A New type of 0.34THz Sine Waveguide Slow Wave Structure

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Abstract: *A new type sine waveguide slow wave structure (SWS) is proposed in this paper considering fabrication feasibility. Unlike the conventional sine waveguide SWS, a round beam tunnel is adopted in this modified structure. The simulation results show that the new structure have the advantages of wide bandwidth and low loss which are important in millimeter-wave and THz TWT. A 3dB bandwidth of 25 GHz and a maximum gain of 27 dB were predicted by PIC simulation for a 40 mm-long slow wave circuit.*

Keywords: Sine Waveguide; traveling wave tube; simulation; THz

Introduction

In the terahertz frequency band, with the frequency increasing, the ohmic loss and transmission are severely preventing current TWT from enhancing the efficiency and expanding the bandwidth1.

In this paper, a new structure is proposed, which inherits the advantages of low loss and broad bandwidth of sine waveguide SWS. Using nano CNC milling to fabricate 0.34THz sine waveguide SWS, the bottom's radius of the sine structure is too small to cut. That's why we choose the chamfered sine waveguide SWS according to the radius of the milling cutter. Meanwhile, we shortened the distance between the upper and lower slow-wave structures in order to increase the interaction impedance. A circular electron tunnel is added to the structure and the circular electron beam is used for easy focusing.

With 4 gradient cycles, the reflection of the input and output structure, is lower than -20dB. The amplification property of the TWT is that the output power is more than 1 W, corresponding output gain is more than 20 dB with over 35GHz bandwidth.

MODEL DESCRIPTION

Comparing the conventional sine waveguide, the new sine waveguide SWS is shown in the Fig. 1. To increase the interaction impedance, we shortened the distance between the upper and lower slow-wave structures. A circular electron tunnel is added to the structure and the circular electron beam is used for easy focusing. Round chamfer design at the top of the sine structure enables the structure to be processed.

By the simulation calculation, Some of the dimensional parameters of the SWS are optimized as follows: a=510um, b=320um, p=0.23mm，r=0.05mm.

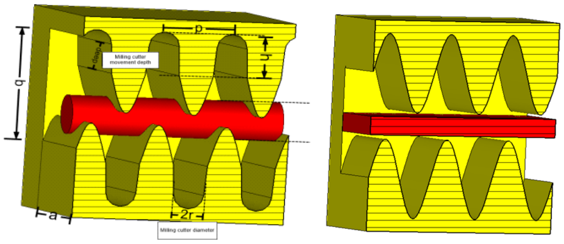

Fig.1. Comparison of new sine waveguide and conventional sine waveguide

Simulation And Results

High-frequency characteristics: Using the eigenmode solver, the normalized dispersion curve and interaction impedance of the new round chamfered sine waveguide structure are calculated as shown in Fig. 2. That in the frequency range from 0.32-0.38THz, the normalized phase velocity curve is flat, which means a wide operating bandwidth with a normalized phase velocity about 0.216. The interaction impedance is approximately 1.18 ohms in the 0.34THz region and greater than 1 ohms range from 0.31-0.35THz.

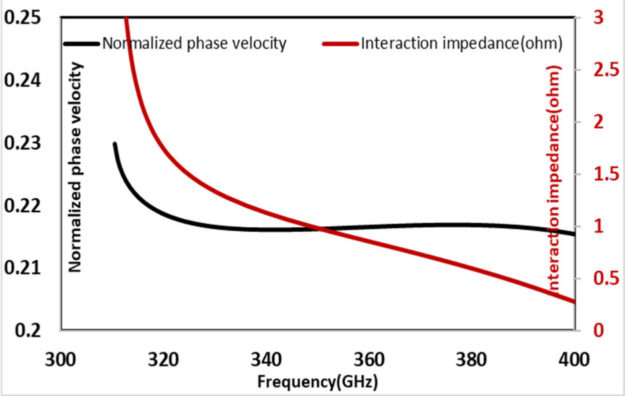

Fig.2. The high frequency characteristics for the 0.34THz sine waveguide structure

The transmission characteristics of the new sine Waveguide: Fig.3 shows the New type round chamfered sine waveguide SWS. And this model includes the main SWS section of 160 periods, the left and right sides have five gradient cycle respectively.

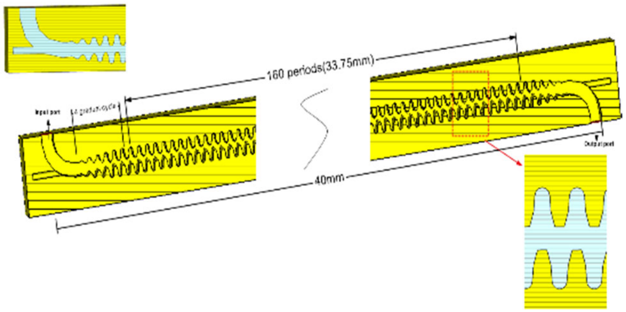

Fig.3. Complete structure with 160 periods

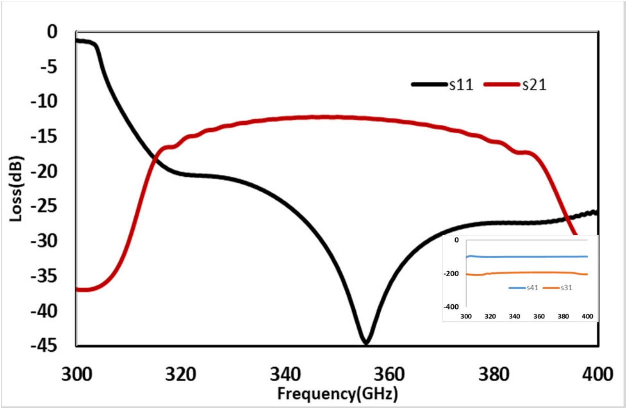

Fig.4. S-parameter

Fig.4 is the S-parameter of the complete structure. It can be seen that the structure has a low reflection coefficient which is lower than -20dB(S11<-20dB) in 0.32-0.4THz, while transmission loss is -11dB(-2.88dB/cm). S31 and S41 show that no energy coupled into the beam tunnel.

Beam-wave interaction characteristics: The effective conductivity of the high frequency circuit is set to 2.49×10^7S/m according to surface roughness. The round electron beam with the current of 30mA and the voltage of 12.65kV is selected. And the electron injection radius is 50um. The focusing magnetic field is 0.6T.

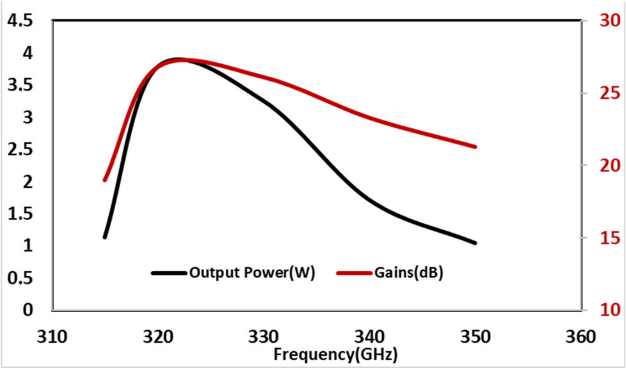

Fig.5. The output power and the corresponding gain versus working frequency

As shown in Fig.5. The total length of the slow-wave structure is 40.68mm. When the input power is 8mW, The output power is above 1W, and the gain is above 20dB in the whole operation frequency band from 0.315 THz to 0.350 THz.

Conclusion

In this paper, a new type 0.34THz sine waveguide slow wave structure (SWS) is proposed which can be fabricated by nano CNC milling. The new structure have the advantages of wide bandwidth and low loss. The amplification property of the TWT is that the output power is more than 1 W, corresponding output gain is more than 20 dB with over 35GHz bandwidth. The next step is to enter the processing test stage. In the first phase, we will use a single-stage slow wave structure(SWS) to achieve W-class output, and in the second phase, we plan to use a two-stage structure to achieve output of more than 10W at 0.34THz.

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