A DC to 40GHz Low Cost Surface Mountable RF-VIA™ Package

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1. Abstract

The ultimate goal for low cost packages for millimeterwave MMIC is to realize a miniature, light weight surface mount type package. This paper describes the design technologies of newly developed package, where we optimized via design by multilayer ceramic structure.

As a result, insertion loss is about –0.5dB at 40 GHz (measurement include mounting board + one feedthrough) has been realized.

2. Introduction

With further increasing demands for higher frequency applications, the requirements of packages for miniaturization, thinner, lighter weight is accelerating to the market, including Point-to-Point Radio and Point-to-Multipoint Radio.

The solution for "cost reduction of the package itself" and "cost reduction of assembly" is a surface mount package (Fig.1). However, reflection occurs at vertical transmission line such as via hole at high frequency range (Ref: Fig.2, Fig.3). Furthermore, the package characteristics of a surface mount packages will differ between the package alone, and after assembly. Therefore for package design, it is important to consider the mounting board. To solve this problem, we have developed a package for high frequency bands with optimized transmission, which is described in this paper.

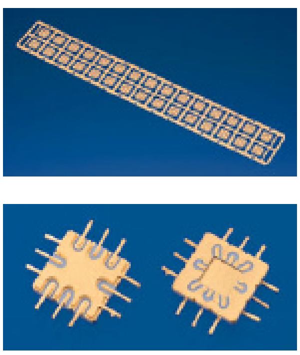


Fig.1

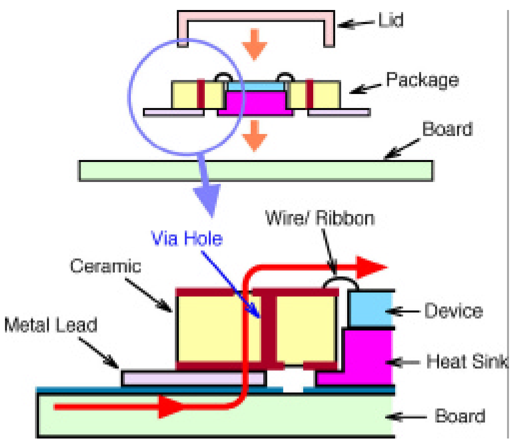


Fig.2

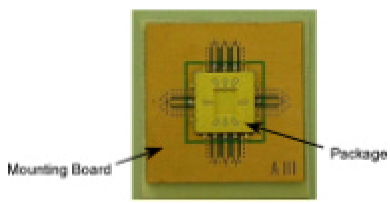


Fig.3

3. Conventional Design

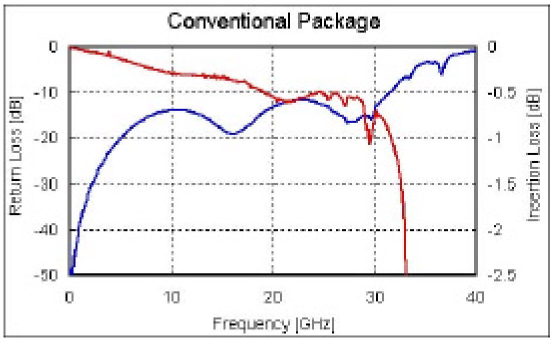


Fig.4

Fig.4 shows the characteristics of a conventional surface mount type package.

At frequencies over 32 GHz, results show insertion loss is over 1dB. Therefore package does not function.

4. Improved Package Design

The package RF characteristic attributes from the optimized quantity and location of the ground via hole around the signal via hole, the thickness of the layer and the gap between signal and ground pattern. Not just the impedance matching is considered, but the inductance value of via holes and ground of uppper/lower layer of total package and the capacitance value between lead pad and ground pattern must be considered when design package. To optimize each condition, the following items were pointed out to improve the package characteristics.

(Ref: Fig.5)

1) Transmission Line
   (Pattern width/gap, Ground via hole location)
2) Via Hole
   (Location, pitch, Gap against Ground pattern)
3) Interconnection
   (Lead frame width, length, Board design)

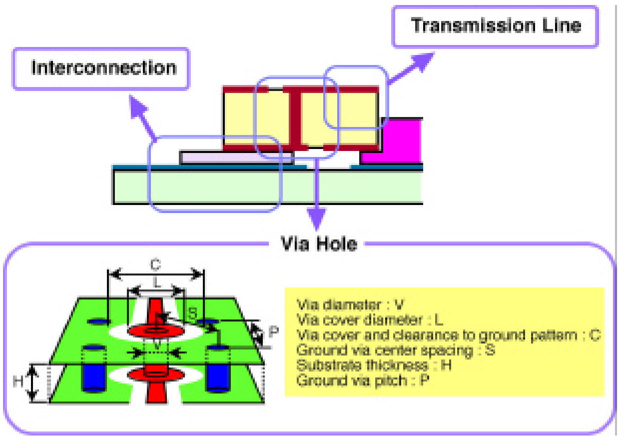


Fig.5

Evaluations for each of the above conditions have been made for optimization.

Prior to have the most optimized results by actual measurement, we simulated several design models in order to reduce numbers of actual sample manufactures & measurements. The results are shown in Fig.6/Fig.7. At 40GHz, insertion loss of about –0.5dB is realized (including mounting board + one feedthrough).

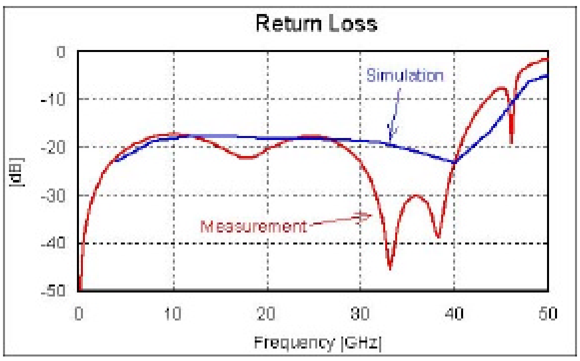


Fig.6

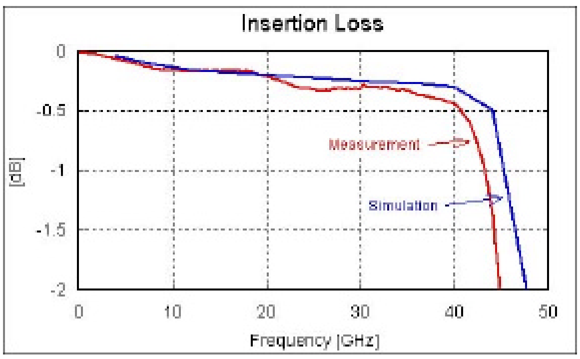
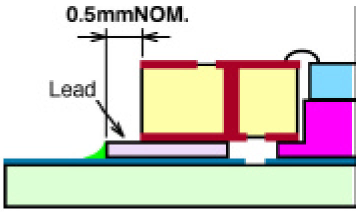
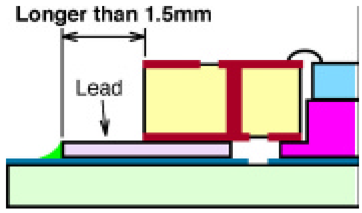
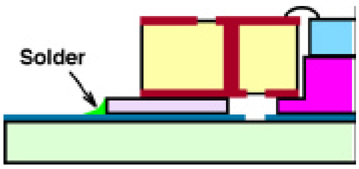
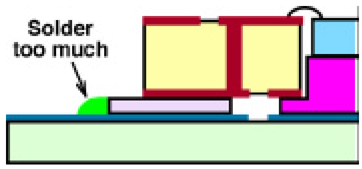


Fig.7

5. Recommendable assemble conditions for the best performance

In the case of high frequency applied surface mountable packages, assemble conditions of second level becomes one of key factor. Therefore, we investigated variation of those assemble conditions such as Lead frame length and/or solder volumes in addition to the optimized design considerations. (Table.1)

Table.1 Recommendable assemble conditions

	GOOD	NO GOOD	Condition
Lead Length			Board Material : RO4003 Board Pattern Design : Coplanar Waveguide (50ohm) Solder: Pb/Sn (4:6) Flux : RMA Temperature : 230+/-deg.C
Solder Volume Control	 Stencil Thickness : 0.1 or 0.15 mm		

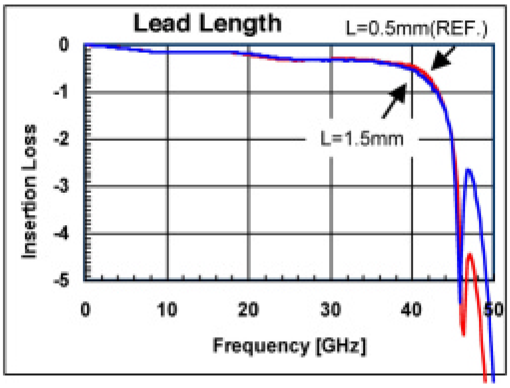


Fig.8

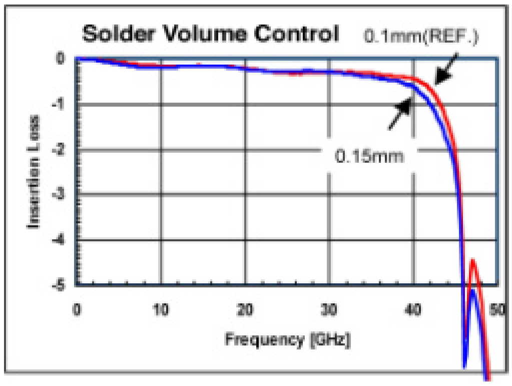


Fig.9

Equivalent electrical performance was confirmed at the condition of lead frame length at 0.5mm and 1.5mm (Fig.8). Namely, if lead frame length is under 1.5mm, those good electrical performances are available to achieve.

Also, at the solder volume condition, it was confirmed that equivalent performance was seen at 0.1mm and 0.15mm of stencil thickness (Fig.9). This fact says that those good electrical performances are available under 0.15mm of stencil thickness. However, considering from assemble reliability, the reliability will be weaken if solder volume is low, we suppose that appropriate stencil thickness would be around 0.1mm to 0.15mm.

6. Reliability

Reliability of the RF-VIA™ package has been assessed at both, the board level and package level. Package level reliability has been assessed by performing tests per EIAJ, while at the board level the package has been tested per MIL-STD-883D. Test results for these are given in Tables 2 and 3.

Table.2 Package Level Reliability Testing

Item	Condition	Results
Body Strength	EIAJ RCX-104/104, 10[N], 10[sec] MIN.	N=5,OK
Solderability	EIAJ RCX-102/101, 5[N], 10[sec] MIN.	N=5,OK
Soldering Heat	EIAJ RCX-102/102	N=5,OK
Resistance to Dissolution	EIAJ RCX-102/103	N=5,OK

Table.3 Board Level Reliability Testing

Item	Condition	Results
Temperature Cycling	MIL-STD-883E, Method 1010.7, Cond. B –55 to 125 deg.C, 1000 cycles	N=5,OK
Substrate Bending	EIAJ RCX-104/101 Bending 2mm, 5 cycles	N=5,OK
Shear	EIAJ RCX-104/102, 5[N], 10[sec] MIN.	N=5,OK
Pull-off Strength	EIAJ RCX-104/103, 5[N], 10[sec] MIN.	N=5,OK

Note: Results are for a package mounted on a Teflon board with Pb/Sn solder

(Lead length : 0.5mm, Solder Volume : Stencil thickness 0.15mm)

7. Conclusion

We have developed a surface mount package for high frequency bands by optimizing the in/out of signal transmission line. As a result, a drastic improvement has been made in package characteristics. This result has proven good transmission characteristics for high frequency bands along with variation of second level assemble condition and package and board level reliabilities. An insertion loss of –0.5dB (including mounting board + one feedthrough) is realized at 40 GHz.

8. References

S.Morioka and Y.Sawa, "Surface Mount Package for High Frequency Band", APMC'99 Proceedings, December 1999, pp958-961

Kyocera America Inc., "A DC to Ka-band Low Cost Surface Mountable RF-VIA™ Package", MICROWAVE JOURNAL, January 2001, pp216-222