§2. High-Efficient Negative Ion Production in an External-Filter Type Negative Ion Source

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A large negative hydrogen ion source with a wide-range of external magnetic filter field has been developed for the LHD-NBI system, which has dimensions of 35 cm x 62 cm in cross section and 20 cm in depth in the arc chamber. A schematic diagram of the external-filter type 1/3-scaled ion source is shown in Fig. 1. In order to improve the source performance, such as the arc efficiency, the operational gas pressure, and the ratio of negative ions to electrons in a beam, a strong external magnetic filter field is generated in wide area inside the arc chamber by a pair of permanent magnet rows which face each other at the distance of 35 cm. The central filter field strength is 53 G and the integrated filter field is about 700 G cm. The external filter configuration is advantageous for the efficient negative ion production compared with the rod filter configuration, because there is a large plasma loss area on the rod surface and the rod makes a shadow on the plasma grid. The cusp magnetic field is also strengthened, 1.8 kG, for the improvement of plasma confinement. For the reduction of the electron current, the magnetic field strength generated by permanent magnets embedded in the extraction grid is strong, 450 G. 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 negative ion beam is detected with a movable multi-channel calorimeter array 2.3 m downstream from the ion source.

The preliminary results show a high source performance in the Cs-mode. Figure 2 shows the negative ion and the extraction currents as a function of the arc power. The gas pressure is 4.6 mTorr. The H^- current is increased with a high arc efficiency of 0.1 A/kW, and reaches 10.1 A. The ratio of the extraction to the H^- currents is about 2.5 as shown in Fig. 2. The optimum gas pressure for the H^- current is around 4 mTorr, and the H^- current is not much reduced at the gas pressure of less than 3 mTorr. The extraction current is still suppressed at the lower gas pressure, and the ratio of the extraction to the H^- currents is less than 3 at 2.5 mTorr.

Even in the pure-volume operation, a high source performance, such as high arc efficiency, low operational gas pressure, small electron current, was demonstrated. These results enable to design the LHD-NBI system.

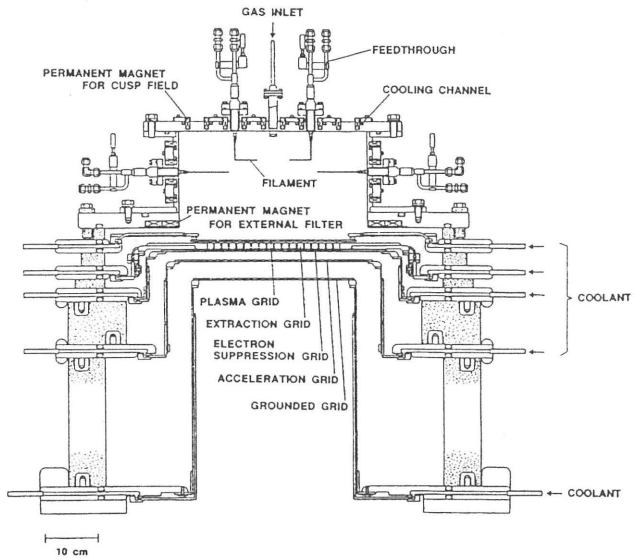

Fig. 1. Schematic diagram of the external-filter type 1/3-scaled ion source.

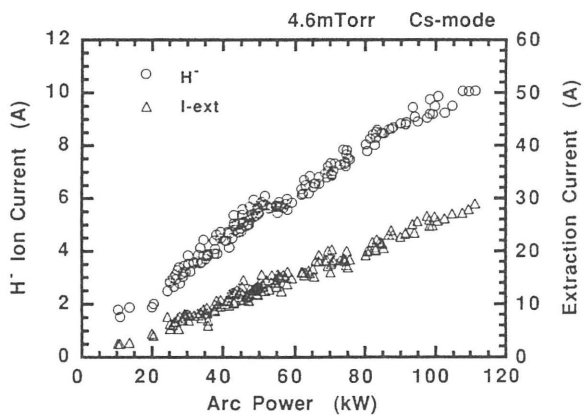

Fig. 2. Negative ion and the extraction currents as a function of the arc power. The gas pressure is 4.6 mTorr.