§15. Accelerated Electron Suppression of a Large Negative-Ion Source

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Accelerated electrons, which would lead to high thermal load of grids, have been suppressed in a high-current large hydrogen negative ion source [1]. The thermal load of the grounded grid is mainly ascribed to the incidence of the accelerated electrons, which are generated in the neutralization of the negative ions by collision with the residual neutral molecules or generated as the secondary electrons on the extraction (or the upstream) grid. The latter electrons must be strongly suppressed by the geometrical grid configuration while the former electrons can be suppressed by reduction of the operational gas pressure.

The extraction grid aperture is shaped so that the secondary electrons generated on the grid aperture surface would be shielded against the acceleration electric field, as shown in Fig. 1. The strong permanent magnets are inserted in the extraction grid for the electron suppression, and the maximum magnetic field strength on the beam axis is 650 G at room temperature. The thermal loads of the grounded grid and the extraction grid are measured by water-calorimetry, and the equivalent thermal load currents, I_{GG} and I_{EG}, are calculated from the thermal loads. The beam extraction area of the plasma grid is 25 cm $\times$ 26 cm and there are 270 apertures of 9 mm diameter.

Figure 2 shows the H^- ion current and the equivalent thermal load currents, I_{EG} and I_{GG}, as a function of the arc power. The gas pressure in the arc chamber is 3.4 mTorr and the beam pulse width is 0.6 sec. The thermal load of the extraction grid is small, and the H^- ion current is more than 70 % of the extraction drain current, I_{ext}. The thermal load of the grounded grid is about 13 % of the H^- ion current, which is about half of that in the case of the straight aperture extraction grid. The acceleration efficiency, defined by the ratio of the negative ion current to the acceleration drain current, I_{acc}, is improved to around 85 %. The shaped aperture extraction grid seems to work well to prevent the secondary electrons from leaking to the acceleration gap, compared with a conventional straight aperture extraction grid. Although the strong magnetic field at the extraction grid also lowers the electron leakage downstream, the aperture shaping of the extraction grid is more effective for the suppression of the accelerated electrons. There remains the accelerated electrons generated by the negative ion neutralization during the acceleration. The direct interception of the accelerated negative ions with the downstream grid is small. The reduction of the operational gas pressure is quite important to achieve the further improvement of the acceleration efficiency.

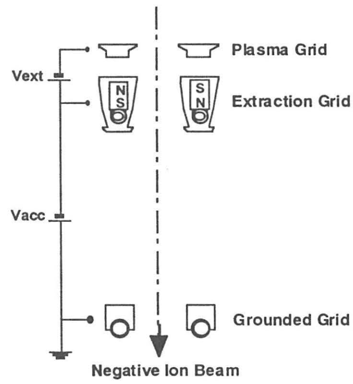

Fig. 1. Grid arrangement of the accelerator with the shaped aperture extraction grid.

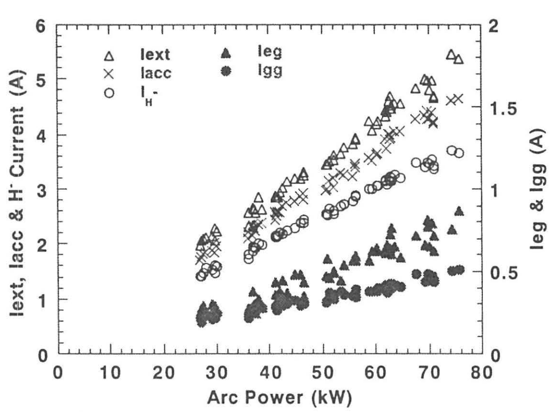

Fig. 2. H^- ion current, the extraction and acceleration currents, and the thermal load currents as a function of the arc power.

[1] Y. Takeiri, *et al.*, Rev. Sci. Instrum. **67**, 1021 (1996).