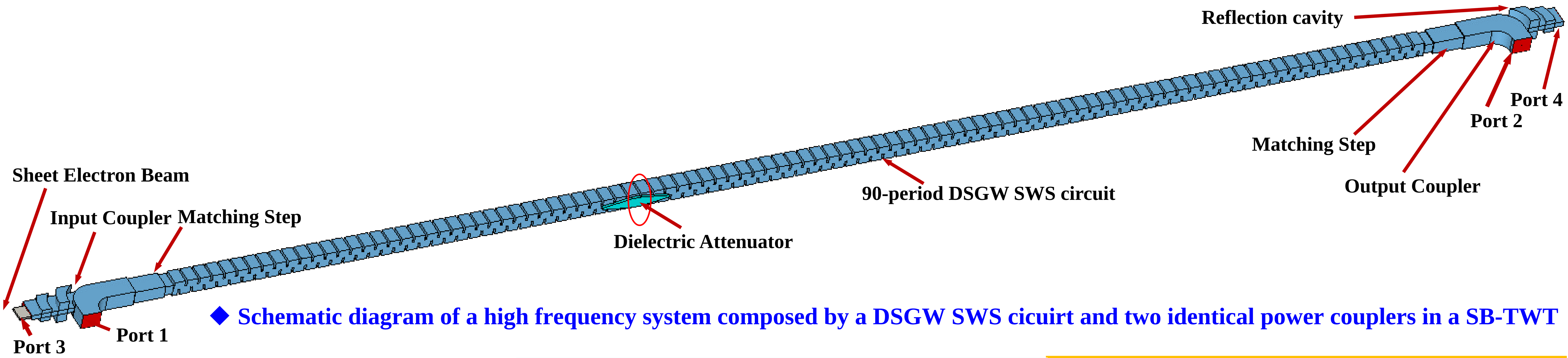
Preliminary Cold Test Of A Terahertz Band Sheet Beam Travelling Wave Tube

深圳大学
SHENZHEN UNIVERSITY

G. X. Shu[1], J. Deng[1], J. Lin[1], L. Chen[1], Z. Huang[1], X. Hua[1], G. Liu[2], and W. He[1]
[1]College of Electronic and Information Engineering, Shenzhen University, Shenzhen 518060, China
[2]School of Electronic Science and Engineering, University of Electronic Science and Technology of China, Chengdu 610054 ,China

I. Introduction

In this paper, the preliminary cold test of a high frequency system composed of two identical input /output couplers and a 90-period double-staggered grating waveguide is presented. A HFS without dielectric attenuators was machined by nano-CNC machining. The vector network analyzer measured results showed that the transmission coefficient S_{21} and port reflection S_{11} were better than -8.0 dB and -15.0 dB in the bandwidth of ~47.2 GHz (241.4-288.6 GHz), respectively. The measured results were indicative of satisfactory machining accuracy and surface roughness and verified the adopted manufacturing technique.



◆ Schematic diagram of a high frequency system composed by a DSGW SWS cicuirt and two identical power couplers in a SB-TWT

II. Cold Cavity Analysis

(1) Input/output Couplers

❑ **Structure**

- L-bend rectangular waveguide:

Intrinsically wide bandwidth, change the propagation direction of the electromagnetic-wave (EM-wave).

- Reflection Cavity:

Reflect back the EM-wave to the SWS, increasing the isolation and the transmission efficiency.

- Matching Step:

Compensate for the discontinuity of the L-bend, enhancing the port reflection.

❑ **Performance**

- Wide bandwidth (~60 GHz)
- Low port reflection (<-15 dB)
- High transmission efficiency (>-0.3 dB)
- Good isolation (<-20 dB)
- Easy-to-fabrication configuration

(2) DSGW SWS circuit

❑ **Structure**

- DSGW SWS:

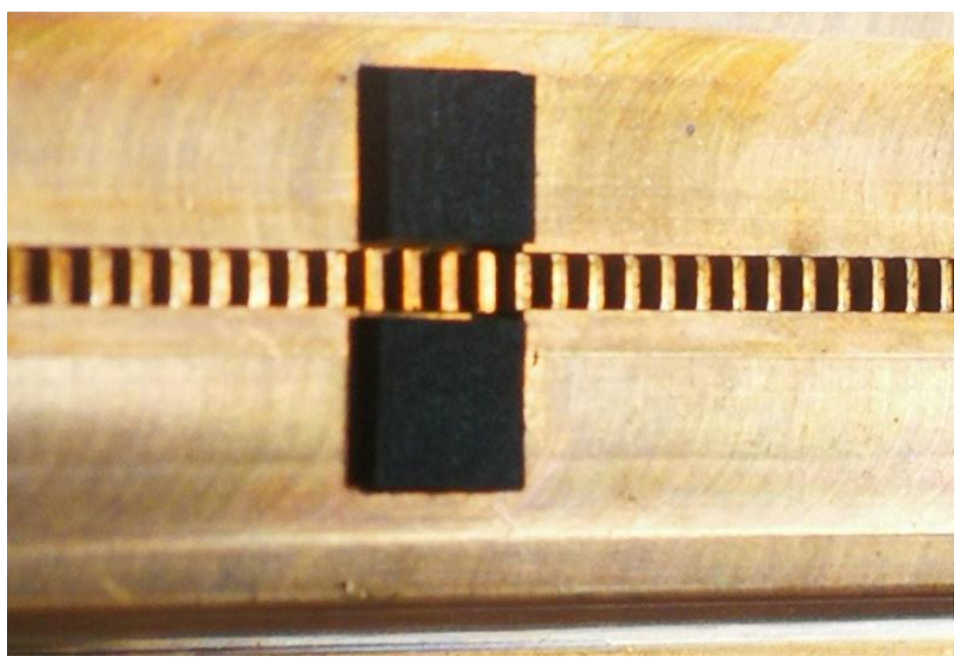
Wide pass-band width, planar 2D configuration.

- Dielectric attenuator:

To suppress the potential parasitic and reflection oscillations, made of BeO-SiC ceramic with heavy attenuation.

❑ **Performances**

- Wide operating bandwidth (~ 50 GHz)
- High average coupling impedance (> 28 Ω)
- Easy-to-fabrication configuration



DSGW with dielectric attenuators

Measured results:

Heavy attenuation: S_{21}<-56 dB, S_{11}<-15 dB

BW: 246.2-290.0 GHz

III. Hot Cavity Analysis

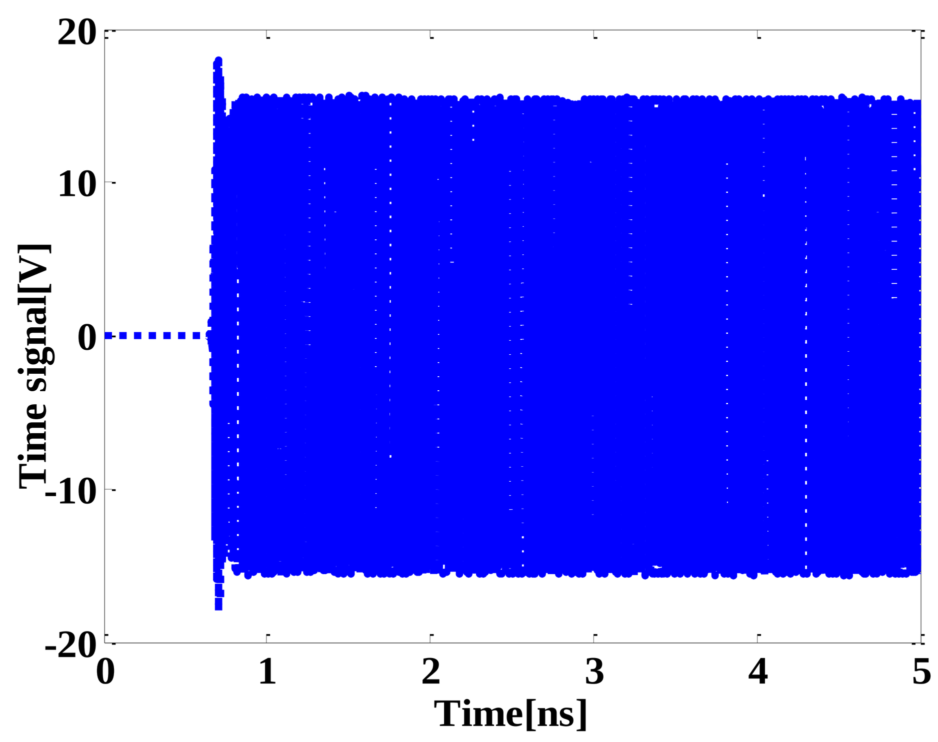
To verify the designs and study the beam-wave interaction performance, particle-in-cell simulations were carried out by using CST Particle Studio.

➢ **Input parameters**

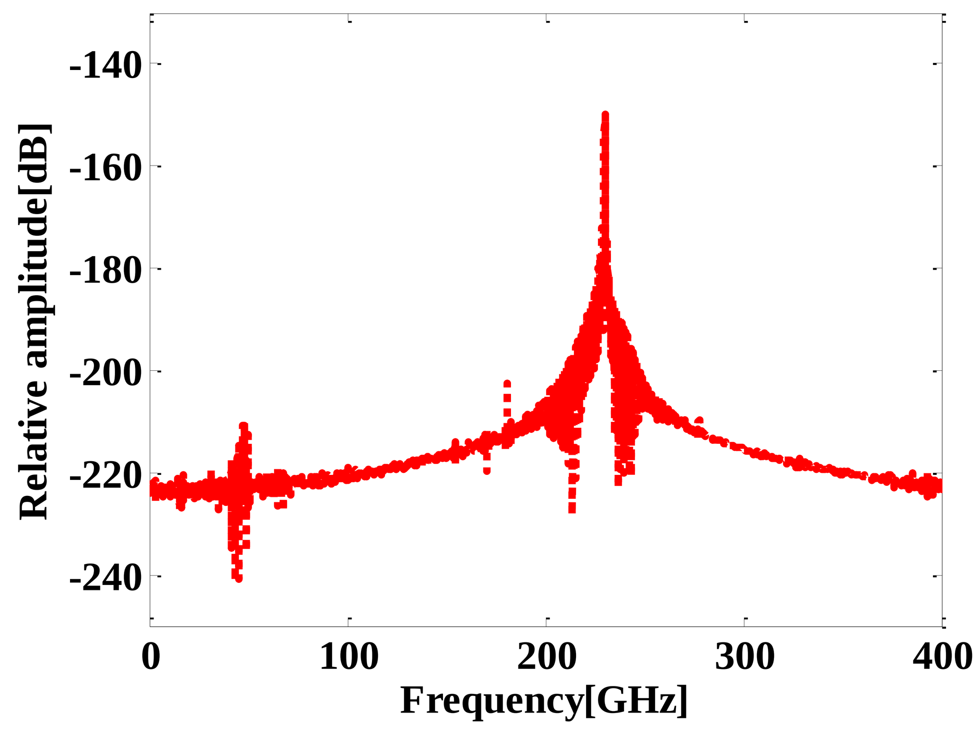
- Beam shape: rectangular cross section shape with an aspect ratio of 7:1
- Beam voltage: 30 kV
- Beam current: 0.2 A
- Frequency of the input signal: 230.0 GHz
- Input power：80 mW
- Conductivity of background material: $\sigma_{Cu}/3$ (σ_{Cu}=5.8×10^{7}S/m)
- Intensity of the focusing magnetic field B_z : 1 T

➢ **Output parameters**

- Output power : 120.1 W
- Gain: 31.8 dB
- Electronic efficiency: 2.0%
- Frequency of the output signal: 230.0 GHz



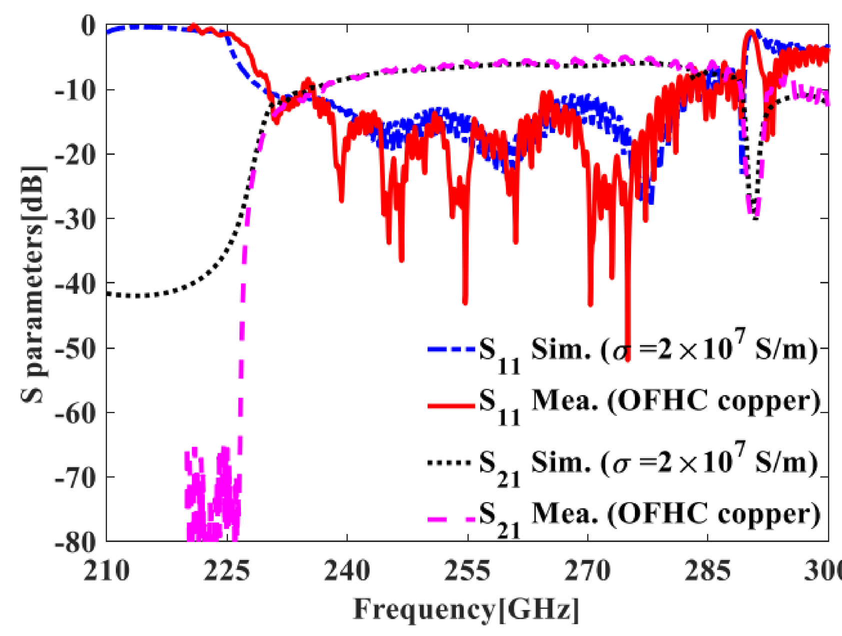
➢ Output voltage signal observed at port 2



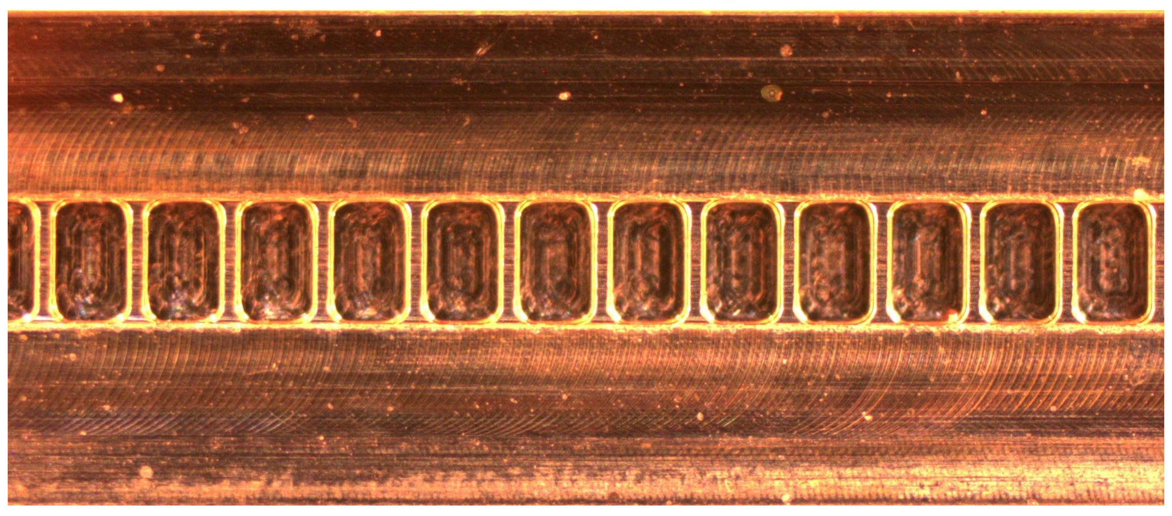
➢ Frequency spectrum obtained by FFT

Initial beam wave interaction simulations showed the SB-TWT achieved a stable output with pure frequency spectrum at 230 GHz. The predicted output power was more than 40 W in a bandwidth of 45 GHz.

IV. Manufacturing of the HFS

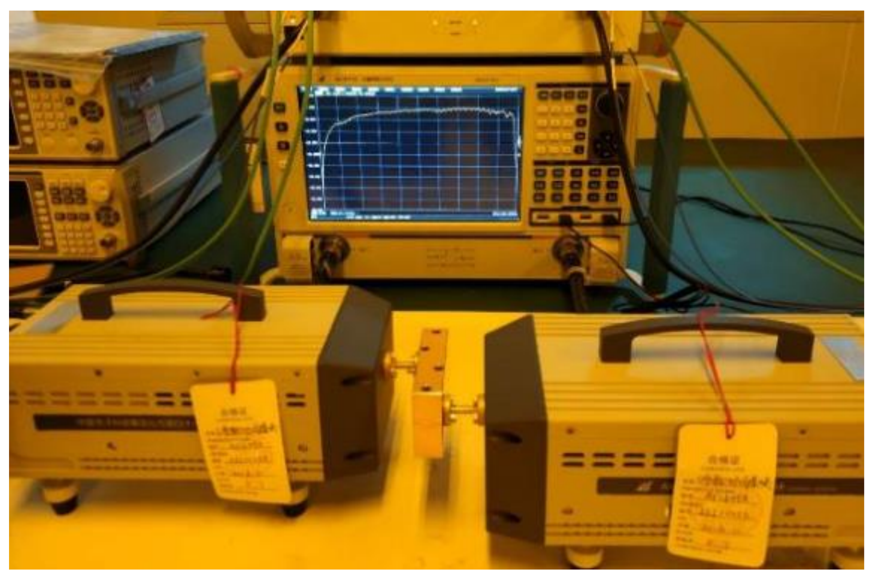


Measured and simulated S-parameters



✓ Images of a part of the fabricated high frequency system observed by an optical microscope

VNA setup



V. Conclusion

Initial interaction beam wave simulation results demonstrated that the SB-TWT was a promising and attractive sub-THz amplifier with high output power and wide bandwidth. A HFS of a terahertz band SB-TWT was nano-CNC machined and preliminary cold tested, which exhibited satisfactory processing and measurement results.

VI. References

[1] J. H. Booske, R. J. Dobbs, C. D. Joye, et al., “Vacuum electronic high power terahertz sources,” *IEEE Trans. Terahertz Sci. Technol.*, vol. 1, no. 1, pp. 54-75, Sep. 2011.
[2] A. Baig, D. Gamzina, T. Kimura, et al., “Performance of a nano-CNC machined 220-GHz traveling wave tube amplifier,” *IEEE Trans. Electron Devices*, vol. 64, no. 5, pp. 590-592, Aug. 2017.
[3] G. X. Shu, J. Deng, L. Xie, et al., “Design, fabrication, and cold test of a high frequency system for an H-band sheet beam travelling wave tube,” *IEEE Trans. Terahertz Sci. Technol.*, vol. 10, no. 3, 2020.