The Improvement of the Electron Gun for the SPring-8 Linac

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1. Introduction

The generation of an emission current up to 18 A with a pulse width of 1 ns was achieved using the Y796 dispenser cathode assembly with a cathode area of 2.0 cm^2 in 1997[1-3]. However, the beam of the linac is required to be supplied for the synchrotron under the conditions of a peak current of 200 mA (gun exit) with the pulse width of 40 ns or a peak current of 2 A with the pulse width of 1ns. Therefore, the emission current of the Y796 electron gun was reduced by controlling the grid bias voltage and the heater power and inserting an iris of diameter of 1.2 or 2.6 mm downstream at an anode.

In the summer of 1998, we replaced the Y796 gun with Y845 gun. In this report, the characteristics of the Y845 electron gun system are described.

2. Thermionic Electron Gun

The thermal limit of the normalized rms emittance ε_n of a beam from a thermionic emitter of radius r_c at a uniform absolute temperature T is;

$\varepsilon_n = 2\pi\, r_c\sqrt{kT/m_0c^2}$ unit: m•rad,

where r_c is the cathode radius (mm), k the Boltzmann constant, and T the absolute temperature.

The minimum emittance is determined by the area and temperature of the cathode. The cathode radius in the SPring-8 gun is approximately 4mm, and then the minimum emittance achievable is

$\varepsilon_n = 1.2 \times 10^{-5}$ m•rad.

The saturated current density J (A/cm^2) is determined using the Richardson-Dushman equation as

$J = 120.4T^2\exp[-e\phi/kT]$

where ϕ is the work function.

The Y845 electron gun was estimated to have an emission current density of 7.77 A/cm^2 according to the above equation. However, the actual emission current is larger than above estimation when the schottky effect is considered. The maximum emission current Is is;

$Is = AJ\exp\left(e/2kT\sqrt{eE/\pi\varepsilon_0}\right)$

where E is the electric field (V/m), and A the cathode area of the Y845 gun(0.5cm^2).

Finally, we obtained the calculated maximum current of 6.23A with the cathode-grid voltage of 250V. The thermionic electron gun is a triode with an EIMAC Y845 grid-cathode assembly. The whole electron gun consists of a high voltage insulator, vacuum chamber and cathode stem.

A simulation of the beam trajectory was performed in order to design an electron gun with an applied voltage of 180 kV by using the code EGUN. The computed beam envelope of the Y845 gun is shown in Fig. 1. The cathode area of the Y845 gun is 0.5 cm^2. The beam diameter is 6.8 mm at 150 mm from the cathode. The dimensions of the anode and cathode electrodes were optimized to obtain the lowest beam emittance at a distance of 150 mm from the cathode. The anode-cathode gap distance is 32 mm and anode hole diameter is 10mm.

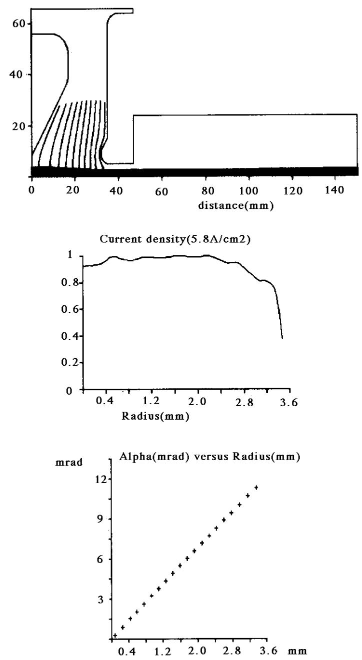

Fig. 1. EGUN simulation of the Y845 gun.

3. Gun Emission Test

We tested the new electron gun (Y845 cathode) at the injector of the SPring-8 linac during its long shutdown period in the summer of 1998 using the setup illustrated in Fig. 2. The electron gun was operated at the repetition rate of 1pps and a maximum voltage of 180kV. The emission tests were performed applying the grid pulses of 40 ns width.

The relationship between the anode voltage and the beam current was measured by a wall current monitor which has rise and fall times of 500ps, and was placed near the gun. The result of the measurement is represented in Fig. 3.

The calculated perveance of the trace is 0.12 μperv. We studied the relationship between the bias voltage and the beam current in the voltage region from 60 to 200 V. A good linearity was obserbed as shown in Fig.4.

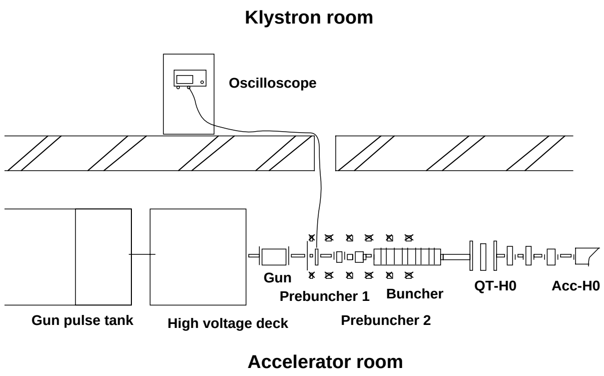

Fig. 2. Test of Y845 electron gun.

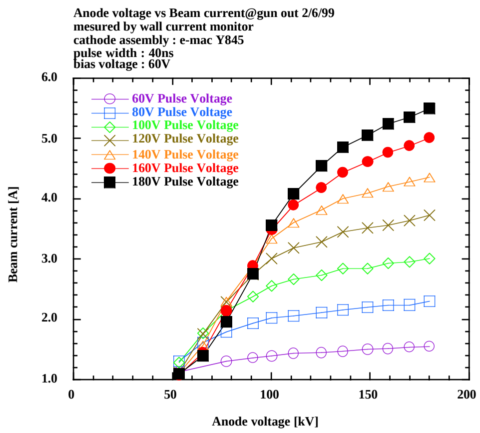

Fig. 3. Characteristic measurement of the Y845 electron gun. - Anode voltage vs Beam current -

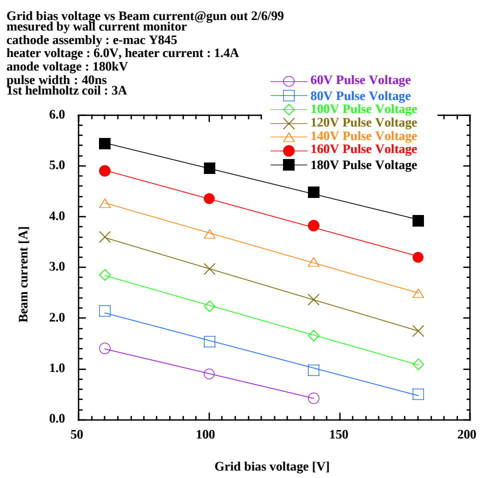

Fig. 4. Characteristic measurement of the Y845 electron gun. - Grid bias voltage vs Beam current -

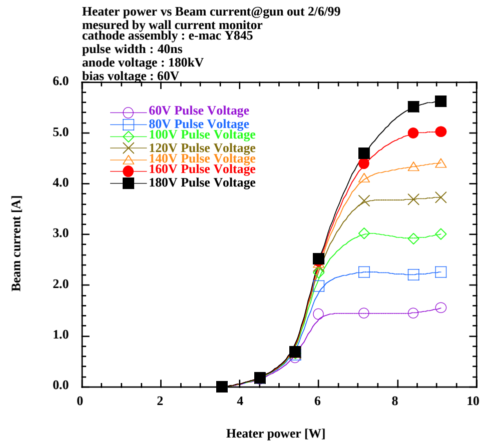

Fig. 5. Characteristic measurement of the Y845 electron gun. - Heater power vs Beam current -

Figure 5 expesses the heater power versus emission current. The temperature limited region of the gun emission were checked by increasing the heater power from 0 to 9 W. We decided to set the heater power at 8 W where the emission seems to saturate.

4. Construction of Gun Test Stand

The test stand of the electron gun was constructed to check its performance (high voltage test, vacuum test, emission test and so on). The test bench is composed of a gun, a high voltage generator, a vacuum chamber, three ion pumps, two screen monitors, two beam slits, two wall current monitors and a coaxial beam catcher.

5. Conclusions

In the summer of 1998, we replaced the Y796 gun with Y845 gun in order to decrease an emission current. The emission current can be reduced from 18 A to 5 A without the iris. We succeeded in installing the Y845 electron gun.

Acknowledgments

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References

[1] H. Yoshikawa *et al.*, Proc. 17th Int. Linear Accelerator Conf., 410 Tsukuba, (1994).
[2] T. Asaka *et al.*, Particle Accelerator Conf., 12 (Vancouver,1997).
[3] T. Kobayashi *et al.*, Proc. 19th Int. Linear Accelerator Conf., 58 (Chicago ,1998).