Electromagnetic modelling of 3D multilayer CPW transmission lines on GaAs/Si substrates for MMICs.

Laleh Lalehparvar
Djuradj Budimir

School of Informatics

Electromagnetic Modelling of 3D Multilayer CPW Transmission Lines on GaAs/Si Substrates For MMICs

L. Lalehparvar and D.Budimir

Abstract — **3D multilayer coplanar waveguide structures for MMIC applications on both Silicon and Gallium Arsenide substrates are proposed. Their performances are investigated with electromagnetic simulations and their results are compared in order to find the best possible structure. These structures can reduce the radiation loss.**

Index Terms — **Multilayer MMICs, Si and GaAs ICs, CPW structures, transmission lines.**

I. INTRODUCTION

Multilayer CPW techniques are being used extensively in MMICs. The multilayer technique allows a higher packing density for these microwave circuits. The problem of current crowding at the conductor edges is also overcome by employing a V_shaped signal conductor, with ground planes that overlap on different metal levels. These proposed closed structures, also reduce the radiation problem from the signal and ground conductors in the top layer.
In this paper transmission lines are presented by using CPW mutilayer techniques. Since both Si and GaAs are used as dielectric substrates, which form the base of these multiplayer structures, the performance of the transmission lines can be investigated and compared in order to find the best dielectric substrate for these lines. Also the performance of each structure is investigated even more by first using polyimide in between the metal layers and then a mixture of air and polyimide in order to see which structure has the best performance.
HFSS™ software is used to produce the S12 responses of these transmission lines

II. PROPOSED CONFIGURATION

Each structure consists of 3 layers on both Si and GaAs dielectrics, which have a length of 600μm. Si and GaAs substrates are 400μm thick and their relative dielectric constants are 11.9 and 12.85 respectively. Top section (M3), is made from a 3μm thick metalization layer and the space in between this layer and the metallic box is filled with air. The thickness of air is 50μm. The bottom two sections (M1 and M3) are made up of 1μm thick matalization layers. In each of the GaAs and Si structures, the space in the bottom two sections is filled, first with polyimide layers, with a thickness of 4μm and then a mixture of air which has a thickness of 3μm and polyimide with a thickness of 1μm. The relative dielectric constant of the polyimde is 3.4.

The authors are with the Wireless Communications Research Group, Department of Electronic Systems, Westminster University London, W1W 6UW, UK.

III. RESULTS

The four proposed structures with their corresponding S12 responses are shown in figures 1 _4. As we can see from the performances, GaAs serves as a better dielectric material since the insersion loss is lower than when Si is used, see figures 1(b) and 2(b).
Also when a mixture of air and polyimide is used instead of pure polyimide in the bottom two sections, the response is better, since the dielectric loss is reduced, see figures 3(b) and 4(b).

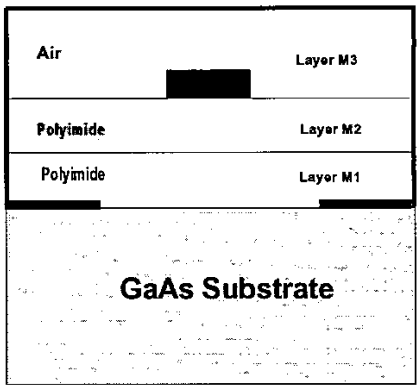

Fig. 1(a). Cross section of shielded CPW transmission line on GaAs substrate.

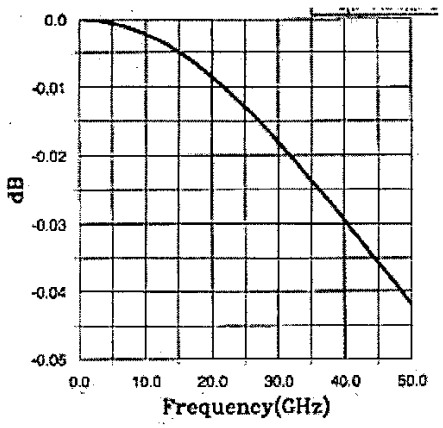

Fig.1(b). Simulated S12 response for shielded CPW line on GaAs.

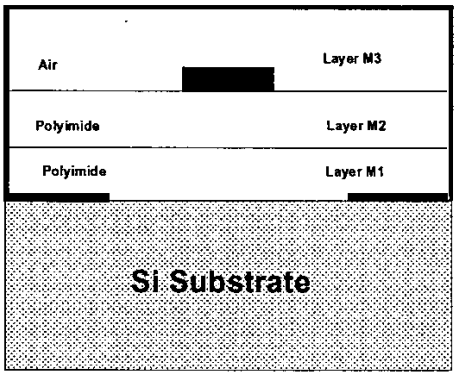

Fig. 2(a). Cross section of shielded CPW transmission line on Si substrate

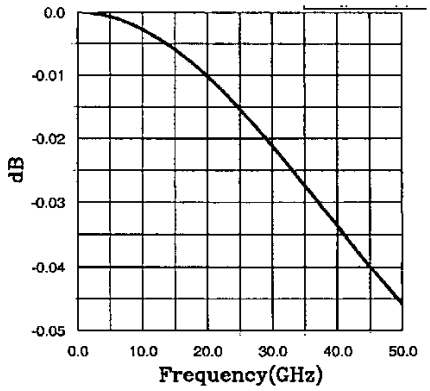

Fig.2(b). Simulated S12 response for shielded CPW line on Si substrate.

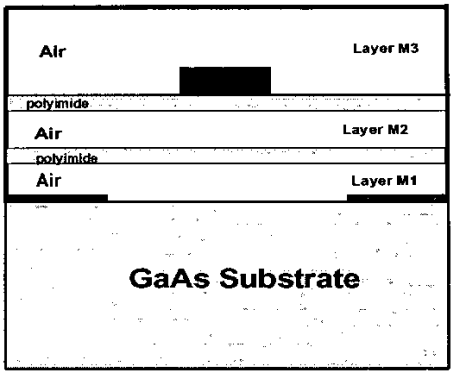

Fig. 3(a). Cross section of shielded and membrane_mounted CPW transmission line on GaAs.

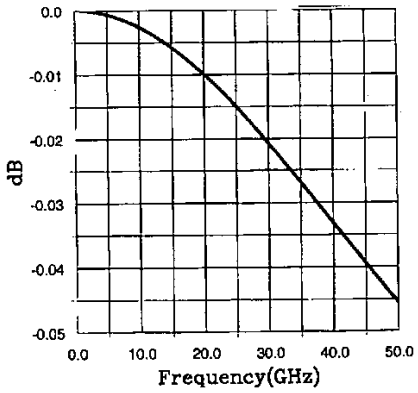

Fig.3(b). Simulated S12 response for shielded and membrane_mounted CPW line on GaAs.

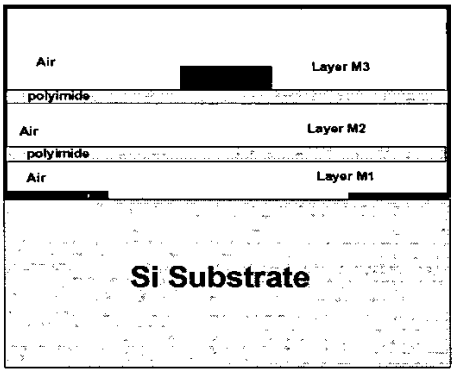

Fig. 4(a). Cross section of shielded and membrane_mounted CPW transmission line on Si substrate.

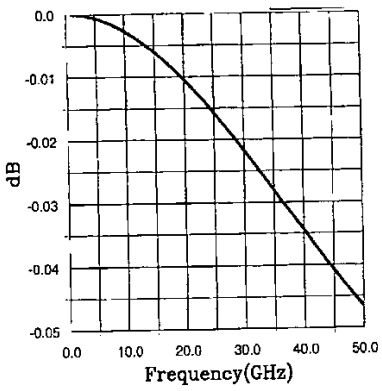

Fig.4(b). Simulated S12 response for shielded and membrane_mounted CPW line on Si substrate.

VI. Conclusion

The multilayer CPW structures have been investigated and their responses are compared in order to find the best possible solution. Simulated results show that by using GaAs as a substrate, the insersion loss is reduced. The results also show that by using a combination of polyimide and air, the dielectric losses are reduced, so we have a better response. Agilent HFSS was used for electromagnetic simulation of the proposed structures.

ACKNOWLEDGEMENT

This work was supported by the Engineering and Physical Science Research Council (EPSRC), United Kingdom

References

[1] T.Tokumitsu, T.Hiraoka, H. Nakamoto, and T. Takenka, Multilayer MMIC using a 3um x 3-layer dielectric film structure,*"IEEE MTT-S Int. Microwave Symp. Dig.*, pp.831-834, 1990.

[2] H.Ogawa, T. Hasigawa, s.Banba and H,Nakamoto,MMIC transmission lines for multi-layered MMIC's"*IEEE MTT-S*, pp.1067-1070, 1991.

[3] Budimir, D., Q. H. Wang, A. A. Rezazadeh and I. D. Robertson, "V-Shaped Transmission Lines for Multilayer MMICs", *Electronics Letters*, pp. 1928-1929, vol. 31, no. 22, 26th October 1995.

[4] Budimir, D., I. D. Robertson, A. H. Khalid, and A. A. Rezazadeh, "Low Loss Multilayer Coplanar Waveguide Transmission Lines on Silicon Substrate for MMICs", *26th European Microwave Conference*, Prague, Czech Republic, September 1996.

[5] Gokdemir, T., U. Karacaoglu, D. Budimir, S. B. Economides, A. H. Khalid, A. A. Rezazadeh, and I. D. Robertson, "Multilayer passive components for uniplanar Si/SiGe MMICs", *IEEE MTT-S Digest*, Denver, CO, USA, June 1997.

[6] *HFSS Reference Manual*, Release 5.6, Agilent Technologies, CA, USA, 2000.