Characteristics of Valley Microstrip Lines for use in Multilayer MMIC's

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***Abstract*—A valley microstrip line fabricated by using multilayer MMIC technologies is proposed and its performance is investigated experimentally. Insertion loss of the valley microstrip line is smaller than that of conventional microstrip lines having the same width of strip conductor.**

I. Introduction

VERY small multilayer MMIC's have being developed in ATR [1]–[4]. Microstrip lines, coplanar waveguides, and slot lines are utilized for a fundamental transmission lines. These transmission lines are used together and make up a circuit. The coplanar waveguides or the slot lines are fabricated on a GaAs substrate. The microstrip lines with the narrow width strip conductor are fabricated on a thin dielectric film prepared on a GaAs substrate. For ground plane of these microstrip lines, that of uniplanar transmission lines such as coplanar waveguides are untilized. These microstrip lines can be crossed easily if the thickness of dielectric film of each microstrip line is different. Although multilayer MMIC's can reduce the overall circuit size, these narrow-width microstrip lines have larger insertion loss than microstrip lines in conventional MMIC's [4]. To reduce this insertion loss, this paper proposes new valley microstrip line structures for use in multilayer MMIC's.

II. Configuration

Fig. 1 shows the cross section of transmission lines for use in multilayer MMICs. Fig. 1(a) is a microstrip line with dielectric overlay. This microstrip line is fabricated by using thick dielectric films of several-μm on a GaAs substrate. Reducing the insertion loss is normally accomplished by increasing the width of the strip conductor, but as a result, circuit size becomes very large. Conversely, narrowing the width of the strip conductor to miniaturize circuit size, increases the insertion loss.

The valley microstrip line is shown in Fig. 1(b). This new structure can eliminate the current concentration at both edges of the strip conductor. Since the distance between the ground plane and the center of the valley microstrip conductor is smaller than between the ground plane and the edge of the conductor, the concentration of current is dispersed between the three points, i.e., the center and both edges of the valley microstrip conductor [5]. Also, the length, W', along the valley microstrip conductor is wider than the conductor width W. Therefore, the dispersion degree of current in the valley microstrip conductor becomes higher than in the microstrip conductor if the width of the valley microstrip conductor nearly equal to the width of the microstrip conductor for the same characteristic impedances. These two effects reduce the conduction loss of the valley microstrip line.

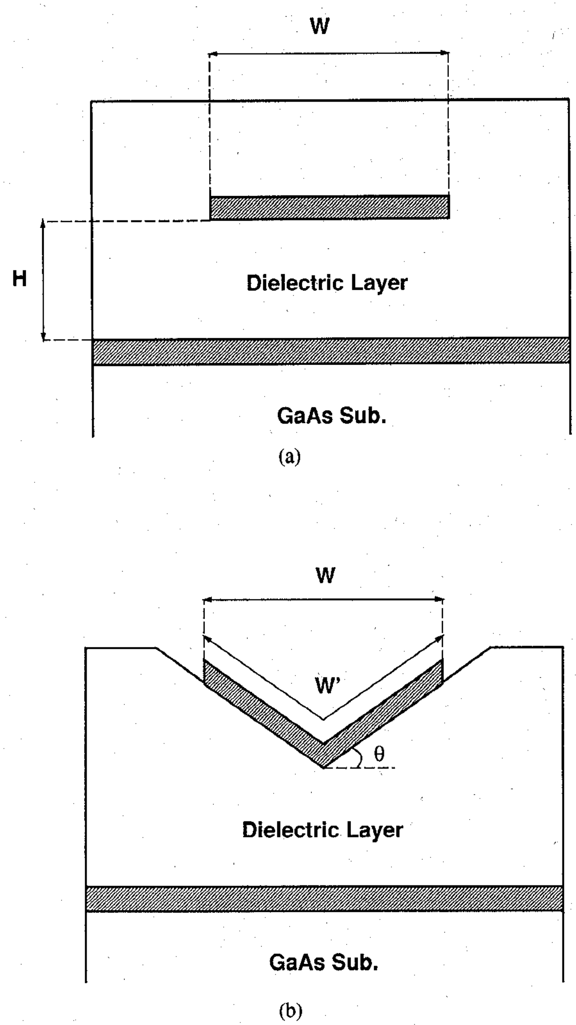

Fig. 1. Cross section of transmission lines for multilayer MMIC's; shaded portions show metal. (a) Microstrip line with dielectric overlay. (b) Valley microstrip line.

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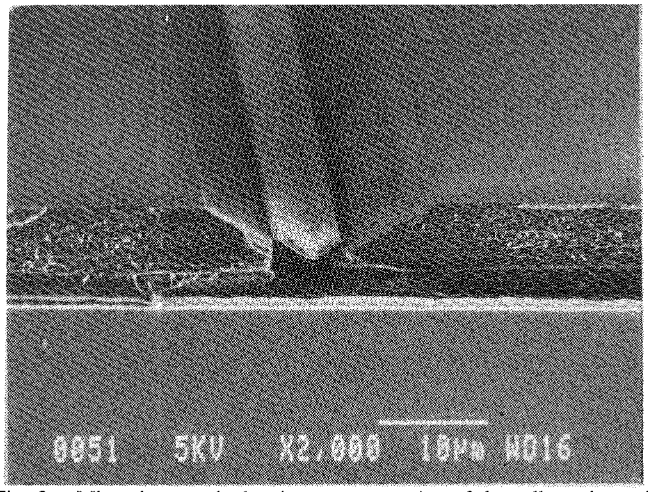

Fig. 2. Microphotograph showing a cross section of the valley microstrip line.

III. Fabrication

Polyimide film is utilized for the dielectric layers and is fabricated by using multilayer MMIC technologies. The polyimide film is prepared by spincoating and heat-treatments [6]. The total dielectric film consists of four 2.5 μm-thick layers. Polyimide possesses low film stress and allows fabrication of a thick dielectric layer of several μm. Furthermore, polyimide film can be processed in a valley-shape by using chemical etching [6]. The relative dielectric constant of the polyimide film is 3.3. The strip conductor of 1-μm thickness is fabricated by standard lift-off technique.

Fig. 2 shows the microphotography of the valley microstrip line. The depth of valley is 7 μm and the width, W, of the strip conductor is 6 μm. The valley taper angle, θ, is 35 degrees.

IV. Experiment Results

Each transmission line was measured by using on-wafer probers and a HP8510 network analyzer. Four microstrip lines with dielectric overlay, whose polyimide layer thickness/strip conductor width is 2.5 μm/5 μm, 5 μm/10 μm, 7.5 μm/16 μm and 10 μm/22 μm were measured. Characteristic impedances of each line is 50 Ω. For the valley microstrip line, the polyimide layer thickness underneath varies from 3–10 μm. With a strip conductor width of 6 μm, the characteristic impedance is 50 Ω.

Fig. 3 shows the insertion loss of the microstrip lines with dielectric overlay as a function of frequency. When the strip conductor width is narrowed in order to miniaturize circuit size, insertion loss increases. Fig. 4 shows the comparison of insertion loss between the valley microstrip line and the microstrip line with dielectric overlay as a function of frequency. This microstrip line which is compared has the same conductor width as the valley microstrip conductor, with 50 Ω characteristic impedance. Insertion loss of this microstrip line is estimated from four lines in Fig. 3. The insertion loss of the valley microstrip line can be up to 20% less than that of the microstrip line with the same conductor width.

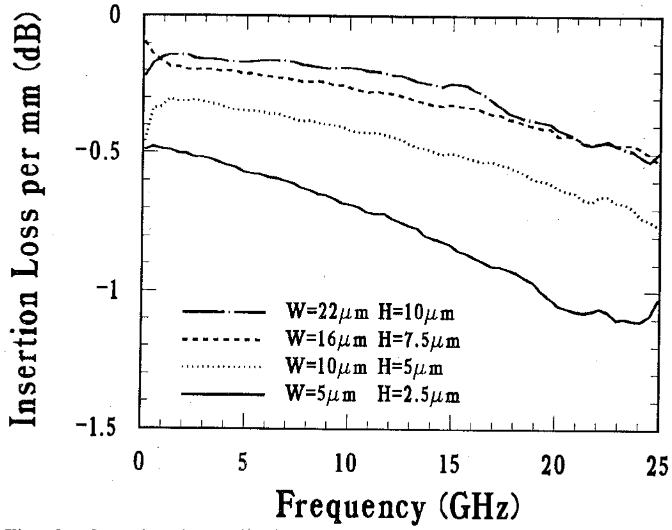

Fig. 3. Insertion loss of microstrip lines with dielectric overlay as a function of frequency.

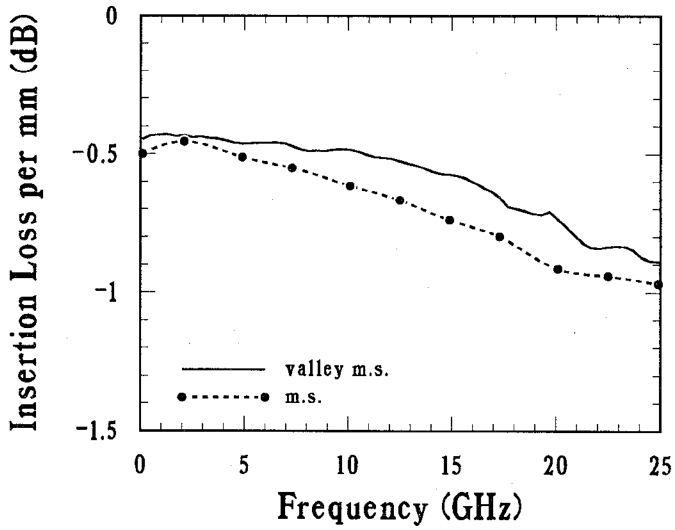

Fig. 4. Comparison of insertion loss as a function of frequency between the valley microstrip line and the microstrip line with dielectric overlay having the same conductor width.

V. Conclusion

The valley microstrip line utilizing the characteristics of polyimide is newly developed for multilayer MMIC's and has been experimentally investigated. The insertion loss of the valley microstrip line is approximatery 20% less than microstrip lines with the same conductor width. Therefore, use of the valley microstrip line can reduce increase of insertion loss even when the strip conductor width is reduced. Experimental investigation of characteristics of the valley microstrip lines varing the polyimide layer thickness and of the multilayer MMIC's fabricated by utilizing the valley microstrip lines, which are still required.

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