ALTER
TECHNOLOGY

Executive Summary Report

SiC Plastic High Temperature Diodes

Contents

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1. INTRODUCTION

This document aims to present a summary of the developments achieved and tests results gathered in the frame of COTS Plastic Parts as applicable to extreme temperature 4000136135/21/NL/GLC/ov OSIP contract.

2. RESULTS ANALYSIS

2.1. DEVICES PRODUCED

Industry pushes towards higher operation temperatures of diodes while reducing cost. SiC technology with plastic packaging offers promising results able to match these requirements. Some applications (i.e. spaceship solar arrays) requirements are as high as 250°C. This application was considered as potential target application for the project test units designed.

Three different device types were designed, manufactured, and tested in the frame of the project using well known SiC Schottky dies, three mould compounds and two die configurations:

- Type 1: Single die QFN32 5x5 with Mould 1
- Type 2: Twin die (common cathode) QFN64 9x9 Mould 2
- Type 3: Twin die (common cathode) QFN64 9x9 Mould 3

2.2. TEST RESULTS SUMMARY

2.2.1. Temperature/Voltage Step Stress (Limits Pre-Assessment):

This test was carried out onto 3 pcs of each type. Major concern about these plastic modules operation at high voltage (250V) was the electrical isolation capability of the mould compounds.

Bias steps of 1 minutes with reverse voltage values increasing from 100V to 250V were applied at 6 different temperatures starting at 125ºC up to 250ºC. In this way, mid term electrical isolation of the moulds was confirmed, discarding the possibility of having arcing while biasing at high voltage at high temperature.

The three component types demonstrated good electrical isolation capability keeping the reverse current of the modules stable even at 250V and 250ºC for short periods of time.

2.2.2. Materials Characterization:

A sample of each type was submitted to a test sequence combining TMA (Thermo Mechanical Analysis) and SAM (Scanning Acoustic Microscopy) techniques in order to determine the limits of the assembly from a non-operational perspective.

TMA sweeps from -25ºC to increasing temperatures were carried out with intermediate SAM. Maximum temperature of the TMA sweeps was rise each one of the 4 steps from 150ºC to 300ºC. The intermediate SAM allowed to detect degradation caused by the thermo-mechanical stress.

Similar results were obtained for the three device types. Die attach delamination was observed after the 200ºC TMA. The following table shows the evolution of the interfaces (non-chip view) after each TMA step for the device type 3 as an example:

Briefly summarizing, the following conclusions were obtained:

- Die attach and MC/paddle interfaces are the most sensitive to delamination issues.
- Some MC/lead fingers interface delamination were detected in the first SAM. However, these interfaces maintained its physical integrity after TMA tests.
- MC/Die interface maintained its physical integrity until 250 ºC. After TMA at 300 ºC die delaminations were detected.

2.2.3. High/Low Temperature Characterization:

Samples of each type were submitted to a thermal/electrical characterization test sequence in order to determine the limits of the assembly from an operational perspective while also including intermediate CSAM inspections. This sequence was based but not limited to the tests considered for space grace parts in ESCC5000.

This sequence comprised the following tests:

- External Visual Inspection
- Electrical Characterization at room temperature
- Radiographic Inspection
- SAM
- High and Low temperature electrical characterization cycle (-55ºC to 250ºC) at small temperature steps.
- Electrical Characterization at room temperature
- SAM
- Radiographic Inspection
- External Visual Inspection

Good results were obtained for nearly all the parts in the initial electrical characterization even at maximum voltage demonstrating isolation capabilities of the mold compound. However major issues were observed in initial SAM inspection: 8 out of 18 devices rejected during SAM inspection for type 1. Single void within the die attach larger than 15 % of the contact area. (ESCC 25200 Issue 2 §7.3.b). 100% rejected for types 2 & 3.

Two Type 1 samples were segregated and submitted to cross section confirm delamination observed during SAM. These were confirmed and all the remaining samples continued in the test sequence tracking closely the evolution of these problems.

Electrical Thermal characterization showed gave relatively good results. Good electrical isolation was observed for the 3 molds at extreme temperature. Mechanical robustness of the mold was also demonstrated at high temperature.

Types 2 and 3 showed an average increase of 9 and 8 percent respectively in forward voltage parameter (V, Ifwd=2.5A) which seems to be related to a bigger evolution of the delaminations compared to type 1. These two types are two dies modules and the drift may be related to a combination of this fact and the slightly better CSAM results for Type 1 which had better die attach (which is a series resistance for the forward characterization of the diodes).

Even if pulsed electrical characterization carried out within the project gave relatively good results, however, thermomechanical stresses produced severe delamination’s. These issues would cause problems with high power operation of the devices.

3. CONCLUSIONS

All evaluated Epoxy Mold Compounds demonstrated suitability for applications up to 200ºC, with an indication that they could perform better also at higher temperatures if the materials and surface finished selections were optimized.

Delamination observed in the silver sintering used for die attach, were related to CTE mismatch of the materials that could be addressed by selecting different silver sintering materials and improving surface adhesion. This delamination was not a problem for the project measurements but could potentially affect long term high power operation, if not improved.

Further studies are needed to optimize the devices and reach targeted operation temperature. Changing construction materials i.e. of different plating of the leadframes to improve adhesion and silver sintering attach material to closer match CTE mismatch are some of the paths that will be explored in future activities.