A 0.67THz Sheet Electron Beam TWT Based upon Sine Waveguide

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Abstract: *A 0.67THz sheet electron beam traveling-wave tube based upon sine waveguide slow-wave structure is studied. In this paper, the high frequency characteristics and transmission characteristics are calculated by a 3-D high frequency simulation software. The beam-wave interaction is also simulated. From the simulation results, the peak output power is 1.7W ranging from 0.65THz to 0.69THz with synchronous voltage of 17kV, operation current of 10mA and input power of 3.2mW.*

Keywords: Sheet electron beam; terahertz; sine waveguide; traveling-wave tube(TWT).

Introduction

Terahertz science and technology have great scientific value in many fields, such as defense, radar guidance, imaging[1], communication[2] and other application fields. The traveling-wave tube (TWT) as an important vacuum electron device can produce and amplify the terahertz wave. And the slow-wave structure (SWS) is the key component of TWT.

Sine waveguide [3][4] is a kind of all-metal SWS which has large power capacity and is easy to fabricate. With low metal loss and natural sheet electron beam tunnel, sine waveguide is a promising SWS for sheet electron beam terahertz TWT.

Model Description

Figure 1 shows the sine waveguide's structure model. Here, the wide length *a* is 255 μm; the narrow side length *b* is 190 μm; the oscillating period *p* and oscillating amplitude *h* are 140 μm and 75 μm, respectively. The height of the electron beam tunnel h_b is 40 μm. Figure 2 illustrates the dispersion characteristics of the sine waveguide with the dimensional parameters which are mentioned above. The dispersion curve is calculated by simulation software HFSS[5].

High Frequency Characteristics

The transmission model showed in figure 3 is comprised of 190 main periods and 6 periods of transition couplers on each side. UV-LIGA microfabrication technology can be used to fabricate the 0.67 THz high frequency slow-wave circuit. The conductivity of the transmission model is set as 3.36×10^7 S/m, considering the surface roughness of the oxygen-free high conductivity copper (OFHC). Figure 4 shows the transmission characteristics through 3-D electromagnetic simulation software CST MWS. The insertion loss S_{21} is more than -17.2dB and the return loss S_{11} is less than -30dB from 0.64THz to 0.7THz.

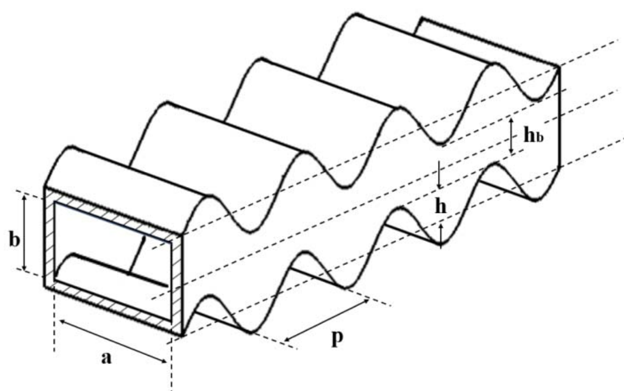

Figure 1. Dimensional parameters of the sine waveguide.

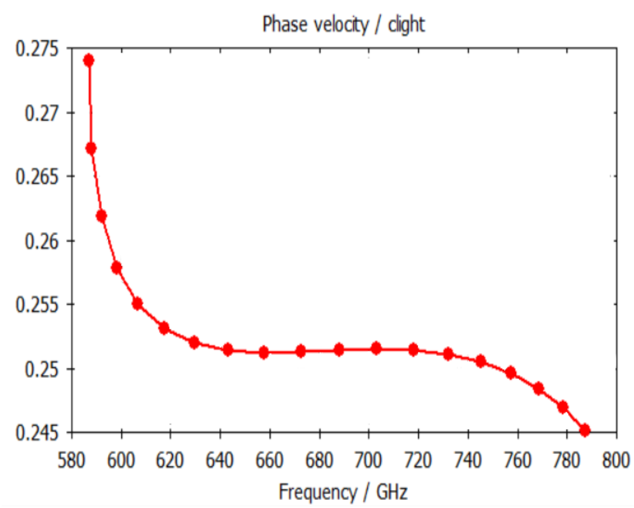

Figure 2. Dispersion characteristics of the 0.67THz sheet electron beam sine waveguide SWS.

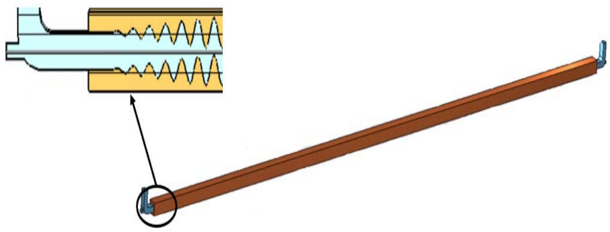

Figure 3. Model of 0.67 THz sine waveguide high-frequency transmission system.

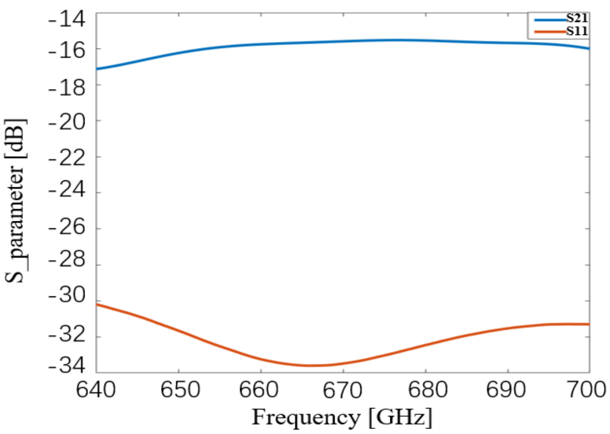

Figure 4. Transmission and reflection coefficient.

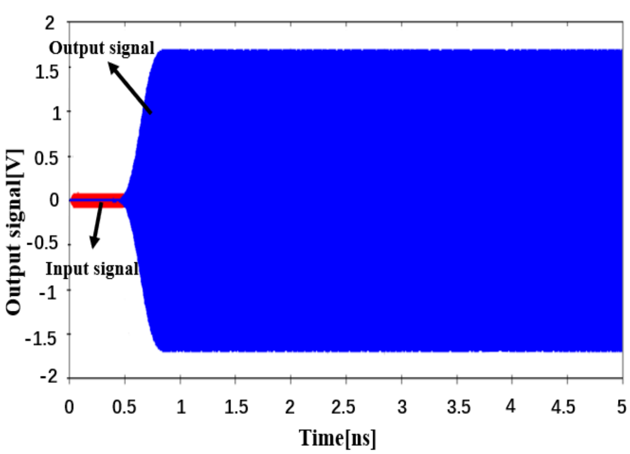

Figure 5. Input and output signals of sine waveguide TWT at 0.67THz.

Beam-wave Interaction

The simulation of beam-wave interaction process is carried out based on the circuit model mentioned above with the PIC solver in CST Particle Studio[6]. In the PIC simulation, we set that a sheet electron beam has a cross-sectional area of 127.5×95 μm^2 with a voltage of 17 kV and a current of 10 mA. A uniform longitudinal magnetic field is 1 T to focus the sheet electron beam. And the power of input signal is set as 3.2 mW. Figure 5 shows the simulation results that the amplitudes of input and output signals. The output power is about 1.4 W at 0.67THz. From the Fig. 6, the maximum output power is about 1.7 W and the gain of the beam-wave interaction is more than 25dB ranging from 0.65THz to 0.69THz.

Summary

The sheet electron beam TWT based upon sine waveguide SWS operating from 0.65THz to 0.69THz has been presented in this paper. The simulation result shows that the gain is more than 25 dB in the working bandwidth. And the output power is about 1.4 W at 0.67THz with the input power of 3.2mW.

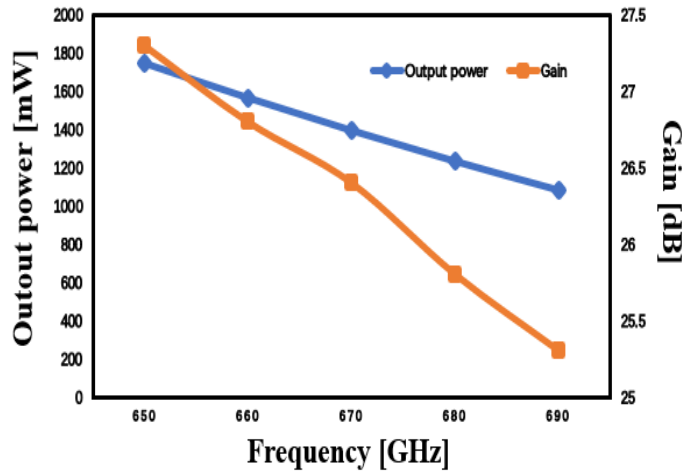

Figure 6. Output power and gain vs frequency.

Acknowledgements

This work was supported in part by National Key R&D Program of China(Grant No.2017YFE0130000), and in part by the National Nature Science Foundation of China(Grant No. 61771117)

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