Design and Cold Test of a Ka-band Fan-Shaped Metal Loaded Helix Traveling Wave Tube

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Abstract: *This paper describs a fan-shaped metal loaded helix traveling wave tube working at Ka–band. It has the gain of 37.3-48.7dB, electronic efficiency of 15.18%-19.42% and output power is greater than 286W when it works at a voltage of 9KV and a current of 210mA. The simulation results of VSWR for its coaxial energy coupler are below 1.35, and the test results of it is below 2.1 at the working frequency range.*

Keywords: Ka-band; fan-shaped metal loaded; helix TWT; transmission test

Introduction

As a well-developed and widely used TWT, helix TWT plays a very important role in military, communication and electronic countermeasures [1]. The helix TWT has its wide frequency band as the main advantage. Millimeter wave TWTs with broad bandwidth, high power and high efficiency are still focus of intense research. It is reported that L3 EDD developed a Ka-band TWT with an output power of 550W in the 4GHz bandwidth [2]. BVERI also reported a TWT, which can deliver over 150W power from 26.5 to 40 GHz [3]. In this paper, a TWT working at Ka-band was introduced which has a designed output power of up to 286W and gain of more than 37.3dB.

Simulation results

Figure 1. (a) gives the cross sectional view of the conventional vane-loaded metal loaded helix. Figure1. (b) shows the fan-shaped helix structure discussed in this paper. To compare them, the high frequency characteristics of the two structures are simulated. They have the same pitch, inner diameter of helix, inner radius of the shield, and the same parameter of the loaded metal vane. The only difference is the supporting rod. As Figure 2. and Figure 3.show, although the interaction impedance of the structure(a) in Figure 1. Is greater, the structure(b) in Figure 1. has flatter dispersion. Meanwhile, for the millimeter wave TWT, the latter structure can provide more angular space to assemble. So when we need the TWT work in wider frequency range, the fan-shaped helix structure is more suitable.

In the frequency range of 26-40 GHz, the gain of the helix TWT is between 37.7-48.7 dB, the electronic efficiency is between 15.18%-19.42%, and the output power is greater than 286W[4].

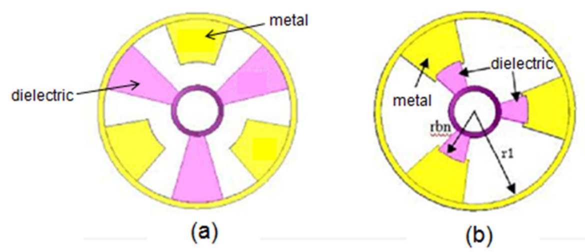

Figure 1. Two slow wave structures with different metal loaded

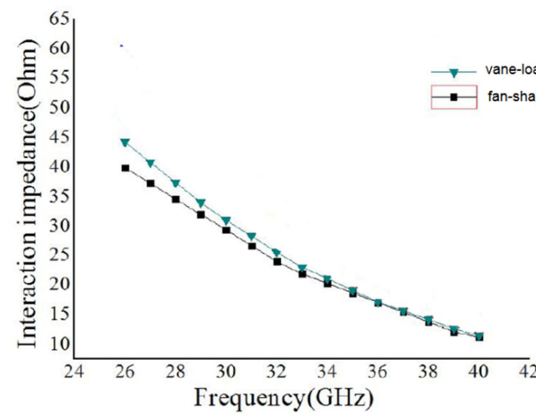

Figure 2. Interaction impedance of the two structures in Fig.1

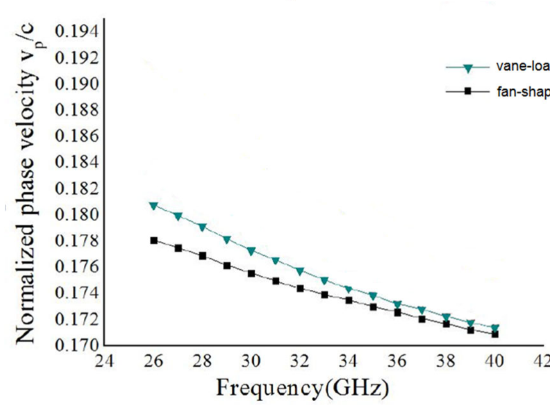

Figure 3. Normalized phase velocity of the two structures in Fig.1

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A coaxial energy coulper was designed for the fan-shaped metal loaded helix TWT as the Figure 4. shows. It contains the coaxial ceramic window and the impedance transformer. A beryllia sheet with 0.7*mm* thickness was designed as the vacuum window.

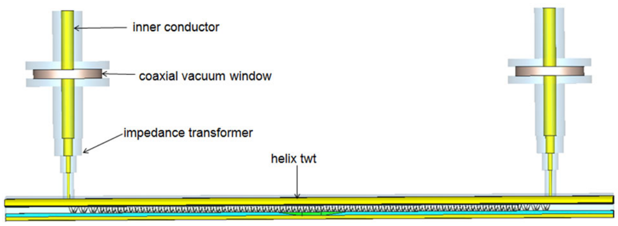

Figure 4. CST simulation model of TWT

The overall structure is optimized to obtain the reflection coefficient. The final result is presented in Figure 5. It is clear that the volatge standing wave ratio of the whole tube is below 1.35 from 24GHz to 46GHz, which means the tube can work in a wide bandwidth.

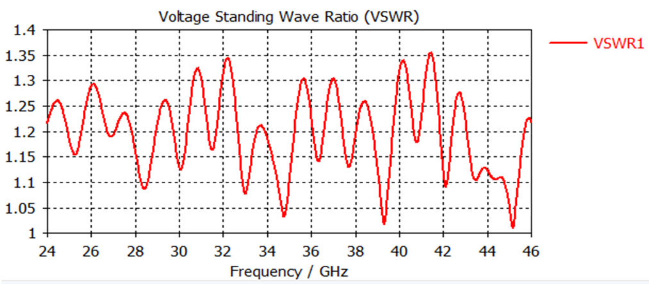

Figure 5. Simulated VSWR of the structure shown in Fig.4

Transmission test results

After the simulation process above mentioned, the coaxial energy coupler and the fan-shaped metal loaded helix were fabricated. Figure 6. is the cross-sectional view of the assembled SWS.

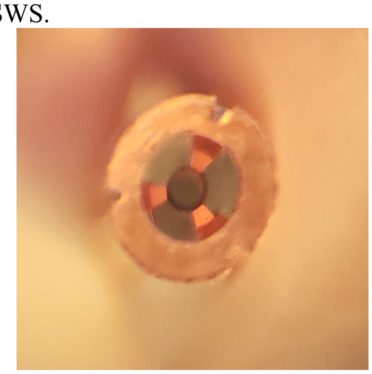

Figure 6. Cross-sectional view of the fan-shaped metal loaded helix

Figure 7. demonstrates the simulation and testing VSWR of the high frequency structure shown in fig.4, the latter are below 2.1 within the working frequency range. But we can see that the simulation results are quite different from the testing results especially at the lower frequency range. It is because of errors in the process of machining and welding. The recent work would be focused on the error analysis and its correction, then the standing wave ratio aim to below 1.8 in the whole working band.

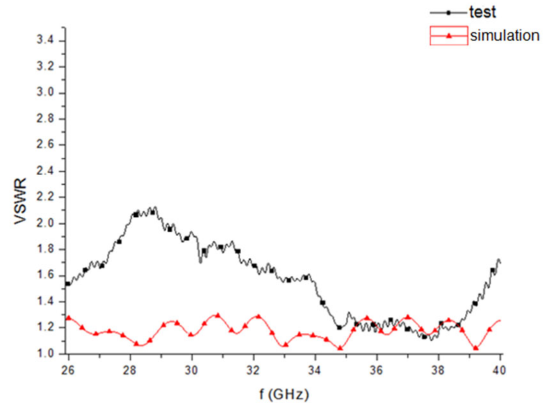

Figure 7. Comparison of simulation and test results of VSWR

Conclusion

The Ka-band fan-shaped metal loaded helix TWT is presented in this paper.It can produce output power greater than 286W across the 26-46GHz operating bandwith. It has the gain of 37.3-48.7dB and electronic efficiency of 15.18%-19.42%. The coaxial energy coupler is designed for this TWT. The cold test result of VSWR is below 2.1.

Acknowledgements

This work was supported in part by 973 program (Grant No. 613233), and in part by the National Natural Science Foundation of China (Grant No. 61771117) .

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