Design and Fabrication Aspects of an E-band Double Corrugated Waveguide Traveling Wave Tube

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***Abstract*—E-band (71 - 76 GHz, 81 - 86 GHz) front ends are commercially available for point to point links with a few gigabit per second (Gb/s) for range of about one kilometer at full capacity. The transmission power of E-band front ends is produced by solid state amplifiers, typically not higher than a few Watts. For this reason E-band front ends have to use large diameter antennas to ensure the required EIRP (Equivalent, Isotropically Radiated Power). The availability of power in the range of tens of Watts would enable long links with high signal to noise ratio for high modulation schemes and tens of Gb/s capacity.**

An E-band (71 - 76 GHz) traveling wave amplifiers has been designed to enhance the capacity of future E-band links. This paper discuss the first version of the TWT based on a single section double corrugated waveguide slow wave structure. This first prototype of E-band TWT will be preparatory to the fabrication of a more complex 70 W two sections E-band TWT.

***Index Terms*—E-band, TWT, traveling wave tube, wireless link, double corrugated waveguide.**

I. Introduction

The E-band (71 - 76 GHz, 81 - 86 GHz) with 10 GHz available is already used for high capacity long range links of 1 kilometer or more with a few gigabit per second (Gb/s) data rate [1]. The actual limitation in the transmission power can be only partially compensated by large high gain antennas to overcome the free space path loss and the atmospheric losses. A typical E-band SSPA module can provide not more than 2 - 3 W.

The availability of tens of Watts of transmission power could provide links with 40 - 50 Gb/s with 99.99 % availability in rain condition (e.g. ITU zone K) [2].

Traveling wave tubes have been demonstrated to provide more than one order of magnitude of power than solid state amplifiers [3], [4]. A novel 70 W E-band TWT has been designed based on the double corrugated waveguide (DCW) with two sections separated by a sever [5]. Due to the fabrication challenges, as first test vehicle, a single section version of the same TWT has been designed to test design, fabrication and assembly. The single section DCW, with reduced interaction length, makes easier the beam alignment and calibration of magnets of the periodic permanent magnetic. The experience gained will be used for the final fabrication of the more challenging two sections TWT.

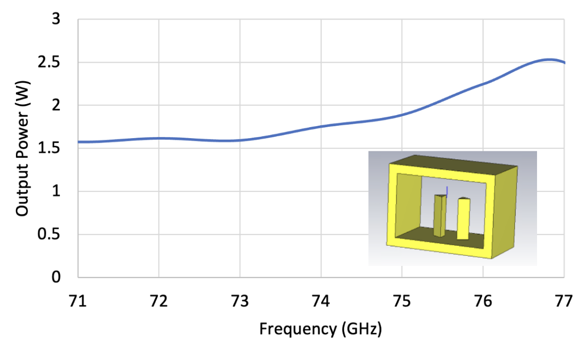

Fig. 1. Output power as a function of frequency (inset: triangular pillars DCW).

Fig. 2. Gun envelope with anode

In the following, some aspects of the design and fabrication of the single section E-band TWT will be discussed.

II. E-band TWT performance

The DCW (inset Fig. 1) was designed to theoretically support 12.2 kV beam voltage. The single section DCW consists of 45 periods with triangular pillars with cross section 200 x 200 microns. The input and output couplers include 15 pillars with square cross section tapered in height. The electron beam used in the Particle in Cell simulations has a higher beam voltage to improve the performance (13.05 kV), 90 mA beam current and 130 microns radius. The simulated output power is better than 1.5 W, with a gain higher than 22 dB (Fig. 1) over the 71 - 76 GHz band, with 10 mW input power. The output power value does not pose risk of oscillations, permitting to avoid the sever.

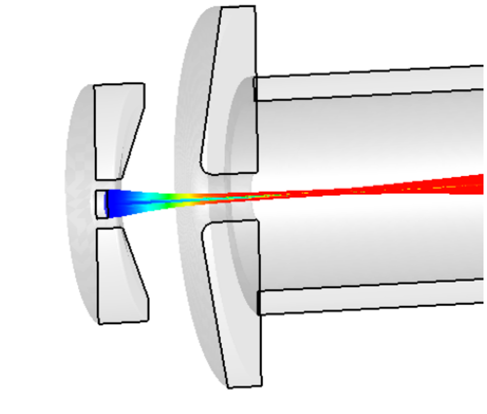

Fig. 3. 3D beam optics view.

III. Electron gun

The electron gun for the E-band TWT was designed to produce an electron beam with 13.05 kV beam voltage, 90 mA current and 130 microns radius. The structure of the electron gun includes two parts [6], the cylindrical envelop with the anode and the bottom plate with the support for the high voltage feedthroughs and the cathode sub-assembly. Figure 2 shows the body of the electron gun. It is visible the anode with its quasi-conical shape and the hole for the electron beam. It was built in a single piece for the most accurate alignement. The four holes around the cathodes are for making the structure lighter and improving the evacuation. The 3D shape of the beam optics and the beam propagation without magnetic field are shown in Fig. 3.

IV. DCW circuit fabrication and assembly

The DCW was built in two shaped split blocks. One includes waveguide, pillars and beam tunnel. One is a flat lid. The two blocks are bonded vacuum tight by diffusion bonding. Figure 4 shows the shaped block of the single section DCW including the pillars, the couplers and the alignment dowel pin holes. The DCW has two parallel rows of 45 triangular pillars each where the beam travel in longitudinal axis, the region of higher interaction. Each coupler consists of 15 square pillars tapered in height to transform the hybrid mode in the DCW in the fundamental mode TE_{10} at the WR-10 flanges. Figure 5 shows the sub-assembly of the full RF circuit. It includes the DCW, the flanges for the assembly with the electron gun on one side and the collector on the other side and the RF windows. The brazing of the sub-assembly is performed in different steps. It requires specific fixture to ensure the perfect alignment of the parts. The RF windows use and Alumina sheet 500 microns thick. The input and output are on opposite side for an easier connection to the measurement system. This sub-assembly will be then laser welded to the collector and the electron gun to complete the TWT assembly, ready for vacuum baking.

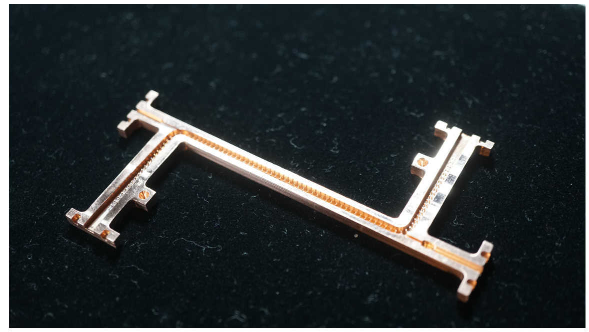

Fig. 4. Shaped block of the DCW circuit with pillars and couplers.

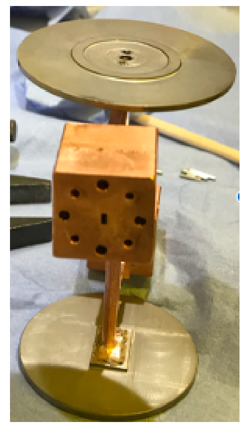

Fig. 5. Sub-assembly of the DCW circuit with flanges and RF windows.

Conclusions

The single section E-band TWT is in the final assembly phase. It will experimentally demonstrate the feasibility of low cost TWT for enabling E-band links.

Acknowledgment

The work has received funding from DSTL and DLINK-D-band Wireless Link with Fibre Data Rate project funded by EPSRC grants EP/S009620/1.

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