Laterally Shielded Coplanar Waveguide for Millimeter Waves

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***Abstract*— A laterally shielded coplanar waveguide has been proposed for millimeter wave use. It is the CPW sandwiched vertically in a below cutoff parallel plate waveguide and can suppress unwanted waves in circuits. A right angle bend as well as a straight portion of the laterally shielded CPW exhibited excellent performance.**

I. Introduction

Recently, coplanar waveguide (CPW) structures have been widely used in microwave and millimeter-wave integrated circuits because of easy mounting of two and three terminal devices on circuits. As frequency increases, however, additional power losses in the CPW occur in the form of leaky surface waves [1] and radiation at circuit discontinuities. It has also been reported that upper and back shielding of the CPW can reduce radiation, but they fail in eliminating unwanted leaky parallel plate modes [2]. These difficulties can be overcome with the use of parallel metal plates of a separation less than a half-wavelength to shield the CPW laterally. The grooves or slits to hold the CPW at its position in the shielding structure are not employed here in order to avoid a complicated fabrication process.

An unwanted TEM mode that might propagate along small gaps between the ground planes of the CPW and the shielding plates can be suppressed by means of notch arrays etched on the edges of the ground planes. A right angle bend as well as a straight portion of the laterally shielded CPW were measured to confirm excellent performance at millimeter wavelengths.

II. Straight Line

The laterally shielded CPW is simply constructed by holding the CPW vertically in a below cutoff parallel plate waveguide as depicted in Fig. 1. The distance between the shielding plates must be kept smaller than a half-wavelength even at the upper end of the frequency range of operation in order to avoid generation of unwanted radiation and surface wave modes. The CPW itself is etched in the middle of a copper coated teflon-fiber substrate whose relative permittivity is 2.6.

Since there are unavoidable gaps between the CPW ground planes and shielding plates, another unwanted mode can be generated due to the coupling from the CPW mode. Reduction of such coupling can be achieved by introducing notch arrays on the edges of the CPW ground planes as indicated in Fig. 1. The notch arrays act to introduce phase velocity difference between the CPW mode and the TEM mode in the gap and consequently to reduce the coupling considerably [3].

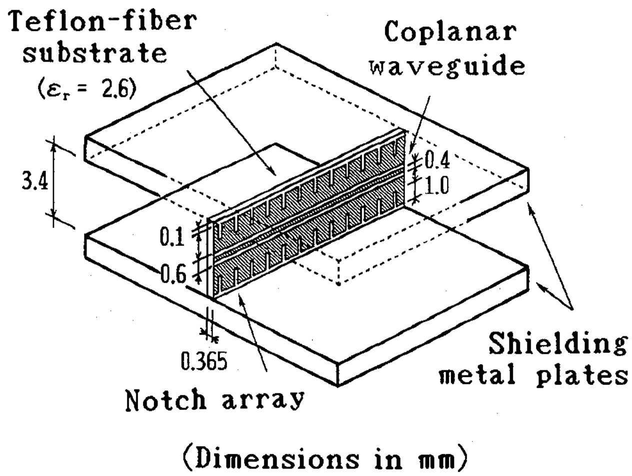

Fig. 1. Structure of laterally shielded CPW.

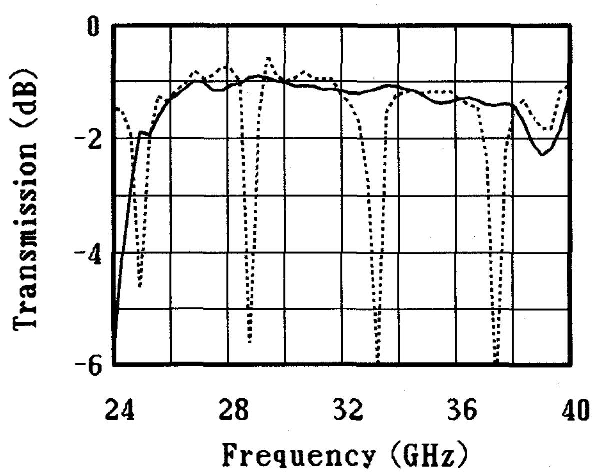

Fig. 2. Transmission losses of laterally shielded CPW's: — with the notch arrays and ··· without the notch arrays.

The possibility of power leakage from the CPW mode into surface wave modes is also examined [1], but it is denied over the frequency range from 24 GHz to 40 GHz at least.

The circuit was held at its position in the shielding structure and connected to a measurement system by K-connectors at the input and output ports. In order to confirm the effect of the notch arrays as well as performance of the laterally shielded CPW, transmission losses of 30-mm long straight lines with and without the notch arrays were measured in the frequency range from 24 GHz to 40 GHz. The obtained results are compared in Fig. 2. The sharp minima observed on

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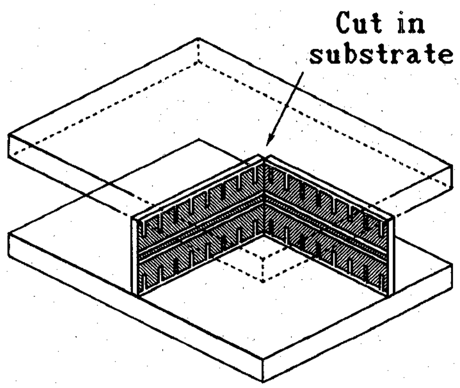

Fig. 3. Structure of right angle bend in the laterally shielded CPW.

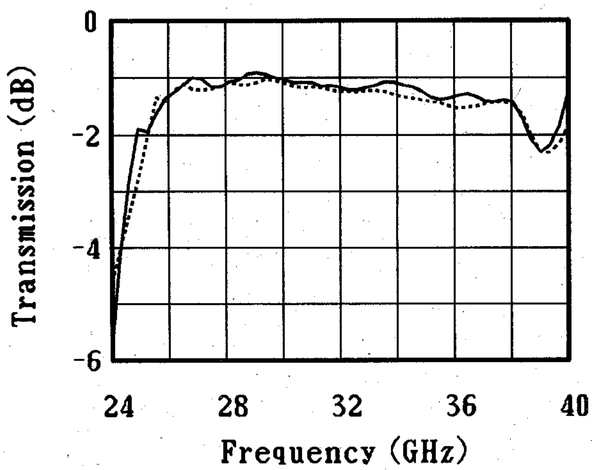

Fig. 4. Transmission losses of laterally shielded CPW's: — straight line and ··· right angle bend.

the transmission curve of the CPW without the notch arrays suggest the existence of strong coupling between the CPW mode and the undesired gap mode as predicted. The notch arrays of a proper stub length can significantly improve the transmission characteristics of the laterally shielded CPW as shown in Fig. 2. It was also confirmed experimentally that the longer the notch array stubs, the weaker the coupling is. The return loss measured at the input port was smaller than –15 dB over the most frequency range of operation when the notch arrays were used.

III. Right Angle Bend

A right angle bend in the laterally shielded CPW is shown in Fig. 3. In order to fabricate the bend, a perpendicular cut is created on the back of the substrate. The measured transmission losses of the straight line and bend of the same length are shown in Fig. 4. The difference between the two curves is only slight, and this fact implies that the shielding plates can suppress radiation down to a negligible level and guarantee the low transmission loss even at a right angle bend. It is also surprising to see that reflection at the bend is extremely small. This clearly demonstrates the great advantage of the laterally shielded CPW for practical applications. The physical reason for the small reflection at the right angle bend is remained to be considered.

IV. Conclusion

A novel type of shielded CPW has been proposed. Because grooves or slits are not used to hold the CPW at the position in the shielding structure, a good flexibility can be obtained for the design and fine adjustments of circuits. It has also been shown that right angle bends can be implemented in circuits without any degradation in transmission characteristics. The results presented here imply that three-dimensional millimeter wave integrated circuits can be built by using the laterally shielded CPW.

References

[1] M. Tsuji, H. Shigesawa, and A. A. Oliner, "New interesting leakage behavior on coplanar waveguides of finite and infinite widths," *IEEE Trans. Microwave Theory Tech.*, vol. 39, pp. 2130–2137, Dec. 1991.

[2] E. W. McKinzie, and N. G. Alexopoulos, "Leakage losses for the dominant mode of conductor-backed coplanar waveguide," *IEEE Microwave Guided Wave Lett.*, vol. 2, pp. 65–66, Feb. 1992.

[3] R. E. Collin, *Foundations for Microwave Engineering*. McGraw-Hill, 1966, pp. 363–398.