

Low CTE LCP for Ultra Low Stress Near Hermetic Package for MMIC Applications

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Abstract

A low cost, near hermetic, lighter weight than ceramic package with a low coefficient of thermal expansion (CTE) utilizing liquid crystal polymer (LCP) core substrate has been fabricated. An air cavity package is developed to reduce stress on die and warpage while providing better RF performance by reducing the dielectric environment to air. Initial prototypes include a heat sink of metal matrix composite (MMC) AlSiC material, 4 mils core of 5 ppm/K LCP and an LCP lid. The package outline dimensions are 4.0 mm x 7.65 mm x 1.0 mm. Two major issues were discovered during assembly process, the heatsink attach process due to tight dimensions has misalignment problems and caused warpage to the overall package due to pressure applied during assembly. The second issue is the LCP substrate bottom layer has a 5 mil recess from the bottom of heat sink, which does not match IPC standards of 4 mil maximum for level 2 packaging to the board. An alternative approach of embedding AlSiC material shows promise for overcoming the above two issues.

Key words: Air cavity, MMIC, Packaging, LCP, MMIC, Microelectronic.

Introduction

Advances in MMIC packaging technology for next generation communication applications depend on co-development efforts between RF chip designer and electronics packages providers. High cost air cavity ceramic packages, which offer hermetic sealing was introduced more than a decade ago for a small volume manufacturing. Currently, over-molded LTCC and plastic based package are acceptable solutions for low frequency RF application. However, for a higher frequency, it is preferred better RF performance, better moisture barrier, lower cost than ceramics, and low stresses packages. LCP is well known for its barrier properties and excellent stable RF characteristics [1-3]. LCP packages have the potential for a high volume applications and meeting cost goals for high frequency RF applications.

Figure 1 shows an air cavity LCP package; the package has a lid and a substrate. The lid is made of LCP, and the substrate has a cavity with an attached heatsink. The LCP substrate of 5 ppm/K CTE and the heatsink of 4.8-8.6 ppm/K CTE match MMIC GaAs CTE of 5.8 ppm/K. Matching the CTE between the die and the heatsink increase the device stability and reliability during the temperature cycling and extend the life of the product. The lid and the substrate are

attached by epoxy, furthermore we have used solder, vibration and ultrasonic as an attachment methods.

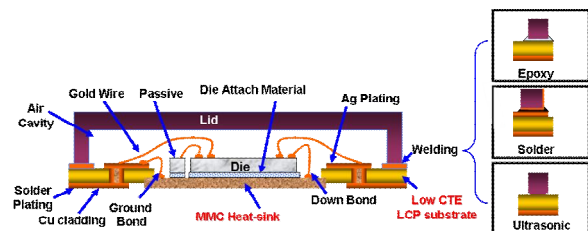


Figure 1. LCP-based PCB Air Cavity package with MMC heatsink is illustrated.

We have modeled, fabricated, and compared the RF performance of the illustrated package to a bare die and an over-molded plastic package for low frequency low noise amplifier (LNA).

Modeling

To minimize return losses, via dimension has been optimized. Figure 2 shows a better than 20 dB over the desire frequency band; top right picture shows a complete assembled package without the lid, and the bottom left picture shows the actual model. Furthermore, we have demonstrated better than -23 dB from 20 to 40GHz; HFSS was used for modeling, and via optimization. Tuning features was required

for the higher frequency and it enables broader band width due to impedance matching benefits.

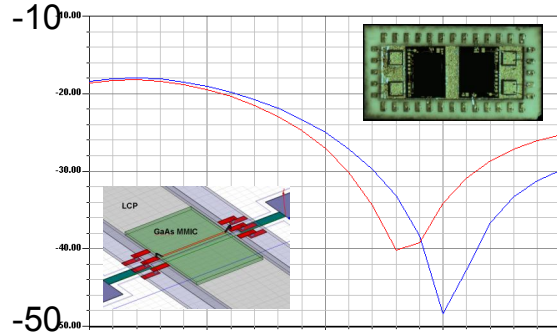


Figure 2. Modeling of return losses versus frequency shows better than 20 dB.

Fabrication

Figure 3 shows an exploded view of the package which consists of LCP based PCB of 4 mils core and ½ oz patterned copper on both sides. The package has a QFN standard JEDEC SMT foot print. We attach metal matrix composite (MMC) of 5 mils AlSiC substrate as a heatsink to the LCP PCB substrate, followed by die attached (DA) process. A fixture was designed to overcome misalignment between the LCP substrate and the MMC heatsink. DA process includes 4 capacitors and 2 LNA chip; they were mounted on AlSiC substrate as a heatsink. 1-mils gold wire bonding was used, and final step was attaching LCP lid to LCP substrate with an epoxy.

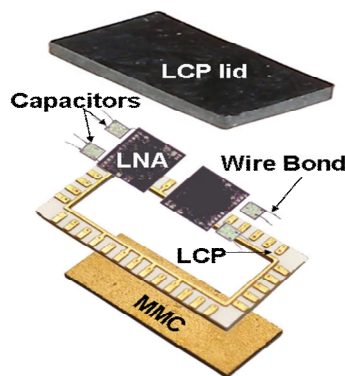


Figure 3. Exploded view of the assembled package

We have embedded the heatsink during lamination and increase the dielectric thickness from 4 to 8 mils to overcome 5 mils heatsink recess, and comply with SMT assembly design rules. RF testing was performed on first prototype.

Testing

A QFN test fixture was used. Figure 5 shows a comparison between a bare die, an over molded QFN plastic package, to an LCP cavity package. There are 3 to 4 dB gain differences over the frequency measured. These results prove there are no package effects on RF performance over the testing frequency.

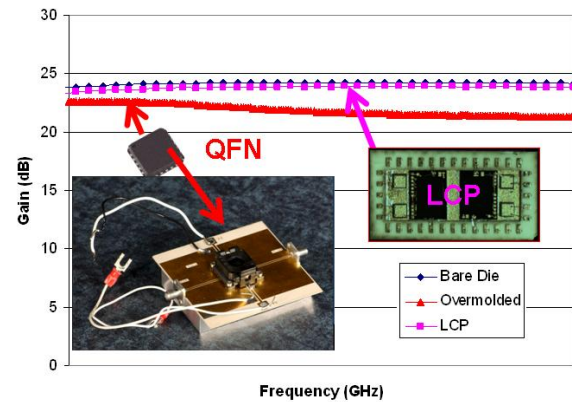


Figure 4. Test fixture and testing data illustrate no difference between bare die and LCP measurements.

Conclusion

We have demonstrated a low CTE package with an air cavity; it shows a better RF performance than over-molded package and similar to a bare die.

Acknowledgment

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References

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