§20. Develoment of LaB_6 Cathode Electron Gun for Nonneutral Helical Plasmas

Nakashima, C., Yoshida, Z., Himura, H., Fukao, M., Morikawa, J., Numata, R., Saito, H., Wakabayashi, H.
(The University of Tokyo)

A possibility of producing a high-β equilibrium has been theoretically predicted by the Beltrami/Bernoulli conditions. A non-neutralized plasma has a self-electric field $\boldsymbol{E}$ which could cause a strong $\boldsymbol{E}$ x $\boldsymbol{B}$ perpendicular flow. Since the flow has large hydrodynamic pressure, it may be balanced with the thermal pressure of the plasma[1].

In order to produce a non-neutral plasma in a helical magnetic field, we have developed an electron gun using the LaB_6 cathode (Fig.1). The current density emitted from the cathode is up to ~2 A/cm^2 at ~1600 ℃. The plane diode geometry is employed for the setup of the cathode and an anode. The areas of the cathode and the aperture of the anode are 1 cm^2. The gap length between the cathode and the anode is 2 mm, which enables us to extract the maximum current (~ 2A) that is smaller than the space charge limited current (the product of the space charge limited current density and the area of the aperture).

At first, we tested the electron gun in a vacuum chamber without magnetic fields. In Fig. 2, the beam current (I_b) emitted from the gun is plotted against the acceleration voltage V_{acc}. The solid line shows the calculated space charge limited current. The different symbols indicate the data taken with the different cathode currents ($I_{cathode}$). For the cases of $I_{cathode}$ = 21 and 24 A, values of the I_b are saturated when V_{acc} > ~1 kV, which reflects the temperature limited region. For $I_{cathode}$ = 26 and 28 A cases, the values of the I_b are also saturated but when V_{acc} > ~1.4 kV because of the current limit of the DC power supply. As recognized from Fig. 2, the I_b is about 30 % of the space charge limited current when $I_{cathode}$ = 28 A.

We have injected the electron beam into a vacuum magnetic field of the Proto-RT device. Figure 3 shows a radial profile of the floating potential Φ_H of an electron plasma produced by the electron gun with V_{acc} = 2 kV. The I_b was constant (~ 720 mA) for all shots. As seen from the data plotted in Fig. 3, the peak value of Φ_H reaches ~1.4 kV at R ~ 36 cm.

References

1) S. M. Mahajan and Z. Yoshida, Phys. Rev. Lett. **81**, 4863 (1998).

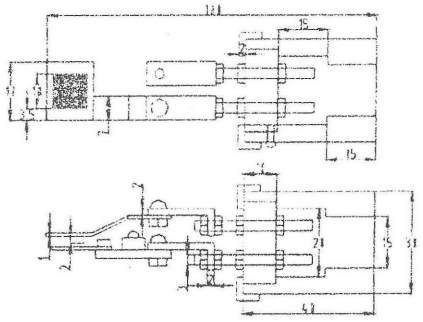

Fig.1 Schematic view of LaB_6 cathode electron gun

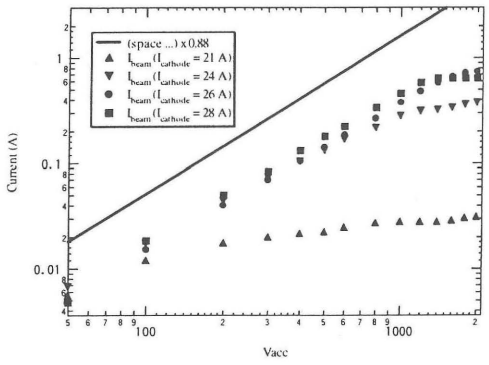

Fig.2 Electron beam current with respect to the acceleration voltage.

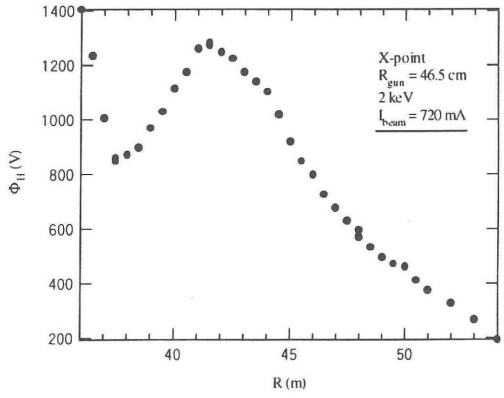

Fig. 3 Potential of an electron plasma trapped on the Proto-RT device.