Design and fabrication of Beam Transmission System for Terahertz Extended Interaction Oscillator

Wenxin Liu, Zhaochuan Zhang, Chao Zhao, Xin Guo and Ke Li
Institute of Electronics, Chinese Academy Sciences, Beijing, 100190, China
Key Laboratory of High Power Microwave Sources and Technologies, Chinese Academy Sciences, Beijing, 100190, China

***Abstract*—The extended interaction oscillator (EIO) is considered to be a novel type of high power Terahertz (THz) source, which has a promising application prospects in Radar, medical imaging, etc. Up to now, CPI and other institutes have developed this type of EIO. The investigation on the J-band (220GHz-325GHz) EIO at the Institute of Electronics, Chinese Academy of Sciences (IECAS) is being developed. The electric and structural designs for the J-band EIO have been accomplished, in which many technical problems are continued to be resolved. The design of electron optical system for EIO is finished and the permanent magnetic uniform field is adopted. This paper presents mainly the design of electron optical system for the J-band EIO in detail.**

I. Introduction

The THz radiation wave with a frequency of 0.1THz to 10 THz, which is a currently active research area, is of importance in varieties of applications to far-infrared spectroscopy, medical and industrial imaging, biomedical research and material science [1-3]. The various schemes for generating THz waves have been employed, such as Quantum cascade lasers (QCLs) [4], ultrafast laser pluses [5] and the vacuum electron devices [6], etc.

During the development of a high-power THz source of extend interaction oscillator(EIO), attention has been newly focused on the novel slow-wave structure (SWS), such as the compounded dielectric SWS, compounded period SWS, folded waveguide, etc. The folded waveguide [7,8] is one of the most important whole-metal SWS for sub-millimeter and THz waves of EIO. This structure uses an electric field plane bend serpentine rectangular waveguide as a slow wave circuit. A linear electron beam passing through small holes in the broad wall of a rectangular waveguide interacts with the collinear electric field of a propagating, fundamental mode. It has advantages of high power-handling capability at higher frequencies, with the further advantages of simple coupling and robust structure. Also, its compatibility with planar fabrication by MEMS technologies draws an attention to develop a miniaturized radiation sources in millimeter and sub-millimeter wave regimes.

This paper presents mainly the design of electron optical system for the J-band EIO in detail.

II. Parameter of the Electron Gun

The operation voltage of J-band EIO 18.1kV, and the current 72mA, the beam perveance is 0.03, the operation life ,the emission current density is less than 5A/cm^2,The main parameters of the electron gun for G-band EIO are listed in Table 1.

TABLE 1 Main parameters of the electron gun

Operation Voltage	Beam Current	Beam Perveance	Beam Waist
18.0kV	72mA	0.03μP	<0.12mm

III. Design of Focusing Magnetic

For the size of EIO is small, the focus magnetic system is adopted permanent magnetic. Actually, the material is used Sm-Co2-17 and Nd-Fe-B, the former is employed in this electric optics system.

The focus magnetic system includes four parts, cathode area, transition region, uniform area and collector area. According to the beam radius, beam current and voltage, the amplitude of focus magnetic area is determined by (1)[9]:

$$B_b = \frac{830}{b}\frac{I_0^{1/2}}{V_0^{1/4}}\,(\text{Gs}) \tag{1}$$

which the units of V_0, I_0 and b is V, A and cm, respectively.

Actually, the focus method is adopted by part limited current, and the uniform magnetic B_0 is depended on the following:

$$B_0 = \frac{B_b}{\sqrt{1-K}} \tag{2}$$

where K is cathode parameter, and it represents the flux coming from the magnetic field. K is determined by:

$$K = (B_K / B_0)^2 (r_K / r_b)^2 \tag{3}$$

In which B_K is the amplitude of cathode emission side, r_K is the radius of cathode, and r_b is the beam radius. The B_0 can be obtained by (4) when the electric optics system is made of single beam:

$$B_0=(1.5\sim2.5)\times B_b \tag{4}$$

The magnetic at cathode emission side is depended on (5)

$$B_K = \frac{r_b}{r_K} B_0 \sqrt{1-(B_b / B_0)^2} \tag{5}$$

According to the B_0 and B_b, the focus magnetic is designed in Fig.2. Fig.3 is the distribution of longitudinal magnetic field.

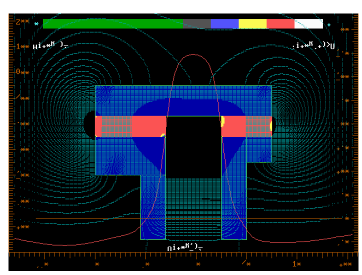

Fig.2 Focus Magnetic Field

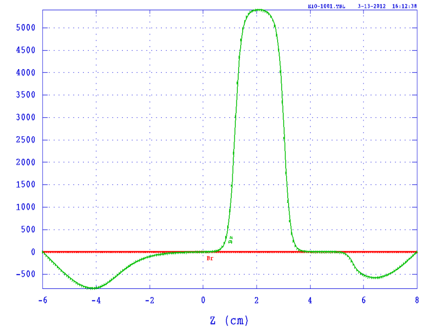

Fig.3 The distribution of Magnetic Field

Fig.4 The test of Magnetic field

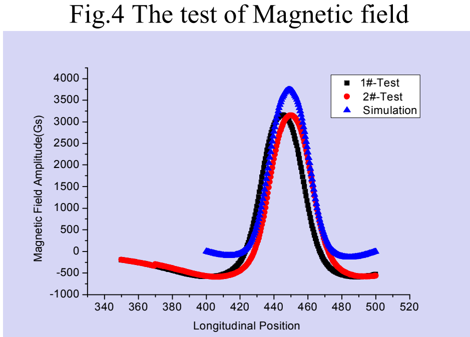

Fig.5 The results of test magnetic field

Fig.4 is the test magnetic field and the fig.5 is the results of that of test. The results show that the fabrication of magnetic field is agreed with the theoretical design.

IV. The Simulation and Test of Electronic Optics System

The electron gun was designed by using the 2-D software codes. The electrostatic electron beam trace is calculated by 2-D EGUN codes, and the trace of the electron beam is obtained Egun, which is shown in figure 6. Figure 6 shows that the electron beam trajectory is good with laminar flow. The trochoid of electron beam at the uniform is flat, and it is radiated in collector. Now the beam tube is manufactured for THz EIO is shown in Fig.7, and the beam passing exceeds 90% when the operation voltage is over 5kV. The optimum beam tube is performing.

V. Conclusion

In this paper, the electronic optics system is designed for THz EIO. The cathode and uniform magnetic etc are calculated based on the experience formula. Through the simulation, the electron can be emitted and transported with a good trajectory . The beam passing exceeds 90% at the voltage 4kV, and the optimum optic system is under performance.

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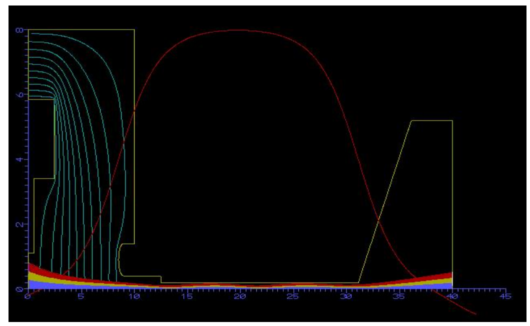
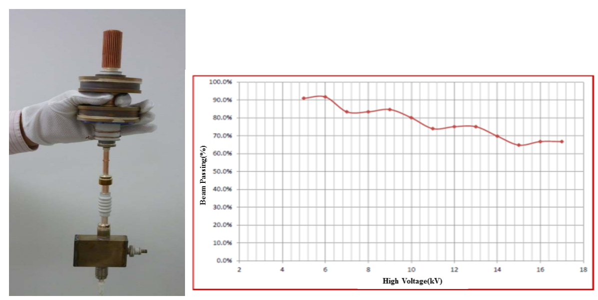


Fig.6 2-D The trajectory of electron beam



(a) (b)

Fig.7 (a) Beam tube (b) Test result

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