DEVELOPMENT OF AN ITC-RF GUN FOR COMPACT THz FEL

W. Bai*, X.M. Shen, M. Li, H.B. Wang, Y.N. Chen, L.J. Shan
Institute of Applied Electronics, CAEP, Mianyang 621900, China

Abstract

An independent tunable cells thermionic rf gun (ITC-RF Gun) used for compact Tera-hertz (THz) free electron laser(FEL) is developed at Institute of Applied Electronics, China Academy of Engineering Physics (CAEP). This RF-gun consists of a single cell and a 3-cells accelerating cavity which are excited independently, so the amplitude and phase of the two parts can be adjusted easily. The paper introduces some results of the simulation, cold test and preliminary hot test. The preliminary test results match most of the expected macroscopic parameters of the extracted beam.

INTRODUCTION

Tera-hertz radiation technology is of important science value and wide application prospects in many research areas such as physics, chymistry, informatics, and biology etc. Among different kinds of tera-hertz radiation source, free electron laser (FEL) tera-hertz source offers some outstanding merit. For example, continuous tune of its wavelength within a long range, adjustable time structure of light pulse, as well as the distinguishing feature of its high power and high efficiency. With compact structure, low cost and good performance, the thermionic-cathode RF gun has a widely application prospect [3] in FEL injector development. However back electron bombardment is the unavoidable problem for all thermionic-cathode rf gun. At present, some efficient ways of reducing back electron bombardment have been proposed at home and abroad [4-9]. And some preferable progress has been achieved already.

In order to decrease the back electron bombardment and get the high quality electron beam, a design study of a multicell thermionic-cathode rf gun with two microwave feed-in ports of which phase displacement be adjustable is pursue in this paper. Two microwave feed-in ports are used to drive the microwave gun. One is used to drive the first cavity and draw elections from the cathode surface. Another is used to excite the following cavity. There is no electromagnetic coupling between the first cavity and the following cavities. And the phase displacement between the two feed-in microwave ports is adjustable (0°~360°).

Up to now, we have completed the processing, cold test, weld of the cavity, and established a hot test experimental facility, performed the preliminary hot test experimental research.

LAYOUT OF THZ FEL DEVICE

As shown in Figure 1, the principal components of our THz FEL device include Thermionic ca thode microwave gun, bending magnet with energy selection slit, main accelerator, microwave power source, beam transmission line, optical cavity, wiggler, measure and diagnostic system etc.

*bweimail@163.com

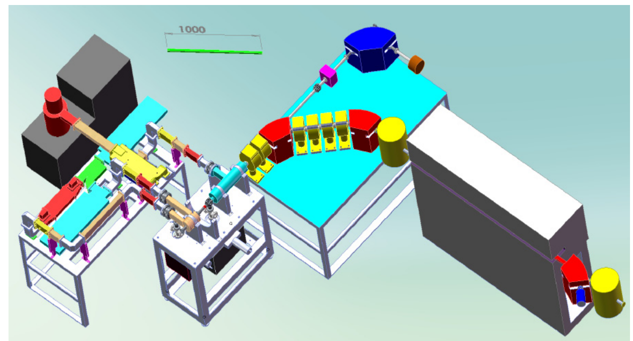


Figure 1: Layout of the compact THz FEL device.

DEVELOPMENT OF THE RF GUN

Physical Design and Cold Test Results

As shown in Figure 2 the cutaway view of the rf gun, the rf gun is consist of four accelerating cavities and two coupling cavities, with a total length of about 140 mm and two independent microwave feed in ports locating at the first cavity and the last cavity respectively. Figure 3 shows the designed 3D shape of the rf gun.

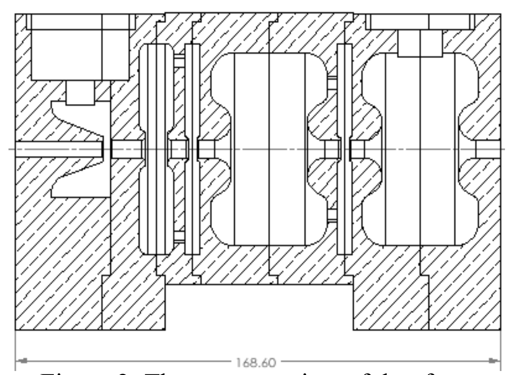


Figure 2: The cutaway view of the rf gun.

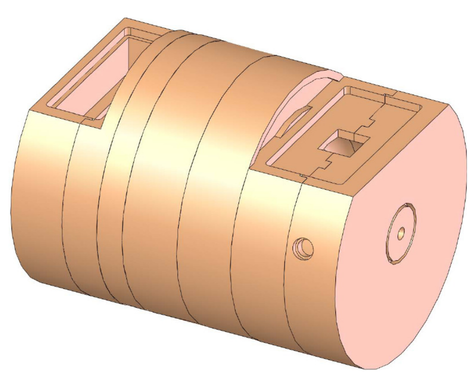


Figure 3: Designed 3D shape of the rf gun.

ISBN 978-3-95450-117-5

The formal cavities and its testing device is shown by the Fig. 4. And the measured resonance spectrum and field distribution of accelerating tube (not including the first cavity) is presented by Fig. 5. And from the picture of field distribution, it can be get that the relative field intensity of the last three accelerating cavities is about 1 : 2.5 : 2.5.

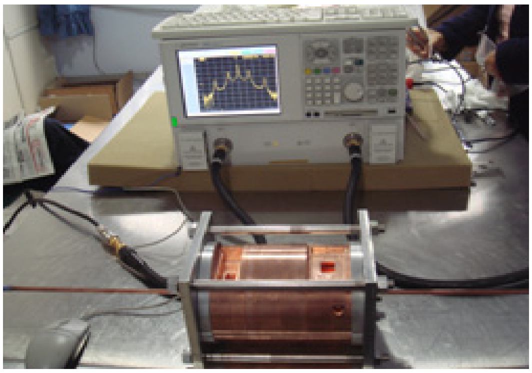
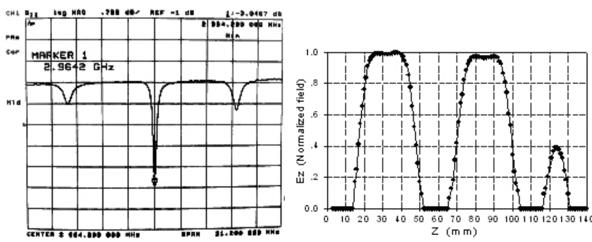


Figure 4: The measurement set of formal cavities.



a resonance spectrum b field distribution

Figure 5: Resonance spectrum and field distribution of the last three accelerating cavities

Device Setting up and Hot Test

In condition of the existed experimental device in our laboratory, we build a preliminary hot test facility of the thermionic cathode rf gun. Figure 6 shows the hot test facility of the thermionic cathode rf gun. The beam current of the microwave rf gun is measured by beam current transformer (BCT) in the experiment, and the measured beam intensity of macro pulse is about 528 mA. At the same time, we measured the beam spot and other parameters of the microwave rf gun. Table 1 shows the tested results of the rf gun.

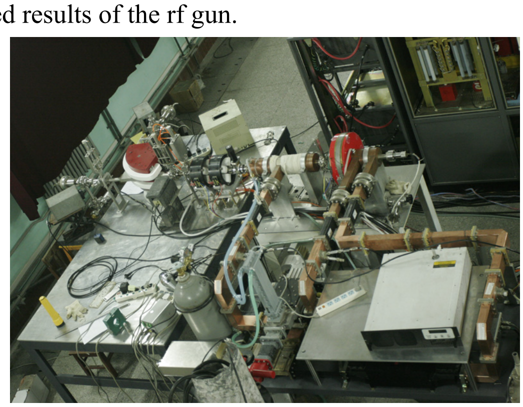


Figure 6: Hot test facility of the thermionic cathode rf gun.

Table 1: The Tested Parameters of the Rf Gun

Parameter	Tested	Designed
Current of macro pulse / mA	528	590
Width of macro pulse / μs	4.1	4
Repetition rate / Hz	4	1~10
Normalized emittance / πmm.mrad	~13	10
Electron beam spot / mm	~3	2.0

CONCLUSION

A thermionic cathode rf electron gun is being developed in Applied Electronics Institute, China Academy of Engineering Physics. We pursued a design scheme of an independent tunable cells thermionic rf gun. At present, the rf gun has gotten through the preliminary hot test experiment, and a quite stable output beam has obtained. The test results agree well with the designed ones.

REFERENCES

[1] Liu Shenggang, Yan Yang, and Zhu Dajun, et al.. The possible contribution of vacuum electronics to THz radiation sources. IEEE International Conference on Vacuum Electronics. Korea, 2003, 4: 357-358.

[2] Liu Sheng-gang. Recent development of terahertz science and technology. China Basic Science, 2006, 8(1): 7-12.

[3] Jialin Xie, Microwave Electron Gun, Science Foundation of China, 1996, Vol 3:215-217.

[4] Kai Masuda, Koichi Kusukame, Toshiteru Kii, et al. Particle Simulations Of A Thermionic Rf Gun With Gridded Triode Structure For Reduction Of Back-Bombardment, 2005, Stanford, California,USA, Proceedings of the 27th International Free Electron Laser Conference, 588-591.

[5] Xu Z , Hu K S , Liu X S , et al. Research On Back Bombardment Of Electrons On Thermionic Rf-Gun, High Power Laser and Particle Beams, 1996 ,8 (3) : 383-386.

[6] Zhu L , Chen H B , Tong D C , Lin Y Z. (1/ 2 + 1/ 2 + 1) Cell Structure Type Rf Gun, High Power L aser and Particle Beams，2004,16(8):1033-1036.

[7] Tanaka T, Muto T, Hinode F, et al. Development Of An Injector To Generate A Very Short Bunch For A Super Coherent Teraherz Light Source Project. Indore, India: 2007,178-180.

[8] Muto T, Tanaka T, Hinode F, et al. Coherent THz Light Source Using Very Short Electron Bunches from a Thermionic Rf Gun. Novosibirsk, Russia: 2007,476-479.

[9] Yong-Qian X, Bin Q, Guang-Yao F, et al. Preliminary Design of Compact FEL Terahertz Radiation Source. Chinese Physics C. 2008, 32: 301-303.

ISBN 978-3-95450-117-5