A Branchline Hybrid Using Valley Microstrip Lines

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***Abstract*—The branchline hybrid is investigated as an application of valley microstrip lines to a circuit that consists of valley microstrip lines both with and without a slit. It is shown that valley microstrip lines can be utilized for configuring a circuit in accordance with theory.**

I. Introduction

Very small multilayer MMIC's have been developed in ATR [1]–[4]. Microstrip lines are utilized for fundamental transmission lines. These microstrip lines consist of narrow metal strips on a thin dielectric film prepared on a GaAs substrate and the ground metal on a GaAs substrate. Furthermore, valley microstrip lines have been proposed to reduce the insertion loss over that of microstrip lines [5]–[6]. It remains to be seen whether the circuits perform in accordance with the predicted value if they are fabricated using meandering valley microstrip lines to minimize the circuit area, i.e., whether the valley microstrip line impedance and effective dielectric constant are as predicted and whether the meander configuration has no significant effect on circuit performance and fabrication. This letter investigates these points by testing a branchline hybrid using both valley microstrip lines and the newly proposed valley microstrip lines with slits.

II. Configuration of Valley Microstrip Lines With Slits

The configuration of the valley microstrip line with slit is shown in Fig. 1. There is a ground metal slit just under the valley strip metal. The current concentration is dispersed at three points, i.e., the center and the two edges of the valley strip metal. The dispersion characteristics vary according to the slit width. Therefore, the average of electromagnetic intensity in the dielectric film under the valley strip metal and consequently the strip width for the same characteristic impedance can be adjusted by altering the slit width.

Moreover, since the slit leaks an electromagnetic field into the GaAs substrate, the effective dielectric constant increases as the slit is widened. Therefore, this line is advantageous in the insertion loss per unit electrical length.

III. Design of the Branchline Hybrid

Polyimide ($\xi r = 3.3$) is utilized for the dielectric film. The calculated value of the characteristic impedance of a valley microstrip line with slit as a function of the strip widths is shown in Fig. 2 when the slit width is 0, 12 or 24 μm. Where the dielectric film thickness, H, is 10 μm, the valley taper, θ, is 35° and the valley depth is 5 μm. The finite element method is utilized for the calculation. If the slit is widened, a strip having the same characteristic impedance is widened. The slit is adjusted so that 50 Ω and 35 Ω 1/4 wavelength transmission lines have nearly equal strip widths, i.e., nearly equal conductor loss. The strip/slit widths are 24 μm/24 μm for the 50 Ω line and 30 μm/0 μm for the 35Ωline, the effective dielectric constant 3.1 for the former, 2.8 for the latter.

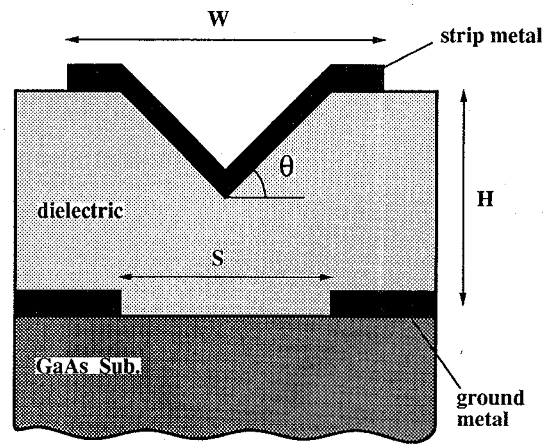

Fig. 1. Cross section of the valley microstrip line with slit.

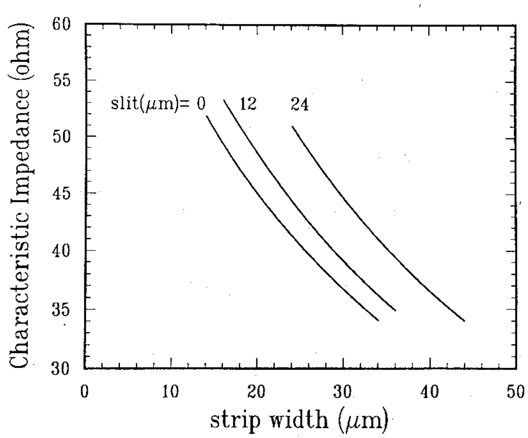

Fig. 2. Calculated value of the characteristic impedance of a valley microstrip line with slit as a function of the strip widths, where the dielectric film thickness, H, is 10 μm, the valley taper, θ, is 35°.

IV. Performance

The experimental results of only the valley microstrip lines without and with slits are evaluated. Transmission lines with

Manuscript received October 8, 1991.

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IEEE Log Number 9105843.

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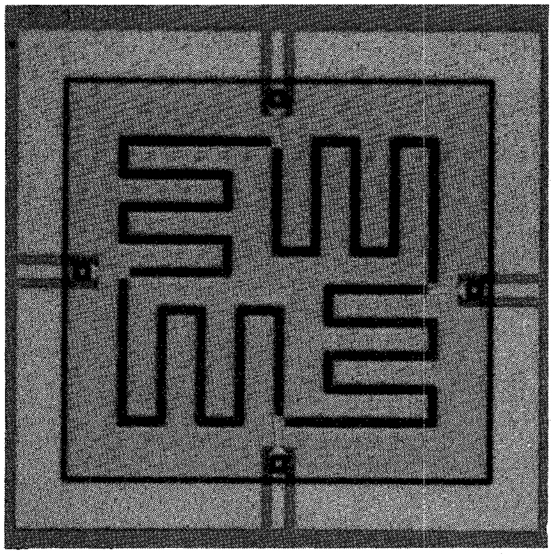
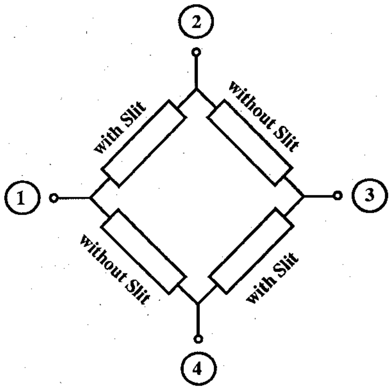


(a)



(b)

Fig. 3. (a) Photomicrograph showing the branchline hybrid using a valley microstrip line with and without slit. (b) Circuit configuration of the branchline hybrid.

$50\ \Omega$ and $35\ \Omega$ characteristic impedances (to be used in the fabrication of the branchline hybrid) are fabricated and tested. The measured impedances/effective dielectric constants are $45\,\Omega/3.4$ and $33\,\Omega/2.8$, respectively. These values conform to the design values. Minor differences arise because the valley depth is greater than expected.

The photomicrograph and the circuit configuration of the branchline hybrid are shown in Fig. 3(a) and (b). The size of the intrinsic area after subtracting the input/output lines is 1.1×1.0 mm. Both the valley microstrip lines with and without a slit are arranged in meander configuration to minimize the circuit area. There was concern that the meander configuration, particularly in corners, would cause problems in fabrication. However, no problems arose.

The branchline hybrid is measured by using on-wafer probe and an HP8510 network analyzer. The measured values of the coupling frequency characteristics are shown in Fig. 4, more with the calculated values. Similarly, the return loss and isolation are shown in Fig. 5, where the performance includes the influence of the input/output lines for on-wafer measurement. In the calculation, the evaluated results of only

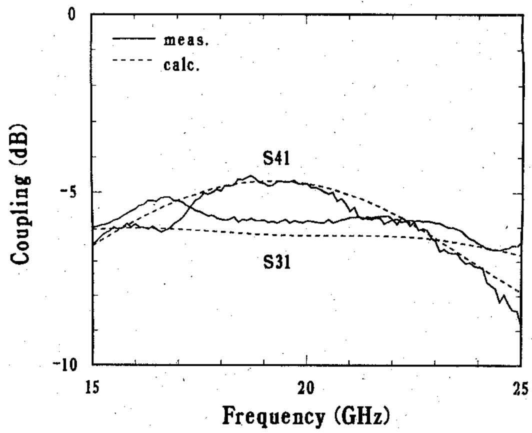


Fig. 4. Coupling of the branchline hybrid as a function of frequency.

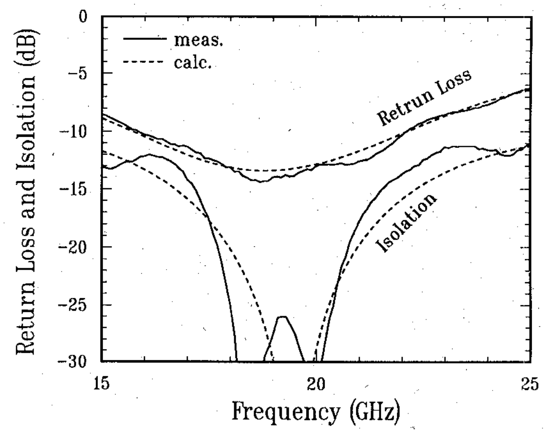


Fig. 5. Return loss and isolation of the branchline hybrid as a function of frequency.

the valley microstrip lines are used. Coupling of 5 ± 0.5 dB in the frequency range of 18–23 GHz, return loss of 13 dB at the center frequency, and isolation of more than 30 dB at the center frequency are obtained. The calculated value well represents the measured value. The meander-like arrangement does not influence the valley microstrip line performance.

V. Conclusion

A branchline hybrid is fabricated and investigated as an application of valley microstrip lines to a circuit. Here, the valley microstrip lines and the newly proposed valley microstrip lines with a slit are properly used and are arranged in a meander configuration. Valley microstrip lines can be utilized to configure a circuit that is in good agreement with the design. The meander-like arrangement for minimizing the circuit is not difficult to fabricate and does not adversely affect high frequency performance.

Acknowledgment

The authors would like to thank Dr. Y. Furuhama and Dr. M. Akaike for their continuous support and encouragement.

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