

§4. High-Energy Acceleration of a High-Current Negative Ion Beam

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A high-current, more than 10 A, H⁻ ion beam has been accelerated to more than 100 keV with the two-stage acceleration as shown in Fig. 1 for the first time. A large negative hydrogen ion source with an external magnetic filter, which has been developed for the LHD-NBI system, produces more than 10 A of the H⁻ ions from the grid area of 25 cm x 50 cm with the arc efficiency of 0.1 A/kW by seeding a small amount of cesium. A 13.6 A of H⁻ ion beam has been accelerated to 125 keV, which corresponds to the injection energy of the LHD-NBI system, at the operational gas pressure of 3.4 mTorr.

Figure 2 shows the simulation results of the gas pressure distribution and the survival H⁻ ion ratio without the stripping loss in the accelerator using the Monte-Carlo gas flow calculation code. The gas temperature is assumed to be constant, 300 K. The gas flow rate is 19 Torr l/s and the calculated gas pressure in the arc chamber is 3.3 mTorr. The total stripping loss of the H⁻ ion beam is calculated at 20%. The stripping losses during the first and the second accelerations of the H⁻ ions are not so large, about 5% and 3%, respectively, of the H⁻ ion current at the plasma grid aperture. The H⁻ ion current accelerated to the full-energy without the stripping loss is calculated at about 95% of the calorimetrically estimated H⁻ ion current. Therefore, the operational gas pressure of 3.3 mTorr is low enough for the neutral beam application of this H⁻ ion source.

Figure 3 shows the measured neutralization efficiency as a function of the gas pressure in the beam transport region. The beam energy is 95 keV. A result of the theoretical calculation is also indicated by a dotted line in the figure. Although the measured neutralization efficiency is a little higher than the calculated one, relatively good agreement is found.

These results presented here enable to design the actual LHD-NBI system with the negative ion beam.

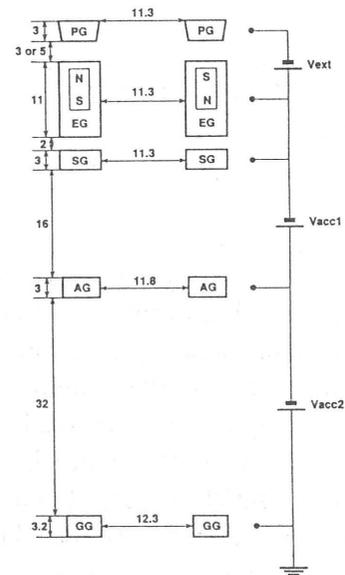


Fig. 1. Grid arrangement along the beam axis.

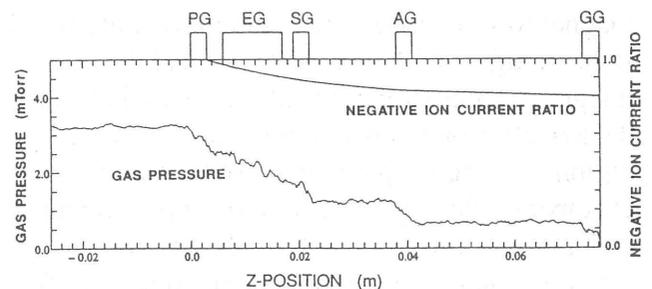


Fig. 2. Monte-Carlo simulation results of the gas pressure distribution and the survival H⁻ ion ratio without the stripping loss.

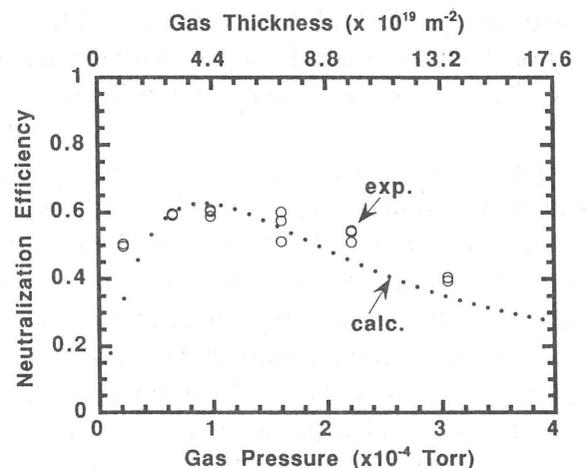


Fig. 3. Measured neutralization efficiency as a function of the gas pressure in the beam transport region.