

"MICROSTRIP LINES"

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5 This invention relates in general to the
fabrication of hybrid microelectronic circuits. More
specifically, the invention relates to the fabrication
of microstrip lines using a thick film process on a
hybrid circuit substrate. It provides a novel
10 fabrication technique that requires less labor and
less specialized equipment than required for known
thin film techniques and overcomes many of the
difficulties associated with known thick film
fabrication techniques.

Some of the problems attendant the
fabrication of microwave hybrid circuits are discussed
in a publication entitled THE MICROWAVE HYBRID
15 CIRCUIT: FABRICATION-PROCESSING CONSIDERATIONS by
William J. MacDonald of Film Microelectronics, Inc.,
17 A Street Burlington, Mass. and Charles A. Wheeler
of Sanders Associates, Inc. Microwave Division,
Nashua, New Hampshire. The authors point out that
20 R.F. current flowing through a film conductor may
experience the "skin effect" phenomenon. Current
concentration at the substrate (ceramic) metallization
interface places certain requirements on film
(conductor) thickness and the bonding mechanism by
25 which the film adheres.

At microwave frequencies the conduction
characteristics of a film line are a function, at
least in part of line width and edge definition as
well as line thickness. Using known copper plated
30 silver and other thick film copper techniques, it is
possible to fabricate a microstrip resonator line
having sufficiently low loss and high-Q as now

required by modern circuit² designs. However, there is insufficient ability to accurately control both the width, edge definition and thickness of the thick film line applied to the substrate. Using known techniques, when multiple layers of copper are printed to develop the desired skin depth thickness, the overlapping of layers destroys any clear definition of edge and the width of the microstrip line becomes uncertain. This reduces the predictability of microstrip line characteristics.

It is possible to achieve good width, edge definition and the thickness control using thin film techniques in which chromium-gold or chromium-nickel-gold is sputtered onto the substrate. However, the use of thin film techniques requires elaborate and expensive machinery. The costs are prohibitive except for mass production.

An exemplary known thin film process for producing thin film microstrip lines includes the following method steps:

1. Vacuum deposit, i.e., either evaporate or sputter, approximately 500 Angstroms of titanium onto a 99.5% Al_2O_3 substrate.
2. Vacuum deposit copper until the total thickness is 2 microns. This produces a phased Cu Ti metallized layer which has high adhesion to the alumina substrate.
3. Copper is then electroplated onto the deposited metallization to increase the metal thickness to 27 microns, i.e., 25 microns of Cu is electrodeposited.
4. The desired pattern is then photo-produced using a liquid photoresist, exposing and developing to leave

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openings in the photoresist where the pattern is to remain.

5. 10-12 microns of gold is then electroplated onto the exposed copper.
6. The photoresist is removed leaving a solid plane of copper with a gold pattern plated onto it.
7. The copper and titanium are then etched from the substrate. The gold pattern acts as a mask so that the copper and titanium under the gold are not etched.

The resulting metallized pattern therefor includes

- 500 Angstrom Titanium
- 19,500 Angstrom Vacuum Deposited Copper
- 25 Microns Electroplated Copper
- 10-12 Microns Electroplated Gold

The process steps required to produce a microstrip line of this nature requires a significant amount of labor and specialized equipment. The thick film technique set forth herein is more simple and requires less labor and specialized equipment.

A small sample of U.S. patents illustrate known techniques for fabricating microelectronic circuits as follows:

- U.S. Patent 4,152,679 - Chen (May 1, 1979)
- U.S. Patent 3,808,049 - Caley et al (April 30, 1978)
- U.S. Patent 3,274,328 - Davis (Sept. 20, 1966)
- U.S. Patent 2,257,629 - Kornreich (June 21, 1966)

The subject matter of these patents are incorporated herein by reference. This is not intended to be an exhaustive list but only a small sample of the U.S. patents issued in the general art area to which this invention pertains.

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In accordance with the present invention there is provided a method for fabricating a microstrip line, the method comprising printing a first conductive layer of the line on a substrate, the first layer
5 having a predetermined width and a thickness less than the desired thickness of the line, printing a second conductive layer over the first layer, the width of the second layer being less than that of the first layer, and thereafter printing as many
10 additional conductive layers as necessary to build up the thickness of the line to a desired value, the width of each additional conductive layer being less than that of the first layer.

In one embodiment of the invention there is
15 printed on a substrate a first layer of copper which has a high adhesion to an Al_2O_3 substrate. This first layer is used to accurately define the width and edge of the microstrip line. A second layer of copper is applied over the first layer. This second
20 layer can have a lower loss than the first layer and a lower adhesion to Al_2O_3 than the first layer. However, in combination with the first layer, the adhesion of the completed line would exceed minimum specification requirements. The second layer is
25 used to build-up the thickness of the line to a desired level, such as for example five (5) skin depths at 150 MHz. It is applied with a width that is slightly less than the width of the first layer. This permits the first layer to continue
30 to define the width and edge of the microstrip line.

Using this technique it is possible to achieve all of the benefits of double printing thick film copper such as multiple skin depths, low loss and high Q without the detrimental effects of double
35 printing, namely loss of width control and edge definition.

By way of example only, an embodiment of the invention will now be described with reference to the accompanying drawings, in which:-

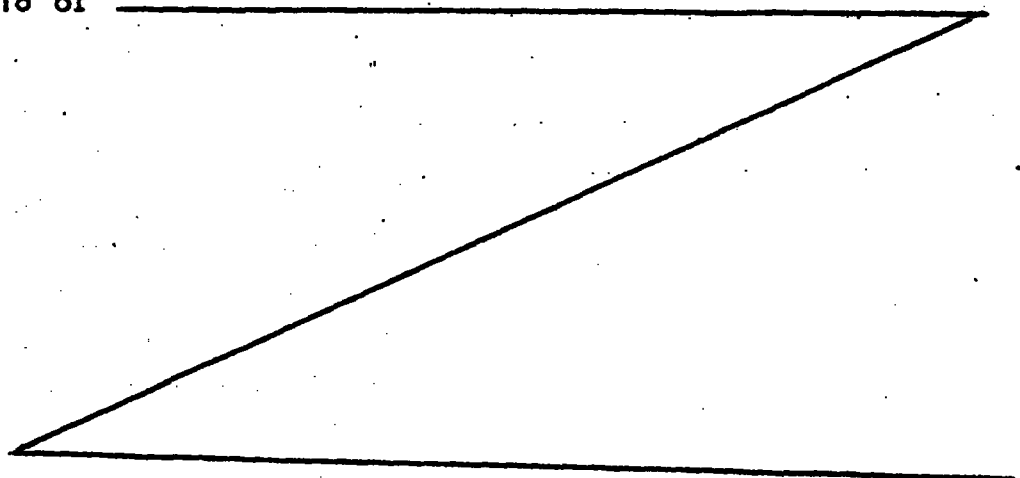
FIGURE 1 is a cutaway side view of a microstrip line after a first layer has been applied for accurately defining its edge and width; and

FIGURE 2 is a cutaway side view of the microstrip line after application of a second layer having a width narrower than the first layer, the second layer being used to increase the thickness of the line without destroying the edge definition of the first layer.

Referring first to FIGURE 1, the fabrication process begins with the provision of a conventional substrate 10. Substrate 10 can be a conventional alumina substrate used in known hybrid circuit fabrication processes. A first thick film copper layer 12 is applied. This first copper layer is preferably fabricated from DP 9923 glass frit bonded thick film conductor composition. DP 9923 is a product of the E.I., DuPont Neumors Company, Inc. (DuPont) and is fully described in its data sheet #E-11728 (9/76). Layer 12 is applied with precise control of the left and right edge portions 14 and 16 so as to achieve precise control over the width 18 of

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the layer. The DP 9923 has sufficient adhesion to firmly attach to substrate 10.

Referring now to FIGURE 2, the remaining fabrication steps are shown. After layer 10 is fired, a second layer 20 is printed over the first layer. Layer 20 is applied to build-up the total thickness of the microstrip line to the desired number of skin depths. This second layer 20 is preferably DP 9925 which is a reactive bonded (oxide copper) copper conductor composition having a lower loss than the DP 9923 used for layer 12. The DP 9925 is also a product of duPont. Layer 20 is applied such that its width 22 is less than width 18 of layer 12. Thus, the precise control over width 18 and the edge definition 14 and 16 thereof are not interfered with. The characteristics of the microstrip line determined by edge definition and width are controlled by that portion of the line closest to the substrate 10. By adding layer 20 on top of layer 12, the desired number of skin depths can be obtained without sacrificing the precise width and edge definition control afforded by the use of a precisely controllable medium for layer 12 such as DP 9923 copper. In FIGURE 2, the interface line 24 between layers 12 and 20 is shown dotted. The DP 9925 having a lower loss can be used for the formation of layer 20 without the requirement of precise edge control as needed for layer 12. If necessary additional layers can be printed on top of layer 20 in order to build up the desired skin-depth as long as the additional layers have a width that is less than that of layer 12 so as not to interfere with its precise edge definition.

C L A I M S



1. A method for fabricating a microstrip line, comprising the steps of:

(a) providing a substrate;

5 (b) printing a first conductive layer of the line on the substrate, the first layer having a pre-determined width and a thickness less than the desired thickness of the line;

10 (c) printing an additional conductive layer over the first layer, the width of the second layer being less than that of the first layer; and

(d) repeating step (c) as often as necessary to build-up the thickness of the line to a desired value, the width of each additional conductive layer being less than that of the first layer.

15 2. A method according to Claim 1 wherein the first layer comprises DP 9923 glass frit bonded thick film copper.

20 3. A method according to Claim 1 or 2 wherein the or each additional layer comprises DP 9925 reactive bonded copper.

4. A microstrip line when formed by a method according to any one of the Claims 1 to 3.

5. A microstrip line, comprising:
a substrate;

25 a first thick film conductive layer formed on the substrate, the first layer having a pre-determined width; and

30 a second thick film layer applied over the first layer and having a width less than that of the first layer.

35 6. A microstrip line according to Claim 5 further including one or more additional thick film layers formed over the second layer, each such additional layer having a width less than that of the first layer.



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7. A microstrip line according to Claim 5 or 6 wherein the first layer is glass frit bonded thick film copper.

8. A microstrip line according to Claim 7 wherein the first layer is DP 9923.

9. A microstrip line according to any one of the Claims 5 to 8 wherein the second layer is reactive bonded copper.

10. A microstrip line according to Claim 9 wherein the reactive bonded copper is DP 9925.

11. A microstrip line according to Claim 6 wherein the additional layers are reactive bonded copper.

12. A microstrip line according to Claim 11 wherein the reactive bonded copper is DP 9925.

13. A method of fabricating a microstrip line substantially as herein described with reference to the accompanying drawings.

14. A microstrip line substantially as herein described with reference to the accompanying drawings.

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