R&D OF THERMIONIC RF GUN

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Abstract

R&D of a thermionic microwave gun with a mesh grid was started in KEK. A pillbox-type cavity was designed and manufactured in the first stage. The design and low power characteristics of the cavity and a test bench design are described.

Introduction

A microwave gun is expected to supply a brilliant electron beam because of its high gradient accelerating field near a cathode surface. The high gradient field makes it possible to extract a dense electron beam and to reduce emittance growth at low energy region.[1] As a cathode of the microwave gun, a photo-cathode or a thermionic cathode can be selected.[1,2] In the former case, since electron emission is caused by laser irradiation, a laser system is necessary and bunch length control is performed by laser pulsation. In the latter case, bunch length is controlled by an additional system because electron beam emission is occurred at almost half period of an rf cycle, and heat control around the cathode is rather complicated because the cathode is bombarded by reversely accelerated electrons at another half rf period.

In KEK microwave gun R&D was started in 1989, a thermionic cathode was chosen in this work. In order to solve the back-bombardment problem we try to control pulse width of emitted electrons by using a cathode with a mesh grid.

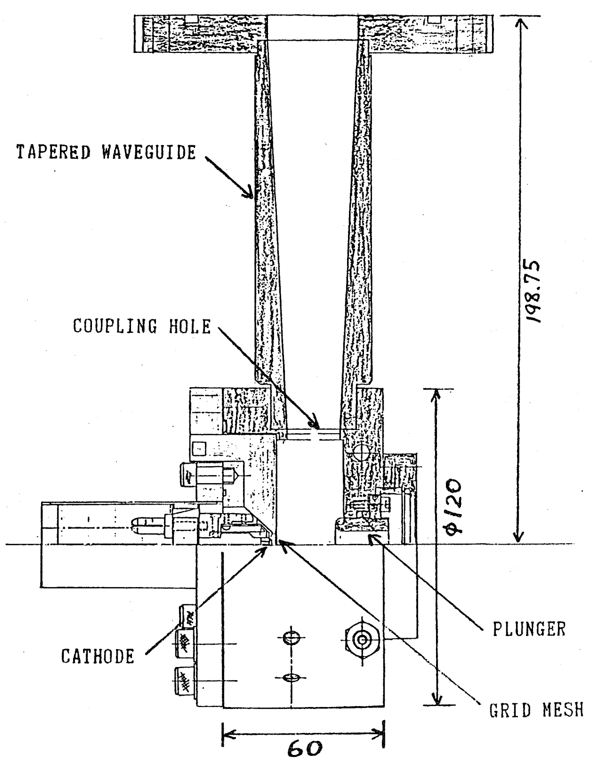

Fig.1 Cross-sectional view of the cavity.

Cavity design and low power characteristics

A pillbox-type cavity was designed and manufactured in the first stage of this work in order to investigate basic feature of the thermionic rf gun and to find problems in manufacturing of the cavity. The cavity diameter is 79.5mm and the resonant frequency is 2856MHz as same as that of our 2.5GeV electron linac. The distance between two end plates is 25mm on the basis of travelling time consideration. Microwave power is supplied through a coupling hole at the end of a tapered rectangular waveguide. The resonant frequency is finally tuned by a cylindrical plunger at a beam extracting hole of the cavity. A grid mesh is made of a molybdenum foil 0.1mm thick and attached to the end plate on the cathode side, which is demountable in order to test several structures of the mesh grid and the cathode. A cross-sectional view of the cavity is shown in Fig.1.

The cavity and the tapered waveguide are made from oxygen-free copper block. At critical coupling loaded Q-value of 5,000 was achieved, but over-coupling will be needed at a high power beam test because of very heavy beam loading. Figure 2 shows results obtained from bead-perturbation measurement of the axial electric field of the cavity with a flat demountable plate without the mesh grid. Measurement for the mesh grid is now prepared.

Low power characteristics of the cavity were measured at several stages of manufacturing in order to find problems in lathing or soldering. Fortunately we found that the soldering gave no serious change in characteristics of the cavity. Field distortion near the beam axis caused by the coupling hole will be measured and compensated in the next design including a hollow on the opposite side to the hole.

We employ a lanthanum hexaboride (LaB_6) cathode with diameter of 3mm which can supply 10A/cm^2 current density at a temperature of 1,900°K. In order to keep a constant temperature of the cavity, cooling water flows through both end plates. Since the current density of 10A/cm^2 is not so high, another cathode of higher current density at a lower temperature will be needed in the next stage.

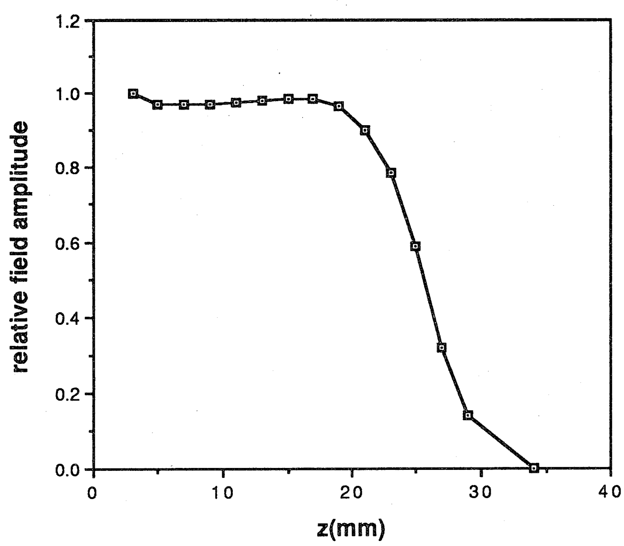

Fig.2 Measured electric field profile along the beam center line of the cavity without a mesh grid.

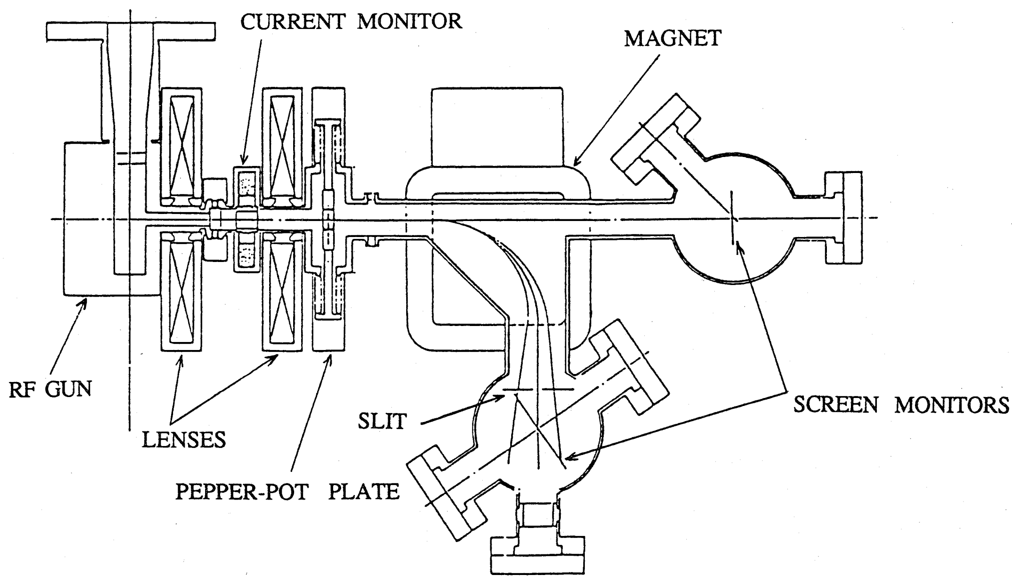

Fig.3 Composition of the test bench.

Test bench design

Figure 3 shows a test bench design containing focusing lenses, an analyzing magnet, a slit, a pepper-pot plate, a current monitor and screen monitors. In this work precise investigation of beam emittance and momentum spectrum is very important. The pepper-pot plate has many holes on it and is prepared to measure the emittance from the image of the beam through the holes.

Before the tapered waveguide a circulator with a dummy load is prepared because input power to the cavity is fully reflected at over-coupling when there is no beam loading.

Two 50 ℓ/s vacuum ion pumps are installed after the circulator.

In order to supply electron beam from the thermionic rf gun to another accelerating tube, bunching mechanism is necessary. Since the relation of electron energy and rf phase is almost monotonous, it is possible to use a momentum spectrometer following the rf gun to limit the phase spread and the bunch length of the beam.[1] In the future stage of this work we must design this kind of momentum filter.

references

1. G.A.Westenskow and J.M.J.Madey, Laser and Particle Beams, Vol.2, 223, (1984).
2. J.S.Fraser et al., Proc. Particle Accelerator Conf., Washington, D.C., March, 16-19, 1987, pp.1705-1709.