THIN FILM TUNNELS VERSUS AIR-BRIDGES IN COPLANAR WAVEGUIDE DISCONTINUITIES

E. A. Soliman, P. Pieters, and E. Beyne

IMEC, Kapeldreef 75, B-3001 Leuven, Belgium

ABSTRACT

In this paper, a new method for the suppression of the slot line (odd) mode in the CPW based microwave circuits is presented. The proposed method replaces the costly and mechanically unstable air-bridges. It uses an under pass (tunnel) on an intermediate metalization layer below the CPW line and above the substrate. This method is convenient for MCM-D technology in which thin films are deposited over the substrate to support the required interconnects. The method is applied on the band reject filter presented in [1] and compared with the case of air bridges.

INTRODUCTION

Suppression of the slot line *(odd)* mode in CPW based microwave circuits may become essential for obtaining an adequate performance. The conventional method for eliminating the unwanted mode is the use of air-bridges [1]-[3]. However, these air-bridges are costly to build and certainly mechanically unstable. Omar and Chow [4] have introduced the use of top and bottom shields instead of the air-bridges. The locations of these planes are optimized such that the slowly decaying, along the normal to the substrate, odd mode is significantly affected and almost eliminated. On the other hand, the coplanar *(even)* mode which possesses quicker decaying behaviour is less affected. The authors applied this method on the band reject filter introduced by Rittweger [1], see Fig(1). This filter was designed to have no transmission at 18 GHz, and good transmission at 36 GHz.

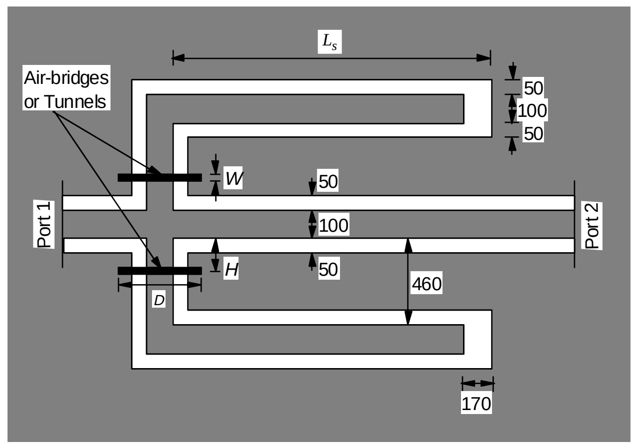

Figure 1: Band reject filter under investigation, all dimensions are in μm: (D = 350 μm, W = 10 μm, and H = 150 μm)

Air-bridges succeed in satisfying the requirements perfectly. The top and bottom shields show good performance, in comparison with air-bridges, except for small deviation around 18 GHz for S_{11} and around 36 GHz for S_{21} [4]. This deviation was explained as power leakage from the dominant CPW mode into the parallel plate TEM mode. This paper aims at introducing a new method for suppressing the odd mode, namely the use of *thin film tunnels.* Microwave components and circuits in MCM-D technology are realized using multiple thin film layers which are deposited over the substrate [5]. These layers play an important role in isolating the required interconnects of the MCM. The IMEC MCM-D technology [5], uses

0-7803-4471-5/98/$10.00 (c) 1998 IEEE

thin films of BCB, $\varepsilon_r = 2.7$, with 10 μm thickness. The proposed thin film tunnels are realized on the top of the substrate and are connected to the required positions using vias through the BCB layer, see Fig(2).

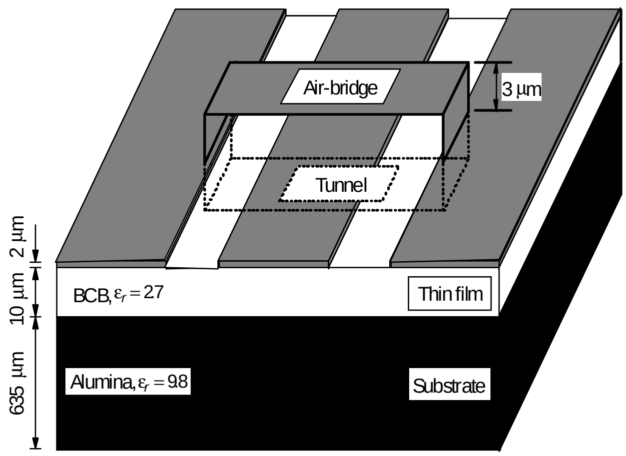

Figure 2: The proposed thin film tunnels and the conventional air-bridges.

Such technology is found to be more mechanically stable and more economic than the air-bridges. Unlike the top and bottom shields, this method offers the possibility of integrating CPW-fed antennas together with the driving electronics and microwave circuits on the same substrate.

RESULTS AND DISCUSSIONS

In order to demonstrate the proposed method, the same band reject filter is studied. The thin film layer tends to slightly reduce the effective dielectric constant. In order to get the same electrical length of the shunt stubs, its length is increased to $L_s = 1830$ μm which is longer than the case of the air-bridges, $L_s = 1420$ μm. The filter under investigation is studied rigorously using HP-Momentum which is based on an integral equation formulation. Figs (3) and (4) show S_{11} and S_{21}, respectively, versus frequency, using both air-bridges and thin film tunnels.

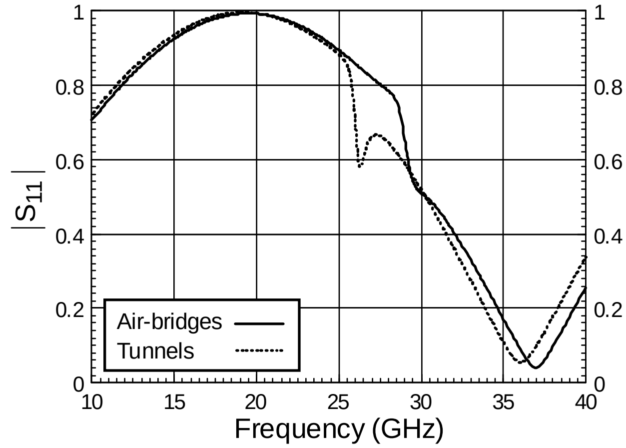

Figure 3: Return loss versus frequency.

It is clear that the thin film tunnels succeed in satisfying the requirements. Perfect matching between the results of the air-bridges, the thin film tunnels, and ref. [1], is observed around both 18 and 36 GHz.

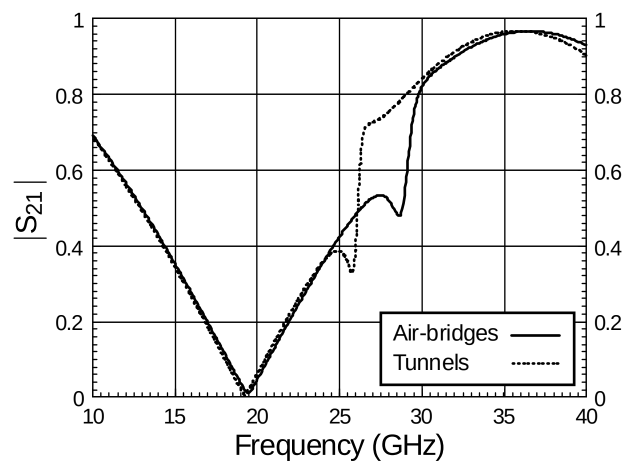

Figure 4: Insertion loss versus frequency.

Fig(5) shows the total losses versus frequency, which equals to: $1 - |S_{11}|^2 - |S_{21}|^2$. The main sources of loss are: coupling to slot line mode, radiation, and surface wave losses. Normally, both radiation and surface wave losses are very small. The main contribution to the losses is due to leaking power to the slot line mode. Consequently, the losses can be considered as an indication of the efficiency of the slot line mode suppression mechanism. The losses for both cases are small, however for the case of thin film tunnels the losses are even smaller specially at low frequencies. This indicates the efficiency of the new mechanism.

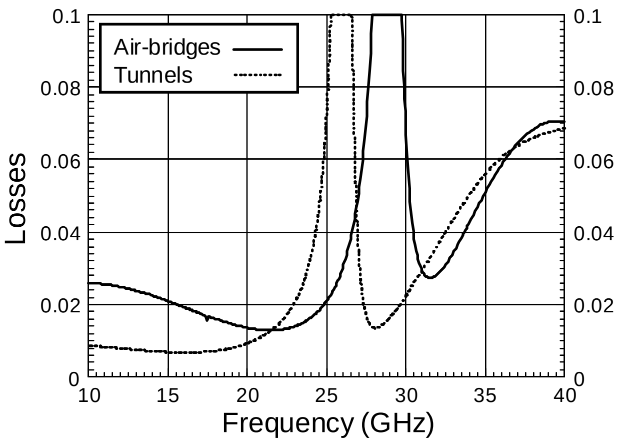

Figure 5: Total losses versus frequency.

The effects of varying the tunnel parameters (*D*, *W*, and *H*), see Fig(1), on the filter performance will be investigated in this section.

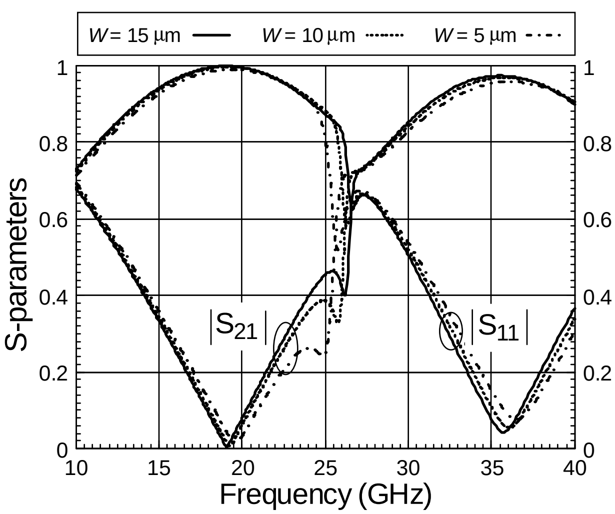

Figure 6: S-parameters versus frequency for different values of the tunnel width: D = 350 µm, and H = 150 µm.

Fig(6) shows the effect of varying the tunnel width, *W*. The capacitance between the tunnel and the center strip increases as the tunnel width increases. Consequently, the effective length of the stubs increases and shifts down the resonance frequencies. The same behavior is reported in [2]. The effect of varying the tunnel length, *D*, is shown in Fig(7). It is clear that this effect is almost negligible.

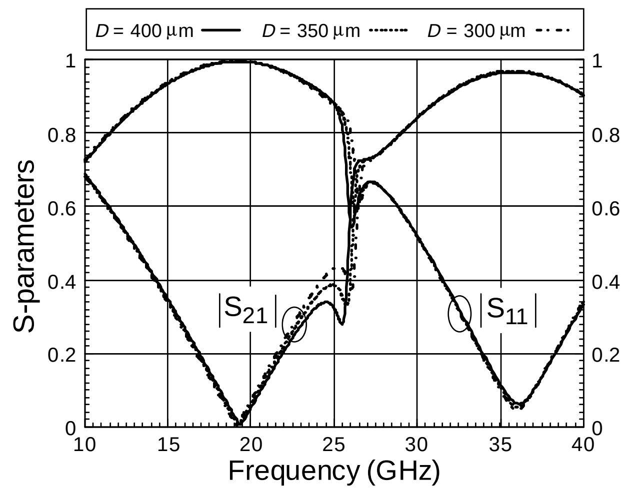

Figure 7: S-parameters versus frequency for different values of the tunnel length: W = 15 µm, and H = 150 µm.

Fig(8) shows the effect of the tunnel location, *H*, on the filter performance. The higher the separation between the tunnel and the discontinuity the higher the resonance frequencies will be. This is explained in [2] as a result of the decrease of the effective length of the stubs due to the propagation of the high speed slot line mode.

CONCLUSION

A new method for suppressing the slot line mode in coplanar waveguide discontinuities has been presented. It replaces the conventional air-bridges by thin-film tunnels running under the CPW. This method is convenient for the microwave circuits built in MCM-D which uses thin films to support the required interconnects.

0-7803-4471-5/98/$10.00 (c) 1998 IEEE

The proposed method is applied on a band reject filter and studied rigorously using a full wave simulation program. The results show that the thin film tunnels are able to suppress the slot line mode and satisfying the filter requirements to a high degree of accuracy.

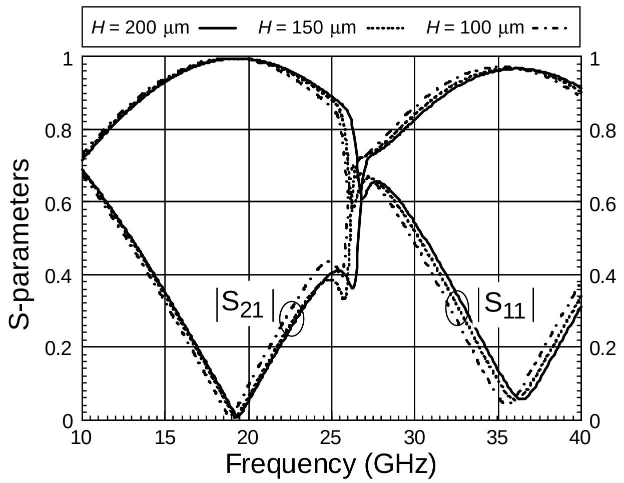

Figure 8: S-parameters versus frequency for different values of the tunnel location: $W = 15$ µm, and $D = 350$ µm.

The effect of varying the tunnel parameters on the filter performance is also studied. The results show that the variation of the tunnel width, is likely to be affected by the manufacture tolerance, has more significant effect than the variation of the tunnel length and location. The smaller the width the much closer the resonance frequencies to the designed values. From the technology point of view, the thin film tunnels are much more stable than the conventional air-bridges. Moreover, they are more economic than the air-bridges. Unlike the top and bottom shields suppression mechanism, thin film tunnels are suitable for microwave circuits driving antenna phased arrays.

REFERENCES

[1] M. Rittweger, M. Abdo, and I. Wolf, "Full-wave analysis of coplanar discontinuities considering three dimensional bond wires," in *IEEE MTT-S Dig*., pp. 465-468, 1991.

[2] A. Omar and Y. L. Chow, "A solution of coplanar waveguide with air-bridges using complex images," *IEEE Trans. Microwave Theory Tech*., vol. MTT-40, pp. 2070-2077, Nov. 1992.

[3] N. I. Dib, M. Gupta, G. E. Ponchak, and L. P. B. Katehi, "Characterization of asymmetric coplanar waveguide discontinuities," *IEEE Trans. Microwave Theory Tech*., vol. MTT-41, pp. 1549-1558, Sept. 1993.

[4] A. Omar and Y. L. Chow, "Coplanar waveguide with top and bottom shields in place of air-bridges," *IEEE Trans. Microwave Theory Tech*., MTT-41, pp. 1559-1563, Sept. 1993.

[5] P. Pieters, S. Brebels, and E. Beyne, "Integration of passive components for microwave filters in MCM-D," in *IEEE Int. Conference on Multichip Modules*, 1997, pp. 357-362, April 1997.

0-7803-4471-5/98/$10.00 (c) 1998 IEEE