# A Large Bandwidth Double-layer Asymmetric Planar Microstrip Line Ka Band Traveling Wave Tube

**_Wenchen Xiang[1], Ningfeng Bai[1], Xiaohan Sun[1], Pan Pan[2], Jun Cai[2], Jinjun Feng[2], Yang Xie[3], Wei Hong[3]_**

1. Research Center for Electronic Device and System Reliability, Southeast University
Nanjing, Jiangsu, China,210096
2. Beijing Vacuum Electronics Institution
Beijing, China, 100016
3. School of electronic and optical engineering, Nanjing University of Science and Technology
Nanjing, Jiangsu, China,210094

**Abstract:** *We present a double-layer asymmetric microstrip line slow wave structure (ADL MML-SWS) amplifies dual band signals at Ka-band this paper. This ADL MML-SWS has two signals at the same time, which can be excited by two electron beams. The center frequency of the low-band signal is 30 GHz and the center of high-band signal is 38 GHz. At 30GHz, the output power is 28.125w, with a gain of 37.5dB, and at 38GHz, the output power is 30.03w, with a gain of 37.8dB. The structure has a wide bandwidth, covering the entire Ka-band of 27GHz-42GHz, and the gain in the entire band is nearly constant, varies in 2 dB.*

**Keywords:** Ka-band; traveling wave tube(TWT); slow wave structure(SWS); microstrip meander-line (MML).

## Introduction

Traveling wave tubes (TWT) are widely used in radar and satellite communications because of their mature technology, wide bandwidth, high gain, and high output. As the core device in satellite communication, TWT must have sufficient power and large bandwidth. And the communication band of the satellite is concentrated in the Ka-band. In addition, with the gradual maturity of 5G technology, the frequency bands used for 5G communication will gradually shift to Ka-band. The research and application of TWT in Ka-band will also be necessary. The planar microstrip meander line (MML) slow wave structure (SWS) exhibits a completely compatible fabrication processing with microelectronic fabrication processing and the high gain and bandwidth characteristics make the MML SWS a reasonable choice for the TWT SWS.

Although researches on the planar MML SWS is relatively mature, the bandwidth of the MML SWS and the low efficiency of electronic exchange are still obstacles for improvement. In a recent research, a MML SWS that is suitable for multiple sheet beam interaction that helps achieve high power, avoiding the problem of dielectric charging and providing more uniform electric field distribution in the beam tunnels [1]. There is also a study of the interaction of wave front interactions through a double-layer symmetric MML to increase the output power of the MML [2], but the process requirements for the upper and lower layers are complex, and a power synthesizer is required to design the upper and lower layers.

Despite the layout of the two-layer MML SWS, the electronic exchange of both layers can theoretically improve the efficiency, but the phase requirements of the upper and lower layers of the MML SWS are very strict. Therefore, it can be considered designing a double-layer asymmetric MML, using different structural parameters, to achieve the output of two modes and further expansion of bandwidth.

This paper shows an asymmetric double-layer (ADL) MML SWS in which the upper MML is designed with a center frequency of 30GHz and the lower layer MML is worked at 38GHz nearby. The ADL MML SWS uses two electron beams to enlarge the bandwidth the space utility, which has the bandwidth covers the range of 27GHz-42GHz to achieve the purpose of covering the Ka-band and meet the requirements of output power.

## Modeling and results

As shown in Figure 1(a), the structure is divided into two layers of MML, and contains two electron beams. The center frequency of the upper layer MML is 30GHz, and the center frequency of the bottom layer MML is 38GHz. In order to avoid interference between the two signals, the distance between the two MML is 1.2mm. The structure of a single MML is shown in Figure 1(b). The specific parameters of the two sets of MML are listed in the table I. The metal part is made of copper with conductivity of $2.25 \times 10^7\ S/m$, and the substrate is $SiO_2$ with a relative dielectric constant of 4. Both electron beams are located in a 0.7T magnetic field and use a 0.1A beam current.

**TABLE I:** Parameters of Meander-Line

| parameters | Value(30GHz) | Value(38GHz) |
|---|---|---|
| l | 0.8mm | 0.7mm |
| sw | 0.09mm | 0.08mm |
| ws | 0.1mm | 0.08mm |
| sss | 0.05mm | 0.05mm |
| t | 0.01mm | 0.01mm |

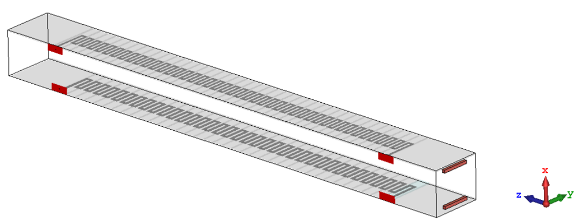
Figure 2 shows the output power versus input power. It can be seen from the figure that the input signal increases from 2mw to 5mw, and the output signal increases accordingly.

When the input signal power reaches 5mw, the signals at both output ports tend to be saturated, so 5mw is chosen as input power to get the relation of output power with frequency.

The output power and gain versus frequency are shown in Figure 3, it can be seen that the saturated power output at the center frequency of 30 GHz is 28.5 W and the gain is 37.6 dB. The saturated output power at the center frequency of 38 GHz is 30.3 W and the gain is 37.8 dB. The output power in the entire Ka-band is above 23 W, and the gain is also above 36dB, varies in 2 dB for whole Ka band. Among them, the 27 GHz-34 GHz signal is amplified by the upper-layer MML SWS, and the 35 GHz-42 GHz signal is amplifier by the bottom-layer MML SWS, which meets the bandwidth requirements. A power concave appears at 35GHz on the output power curve. This is because the frequency point is located near the center points of 30GHz and 38GHz. This can be improved by design a wider bandwidth MML SWS for both structures.

## Conclusion

In this paper, a double-layer asymmetric microstrip meander line SWS has been introduced as a candidate structure to design SWS used in TWT working in Ka-band. A Ka-band bandwidth with nearly constant gain can be observed, while satisfying that the output power is higher than 23 W and the gain is greater than 36dB during the entire frequency band. Compared with single-layer MML SWS, it has higher space utilization and greater bandwidth.



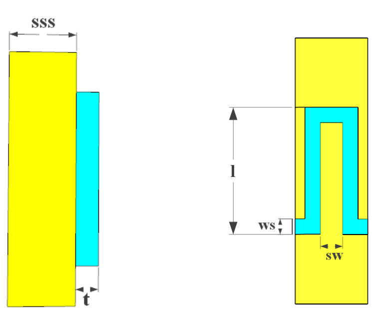




**Figure 1.** (a) Schematic of double-layer asymmetric ML. (b)The top view and cross section of ML.

## References

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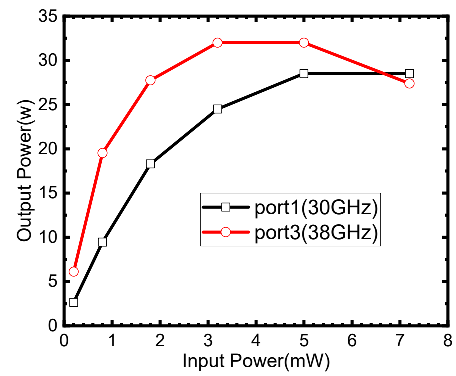


**Figure 2.** The output power and gain versus input voltage.

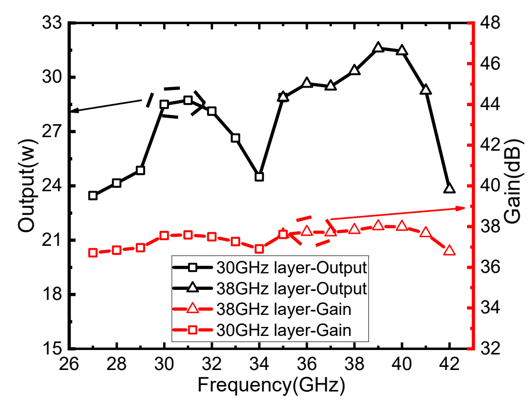


**Figure 3.** The output power and gain versus frequency.