The Effect of Structural Parameters on the Characteristics of Finite Ground Coplanar Waveguides on Silicon Substrates for 60 and 94 GHz Applications

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Millimeter-wave circuits and systems for radar, radiometry, and communication applications have received an increasing attention during the last decades. The demand for reliable low-cost millimeter-wave components and subsystems has led to the development of monolithic microwave integrated circuits (MMICs) in Si and GaAs technologies. With the opening of 7GHz bandwidth around 60GHz for unlicensed use (57-64 GHz in the US, and 59-66 GHz in Japan) and military applications at 94GHz, millimeter-wave band applications have gained a new momentum.

Transmission lines are an integral part of RF and wireless systems. They can be used to make filters, power dividers, matching networks as well as to interconnect multi-chip modules. Traditionally, microstrip lines and coplanar waveguides have been used to fulfill these needs. Recently, Finite Ground Coplanar Waveguide (FGC) has been introduced by researchers at NASA Lewis Research Center and University of Michigan, as a viable choice for the RF and wireless communication circuits. Fig. 1 shows an FGC with the related structural parameters. In this figure, S and B represent the width of the signal line and ground plane respectively while W represents the spacing between them.

In this work, we have reviewed effects of lossy Si substrates on the line characteristics of finite ground coplanar lines. The layer structure for the standard 0.13 -µm RF CMOS process in consideration has been given in Fig. 2. Our preliminary results show that, as compared to microstrip lines, FGC lines produced on lossy-Si substrates in 0.13 µm RF CMOS process have much reduced substrate losses and excellent dispersion characteristics. It has been also observed that, for the same characteristic impedance value (50 Ω), line attenuation has a significant dependence on the substrate conductance and line geometry. The dominant source of the attenuation changes from metallic losses to substrate losses as the size of the structure increases. Results also clearly show that for a given Si substrate conductivity, there is an optimum FGC line geometry that will provide the minimum insertion loss. In a similar work (Ponchak et al., "Finite Ground Coplanar(FGC) Waveguide: It's Characteristics and Advantages for use in RF and Wireless Communication Circuits," 3rd International Wireless Communications Conference (WCC '98) Digest, San Diego, CA, pp. 75-83, Nov. 1-3, 1998) where a high resistivity substrate (2500 Ω-cm) was utilized, it is stated that the ground planes should be twice the center conductor width. However, that conclusion does not hold for FGC lines on lossy Si substrates.

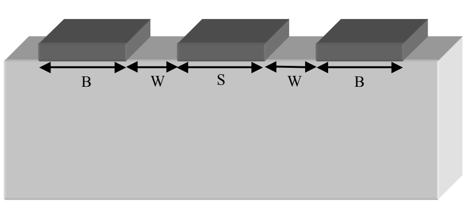

Figure 1. Cross-sectional view of a Finite Ground Coplanar Waveguide

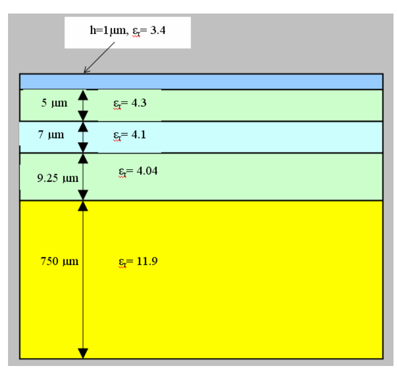

Figure 2. Layer structure for a 0.13 -µm RF CMOS process