Study of a Ka-band Helix TWT with Semi-Metallic Rod

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Abstract: *The high frequency characteristics and beam wave interaction characteristics of a Ka-band (26-40GHz) helix traveling wave tube (TWT) with rectangular semi-metallic rod are presented. The design results show that the TWT has the gain of more than 42dB, the output power of more than 220W and the electronic efficiency of more than 19% in the working bandwidth. Now the high frequency structure of the TWT are manufactured, the preparation for the transmission test is in progress.*

Keywords: Ka-band; helix TWT; semi-metallic rod; high frequency characteristics; beam wave interaction

Introduction

As a power amplifier, with moderately high-power and wide-band width capabilities, millimeter-wave helix TWTs are suitable for applications in high data rate communications and high-resolution radar, specifically at the Ka-band frequencies[1-2]. Over the last decade, helix-TWTs continue to draw strong interest and demand for further improvements due to its unique ability to provide wide-band width interaction with an extremely compact and light weight structure[3-4].

In this paper, a helix TWT with semi-metallic rods is introduced. Here, the semi-metallic rods substitute part of the rectangular insulating supporting rod with metal by welding the metal and ceramic rod. This structure has the advantages of wider bandwidth compared with conventional helix structure without metal loaded. On the other hand, it has more compact angular space to assemble compared with the angular metal vane-loaded helix structure, especially in millimeter wave frequency range.

High Frequency Characteristics

The structure model is shown in Figure 1. a is the inner radius of the helix, b is the outer radius of the helix, r is the inner radius of the shell, h1 is the thickness of the ceramic part of the rod, h2 is the thickness of the metal part of the rod, and the width e of the rod is 0.38mm. The optimal parameters of the slow-wave structure are shown in Table 1, and Figure 2 is the corresponding high frequency characteristic curve. From 26GHz to 40 GHz the normalized phase velocity is between 0.176-0.184, and the coupling impedance is more than 14 ohms in Figure 2.

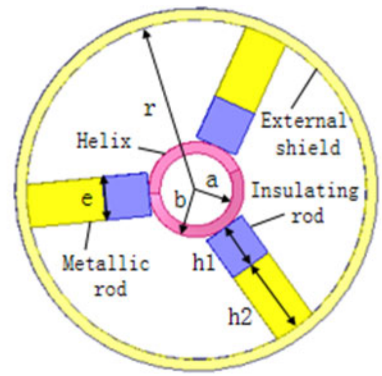

Figure 1. Cross section model of slow wave structure

Table 1. Parameters of the sample Slow wave structure

Parameter	b/a	r/a	h1/a	h2/a
Ratio	1.31	4.69	1.25	2.13

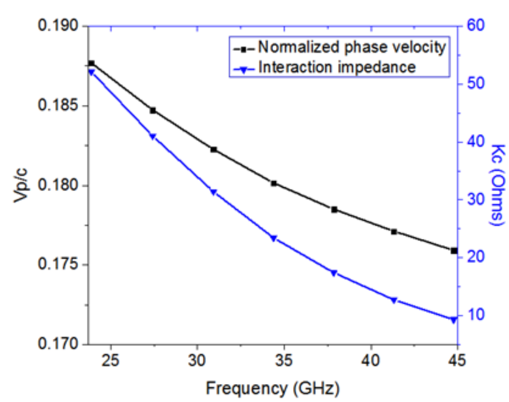

Figure 2. Dispersion and interaction impedance

The beam-wave interaction of the semi-metallic rod helix TWT is calculated. The results are shown from Figure 3 to Figure 4. When the cathode voltage and cathode current is given as 9.3kV and 140mA from 24GHz to 40GHz, respectively, the minimum output power of 223W and the minimum electronic efficiency of 17% can be obtained, and the maximum gain is 52dB.

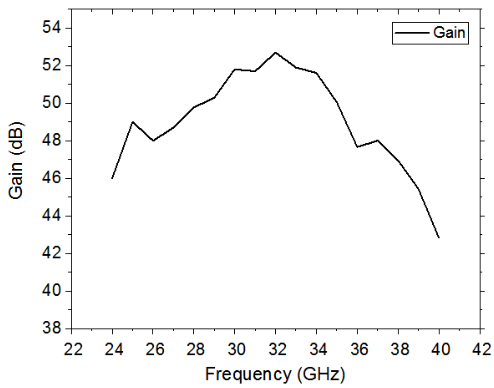

Figure 3. Gain versus frequency

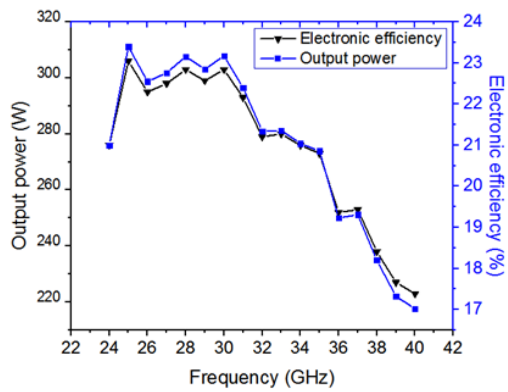

Figure 4. Output power and electronic efficiency versus frequency

The energy output coupling structure consists of the coaxial line, impedance transformer, rectangular diamond windows and the double ridge wave guide as Ref[5] introduced. Fig.7 shows the fabricated output coupling structure. The S-parameters of this TWT are simulated and calculated. In the working frequency range, S11 is less than -15dB, as shown in Figure 5.

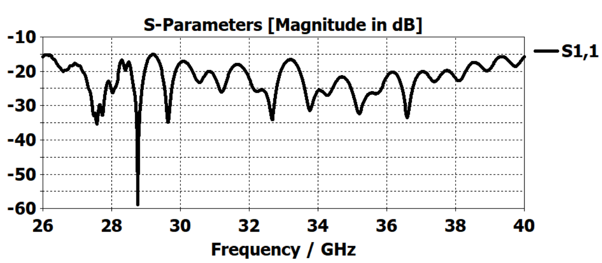

Figure 5. S11 of the TWT

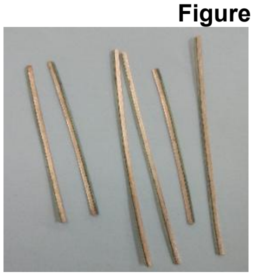

Figure 6. Semi-metallic rods

Figure 7. Output coupler

The welded semi-metallic rods is shown in Figure 6. Fig.8 gives the cross section of assembled slow wave structure.

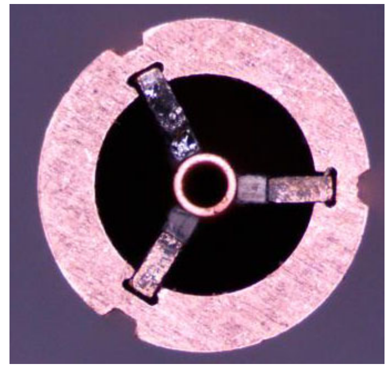

Figure 8. Cross section of the slow wave structure

Conclusion

The helix TWT with semi-metallic rods is presented in this paper. And the high frequency characteristics and the large-signal interaction performances are calculated. The results show that the output power is more than 42dB and the gains are more than 220W in the working frequency range. At present, the optimization and the assembly of the slow-wave structure is still ongoing.

Acknowledgements

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