DEVELOPMENT OF A PACKAGE UTILIZING AN ELECTROMAGNETIC COUPLING STRUCTURE

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Abstract

We have developed a new package for millimeter wave systems. This package employs a feed-through, which utilizes an electromagnetic coupling structure. The chose electromagnetic coupling structure for the package consists of microstrip line/ slot/ microstrip line and has a low insertion loss. The insertion loss at the electromagnetic coupling part is estimated to be about 0.3dB at 60GHz when the structure is made from conventional alumina material. The package is produced by means of ordinary lamination technology which involves tape casting, printing, laminating and co-firing. High performance is compatible with low cost in this package, and it is suitable for new and big markets utilizing millimeter wave frequencies.

Introduction

Some frequencies of millimeter wave have been assigned to new mass markets, such as collision avoidance radar for the automotive industry, wireless LAN and so on. Every such market is expected to grow very big.

Systems in the range of millimeter wave are very expensive now, however, especially mounting costs, which include high package costs. This is a bottleneck for market growth. It is an urgent subject to develop a high performance and low cost package which can be mounted at low cost.

We set targets to develop a new package as follows:

a) The package is to be made of laminated ceramics only, and is to be free from metal parts and brazing processes.

b) The package will have low insertion losses and low reflections in the range of the specified millimeter wave frequency.

c) The package is to be usable for surface mounting.

We have achieved these targets. Our accomplishments will make a contribution to reducing costs in millimeter wave systems. We report our results in the following sections.

The feed-through structure

First, the structure of the feed-through was studied. The conventional structure of a feed-through which is made of microstrip line/ triplate line/ microstrip line or microstrip line/filled via/microstrip line is obviously unsuitable for the above targets. Therefore, an electromagnetic

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coupling structure is employed. The schematic diagram of the electromagnetic coupling structure is shown in Fig.1.

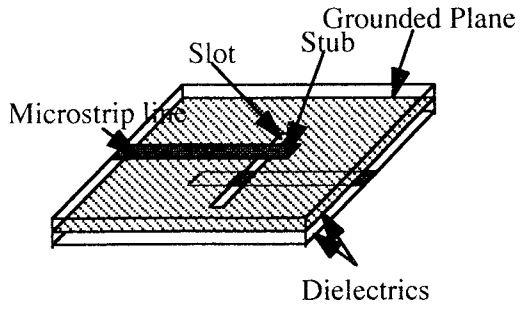

Fig.1 Schematic Diagram of Electromagnetic Coupling

Transmission characteristics of the feed-through utilizing electromagnetic coupling

First, an electromagnetic coupling test sample was measured, which was made from alumina material (Kyocera AO473) designed to be suitable for 60GHz was measured. The surface of the sample was finished with gold plating. The sample must have two electromagnetic coupling areas and two microstrip line/ grounded coplanar waveguide conversion structure for measurement by the network analyzer using air coplanar wafer probes. The schematic diagram of this sample is shown in Fig.2.

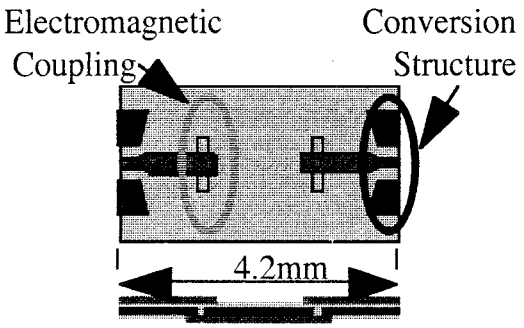

Fig.2 Schematic Diagram of Electromagnetic Coupling Sample for 60GHz

The result is shown in Fig.3. The solid line shows insertion loss data, and the dotted line shows return losses. According to these data, it is evident that 60GHz signals transmit through this sample with very low losses. Compared with the same size microstrip line sample without the electromagnetic coupling structure, the insertion loss of one electromagnetic coupling at 60GHz is estimated at about 0.3dB.

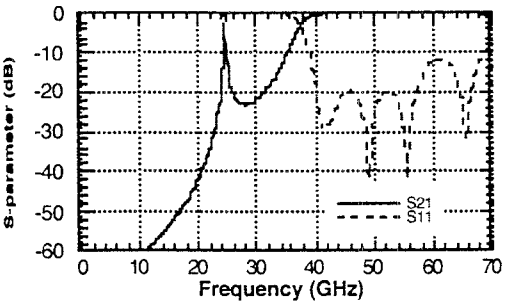

Fig.3 Transmission Characteristics of an Electromagnetic Coupling Sample Designed for 60GHz

Next, the schematic diagram and the measurement data of an electromagnetic coupling test sample designed to be suitable for 77GHz are shown in Fig.4 and 5. In Fig.5, the solid line shows insertion losses and the dotted line shows return losses.

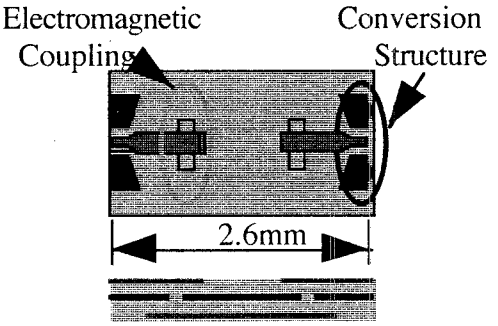

Fig.4 Schematic Diagram of Electromagnetic Coupling Sample Designed for 77GHz

It is found that the insertion loss at 77GHz is very low. Some other significant data are also shown in this figure. This sample is designed for

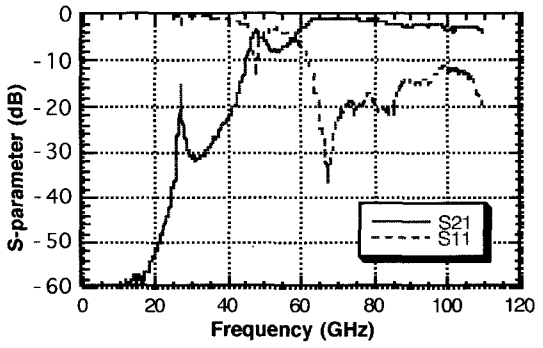

Fig.5 Transmission Characteristics of an Electromagnetic Coupling Sample Designed for 77GHz

77GHz, but insertion losses do not increase until a much higher frequency region. For example, the insertion loss value is about 3.9dB at 110GHz. At this frequency, RF signals do not

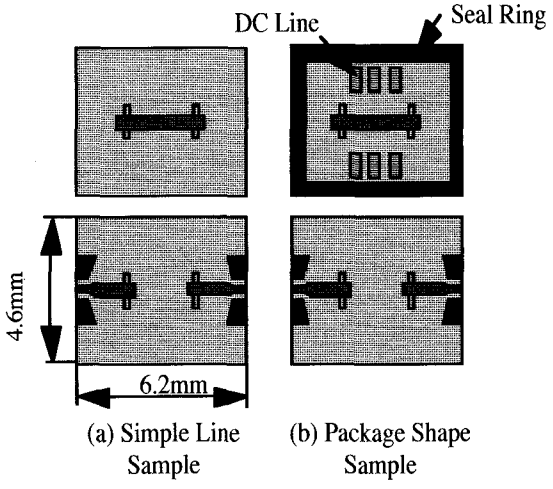

Fig.6 Schematic Diagram of Simple Line Sample and Package Shape Sample

transmit through any feed-through except those utilizing the electromagnetic coupling structure.

The data mentioned above are extracted from the sample containing only RF signal lines utilizing electromagnetic coupling structures. An actual package, however, not only has RF signal lines, but also DC lines, IF lines, base band lines, seal ring, filled vias and other structures. To test an influence of previously mentioned package elements on characteristics of an electromagnetic coupling, a simple line sample and a package shape sample were prepared. The size of two samples is 4.6mm*6.2mm and shown in Fig.6. The target frequency of an electromagnetic coupling in two samples is 60GHz. The package sample has six DC lines, one seal ring and filled vias connecting the seal ring to an inner grounded plane as well as the simple line sample. The data from the simple line sample and from the package shape sample were compared. The results are shown in Fig.7. Both data are in good agreement. Therefore, it is found that electromagnetic coupling architecture is hardly affected by its surroundings.

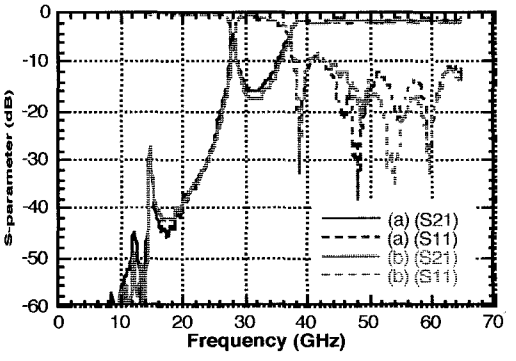

Fig.7 Transmission Characteristics of Simple Line Sample and Package Shape Sample

Transmission characteristics of surface mounted packages

Utilizing the electromagnetic coupling structure, RF signals transmit from the face to the back of the package. A package utilizing an electromagnetic coupling feed-through could be an SMD package for use at millimeter-wave or

an SMD package for use at millimeter-wave or microwave range. A feasibility study was carried out for surface mounting technology at millimeter-wave range. Two pieces of a sample with one electromagnetic coupling structure were prepared. These samples were contacted each other on a glass-teflon board. The mounting configuration is shown in Fig.8.

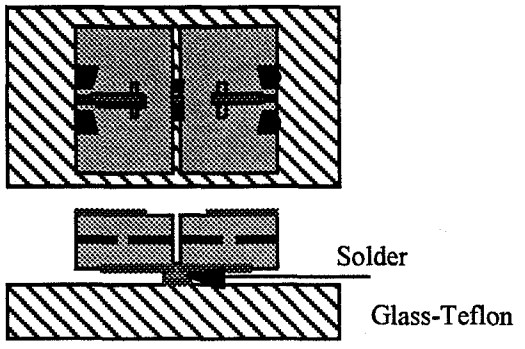

Fig.8 Tested Surface Mounting

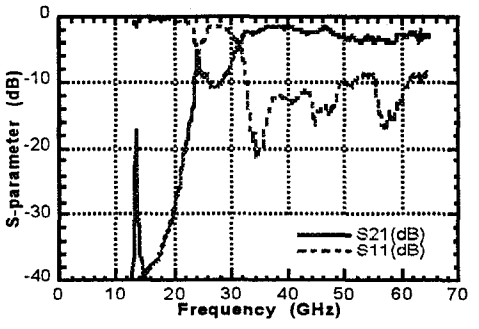

Fig.9 Transmission Characteristics of Surface Mounted Electromagnetic Coupling Feed-Throughs

Transmission characteristics from one sample to another through the wiring board were measured. The results are shown in Fig.9. RF signals transmit from one feed-through to the next with low loss. It is found that the package utilizing an electromagnetic coupling feed-through can be an SMD package.

Conclusion

Transmission characteristics of a feed-through utilizing electromagnetic coupling were studied in detail. It is found that the package with the electromagnetic coupling feed-through structure has high performance as follows.

a) The package has low insertion losses and low reflections in the range of specified millimeter wave frequency.

b) The package is made of only laminated ceramics and is free from metal parts and brazing processes.

c) The package can be used for surface mounting.

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