CONSIDERING SOME UNDESIRED EFFECTS DUE TO DENSE PACKING IN SUPPORTED COPLANAR WAVEGUIDE MMICs BY USING COMBINED METHODS.

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ABSTRACT

Combined methods are used to predict some undesired effects due to dense packing in supported coplanar waveguide monolithic microwave integrated circuits (MMICs). These include , the effects due to the presence of an adjacent grounded side wall or the presence of another adjacent line. The presented information can either be used to consider these effects during the design stage or to help in designing MMICs in which these effects can be ignored. Numerical results are also presented in order to demonstrate these effects.

1. INTRODUCTION.

Due to the increasing demands on coast reduction as well as some special applications, it is desirable to pack MMICs in the smallest possible size. In this case, it is believed that there will be coupling between the MMIC various elements of the same or different kinds deployed on the same substrate or even in different dielectric layers. Moreover, some elements have to be brought adjacent to a grounded side wall. It is understood that such effects are undesirable and should be minimized or at least be taken into account during the design stage. In this contribution, an approach which mainly utilizes the conformal mapping technique combined with other methods is used in order to consider some of these undesired effects due to dense packing in supported coplanar waveguide-monolithic microwave integrated circuits (SCPW-MMICs).These include the effect due to the presence of an adjacent grounded side wall on the design parameters of a SCPW (Fig. 1a) as well as the undesired coupling between adjacent SCPWs (Fig. 1c) deployed on the same substrate . In both cases, it is assumed that the top-cover is far enough such that its effects can be ignored. It is also assumed that the main substrate (which is usually thin and fragile in MMIC applications) is supported by another thick dielectric material in order to increase the mechanical strength of the whole structure as well as to be able

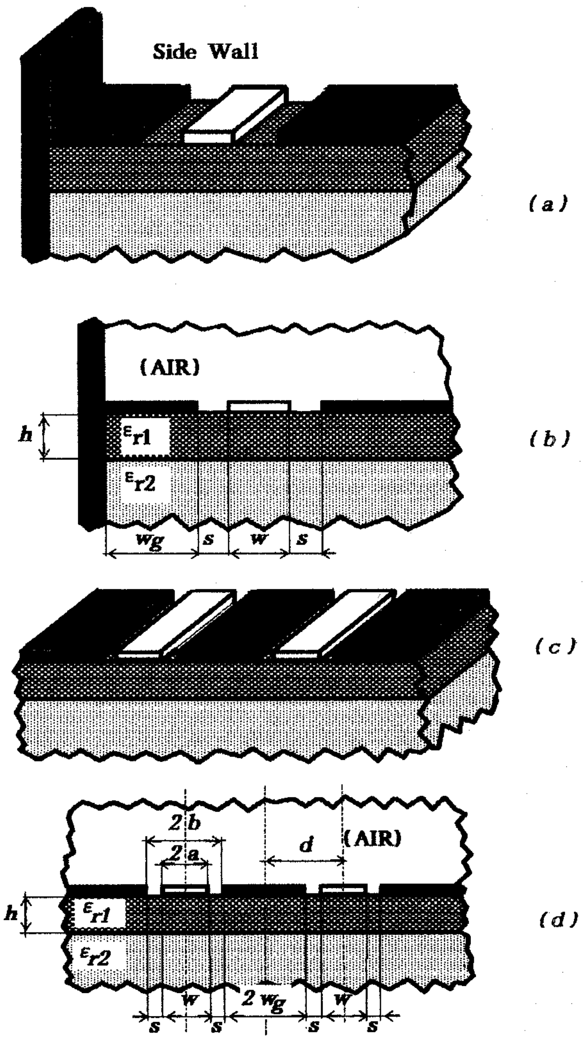

Figure 1 : Some dense packing effects which are considered in this paper; (a) general view for a supported coplanar waveguide (SCPW) adjacent to a grounded side wall, (b) cross-section in Fig.1a, (c) general view for two adjacent SCPWs , and (d) cross-section in Fig. 1 c .

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to ignore the effect of the backed ground plane of the mounting. Cross-sections in both cases are also shown in Figs.1b and 1d, respectively. It should be pointed out here that the grounded conductors or walls are always shown black (this notation will be used allover the text). Several publications have investigated the presence of adjacent grounded side walls [1] to [2], however most of them are dealing with a CPW configuration with backed ground plane which has many undesirable features for CPW-MMICs Design [3] to [5] . Moreover, in all cases it is assumed that the CPW is placed symmetrically between two adjacent grounded side walls. Such configuration can hardly appeare in practical MMICs applications. In practical MMICs, designers may have to bring a CPW adjacent to only one of the grounded sides of the package as shown in Fig. 1a in order to achieve dense packing . Hence, conclusions which will be derived here would be slightly different than those mentioned in [1] and [2]. It should be pointed out that [2] and [3] have mainly employed numerical methods which consume considerable computation time, however, analytic closed form expressions for calculating the characteristic impedance of the CPW configuration with backing ground plane and in the presence of two adjacent grounded side walls have also been given in [1]. Ghione and Naldy [7] have also investigated the coupling between adjacent CPWs in a very simple way which is suitable for CAD-methods, however their analysis was not complete . The approach which will be used here utilizes mainly the conformal mapping technique combined with other methods and has already been used and verified for the calculation of the quasi-TEM parameters of several SCPWs [6] applications. This approach has also proved to be very efficient concerning the speedness of calculations, hence it is recommended to be incorporated in available CAD-programs for CPW-MMICs. Numerical results will be presented in order to demonstrate some of these undesired effects and some conclusions have also been derived. However, designers should be careful about such conclusions which have been derived from the examination of only few cases.

2. CONSIDERING SOME DENSE PACKING EFFECTS ON SCPW.

Since it is a supported coplanar waveguide structure, then the derivation will follow the same way which was described in [6]. It is based on the derivation of an approximate expression for the effective dielectric constant of the structure. This is done by suitably dividing the cross-section of the structure into subregions. Filling factors are then defined for each region whose values can be obtained in terms of some air filled basic capacitances per unit length (CPULs) of corresponding basic air filled coplanar waveguide sections (BCPWSs). The application of this approach for the case of the presence of an adjacent grounded side wall (Fig. 1 a) will be outlined in the following subsection.

A. Effect Of Adjacent Grounded Side Wall.

This problem will require the calculation of the CPULs of the corresponding BCPWSs shown in Figs. 2a and 3a(BCPWS1 and BCPWS2, respectively). In order to calculate the CPUL of BCPWS1, the quarter plane in the Z- Plane (Fig. 2a) is transformed to the half plane in the W-Plane (Fig. 2b) by using the transformation function $W=Z^2$. The resulting transformation represents a half section in an asymmetrical CPW with infinte substrate thickness, for which a closed form expression for its CPUL is already available in literature. Fig. 4 shows the transformation of the BCPWS2 into a wavgide whose cross-section is an incomplete parallel plate capacitor, for which a simple and accurate method for the calculation of its CPUL is already proposed by Getsinger [8] and reoutlined in [6]. The used transformations are, $W=\cosh\left(\frac{\pi Z}{2h_2}\right)$ first, then the incomplete elliptic function of the first kind $T=F(W, k)$.

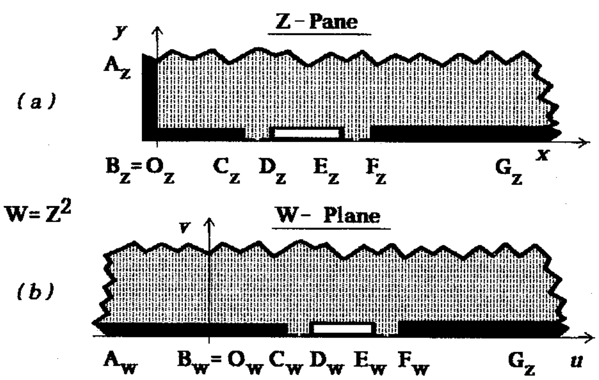

Figure 2 : Conformal mapping of the cross-section of BCPWS1 into a half plane ; (a) Z-plane , and (b) W-plane.

B. Effect Of Coupling Between Adjacent SCPWS.

Before going to the analysis of the second problem (the undesired coupling between adjacent CPW's that are deployed on the same substrate), it should be pointed out that in spite of the fact that the presented approach can be used to analyze the case where the adjacent CPWs are not identical, the presented solution and numerical results will be limited to the case of identical adjacent CPWs. In this case two modes can be isolated, mainly the odd- and the even-modes with electric or magnetic walls placed at the middle and

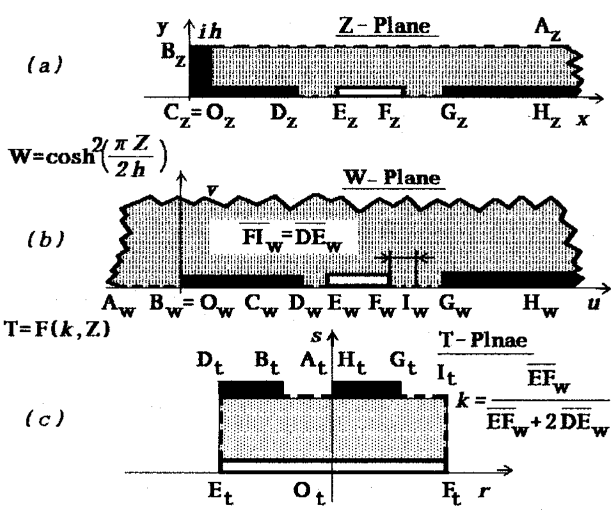

Figure 3 : Conformal mapping of the cross-section BCPWS2 into incomplete parallel plate capacitor cross-section; (a) Z-plane , (b) W-plane, and (c) T-plane.

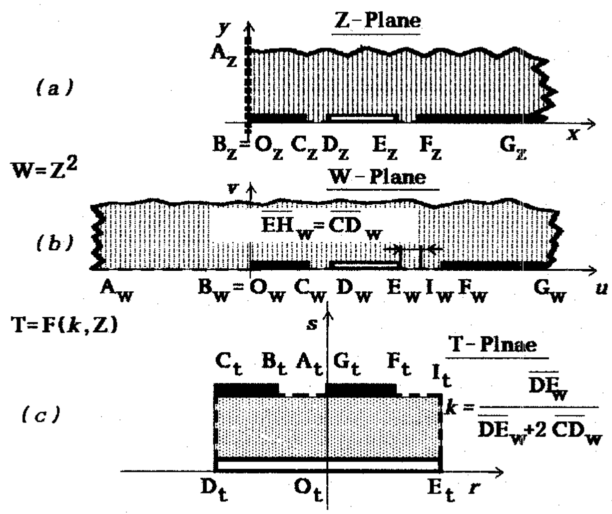

Figure 4: Conformal mapping of the cross-section BCPWS3 into incomplete parallel plate capacitor cross-section; (a) Z-plane , (b) W-plane , and (c) T-plane.

perpendicular to the coplanar ground plane between the two adjacent CPWs. The cross-section of the structure under an odd-mode excitation is similar to that of Fig. 1b, which has been used to investigate the effect of the presence of an adjacent side wall. The difference is only that the grounded side wall is replaced by an electric wall. Hence the odd-mode characteristic impedance as well as the effective dielectric constant can be calculated in the same way as described for considering the effect of the presence of an adjacent grounded side wall. For the calculations of the even-mode characteristic impedance and the effective dielectric constant, it is required to calculate the CPUL of two more BCPWSs which are shown in Figs. 4a and 5a, respectively (BCPWS3 and BCPWS4). Their transformations into an incomplete parallel plate cross-section are also shown in the rest of Figs. 4 and 5, respectively. This has been made by using proper transformation functions which are indicated in the same figures.

3. NUMERICAL RESULTS AND CONCLUSION.

The outlined approach has been used to generate some results, these are displayed in Figs. 6 and 7. The effect of the presence of an adjacent grounded side wall on the characteristic impedance(Z_0) of three fifty ohms SCPWs with various physical dimensions is demonstrated in Fig. 6. As expected, this effect lowers the value of Z_0 and is greater in the case of SCPWs with smaller values of ground planes spacing b. In all cases the value of Z_0 approaches the fifty ohms value as the value of side wall separation w_g increases . The variation of Z_0 with the ratio w_g/b has also been investigated. It has been observed that there is no single fixed dimenions relation after which designers can be sure about being able to ignore such an effect. In order to investigate the effect of the presence of another adjacent SCPW, four scattering parameters are plotted in Figs. 7a to 7d. These are s_{11} (which gives indication about the matching of any of the two adjacent SCPWs), s_{12} (which describes the interaction between the sources of the two adjacent SCPWs), s_{13} (which gives an

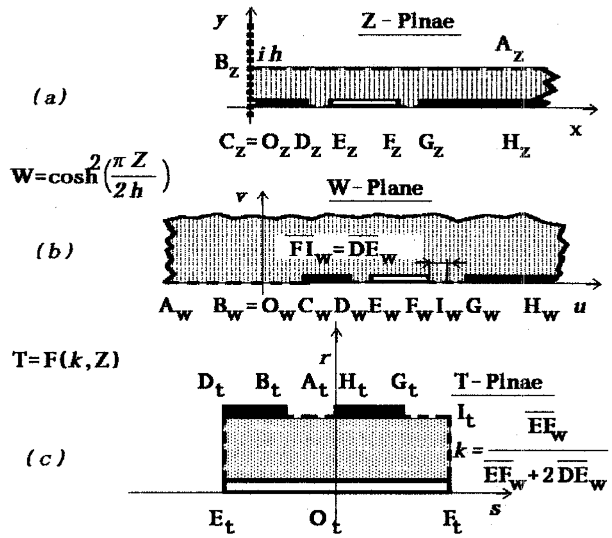

Figure 5 : Conformal mapping of the cross-section BCPWS4 into incomplete parallel plate capacitor cross-section; (a) Z-plane, (b) W-plane, and (c) T-plane.

indication about the amount of power which reaches the output of the second SCPW due an input power at the first SCPW), and s_{14} (which shows how much of the input power of any of the SCPWs is actually reaching its output). As expected s_{11}, s_{12}, and s_{13} increase, while, s_{14} decreases due to this effect and can be ignored as the value of w_g increases. This effect is also found to be higher for SCPWs with small ground plane spacing b . Unlike the case of the effect of the adjacent grounded side wall, the variations of the scattering parameters with the ratio w_g/b coincide for the three fifty ohms SCPWs and also approach the values of the isolated lines at nearly the value $w_g/b=4$. This is in agreement with available information in literature, however, designers should be careful about such a conclusion which is derived from comparisons of three SCPWs only but with various dimensions.

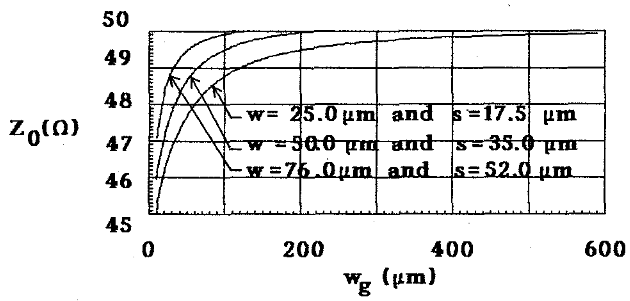

Figure 6 : Variations of the characteristic impedance Z_0 of several fifty ohms SCPWs adjacent to a grounded side wall with w_g.

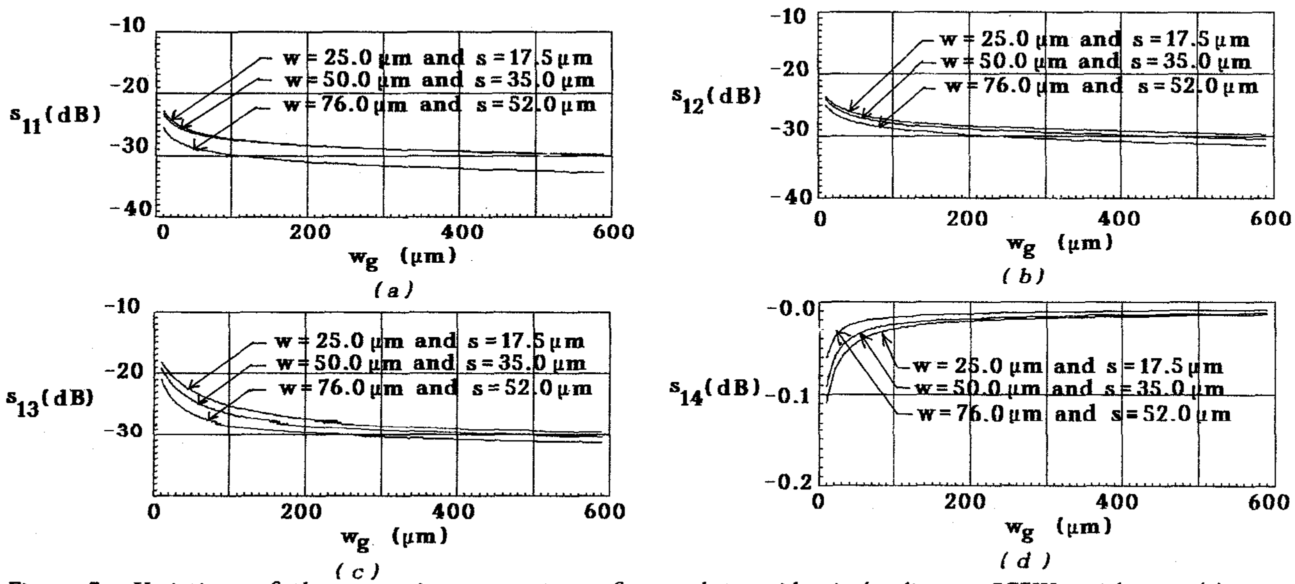

Figure 7 : Variations of the scattering parameters of several two identical adjacent SCPWs with w_g; (a) s_{11} , (b) s_{12} , (c) s_{13} , and (d) s_{14}.

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