Design of the Radial Divergent Sheet Beam Electron Optical System with Cylindrical Emission Surface

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***Abstract*—The radial sheet beam traveling wave tubes can work at the frequency of millimeter wave band, have the properties of high efficiency, broad bandwidth, miniaturized dimensions, and easily to be integrated and so on. The radial divergent sheet beam electron optical system with cylindrical emission surface is designed for the Ka band radial sheet beam traveling wave tubes in this paper. The radial divergent sheet beam with the open angle of 8 deg and the thickness of 0.28 mm, generated by the electron gun with 1800V, 84.9 mA, can achieve 100% transmission efficiency in a 20 mm length radial direction drift tunnel with the open angle of 10 deg and the height of 0.36 mm.**

I. INTRODUCTION

THE development of radial beam vacuum electron device was invented by the Russian scholars, and this kind of the radial beam TWT has attracted many attentions of the researchers over many years, such as the fabrication of the prototype TWT[2], the theory research of the radial electron trajectory in the cylindrical pierce diode[3], and so on. The recent achievement of novel slow wave structure (SWS) for this kind of TWT is named as angular log-periodic meander-line for Ka-band radial sheet beam TWT [4], which is shown in Fig.1. We designed the radial divergent sheet beam electron optical system (RDSBEOS) with hyperbolical emission surface [5], but it was difficult to be fabricated. The RDSBEOS with cylindrical emission surface is proposed in this paper to overcome the fabrication difficulty, which will be used in the angular Log-periodical meander line TWT.

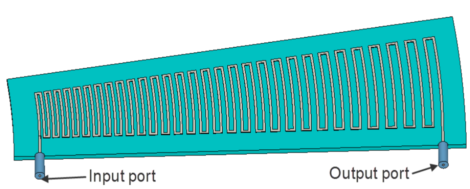


Fig.1. The model of the angular log-periodic meander-line

II. RESULTS

The main parameters for the radial divergent sheet beam electron gun are listed in table 1. The shape of cathode, control electrode, and anode of the electron optical system are illustrated in Fig.2 (a), (b) and (c), respectively. The permanent magnetic field with distribution of radial component Br =0.19T is added to the beam drift tunnel, which is with height of 0.36mm, open angle of 10 degree, and length of 20 mm. All shapes of the electrodes have the same circle center in the radial plane (r-θ) as shown in Fig.3. The magnetic focusing system includes the permanent magnets colored in blue and the pole shoes colored in red shown in Fig.5 (a) also has the same circle center with the electrode of the electron optical system.

Table 1 .Parameters for the radial divergent sheet beam electron gun.

Parameters	**Values**
Cathode dimension Angle(deg)×R(mm)×h(mm)	8×14.5×0.6
Beam Voltage (V)	1800
Distance between cathode and anode (mm)	0.75
Total Current(mA)	84.9

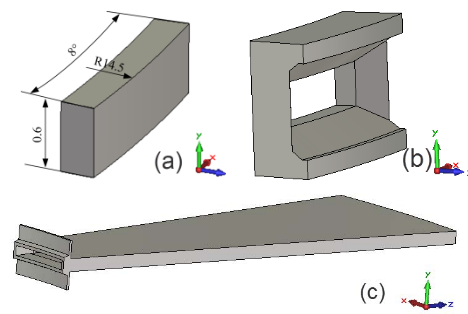


Fig.2. The shapes of (a) cathode, (b) control electrode and (c) anode

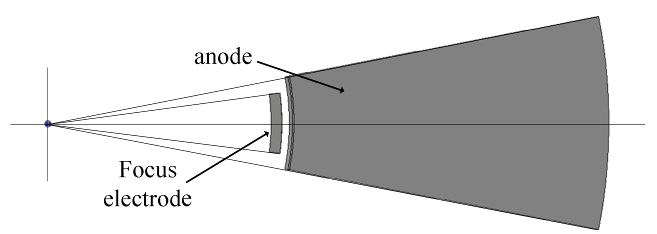
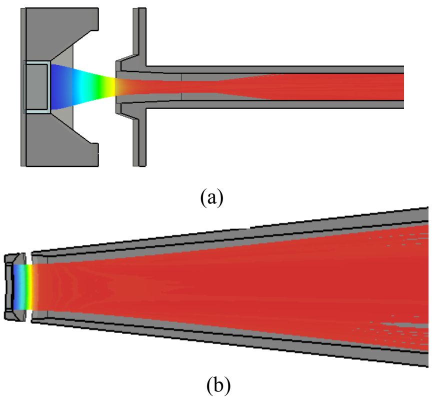


Fig.3. All shapes with the same circle center

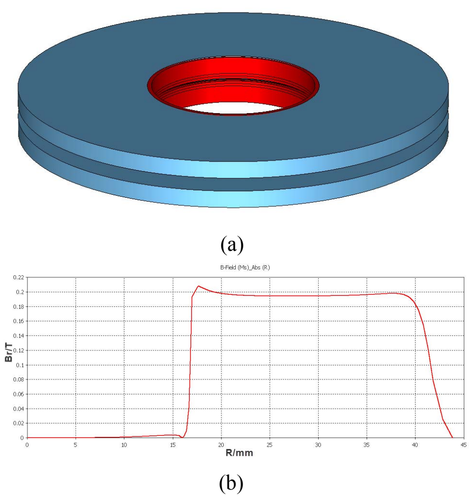
The simulation results of the electron trajectory without magnetic field are shown in Fig.4, which shows the side views of the trajectory along (a) r-z plane and (b) r-θ plane. It is nearly compressed by a factor of 3 in z direction at the waist position. As shown in Fig.4 (b), the electron trajectory overlaps with the radius which starts from the circle center in the r-θ plane in the region from 14.5mm to about 21mm.

The simulation results of the electron transport with the magnetic field are shown in Fig.6, which shows the side views of the trajectory along (a) r-z plane and (b) r-θ plane. As can be seen, the radial sheet beam with the open angle of 8 deg and the thickness of 0.28 mm can stably transport in the 20mm length drift tunnel. The transmission efficiency is 100%. The fluctuation of the radial sheet beam in Fig.6 (b) is mainly caused by the small Br component of the permanent magnetic field leaked into the electron gun region, which is about 0.004T in the region from 14.5mm to 15.3mm at the r-direction.



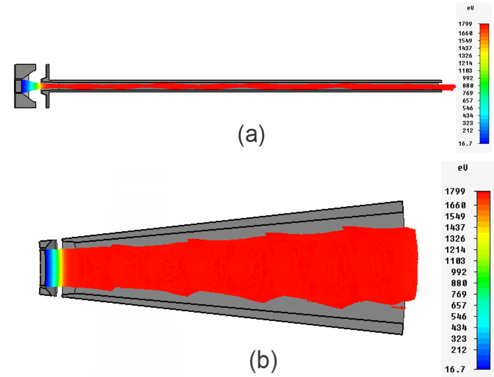
(a) (b)

Fig.4. The side view of the trajectory along (a) r-z plane and (b) r-θ plane without magnetic field



(a) (b)

Fig.5. The shapes of (a) magnetic focusing system and (b) magnetic field distribution along r direction



(a) (b)

Fig.6. The side view of the trajectory along (a) r-z plane and (b) r-θ plane with magnetic field

III. SUMMARY

The divergent radial sheet beam can be formed by the novel electron optical system presented here, which can stably move through the beam tunnel with transverse size of 10 deg ×0.36 mm and the length of 20 mm under the radial permanent magnetic field focusing system. The radial divergent sheet beam electron optical system with cylindrical emission surface is more easily to be fabricated than which with hyperbolical emission surface. The electron gun will be assembled in the near future; then, the emission and transport properties will be tested.

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