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Integration of Mechanical Interlocking Design on Leadframe-Based Device for Interfacial Strength Improvement

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Abstract*— *Integration of mechanical inter-locking design for leadframe-based devices is one of the available options to eliminate the delamination occurrence. In this paper, different die pad interlocking design is illustrated and discussed to cater both assembly and reliability requirement. The inter-locking mechanism focus mainly in mechanically improving the tensile and shear characteristic of the glue-leadframe interface. Moreover, the design of the interlock feature could be extended to cover also the mold-leadframe interface.

Keywords*— *Silicon die; Semiconductor Die; Interlocking; Design Improvements.

I. Introduction

The separation or fracture in the material layering or interfaces, generally known as delamination, is a major detractor in the introduction of new and alternative material for semiconductor devices. Continuous involvement in packages with delamination issue intensify our technical know-how in understanding the defect and improve our ability to provide problem resolution particular to this assembly defect. In one example, an FEA (Finite Element Analysis) is a tool that can be used to predict the occurrence and behavior of mechanical stress inside the architecture of a semiconductor device. Two types of stress were considered during the simulation, (1) the *tensile stress* which refers to the tendency of the material to elongate when force is applied perpendicular to the axis, and (2) the *shear stress* or the stress parallel to the cross section of the material. The design and formulation of a materials like DAF (die attach films), epoxy or mold compound can be changed according to the recommendation from the analysis resulting in the correct adhesion strength to be selected for the material.

However, there are instances that changing a material is not an option, or the alternative material is not similar in terms of other characteristics like thermal and electrical requirement, that would cause degradation of the device functional performance. Herein, an innovative solution through modification in the current design of QFN (Quad flat no-lead) devices is illustrated and discussed, where the modification promotes the improvement in the interfacial strength through integration of the mechanical inter-locking. The key focus of this solution is to improve the tensile and shear responses between the materials through mechanical design improvements without altering the formulation of the direct material.

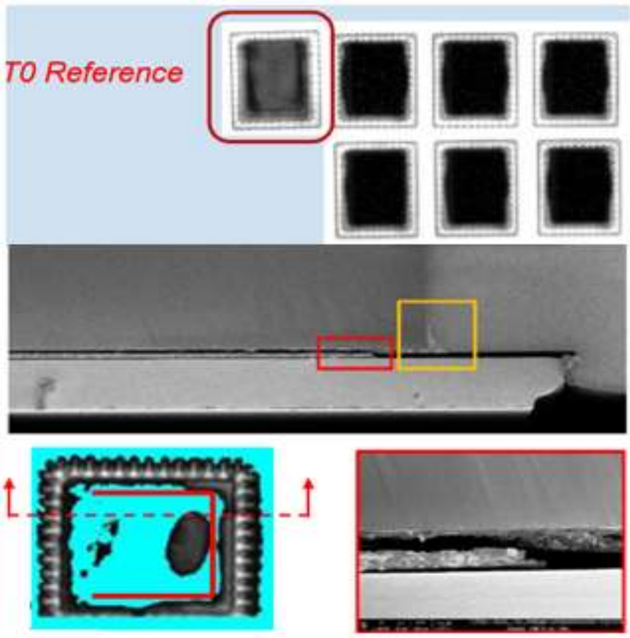

Fig. 1. Delamination in a leadframe-based device.

II. Design and Process Solution

The innovative solution covers leadframe-based packages like QFN and QFP (Quad Flat Packages) as shown in Fig. 2. An epoxy adhesive or DAF can be used in this proposal as primary adhesive material for the silicon die and a plastic or epoxy molding compound is used as encapsulant to cover the internal interconnection and the semiconductor die.

Fig. 3 shows the cross-sectional view of the interlocking design wherein an embossed portion underneath the silicon die is visible. Fig 3. Shows the different design of leadframe inter-locking. Fig. 4A is the applicable interlocking design for glue-based application, promoting even glue distribution and wetting on the carrier metal surface. The pattern of the interlocking can be changed according to the design of the dispense pattern of the machine.

Fig 4B & C are the applicable interlocking design features for DAF or film-based application. A conductive or non-conductive film using thermo-compression bonding is recommended to properly distribute the film around the edges of the interlocking features. A pressure oven, commonly available in the DAF, is an alternative curing process in this case.

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Fig. 2 Cross-sectional illustration of a standard leadframe-based device.

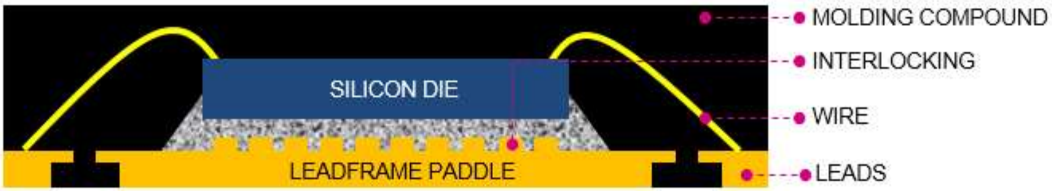

Fig. 3. Cross-sectional illustration of a standard leadframe-based device with interlock-promoting feature on die pad.

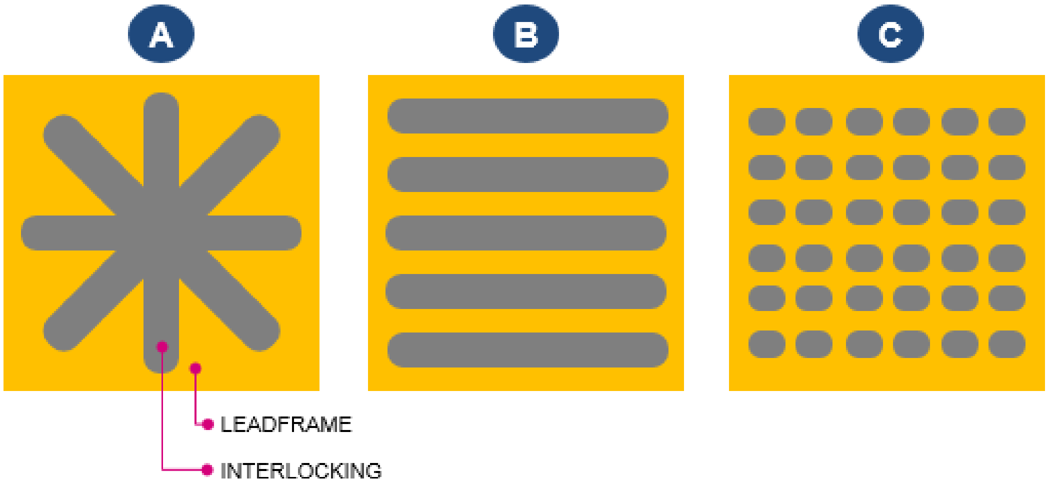

Fig. 4. Interlocking design variants.

Through embossing or integrating an interlocking design in the current leadframe configuration, the contact surface on the leadframe paddle increases which leaves larger area of contact for glue and DAF adhesion. The section in between the embossed part of the interlock feature increases the shear and tensile behavior of the glue material to the leadframe (mechanical interlock). In addition, the increased surface area of contact can be modified by controlled oxidation processes or functionalized with adhesion promoters to reinforce the mechanical interlock mechanism with chemical adhesion through direct bonding of the polymeric adhesive or encapsulant with the modified surface.

III. Conclusion

Material incompatibility, weak interaction at the interfaces and adhesion loss mechanisms induce delamination issues, potentially derailing a successful semiconductor device development. A mechanical interlocking feature, such as embossed portion of the carrier, could be adapted to promote improvement in the interfacial strength between the materials. Since the effective contact surface for glue adhesion in this case becomes larger, the distance between the individual embossed parts is responsible in mechanically improving the shear and tensile characteristics at the interfaces. Surface modification of these interlock features could further strengthen the adhesion via development of chemical bonds between the polymeric materials and the metal/metal oxide interfaces.

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