71 – 76 GHz Traveling Wave Tube for High Data Rate Satellite Communication

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***Abstract*—The increasing demand of high data rate is posing a high pressure to actual mobile networks. Fiber and wireless networks cover most of the populations, but there are many regions uncovered by a satisfactory service. The distribution of internet by satellite communications is already available at microwave frequency. The request of multigigabit data rate needs a wide bandwidth that only millimeter waves can provide. The band 71 – 86 GHz offers two sub bands of 5 GHz each suitable for satellite communications. However, due to the high atmosphere attenuation, an adequate transmission power has to be provided. The preliminary design of a 71 – 76 GHz Traveling Wave Tube based on the Double Corrugated Waveguide, for millimeter wave satellite communications is reported.**

Keywords — double corrugated waveguide; satellite communications, high data rate, traveling wave tube, access. TWT, space

I. Introduction

The distribution of internet by satellite communications is already available. The Ku and Ka band are used to provide broadband especially in areas where the fiber is not deployed or to provide resiliency to the ground network.

The request of multigigabit data rate is increasing and wider frequency bands are needed. In particular, the region including the V-band and the W-band [1] has been indicated as the most promising for high capacity satellite communications, with the 71-76 GHz (V-band) for downlink and the 81-86 (W-band) for uplink. The various attenuation components at those frequencies, such as cloud, rain, and gaseous attenuation determines the needs of high power amplification in the order of tens of Watt. Traveling Wave Tubes (TWT) are the only solution for high power at millimeter wave. The helix, typical slow wave structure (SWS) used at microwave, at the increase of the frequency has critical issue of feasibility. New solutions have to be found to realize millimeter wave TWTs. This abstract proposes a new configuration of V-band TWT for satellite downlink.

The double corrugated waveguide (DCW) has been so far investigated in both forward and backward wave regimes [2 – 4]. The DCW is formed by two parallel rows of pillars with square cross-section in a rectangular waveguide. In the following a 71 - 76 GHz DCW TWT for satellite downlink will be described.

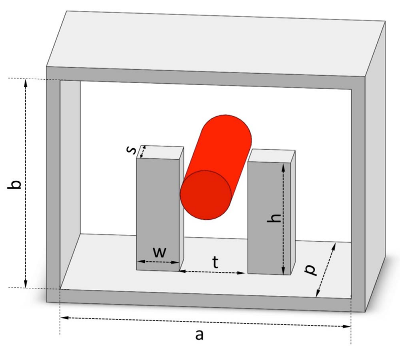


Fig. 1 Double corrugated waveguide dimensions.

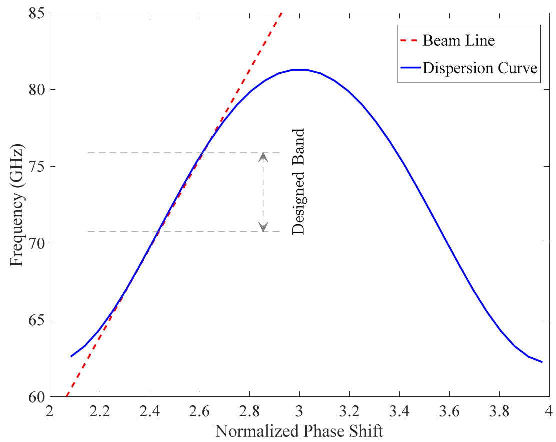


Fig. 2 The dispersion diagram of SWSs with different pillar width.

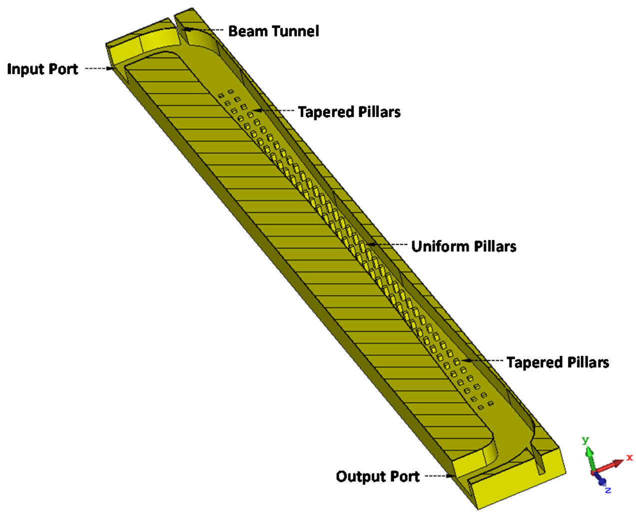
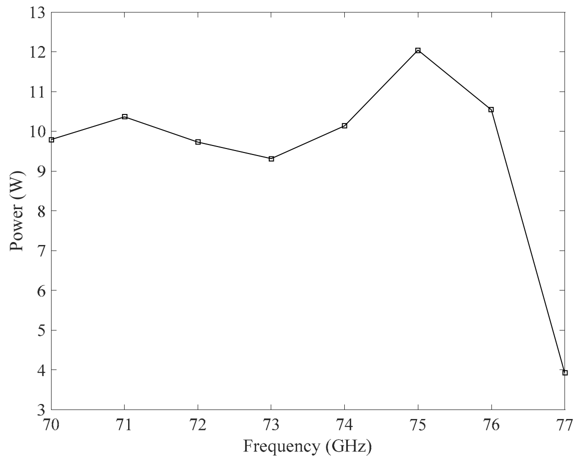
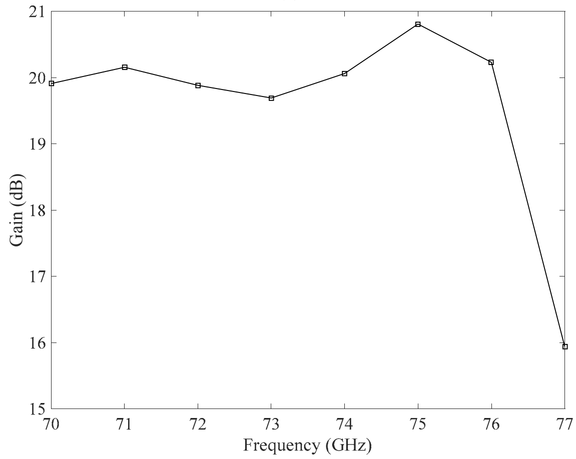


Fig.3 The schematic of the DCW TWT.



(a)



(b)

Fig.4 (a) Output power and (b) gain as a function of the frequency.

II. DCW TWT Simulation

A Double Corrugated Waveguide is designed in the 71 - 76 GHz band, with dimensions to be fabricated by computer numerical controlled (CNC) milling machining and to support a low beam voltage, below 15kV. Fig.2 shows the dispersion diagram of DCWs with pillar width w = 250 μm. A wide frequency region of synchronization is obtained.

A single-section TWT is designed and simulated by adopting the DCW structure shown in Fig.3. A DCW with 80 periods and two couplers of 15 periods each are used. The input and output ports are designed to be connected with WR-10 waveguides. The beam voltage and current are 12.5 kV and 100 mA, respectively. The input power is 100 mW. A uniform focusing magnetic field of 0.3 T is adopted in the simulation region. The simulations were performed by CST Particle Studio. The output power and gain as a function of frequency are shown in Fig. 4. It can be observed that the gain of the designed TWT with pillar width of 250 μm is around 20 dB in the full operating band. Higher gain can be obtained by reducing the dimension of the pillars. This determines an increase of the averaged interaction impedance of the DCW.

III. Fabrication

A first fabrication test of the DCW in aluminum by CNC milling has been performed. Pillars with $w = s$ = 250 um have been considered. Fig.5 shows the microscopic view of the high quality fabricated pillars.

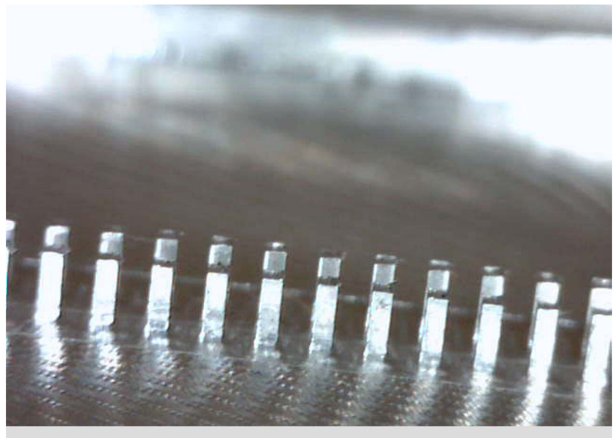


Fig.5 The microscopic view of the fabricated pillars.

IV. Conclusions

The feasibility study of 71 – 76 GHz traveling wave tube based on the double corrugated waveguide for satellite communications is reported. A preliminary simulation has shown up to 20 dB gain in the frequency range of 71-76 GHz for a single SWS section with 80 periods. This demonstrates that a two-section configuration can achieve around 40 dB gain within the frequency band.

Acknowledgment

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References

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