3D coplanar waveguide structures on GaAs/Si substrates for MMIC applications.

Laleh Lalehparvar
Djuradj Budimir

School of Informatics, University of Westminster

Proceedings of APMC2001, Taipei, Taiwan, R.O.C.

3D COPLANAR WAVEGUIDE STRUCTURES ON GaAs/Si SUBSTRATES FOR MMIC APPLICATIONS

L. LALEHPARVAR
Wireless Communications Research Group, Department of Electronic Systems,
Westminster University London, W1W 6UW, UK.
Email: lalehparvar@cmsa.wmin.ac.uk

D.BUDIMIR
Wireless Communications Research Group, Department of Electronic Systems,
Westminster University London, W1W 6UW, UK.
Email: budimid@westminster.ac.uk

3D 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.

1. Introduction

Coplanar waveguide structures are being used extensively in MMICs. In this paper coplanar waveguide structures on GaAs and Si substrates are proposed. These dielectric substrates form the base of these proposed structures. The multilayer CPW structures allow a higher packing density, which is a very important factor in microwave circuits since they need to be very small. 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. The performance of these structures can be investigated and compared in order to find the best dielectric substrate for these lines. Also in multilayer CPW structures, the performance can be investigated further more by employing a mixture of air and polyimide instead of a pure polyimide in between the metal layers to see which structure has the best performance. HFSS^{TM} software is used here in order to investigate the performance of CPW structures.

2. Proposed Configuration

The proposed multilayer CPW structure consists of 3 layers on both Si and GaAs dielectrics, which have a width of 600µm and a length of 1000µm. 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 cross section of these structured are shown in Figures 1-4. Figure 5 and 6 show the cross sections of the conventional CPW structures on GaAs and Si substrate respectively. The structure consists of a single layer, with a length of 1000µm. the metallizations are 1µm thick. GaAs and Si substrates are 400µm thick, 600µm wide and have a dielectric constants of 12.85 and 11.9 respectively. The metallic enclosure is filled with air and has a height of 50µm. The walls of the enclosure are 1µm thick.

0-7803-7138-0/01/$10.00 ©2001 IEEE

3. Results

The corresponding S12 responses of the proposed CPW structures are shown in figures 7-12. 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. Also in multilayer structures, 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 9 and 10. Photomicrograph of fabricated monolithic metallic enclosure on GaAs substrate (100 x 20 microns) is shown in figure 13.

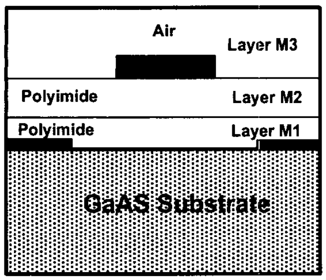

Fig. 1. Cross section of shielded CPW transmission line on GaAs substrate.

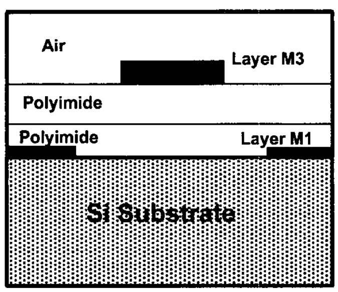

Fig. 2. Cross section of shielded CPW transmission line on Si substrate.

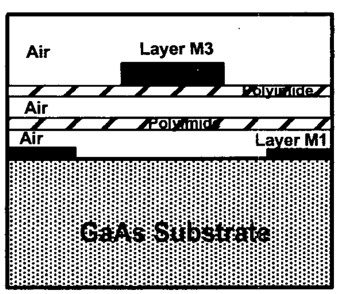

Fig. 3. Cross section of shielded and membrane_mounted CPW transmission line on GaAs substrate.

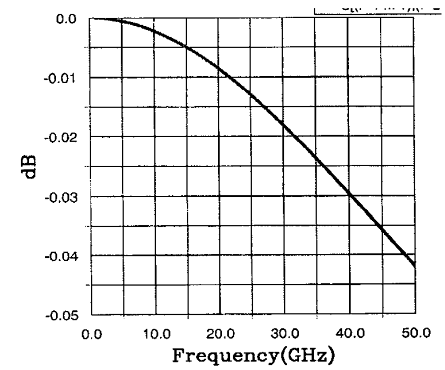

Fig.7. Simulated S12 response for shielded CPW line on GaAs Substrate.

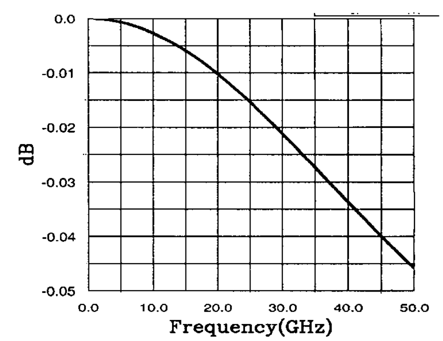

Fig. 8. Simulated S12 response for shielded CPW line on Si substrate.

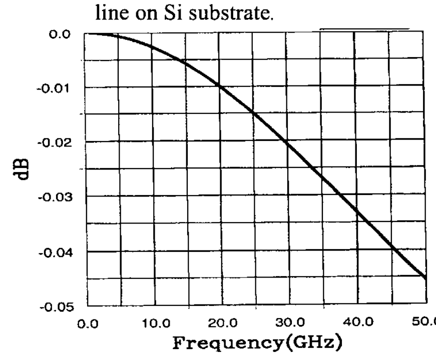

Fig. 9. Simulated S12 response for shielded and membrane_mounted CPW line on GaAs.

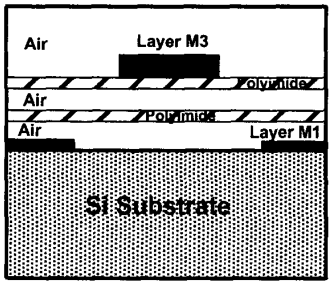

Fig. 4. Cross section of shielded and membrane_ mounted CPW transmission line on Si substrate

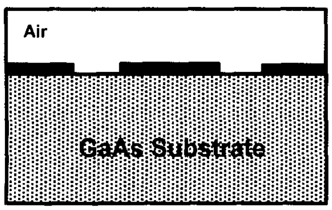

Fig. 5. Cross section of shielded conventional CPW transmission line on GaAs substrate.

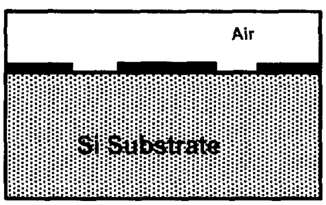

Fig. 6. Cross section of shielded conventional CPW transmission line on Si substrate.

Fig. 13 Photomicrograph of fabricated monolithic metallic enclosure on GaAs substrate (100 x 20 microns).

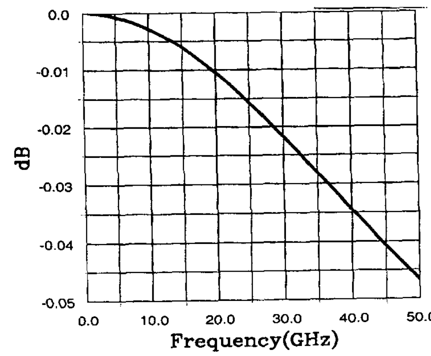

Fig 10. Simulated S12 response for shielded and membrane_mounted CPW line on Si substrate.

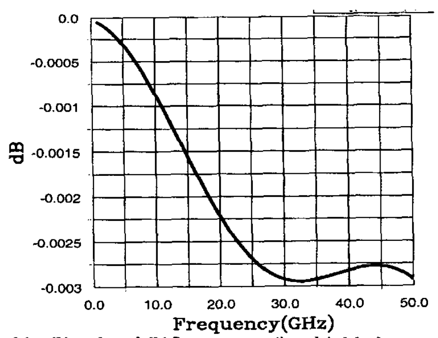

Fig. 11. Simulated S12 response for shielded conventional CPW transmission line on GaAs substrate.

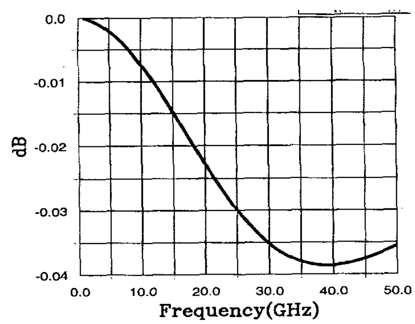

Fig. 12. Simulated S12 response for shielded conventional CPW transmission line on Si substrate.

Conclusion

In CPW structures, by investigating the proposed structures using electromagnetic simulation, it is found that GaAs serves as a better dielectric substrate since the insersion loss is reduced. The results also show that in multilayer CPW structures, 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.