

PowerPAD MSL Performance Improvement

John Tellkamp, Mario Magana, Muhammad Khan

Abstract:

Materials and Controls have been identified to improve the MSL performance of PowerPAD packages from ~ MSL5a @ 235 C to ~ MSL3 @ 260 C for TI's S_PQFP-G packages (48 pin PHP& 64 pin PAP). This performance level now meets the customer's requirement, and is achieved using Lead(Pb)-Free, NiPdAu leadframes. This MSL rating includes thermal path testing (critical for exposed pad packages). New Die Attach and Mold compound materials were necessary to attain this level of performance as well as added controls at Die Attach and Mold.

PowerPAD and other exposed die pad packages present an even greater challenge to achieving good Moisture Sensitivity Level (MSL) performance than conventional plastic IC packages. In addition to the failure modes for a conventional package (top side surface delamination and mold compound cracking) the thermal path is also a key component of these packages. The primary thermal path is the contact between the backside of the die and the exposed die pad. The die to Leadframe joint is usually accomplished by a silver filled adhesive. This adhesive joint has been found to be typically the weakest link in MSL testing of PowerPAD packages. There are several contributing reasons for this sensitivity:

- 1) A Silicon Die has a Thermal Coefficient of Expansion (TCE) of about 3 PPM per Degree C. as compared to a Copper base metal leadframe with a TCE of about 16 PPM. During IC package assembly, processing temperatures change by about 200 to 225 Degrees C. The die attach must be strong enough and flexible enough to allow this movement without fracture.
- 2) An exposed Pad package is, by definition, an un-balanced package. The exposed copper pad has different thermo-mechanical properties than the die and mold compound. The result of this imbalance is that the package has a tendency to warp during temperature changes like a bi-metal strip. This induces "Z axis" stresses between the die and leadframe. The tensile component of this stress needs to be controlled to avoid adhesive or cohesive failure.
- 3) Lead free PCB Reflow @ 260, will be the highest temperature the package will be exposed to. It is at this peak temperature that the stresses are at their highest, and the material strengths are at their lowest.
- 4) When moisture is absorbed by the mold compound and Die Attach material, there mechanical properties change (TCE increase) and their adhesion properties are reduced.

5) During board assembly, both the exposed pad and external leads are soldered to the PC board. After solder solidification, the warpage and "Z axis" expansion of the PC board adds to the mechanical stress on the die to Leadframe interface. The existence of thermal Vias under the die pad add to this condition as they will restrict the PCB expansion. Although this was found to be a secondary effect, the PCB contribution to board assembly failures should not be over-looked as a potential cause of failures in exposed pad packages.

Prior to Lead-Free conversion of a 48 pin PowerPAD package (JEDEC S-PQFP-G) it was found that thermal Path would remain in tact only through an MSL5 @235 C (48 hour Floor life) yet all other functions of the package and device were maintained through MSL3 @235 C (168 hour floor life). This presented a serious issue as there was no definitive test method to capture this failure mechanism. The requirement of a higher reflow temperature (260 C) made it crucial that a thermal test be developed and used for material screening and qualification testing. Such a test was developed, and it allowed the identification of new Die Attach and Mold compounds. The new materials have higher material strengths at higher temperatures (see table 1), and lower water absorption characteristics. After implementing the new materials, MSL3 @ 260 C has been achieved including the thermal path integrity verification.

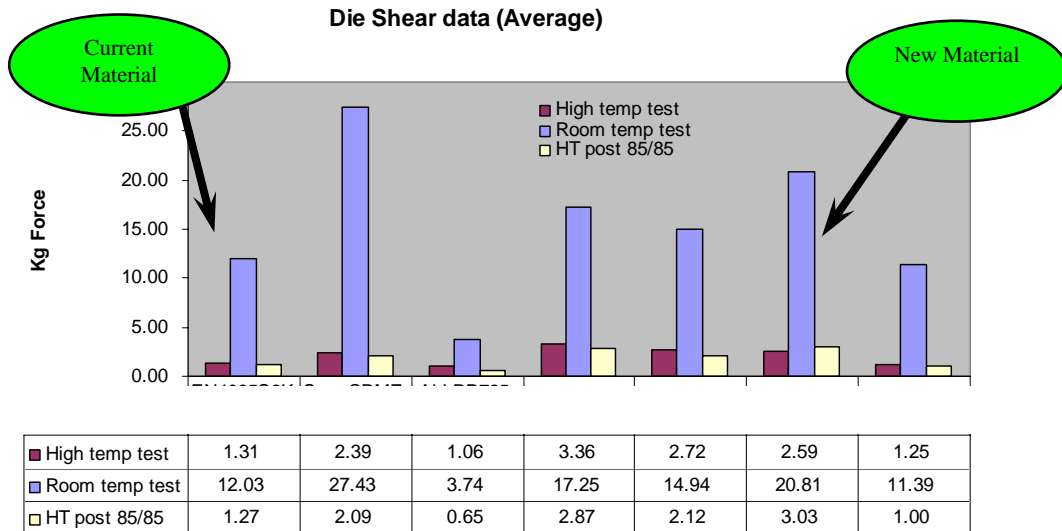
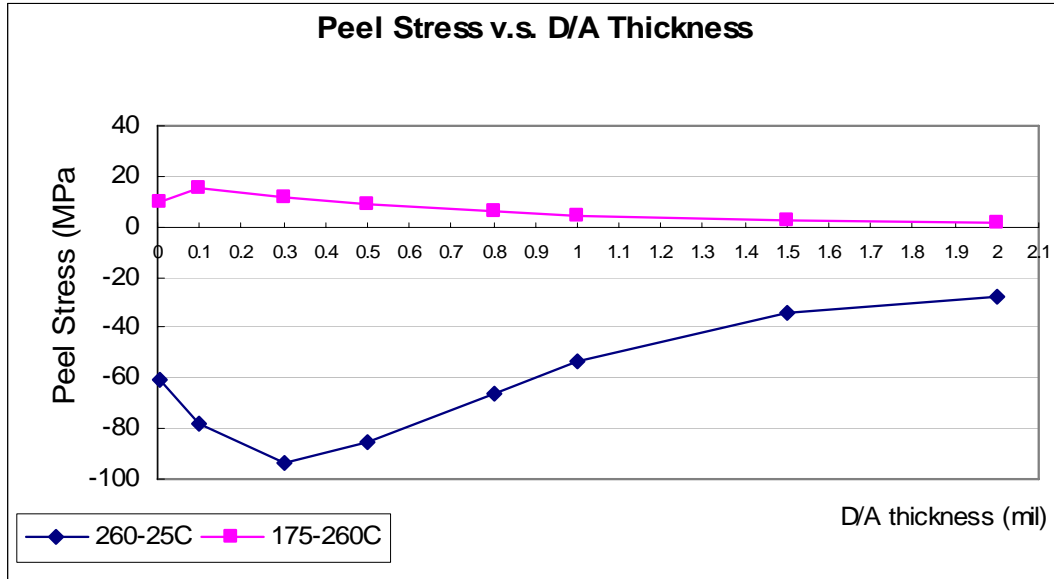


Table 1
Die Attach Shear Strength @: Room Temp, High Temp,
and High Temp after 85Deg C/ 85% RH.

To use these new materials effectively, some key controls have been found to be necessary in order to maintain consistent thermal and MSL performance:

1) Bond line thickness control. Due to the higher strength and lower flexibility of the new die attach, better thickness control is needed on the minimum thickness to avoid initial die to leadframe delamination. Finite Element modeling showed maximum tensile stress occurred at 0.3 mil Bond Line Thickness (BLT). This stress can be reduced by ½ by increasing the BLT to 1 mil (see Graph 1).



Graph 1
Tensile Stress in Die Attach Vs
Bond Line Thickness

2) The new die attach uses a BMI/Acrylate adhesive chemistry instead of the traditional Epoxy chemistry. This has a lower solvent content and different dispense properties, and required refining of the Die Attach process. New dispense techniques and controls were developed.

3) The cure chemistry of the new die attach is based on a free radical cure mechanism instead of the thermal curing mechanism of the previous Epoxy. A different cure profile was used.

4) The new Mold compound required some changes to the Mold process to compensate for the tendency of the compound to stick in the mold. Increased mold conditioning is used.

Consistent MSL performance has been achieved at 260 C reflow, and programs are in place to continue refining the manufacturing process controls. Continued development of thermal path evaluation techniques, interface adhesion testing, and a better understanding of the interaction between the IC packaging materials will be key to continuous improvement in MSL performance.