

§9. Acceleration and Beam Optics of Intense H^- Ion Beam

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In our previous work, we reported a beam optical characteristics using a single H^- beamlet; the size of the plasma, extraction, acceleration apertures are $9\text{mm}\phi$, $13\text{mm}\phi$ and $13\text{mm}\phi$. From an engineering point of view, however, the combination has a difficulty. So the acceleration characteristics of H^- beam have been re-investigated using a single beam let accelerated up to 100 keV by changing the aperture sizes. The H^- beam is extracted from a large negative ion source operated with Cs seeding and is accelerated by a single-stage accelerating system.

Figure 1 shows a configuration of beam-acceleration system. The aperture size of the plasma grid was fixed $9\text{mm}\phi$, and the aperture sizes of the extraction and ground grids are changed with the combinations of $9\text{-}9\text{mm}\phi$, $11\text{-}11\text{mm}\phi$ and $13\text{-}13\text{mm}\phi$. The currents and the spatial profiles of the H^- beams are measured calorimetrically.

The beam divergent angles are obtained by means of gaussian fitting to the measured plots. A minimum divergent angle of 5 mrad is achieved with an H^- current densities of 32 mA/cm^2 and the beam energy of 94 keV . A ratio of acceleration current to H^- current increases suddenly at the region where the H^- current begins to saturate due to a space charge limit. This considered to be caused by emission of secondary electrons at an extraction electrode by collisions of the divergent H^- beams.

The dependence of the divergent angle on the acceleration voltage is measured. The beam divergent angle is shown in Fig. 2 as a function of the field ratio, $E_{\text{acc}} / E_{\text{ext}}$. An optimum ratio the electric fields for H^- extraction and for the acceleration was about $1.6\text{-}1.7$, and the value did

not change in every combination of the apertures of the acceleration system. On the other hand, the extraction and the acceleration currents decreased in the case of the aperture size of more than $11\text{mm}\phi$. This suggests that extracted H^- scratched the wall of the extraction grid in the case of aperture combination of $9\text{-}9\text{-}9\text{mm}\phi$.

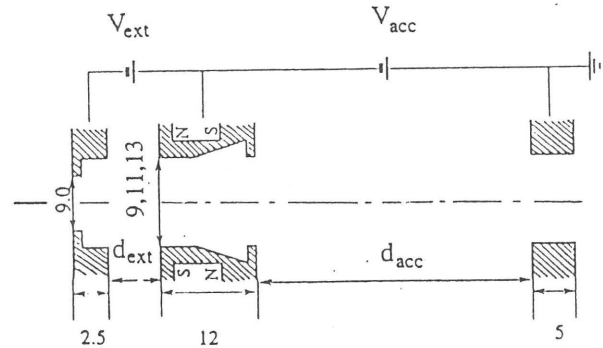


Fig. 1. Structure of the single stage acceleration electrode system.

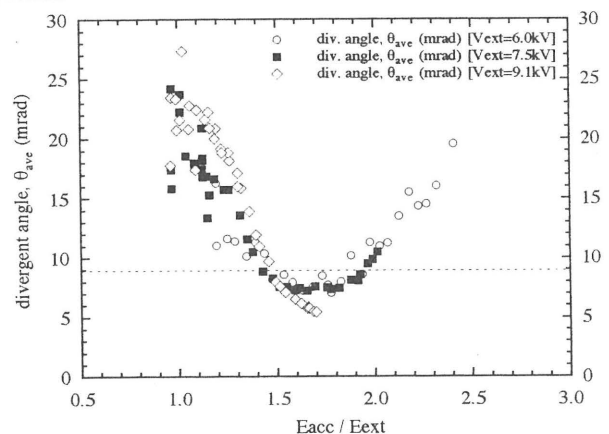


Fig. 2. Dependence of (a) the beam divergent angle and (b) I_{acc} on $E_{\text{acc}} / E_{\text{ext}}$ at $p = 0.71\text{ Pa}$ for three different H^- current densities; (open circles) $P_{\text{arc}} = 26\text{ kW}$, $V_{\text{ext}} = 6.0\text{ kV}$, $J_{H^-} = 15\text{ mA/cm}^2$, (closed square) $P_{\text{arc}} = 46\text{ kW}$, $V_{\text{ext}} = 7.5\text{ kV}$, $J_{H^-} = 22\text{ mA/cm}^2$ and (open diamond) $P_{\text{arc}} = 67\text{ kW}$, $V_{\text{ext}} = 9.1\text{ kV}$, $J_{H^-} = 32\text{ mA/cm}^2$. The combination of aperture sizes are $9\text{mm}\phi$, $11\text{mm}\phi$ and $11\text{mm}\phi$.