第 26卷 第 3期 电 子 科 技 大 学 学 报 Vol. 26 No. 3
1997年 6月 Journal of UEST of China Jun. 1997

Basic Characteristics of A New Circular-shaped Microshield Coplanar Waveguide

Du Zhengwei Ruan Chengli
(Inst. of Appl. Phys. , UEST of China Chengdu 610054)

Abstract In this paper, a new type of circular-shaped microshield and conductor-backed coplanar waveguide (CPW) is proposed. Analytical closed-form expressions for characteristic impedance and effective dielectric constant for the new line are obtained using conformal mapping method under the assumption of pure-TEM propagation and zero dispersion. The new waveguide proposed by this paper and reduce radiation to much less than the conventional CPW and microstrip, and reduce the current concentration at both the edges of the signal, and has no need for viaholes or air-bridges for ground equalization and a wide range of impedances.

Key words conformal mapping; microshield; coplanar waveguide

Recently, a novel planar transmission line– a microshield microstrip line has been studied using conformal mapping method[1]. The microshield lines, compared with the conventional ones such as the microstrip or the coplanar waveguide, have the ability to operate without the need for via-holes or the use of air-bridges for ground equalization and supply a wide range of impedance. Due to the geometry of the line, the level of the conductor losses is expected to be slightly higher than microstrip losses and lower than conventional CPW losses, and the radiation is much less than the conventional CPW and microstrip. An other new type of coplanar structure[2] the geometry which is essentially a conductor-backed CPW where the lower ground plane is bent within the dielectric in a v-shape to form the equal sides of an isosceles triangle (VGCPW) which can reduce the current concentration at both edges of the strip conductor is proposed. In fact, the effect of v-shape can be replaced with that of a direct line as shown in Fig. 1. In the following analysis, we analyze the circular-shaped microshield and conductor-backed coplanar waveguide (CMCBCPW) as shown in Fig. 1a using conformal mapping method based on the assumptions of only pure-TEM propagation and no dispersion effect. This line may be considered as an evolution of the conventional microshield microstrip line and VGCPW. The purpose of this new structure is to use the advantages of the two types of new lines and to obtain CAD oriented closed-form analytical expressions for characteristic impedance and effective dielectric constant.

1 Theory

The configuration to be studied is shown in Fig. 1a, where the upper plane is deformed around the inner conductor as circular-shaped, the radius is b, the central conductor, of width $2a$, is

---

Received July 11, 1996 and revised July 24, 1996

placed between two planes. The spacing which are located on a substrate of thickness h, with relative permittivity X, the distance between the strip conductor and the direct line is d. For practical characteristic impedance the transverse dimensions are small compared to the wavelength and the slots are modeled as magnetic walls[3,4]. It is assumed that all metallic conductors are infinitely thin and perfectly conducting. The assumption has been proved to yield excellent results for practical line dimensions. Hence, the configuration in Fig. 1a can be replaced by two "consisting" waveguides as shown in Fig. 1b, 1c. The total capacitance of the CMCBCPW is the sum of the capacitances of "consisting" waveguides (see Fig. 1b, 1c). Like Ref. [2], with the following conformal mapping

$$t = \sin^2\left(\frac{cz}{2hi}\right) \tag{1}$$

$$w = \int_0^t \frac{dt}{\sqrt{t(t - t_a)(t - t_b)(t + t_c)}} \tag{2}$$

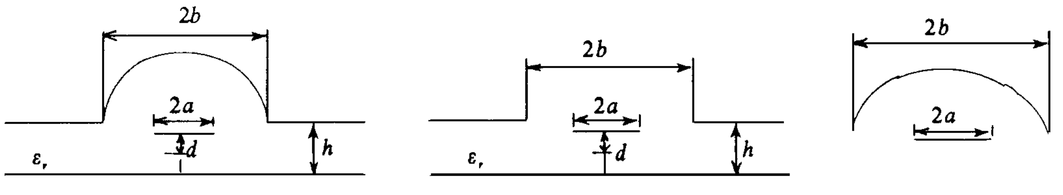
where $i^2 = -1$

$$t_a = \sinh^2\left(\frac{ca}{2h}\right) \tag{3}$$

$$t_b = \sinh^2\left(\frac{cb}{2h}\right) \tag{4}$$

$$t_c = \sin^2\left(\frac{cd}{2h}\right) \tag{5}$$

the structure shown in Fig. 1b is mapped into two parallel plates.



(a) CMCBCPW (b) The lower part (c) The upper part

Fig. 1 The configuration of circular-shaped microshield and conductor-backed coplanar waveguide

The capacitance of the line in Fig. 1b is given by

$$C_1(X) = 2X_0X_r\frac{K(k)}{K(k')} \tag{6}$$

where

$$k = \sqrt{\frac{1 + t_c/t_b}{1 + t_c/t_a}} \tag{7}$$

and $K(k)$ is the complete elliptic integrate of the first kind and $k'^2 = 1 - k^2$.

The capacitance introduced by Fig. 1c is given by

$$C_2(X) = \frac{cX_0X_r}{\ln(2b/a)} \tag{8}$$

The total capacitance of the CMCBCPW, $C(X) = C_1(X) + C_2(X)$, is

$$C(X) = X_0X_r\left[2\frac{K(k)}{K(k')} + \frac{c}{\ln(2b/a)}\right] \tag{9}$$

Hence, the effective permittivity and the characteristic impedance of the line are,

$$\varepsilon_{eff} = \frac{C(\varepsilon_r)}{C(l)} \tag{10}$$

$$Z_0 = \frac{\sqrt{\mu_0\varepsilon_0}}{\sqrt{\varepsilon_{eff}}\,C(1)} \tag{11}$$

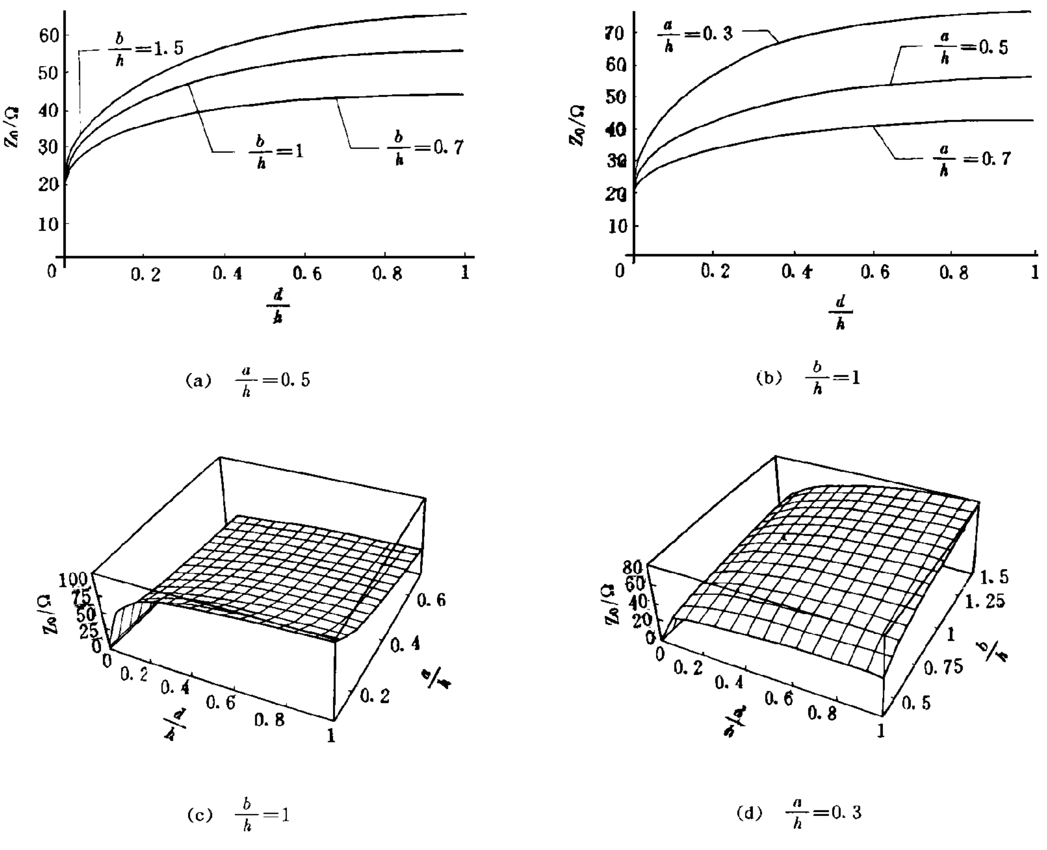
respectively.

1) $d = h$: In this case, from Eqs. (3)~ (5) and Eq. (7), we have

$$k = \frac{\tanh(\pi a/2h)}{\tanh(\pi a/2h)} \tag{12}$$

Substitute Eq. (12) into Eqs. (10) and (11), we obtain the results circular-shaped microshield transmission line, a result known from Ref. [1].

(2) $h \to \infty$ and $d \to \infty$: From Eqs. (3)~ (5) and Eq. (7), we have $k = a/b$ and can obtain the results which are those of the circular-shaped microshield no lower shielding.



(a) $\frac{a}{h}=0.5$ (b) $\frac{b}{h}=1$

(c) $\frac{b}{h}=1$ (d) $\frac{a}{h}=0.3$

Fig. 2 The characteristic impedance of the CMCBCPW ($\varepsilon_r = 2.55$)

2 Numerical Results

The characteristic impedance of the circular-shaped microshield and conductor-backed waveguide is shown in Fig. 2. Fig. 2a gives the change of the characteristic impedance with d/h when $a/h=0.5$, and the change with d/h when $b/h=1$ is shown in Fig. 2b. Fig. 2c and Fig. 2d show the changes of the characteristic impedance in three dimensions. We can get a proper characteristic impedance by changing the structure.

3 Conclusions

A novel microshield lines are proposed for MMIC applications. The model and analytical closed-form expressions for characteristic impedance and effective dielectric constant for the circular-shaped microshield and conductor-backed waveguide are obtained. The formulas are based on the assumption of pure-TEM mode and derived using conformal mapping technique.

References

1 Yuan Naichang, Ruan Chengli, Lin Weigan. Analytical analyses of v, elliptic, and circular-shaped microshield transmission lines. IEEE Trans MTT, 1994, 42(5): 855~859

2 Cheng K-K M, Robertson I D. Quasi-TEM analysis of v-shaped conductor-backed coplanar waveguide. IEEE Trans MTT, 1995, 43(8): 1992~1994

3 Hanna F. Finite boundary corrections to coplanar stripline analysis. Electron Lett, 1980, 16(15): 604~605

4 Gevorgian S, Linner L J P, Kollberg E L. CAD models for shielded multilayered CPW. IEEE Trans MTT, 1995, 43(4): 772~779

一种新型圆形微屏蔽共平面波导的基本特性

杜正伟*　　阮成礼
(电子科技大学应用物理研究所　成都　610054)

【摘要】 提出了一种新型圆形微屏蔽—脊导体共平面波导。基于假设只有纯 TEM波传播和零色散的情况下,通过保角变换得到了特性阻抗和有效介电常数的闭合形式的解析表达式。这种新型波导大大降低了传统共平面波导和微带线的辐射损耗和信号线边缘的电流,并且不需要打孔或空桥接地。

关　键　词　保角变换; 微屏蔽; 共平面波导

中图分类号　TN015

编辑　叶　红

1996年 7月 11日收稿, 1996年 7月 24日修改定稿

* 男　24岁　博士生