



Specialized Lead Design of Leadframe Packages for Improved Mold Adhesion

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Authors' contributions

This work was carried out in collaboration amongst the authors. Both authors read, reviewed and approved the final manuscript.

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ABSTRACT

This paper presents an advanced design of Quad-Flat No-leads (QFN) and Quad-Flat Package (QFP) leadframe to mitigate the propagation of delamination between high stress level areas particularly the mold-to-leads interface. The integration of through-hole mechanism on leadframe provides mechanical anchoring of mold material to the lead junction interface and/or vice versa. To produce interlocking, the through-hole design will be penetrated by the epoxy mold compound during conventional molding process affixing each individual lead to the encapsulation material. On the other hand, the package design is materialized through repeated cycle of chemical etching and masking process during leadframe manufacturing, the mechanical anchoring can be implemented on the conventional design of carriers. This approach, considering the design and assembly method of the new leadframe design, is a cost-effective alternative in improving the interfaces of key material such as mold and leadframe.

Keywords: Leadframe design; QFN; QFP; delamination; anchoring.

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1. INTRODUCTION

The continuous effort to improve the reliability performance of surface mount technology leadframe packages such as Quad-Flat No-leads (QFN) packages and Quad-Flat Packages (QFP) is to extend its application for automotive, medical and aeronautics businesses wherein it is foreseen to gain more stable and better opportunities. However, the qualification of this product is challenged by the intensive requirement resulting to package reliability concerns. Note that new packaging technologies bring along its challenges, either from constraint in equipment, manufacturability, design aspect, or material compatibility [1-5]. Delamination between the interface of the unit is one of the failures encountered when the thermal cycling test is increased from 1000 to 2000 cycles. It is noticeable that on conventional design and material of QFN devices, it faced interfacial break down prior reaching the 2000 cycles requirement. As such, the semiconductor industry is interested in finding solution to mitigate the issue of delamination. One of the practical alternatives is the qualification of direct material which is the epoxy mold compound with high resistance to deformation. Moreover, the specific design of QFN is also considered for positive impact in the reliability performance as well.

Mechanical interlocking or anchoring is one of the known techniques to improve the interfacial strength mechanically between the key interfaces of a QFN. This paper discussed the innovative design and method of fabrication of a leadframe incorporated with through-hole interlocking design to eliminate the propagation of delamination on the lead area.

From assembly standard, delamination has acceptable criteria of 20% for inactive surface but any form of delamination to the active surface like wirings on the lead or ground is unacceptable [6,7]. A QFN leadframe package in Fig. 1 exhibits a delamination propagating from the lead junction until the gold wiring location producing an “open-reject” during test.

The signature of reject shows that the wire delaminates together with mold compound during thermal cycle. The delamination first observed on the mold and lead junction interface that gradually worsen during the time of the thermal cycle until it reaches and delaminates the intermetallic connection of the wire to the lead.

2. PACKAGE DESIGN AND PROCESS IMPROVEMENT

Incorporating an interlocking mechanism on the conventional design of leadframes aims to improve the interfacial strength particularly the mold-to-leads adhesion. Presented in Fig. 2 is the actual illustration of the design wherein each individual lead is incorporated with interlock. The implementation of the interlock design can be present to all individual lead or pre-identified lead only. In semiconductor industry practice, thermo-mechanical analysis (TMA) is a reliable tool to locate high stress areas inside a package. The identified high stress areas are a potential origin of delamination inside the package. In case there is localized origin of delamination, a single through-hole interlock can be incorporated. However, a random occurrence or multiple location of delamination is suggested to integrate each location with interlock.

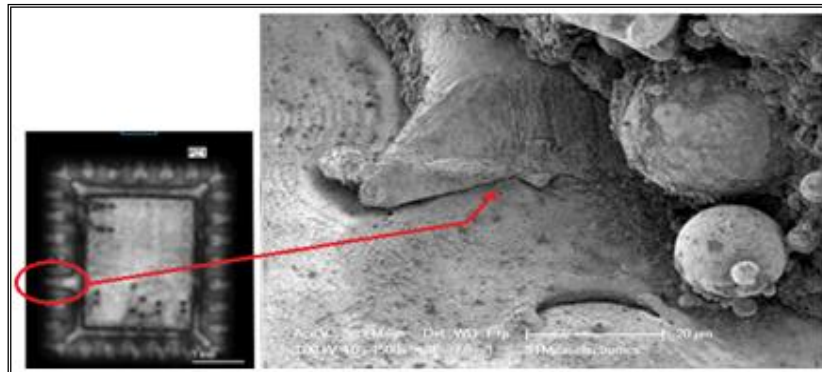


Fig. 1. Delamination on lead and wire

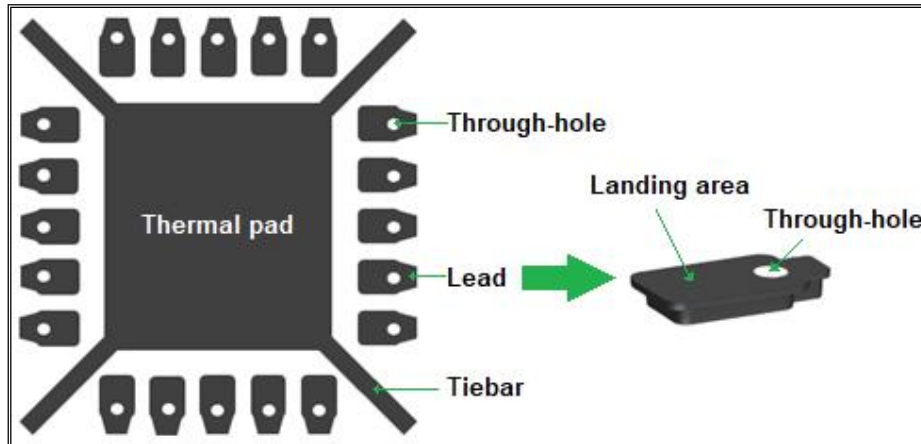


Fig. 2. Through-hole interlock

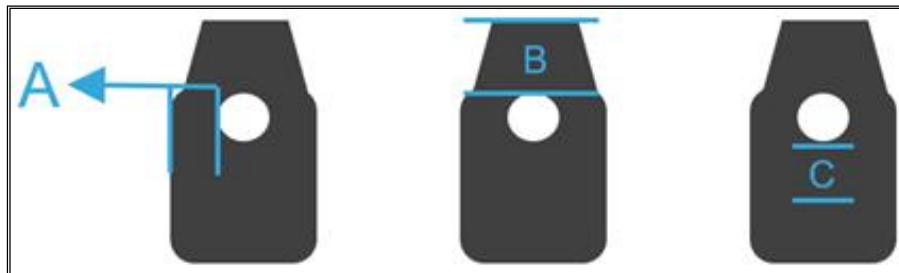


Fig. 3. Interlock design

The recommended placement and measurement of through-hole interlock in the lead is given in Fig. 3. There are three considerations in implementing an interlock in the design of leads. First is the placement of through-hole interlock on lead has minimum of 0.12 mm clearance from solid metal. Measurement is from the edge of the lead to the edge of the etched part of the interlock as shown in Fig. 3a. Second, the minimum distance between the interlock and tiebar follows: $D = \frac{1}{2}(M) + M2 + 0.1$ mm wherein D is the distance of the interlock from the tiebar, M is the width of the singulation blade and M2 is the cutting capability of the singulation, as illustrated in Fig. 3b. Finally, the distance of the interlock from the landing area shown in Fig. 3c is recommended with, $L = W + C + 0.1$ mm, wherein L is the distance of the interlock to the landing area, W is the placement capability of the wire and C is the bonding capability.

3. RESULTS AND DISCUSSION

Cross-sectional measurement of the interlock including the depth, etching process, and interlock structure of the through-hole design, as

highlighted in Fig. 4. To build the mold interlocking structure, the 1st etching process is done on the top portion of the leadframe while 2nd etching process is done on the bottom part. The opening diameter of the through-hole on the 1st etching is recommended to be smaller by minimum of 0.05 mm from bottom through-hole diameter. The depth of the etching process has minimum of 0.12 mm based on the supplier's etching capability. The recommended minimum diameter of the through-hole follows: $D = 3(F)$ wherein D is the minimum diameter required and F is the mold filler size.

The fabrication of the interlock can be done during the manufacturing of the leadframes. Shown in Fig. 5 is a simplified procedure in fabricating the interlock on the leadframe. The masking process is done on the top portion of bare copper sheet. Masking includes the defined measurement and design of the leadframe. Etching process is performed to remove the copper from the un-masked part of the bare copper sheet. A 2nd masking is performed on the bottom part of the bare copper sheet including the bottom of the leadframe. The 2nd etching

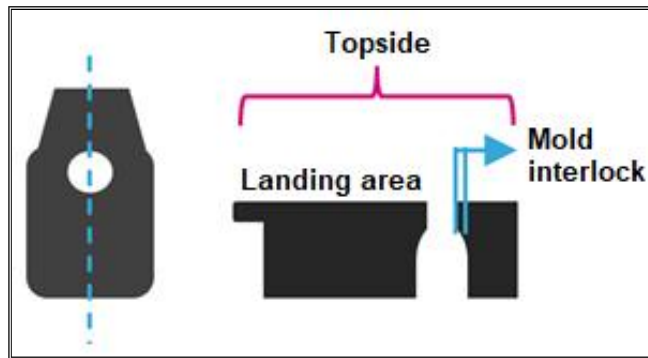


Fig. 4. Cross-sectional view of through-hole interlock design

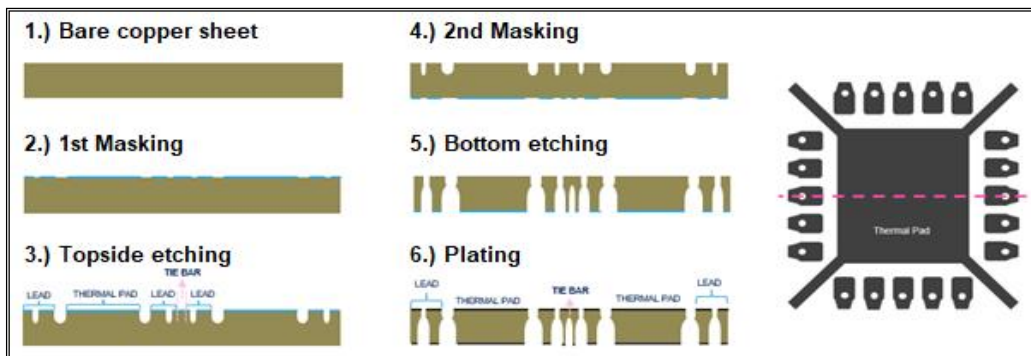


Fig. 5. Fabrication method

process is required to remove the un-masked copper from the bottom part that will overlap to the 1st etching process. Finally, plating is done to coat the required part in a leadframe such as lead and thermal pads. Worthy to note that fabrication method and assembly process flow vary with the product and the technology [3,4,8].

The through-hole interlocking will be occupied by the molding compound during the integrated circuit assembly resulting to create mechanical anchoring between mold and lead/leadframe. Implementing this design on conventional design of QFN devices benefits time 0 and thermal cycle performance of the unit.

4. CONCLUSION AND RECOMMENDATIONS

An improved QFN and QFP leadframe design was presented with the specialized lead design with through-hole interlock. The design would improve the capability for thinner semiconductor device processing. More importantly, the improved leadframe design would mitigate

assembly rejection related to package delamination. Prototypes are helpful for future works to validate the effectiveness of the specialized lead design on leadframe devices.

Although the paper focused on the improvement in the mold-to-leads interface of leadframe package, continuous process and design improvement is imperative to sustain high quality performance of semiconductor products and its assembly manufacturing. Discussions and works shared in [9-11] are useful in reinforcing robustness and optimization of package design and assembly processes.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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