Study of Multiple Beam Backward Wave Oscillator Based on Corrugated Waveguide TWT

Luanfeng Gao[1],YanMei Wang[2],Yulu Hu[1], Claudio Paoloni[3], Bin Li[1]
[1]National Key Laboratory of Science and Technology on Vacuum Electronics
University of Electronic Science and Technology of China
No.4, Section 2, North Jianshe Road, Chengdu, P. R. China 610054
[2] Beijing Vacuum Electronics Research Institute
P.O. Box 749, Beijing 100016, P. R. China
[3] Engineering Department,Lancaster University
Lancaster, LA1 4YW, UK

***Abstract*—The multiple beam Backward Wave Oscillator (BWO) which based on corrugated waveguide is simulated by Microwave Tube Simulation Suite (MTSS) and CST Particle Studio(PIC). Simulation results show that the saturated output power is about 45W at the expected operating frequency of 220GHz, when the cylindrical electron beam current and Voltage are 20 mA and 44keV.**

***Keywords*—BWO; Double Corrugated Waveguide;Four Corrugated Waveguide; Terahertz**

I. INTRODUCTION

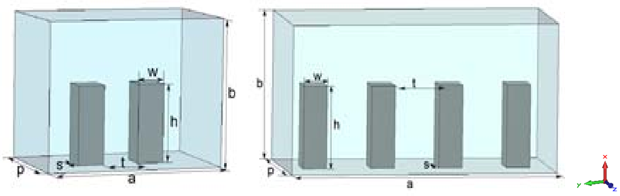
Terahertz band is between the highest frequency of micro-wave and the lowest frequency of photonic. Recently, there has been great effort in the development of Terahertz wave radiation sources which have many potential applications, such as remote atmospheric monitoring, high resolution radar imaging, high speed data rate communication, biochemical sensing, and security applications. Due to lack of output power which at the level of Watt, the utilization rate of those applications above was very low. Here, many devices which can generate THz wave radiation have been investigated like solid state electron devices, optical devices, and vacuum electron devices (VEDs).

Nowadays VEDs are expected as the most potential devices to realize high power at Terahertz. Backward-wave Oscillator based on VEDs, generates electron beams that interacts with a slow-wave structure(SWS), is a kind of wonderfully and widely investigated sources at Terahertz band[2].

As we know slow wave structure is the heart of BWO. To enhance the BWO output power, many SWSs have been successfully used, such as folded waveguide, sine waveguide and staggered double vane. The double corrugated wave-guide(DCW) SWS was proposed by Lancaster University[3] aims to reduce the fabrication effort and the cost. The simple and novel structure makes it becomes the most promising slow wave structure to design TWTs and BWOs, which can be realized by modern microfabrication techniques and assures an effective interaction with a cylindrical beam.

II. DESIGN OF MULTIPLE BEAM BWO

In this paper, the design of multiple beam BWO was based on a quadruple-corrugated waveguide (QCW) SWS which is proposed to achieve a significantly higher output power. It consists of a rectangular waveguide including four identical parallel corrugations, which are separated to form three channels where electron beams flow (Fig. 1 (b)). The date of signal beam and multiple beam BWO in TABLE I was based on the Double Corrugated Waveguide Traveling Wave Tube(TWT)[3]. The geometry dimension of BWOs at 220GHz with single electron beam and multiple electron beams are all the same except the number of beam channels, as shown in Fig. 1.



(a) DCW (b) QCW

Fig. 1 Unit cell of SWS used in the eigenmode calculation.

TABLE I PARAMETERS OF DCWAND QCW

Geometrical Parameters	DCW(um)[3]	QCW(um)
Corrugation width(w)	80	80
Corrugation high(h)	210	210
Corrugation distance(t)	150	150
Period(p)	360	360
Ridge width(s)	80	80
Waveguide width(a)	530	900
Waveguide height(b)	380	380
delta	25	25

A. Eigenmode calculations

The dispersion relationship between the two different SWSs (Fig. 1) and each electron beam mode which computed

978-1-5090-5916-4/17/$31.00 ©2017 IEEE

by MTSS[1] are shown in Fig. 2. It also show that QCW has wider bandwidth than DCW.

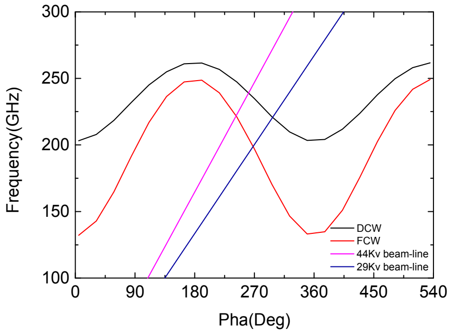


Fig. 2 Dispersion characteristics of DCW and QCW SWS

B. PIC simulation

The transmission characteristic multiple beam BWO (Fig.3) for is calculated by transient mode solver in the CST Studio Suite are shown in Fig.4. It is notable the transmission characteristic of multiple beam BWO in the frequency band（200GHz-240GHz）especially around 220GHz has very good return loss.

The hot simulation was performed by CST-Particle Studio. In the PIC simulation the homogeneous magnetic field 1.5T generated by the permanent magnets was applied along the path of the electron beam, the QCW model shown in Fig. 3. Then adjusted the energy of the electron beam to achieve a radiation frequency of 220 GHz, and determined to use the cylindrical electron beam with current of 20mA to make the input power constant. A simulation time of 9ns was chosen to provide a stable output signal (Fig.5) is about 45W, with an efficiency of 5.1%.

III. Conclusiion

The design of a 220GHz multiple beam backward-wave oscillator with 60 periods QCWs SWS, Simulation results show that a 45W saturated output power is gained at 220GHz, when the cylindrical electron beam current and Voltage are 20 mA and 44keV. In summary, multiple beam SWS can indeed enhance the current, dimension, transmission characteristics and output power of THz BWO.

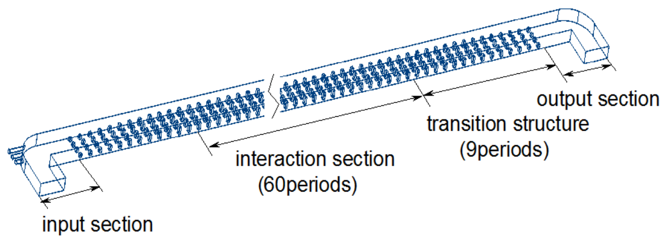


Fig. 3 PIC Model with 60 periods of QCW with beam

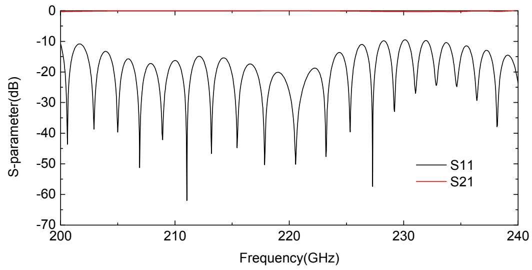


Fig. 4 Transmission characteristic of Multiple beam BWO

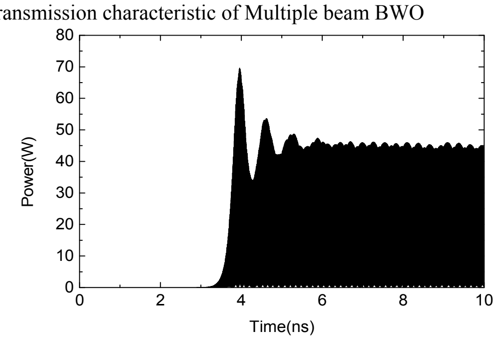


Fig. 5 Multiple Beam BWO output power

Acknowledgements

This work is supported by the National Natural Science Foundations of China (Grant No. 61301054).

References

[1] B. Li, Z. H. Yang, J. Q. Li, and X. F. Zhu, "Theory and Design of Microwave-Tube Simulator Suite," IEEE Transactions on Electron Devices, vol. 56, pp. 919-927, 2009.

[2] H. U. Lin-Lin, J. C. Cai, and H. B. Chen, "Applications and Development of Terahertz Backward Wave Oscillators," Acta Electronica Sinica, 2016

[3] C. Paoloni and M. Mineo, "Double Corrugated Waveguide for G-Band Traveling Wave Tubes," Electron Devices IEEE Transactions on, vol. 61, pp. 4259-4263, 2014.