was increased at the same extraction voltage of 6.8 kV. Although the obtained current density was different in each type of the aperture shape, similar beam width was measured at the same current density. This result suggested that the meniscus formations for the core component of the beam were not changed between the original and taper types. Detail measurements with an emittance scanner are required to understand the formation of the meniscus structure.

These results implied the improvement of the negative ion current by controlling the aperture shape of the plasma grid.

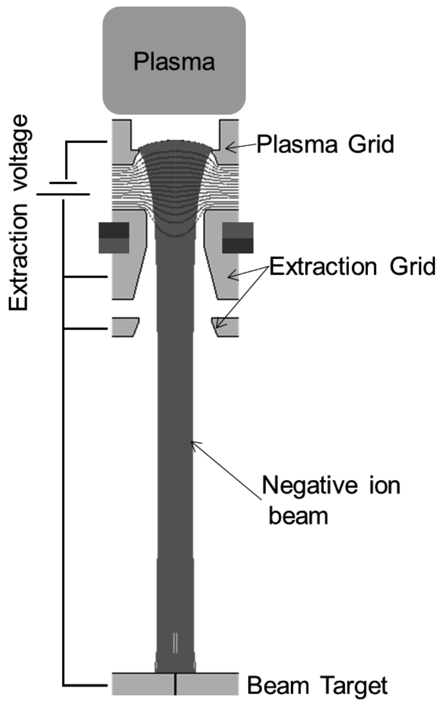

Figure 1. Schematic view of the experiment for the negative ion production and extraction.

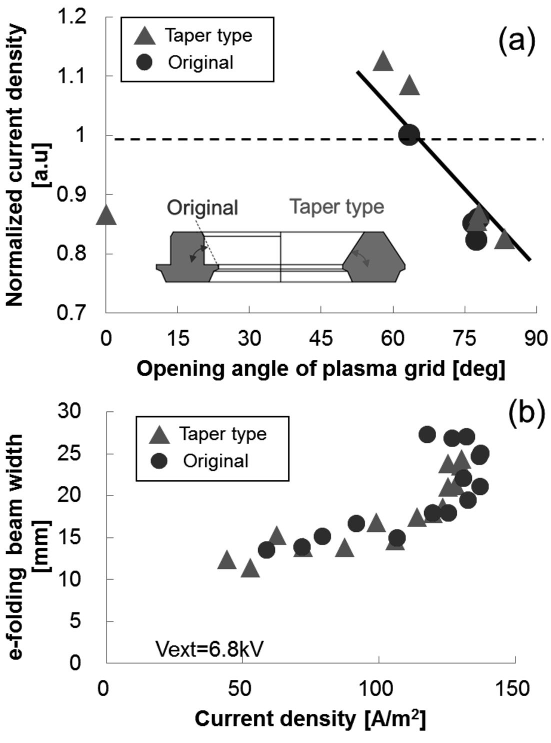

Figure 2. Experimental results obtained by changing the configuration of the plasma grid aperture (a) extracted negative ion current density (b) beam width.