AN HERMETIC COPLANAR WAVEGUIDE-TO-HDI MICROSTRIP MICROWAVE FEEDTHROUGH

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ABSTRACT

We describe the design, construction and performance of a novel hermetic, multi-layer ceramic feedthrough for microwave modules. In particular, the feedthrough takes a coplanar waveguide input and provides a three-via output compatible with a microstrip module utilizing High Density Interconnect (HDI) microstrip or coplanar transmission lines. The same feedthrough also carries DC and logic signals. We designed the feedthrough using a commercial finite element analysis tool. The feedthrough was fabricated from multiple layers of ceramic using the HTCC process. Measurements of two feedthroughs in a fixture show wide band performance: less than 1 dB of insertion loss (including 0.5 dB from the fixture) from 2 to 3.6 GHz, and less than 2 dB insertion loss up to 5 GHz.

INTRODUCTION

Microwave multi-chip modules serve a variety of functions in modern systems. However, in common to all microwave modules are package feedthroughs, able to function at microwave frequencies, which interconnect the circuitry inside the module with other modules in the microwave system. A well-designed feedthrough must have low insertion loss in the frequency band of operation, be well matched to the interconnected transmission lines, and not be a source of unwanted microwave leakage. Further, many modules require hermetic feedthroughs.

Lockheed Martin builds microwave modules using our High-Density Interconnect (HDI) technology [1]: MMICs are mounted in wells on an otherwise flat package surface, and the interconnections are made via a multi-layer Kapton-based dielectric structure. HDI processing requires that the surface over which all the interconnections are to be made be a planar one, and this requirement extends to the interconnections made between the MMICs and the feedthrough. Since HDI is processed in batch, cost lowers as the area of the modules decreases. Thus, there is a need for a compact feedthrough, compatible with an HDI module.

Clark and co-workers [2] invented an hermetic, microstrip-to-microstrip feedthrough that was integral to an Alumina-based module package. Their feedthrough used 7-via coax-like transmission line to drop down and then a co-planar transmission line to go under a seal ring. Another via transmission line brought the RF signal back up into the package interior. Their design had a basic flaw in that the coplanar waveguide trace was exposed at the bottom of the package, causing undesired RF leakage. Further, their feedthrough was not compatible with HDI technology.

We have invented a microwave feedthrough that meets the HDI processing requirements [3]. The feedthrough can be fabricated separately, and inserted into a module package. When used in an AlSiC-based housing, the feedthrough can be cast with the housing to produce a hermetic package [4] . Unlike Clark's feedthrough, our design does not expose any conductors to the module external environment except the interconnection traces. We will describe the design, fabrication and measured performance of the feedthrough in the remainder of this paper.

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DESIGN CONCEPT

Figure 1 shows an isometric drawing of the feedthrough. The feedthrough is built from multi-layer ceramic--either high or low temperature co-fired technologies could be used. Coplanar conductor pads are used for connections to external components. A coaxial connector can be epoxied or soldered to the pads if desired. A three-via transmission line brings the RF energy down to another coplanar transmission line, embedded inside the feedthrough, which traverses the "notch" region. A conductive seal ring, which provides hermeticity, lays in the notch. Another three-via transmission line brings the RF energy up to the HDI circuitry. Figure 1 shows a microstrip conductor connected to the center conductor. However, coplanar waveguide could be used also. The feedthrough can also carry DC and logic signals to the internal circuitry.

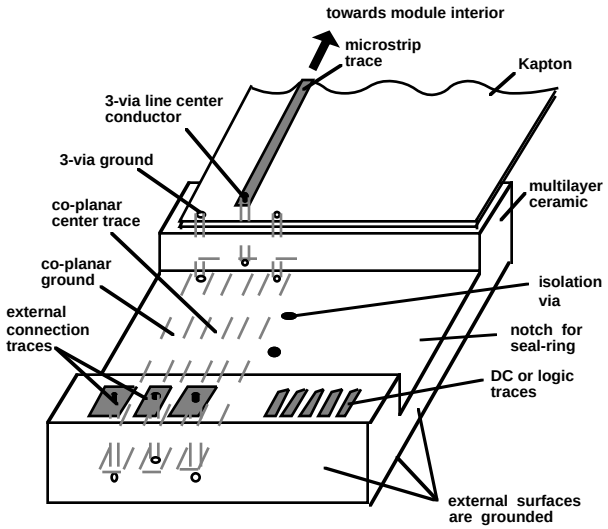

Figure 1: Feedthrough Isometric view

FABRICATION AND TEST

We designed a feedthrough for S-Band operation using commercial finite element electromagnetic analysis software. The feedthrough was built using multi-layer Alumina, HTCC technology. Figure 2 shows photographs of two feedthroughs epoxied into a prototype microwave module. The upper photograph shows the module prior to HDI processing and the lower photograph shows the module after completion of 4 layers of HDI processing.

To test the feedthrough, we placed two feedthroughs in a module housing like that in Figure 2, and connected them with a duroid substrate. The feedthroughs were connected to a microstrip line on the substrate using wirebonds. The module was then placed in a test fixture which had 1 inch Alumina substrates on either side of the module. Coax-to-microstrip connectors were connected to the Alumina substrates, and metal-on-elastomer (MOE) blocks were used to connect the module with the feedthroughs to the Alumina substrates on the test fixture. Figure 3 shows the measured insertion loss of the feedthroughs from 2 to 5 GHz. Including the test fixture losses, the loss of each feedthrough is less than 0.5 dB up to 3.6 GHz. We estimate the total losses of the fixture to be about 0.5 dB, so the feedthrough insertion loss alone is less than 0.25 dB.

ACKNOWLEDGMENTS

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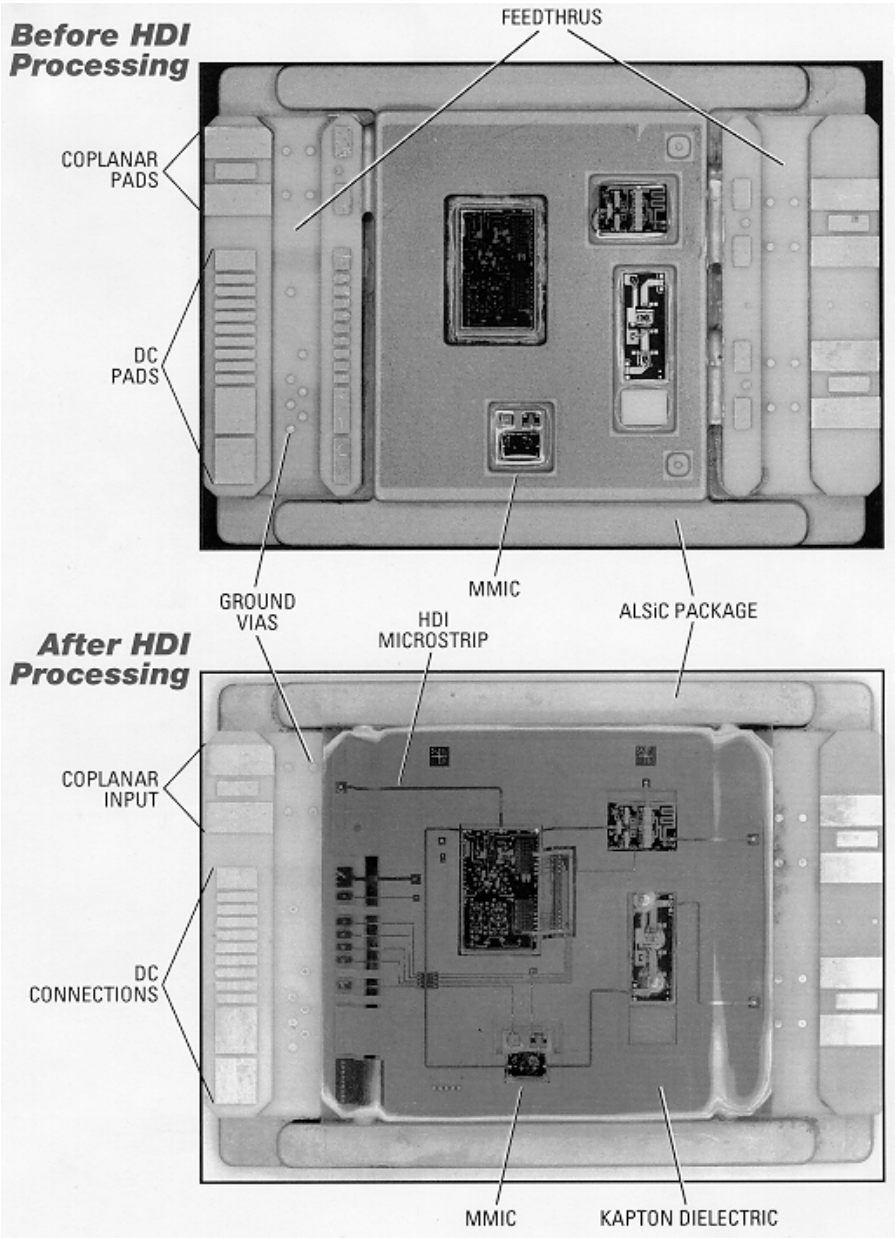

Figure 2: Microwave Module with two feedthroughs. Shown before and after HDI processing.

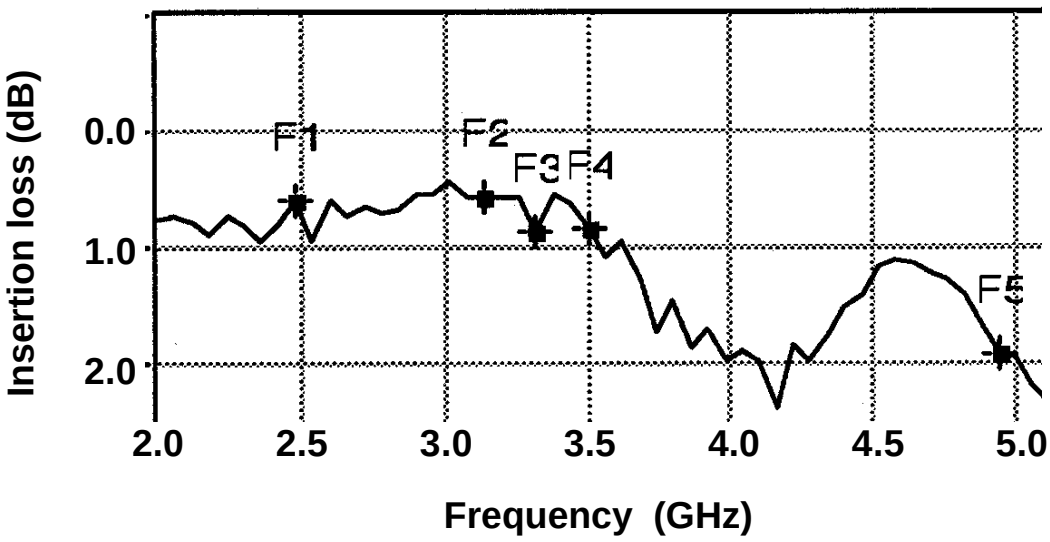

Figure 3: Insertion loss of two feedthroughs in a test fixture. Text fixture loss is about 0.5 dB.