DEVELOPMENT OF INJECTOR FOR COMPACT FEL TERA-HERTZ SOURCE IN CAEP

Wei BAI*, Ming LI, Xingfan YANG, Xuming SHEN, and Yanan CHEN
Institute of Applied Electronics, China Academy of Engineering Physics, Mianyang, China.

Abstract

This paper introducs the development of a injector for compact FEL tera-hertz source in China Academy of Engineering Physics (IAE/CAEP). The injector consists of an 9Cell accelerator for energy booster section and a multicavity thermionic-cathode rf gun with low back bombardment, with total length no more than one meter. Numerical simulation result shows that the back bombardment power is less for the thermionic-cathode rf gun of the injector and the main accelerator has a good performance, which can provide high quality electron beam with emittance about 10 pi mm mrad, energy 6~7 MeV and energy spread about 1%. At present, the preliminary hot test experiment on the injector has been done. The test results indicate that the mainly tested parameters agree well with the theoretical design ones. The process of the preliminary hot test experiment on the injector is present in this paper.

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 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 get high quality electron beam, the development of injector for compact FEL tera-hertz source is pursued in China Academy of Engineering Physics (CAEP). The injector consists of a multicavity thermionic-cathode rf gun for pulling out the electron and an 9Cell accelerator for energy booster section. To the rf gun, two microwave feed-in ports will be used. One is used to drive the electron field in the first cavity and draw elections from the cathode, another is used to drive the electron field in the following cavity. The back electron bombardment power can be reduced and adjusted notably by this way. To the energy booster section, an 9Cell standing wave accelerator is used for the FEL. The injector works at S band (2856 MHz), and is excited by a microwave power of about 3.5 MW. This paper gives a brift introduction about the design, machining and experiment of the injector.

DESIGN OF THE INJECTOR

The THz FEL injector scheme for simulation is shown by Figure 1. Electron beam is generated by the rf gun, focused by a solenoid, and then it passes through a rather long distance and arrives the energy booster section. At the end of energy booster section, its energy is boosted to 6~7 MeV.

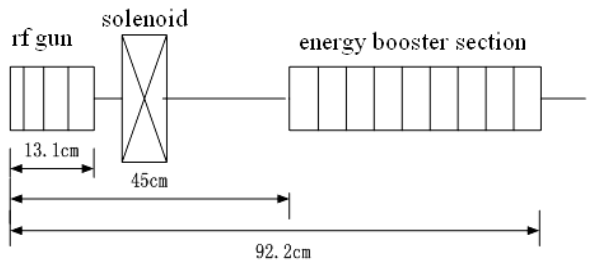


Figure 1:The THz FEL injector scheme for simulation

Table 1 shows some parameters of injector simulation, and figure 2 gives the energy and phase distribution of the simulation results.

Table 1:Some parameters of injector simulation

current A	rms x mm	rms y mm	emittance πmm mrad	bunch ps
0.515	1.126	1.124	8.304	9.032

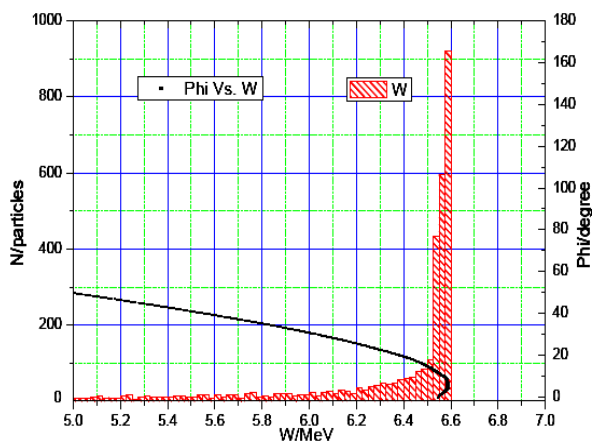


Figure 2:Energy and phase distribution of simulation

DELOPMENT OF THE INJECTOR

According to theoretical design results, we have completed the machining, cold test and welding of the rf

* bweimail@163.com

gun and 9Cell accelerator. The following figure 3 shows the welding rf gun and 9Cell accelerating tube. The total length is no more than 131 mm for rf gun, and no more than 472 mm for the 9Cell accelerating tube. Figure 4 is the the tested field distribution of injector. It can be seen from the picture of field distribution, it can be get that, for the rf gun, the ratio of relative field intensity in the last three accelerating cavities is about 1 : 2.5 : 2.5, and for the booster, the relative field intensity is nearly the same one.

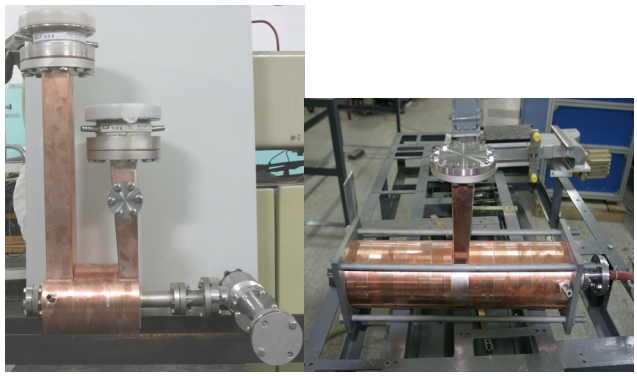
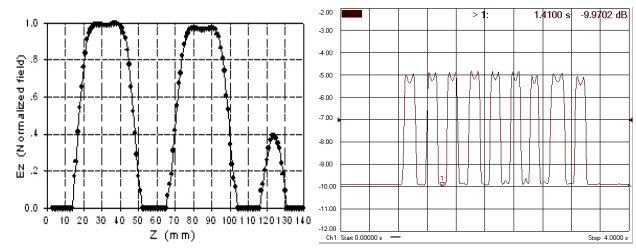


Figure 3:The welding rf gun and 9Cell accelerating tube



Field distribution of rf gun Field distribution of booster

Figure 4:The tested field distribution of injector

EXPERIMENT TEST OF THE INJECTOR

The hot test experimental platform of the injector has been built (Figure 5 shows the experimental platform of the injector), and the parameters of electron beam have been preliminarily tested.

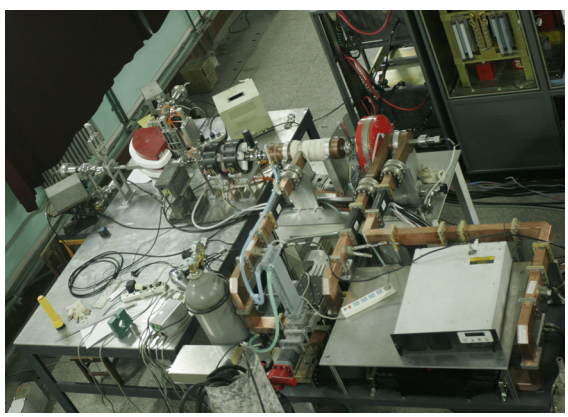


Figure 5:Experiment platform of the injector

Table 2 shows the tested parameters of the injector. It can be seen form the table, beam current of the injector is over 500 mA, the normalized emittance is about 13πmm.mrad. and the beam spot is about 3 mm.

Table 2:Tested Parameters vs. Designed Ones

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

An injector for compact FEL tera-hertz source has been developed in China Academy of Engineering Physics (CAEP). The injector consists of an 9Cell accelerator for energy booster section and a multicavity thermionic-cathode rf gun for electron beam generation. At present, the injector has gotten through the preliminary hot test experiment, and a quite stable output beam has obtained. Each tested parameter agrees well with the theoretical design result.

[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.