1 THz Trapezoidal Staggered Grating Traveling Wave Tube

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Abstract: *In this paper, the high frequency characteristics of Trapezoidal Staggered Grating Slow-wave Structure for 1THz Traveling Wave Tube has been studied. The transmission structure has been simulated, the reflection coefficient is less than -20dB in the frequency of 1015GHz to 1055GHz and the loss of the structure is over 58dB. The PIC simulation shows that the saturation output power is 405mW at the frequency of 1030GHz, and the corresponding gain is 19.08dB.*

Keywords: THz; Slow-wave Structure (SWS); Traveling wave tube (TWT).

Introduction

THz wave is the electromagnetic wave with a frequency of 100 GHz to 3000 GHz, and its corresponding wavelength is 3 mm to 0.1 mm. As terahertz wave has unique application value in the fields of public safety, biomedicine, communication, etc. [1] Scholars from various countries have carried out a lot of research on terahertz devices in recent years. The Department of Defense Advanced Research Agency (DARPA) started the THz Electronics Projects [2] in 2010 to focus the operating frequency of amplifier at 0.67THz, 0.85THz, and 1.03THz, and the corresponding output powers are 63mW, 25mW, and 10mW, with the bandwidth of 15GHz. The project of OPTHER [3] is aimed to realize the 1THz amplifier.

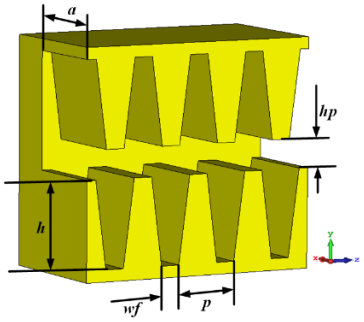

Figure 1. The model of Trapezoidal Staggered Grating Slow-wave Structure

There are several types of SWS which is suitable to work in THz TWT, such as staggered double grating slow-wave structure [4], sine waveguide slow-wave structure [5] and folded waveguide slow-wave structure [6]. Trapezoidal Staggered Grating Slow-wave Structure (shown in figure 1) is a SWS which can be seen as the modified structure of staggered double grating slow-wave structure and sine waveguide slow-wave structure, it can be fabricated by UV-LIGA or DRIE. In this paper, the high frequency of 1THz staggered grating Slow-wave structure has been simulated, and the interaction results has been proposed.

High Frequency Characteristics Simulation

Figure 1 is the model of Trapezoidal Staggered Grating Slow-wave Structure. The width of the SWS is *a*, the height of the grating is *h*, the height of the beam channel is *hp*, both the length of the grating and the space length between the gratings is *wf* and the period length is *p*.

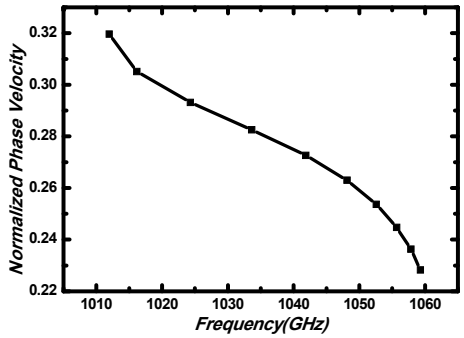

Figure 2. Normalized Phase Velocity of Trapezoidal Staggered Grating Slow-wave Structure

Figure 2 shows the normalized phase velocity of Trapezoidal Staggered Grating Slow-wave Structure. It can be seen that the normalized phase velocity at 1.03THz is about 0.2867, which means that the working voltage of the Trapezoidal Staggered Grating Traveling wave tube is around 22.4kV.

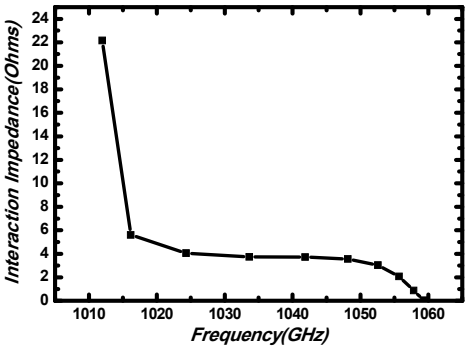

Figure 3. Interaction Impedance of Trapezoidal Staggered Grating Slow-wave Structure

The interaction impedance of the SWS is shown in figure 3, the interaction impedance of the Trapezoidal Staggered Grating Slow-wave Structure is over 3.5Ohms in the frequency of 1025GHz to 1040GHz.

Simulation of transmission structure

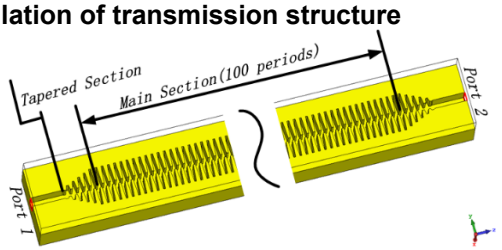

Figure 4. The transmission model of Trapezoidal Staggered Grating Slow-wave Structure

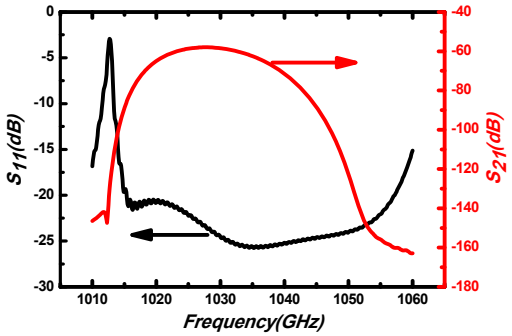

Figure 5. The S-parameters of the transmission model

Figure 4 is the transmission model of trapezoidal staggered grating slow-wave structure. It contains three parts, the rectangular waveguide, the tapered section and the main section which has 100 periods of SWS. The material of the structure is copper, considering the roughness of the structure, the conductivity of the copper is assumed to $2.5x10^7$S/m.

The simulation result of the model is shown in figure 5. The reflection coefficient is less than -20dB in the frequency range of 1015GHz to 1055GHz. But the loss of the structure is over 58dB in the entire frequency band.

PIC simulation

Through the optimization, the working voltage of the trapezoidal staggered grating traveling wave tube is 22.4kV, and the beam current was setting to 17mA, the current density is 400A/cm^2 correspondingly.

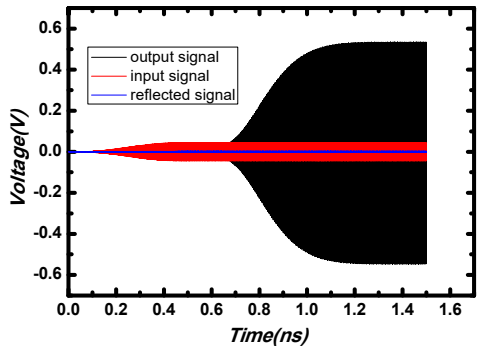

Figure 6. The output signal of the trapezoidal staggered grating traveling wave tube

Figure 6 shows the output signal of the TWT which has 250 cycles trapezoidal staggered grating slow-wave structure while the input power is 1mW. It can be seen in figure, the voltage of the output signal is around 0.535V, which means the output power is 143.1mW.

Figure 7 is the output power vary with input power. While the input power varies from 0.2mW to 5mW, the output power increased from 32.77mW to saturation power 405mW, the corresponding gain is from 22.14dB to 19.08dB.

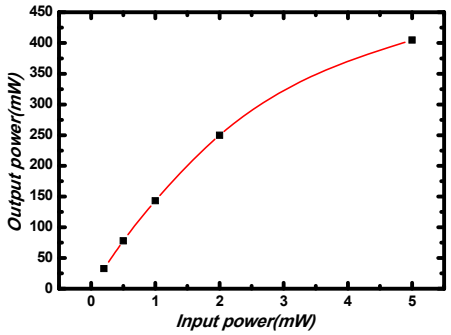

Figure 7. Vary of output power with input power

Conclusion

In this paper, 1THz TWT based on staggered grating slow-wave structure has been simulated. The PIC simulation shows that the saturation output power is 405mW at the frequency of 1030GHz, and the corresponding gain is 19.08dB.

Acknowledgments

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