§3. High-Current Negative Ion Beam Production with an External-Filter-Type Negative Ion Source

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A high-current negative hydrogen-ion beam has been produced at a high source efficiency with an external-filter-type large negative-ion source developed for the LHD-NBI system. A schematic diagram of the ion source is shown in Fig. 1. The dimensions of the arc chamber are 35 cm x 62 cm in cross section and 20.6 cm in depth, corresponding to a 1/3-scale of the LHD-NBI ion source. The ion source is characterized by a strong external magnetic filter field in the wide area of 35 cm x 62 cm produced by a pair of permanent magnet rows located with 35.4 cm separation. The filter strength is 70 G in the center and the line-integrated filter strength is 850 G cm, which keeps the low electron temperature in the extraction region. Strong cusp magnetic field, 1.8 kG on the chamber surface, is generated for improvement of the plasma confinement. The negative ion extraction and acceleration system consists of five grids, and the aperture diameter of the plasma grid is 11.3 mm and the number of aperture is 522 (18 x 29). The magnetic field generated by the permanent magnets embedded in the extraction grid is also strong, 450 G, for the reduction of the electron current extracted together with the negative ions. The ion source is operated with cesium seeded.

Figure 2 shows the negative ion current and the extraction current as a function of the arc power. The gas pressure is 3.8 mTorr. The H^- ion current is increased with a high arc efficiency of 0.1 A/kW, and reaches 16.2 A, corresponding to 31 mA/cm^2 of the average current density at the plasma grid, with the energy of 47 keV. The extraction current is also proportional to the arc power and the ratio of the extraction current to the H^- ion current is as low as 2.2. The gas pressure dependence of the H^- ion current is shown in Fig. 3. Even at a low gas pressure of 3 mTorr, the arc efficiency is still 0.1 A/kW.

These results satisfy the specification for the LHD-NBI ion source.

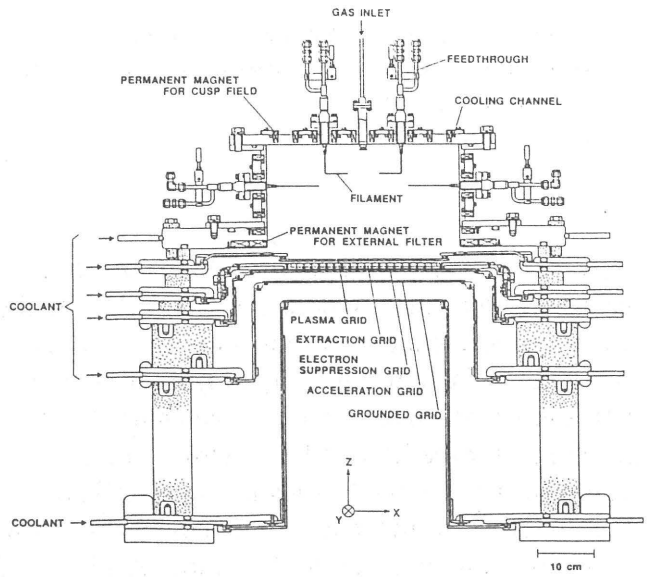

Fig. 1. Schematic diagram of the external-filter-type 1/3-scaled ion source.

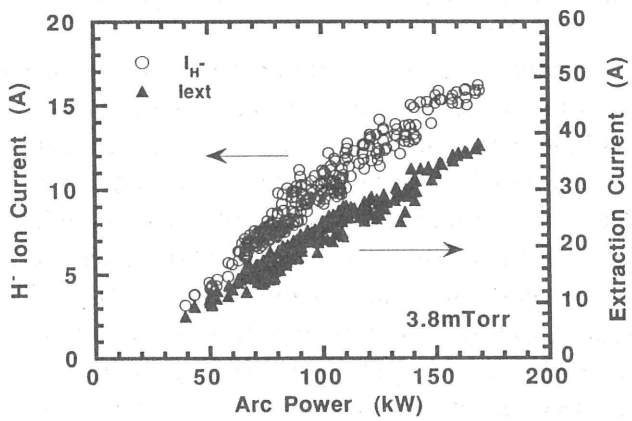

Fig. 2. Negative ion current and the extraction current as a function of the arc power.

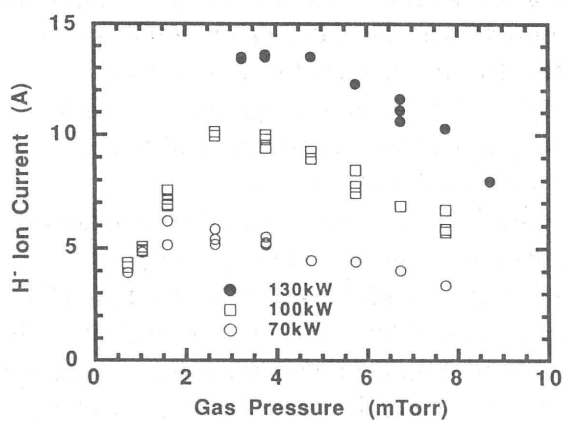

Fig. 3. Negative ion current as a function of the gas pressure. The parameter is the arc power.