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Embedded Mechanical Interlock into the Silver Plating Layer for Robust Epoxy Molding Compound-To-Carrier Adhesion

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***Abstract*— *Leadless semiconductor package with mechanical interlock is achieved by using a carrier with Cu base material, with selectively plated Ag layer on the leads and the pad. An embedded interlock on the plated layer is introduced, through masking, such that the center of the groove is filled with the plated material or have an enclosed exposed base material surface. The groove/dimple offers a mechanical interlock feature between the exposed Cu base material and/or the plated layer surface, resulting in a stronger adhesion of the epoxy molding compound (EMC) thereby preventing the occurrence of delamination.*

***Keywords*— *Delamination, interlock, adhesion, Ag plating, copper.*

I. INTRODUCTION

Delamination is a common reliability failure arising from the weak interfacial interaction between two or more materials (*e.g.* leadframe/epoxy mold compound) [1]. Adhesion promoters are physical and/or chemical configurations introduced on a surface to promote adhesion between two or more materials. These configurations work by providing physical or chemical interlocking mechanisms that enhance the integrity of the interface [2]. Adhesion promoters are used to prevent delamination, which causes reliability concerns both in the semiconductor assembly front-end and back-end products.

Delamination is a common failure mode, with negative reliability impact, arising from the weak interfacial interaction between surfaces (Fig. 1). Metal/polymer interaction, similar to what exists between the leadframe surface and the epoxy molding compound (EMC), varies strongly depending on the nature of the metal and the organic components of the EMC [2,3]. Metallic layers (*e.g.* Cu), often used as the carrier base material, has low affinity to organic polymers [4-6].

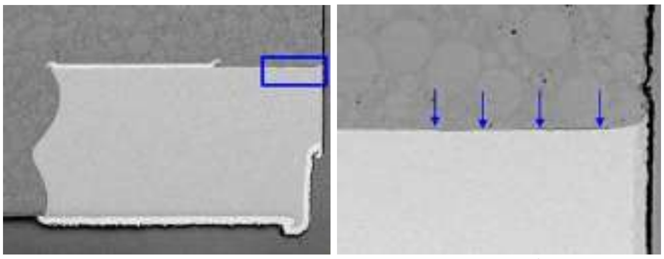

Fig. 1. Delamination along the EMC-to-carrier interface.

The introduction of an oxide layer (Cu_2O) promotes adhesion since the functional groups in the EMC have preferential interaction with the oxide as compared with unoxidized Cu. Cu_2O is a meta-stable oxide with the tendency to proceed with further oxidation forming CuO, a brittle material susceptible to fracture. Fracture along the CuO layer is observed in severely oxidized Cu frames, manifested as delamination [4,7]. Fig. 2 shows a lead with a Cu base material where the exposed Cu is oxidized while a portion of the surface is plated with a Ag layer.

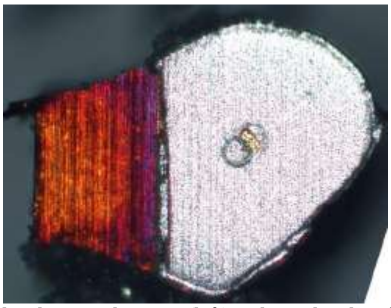

Fig. 2. Oxidized exposed copper (left) and Ag plated surface (right).

II. DESIGN AND PROCESS SOLUTION

The solution assembles leadless semiconductor packages using a leadframe with selective Ag plating on the bonding area of the leads, and the pad, on a Cu base material (Fig. 3). The Ag plating surface coverage will be maximized to diminish the exposed Cu surface. A dimple/groove on the plated layer will be introduced, through masking, such that the center of the groove can be filled with the plated material or will have an enclosed exposed base material surface (Fig. 4). The dimple will offer a mechanical interlock feature between the exposed Cu base material and/or the plated layer surface (Fig. 5).

The enclosed exposed base material is expected to have a slower oxidation layer growth compared with the fully exposed Cu layer. The oxidation is promoted by the various thermal processes during the assembly of the package. The slope created by the plated layer growth will offer additional contact surface area promoting stronger interfacial interaction between the carrier surface and the EMC. The partially oxidized enclosed based material and the plated material will have stronger adhesion with the EMC as compared with bare or severely oxidized Cu layer.

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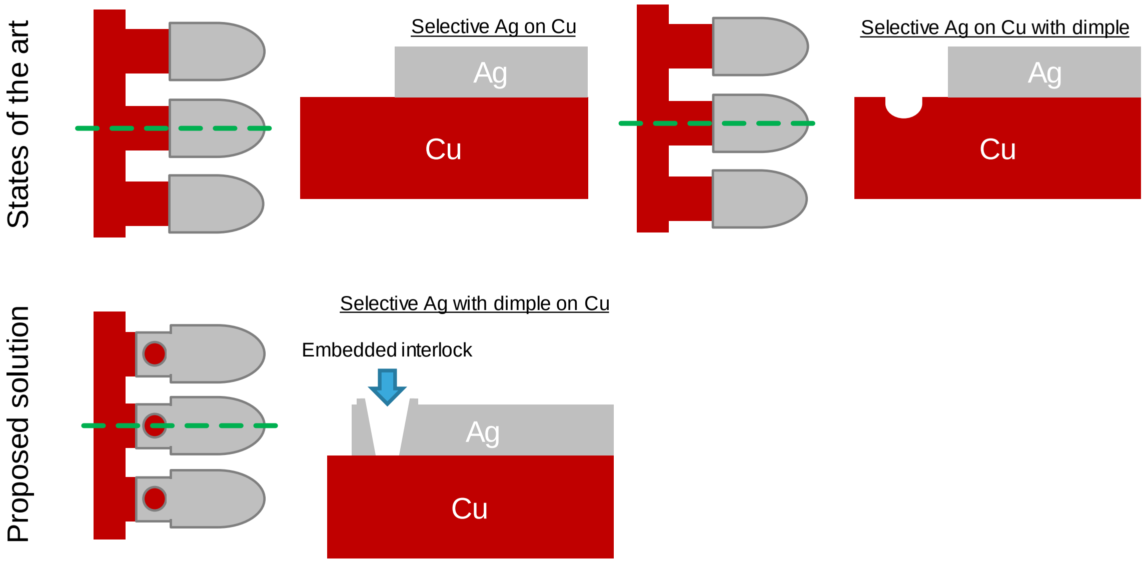

Fig. 3. Schematic representation of selective Ag on Cu, Selective Ag on Cu with dimple and the selective Ag with dimple on Cu.

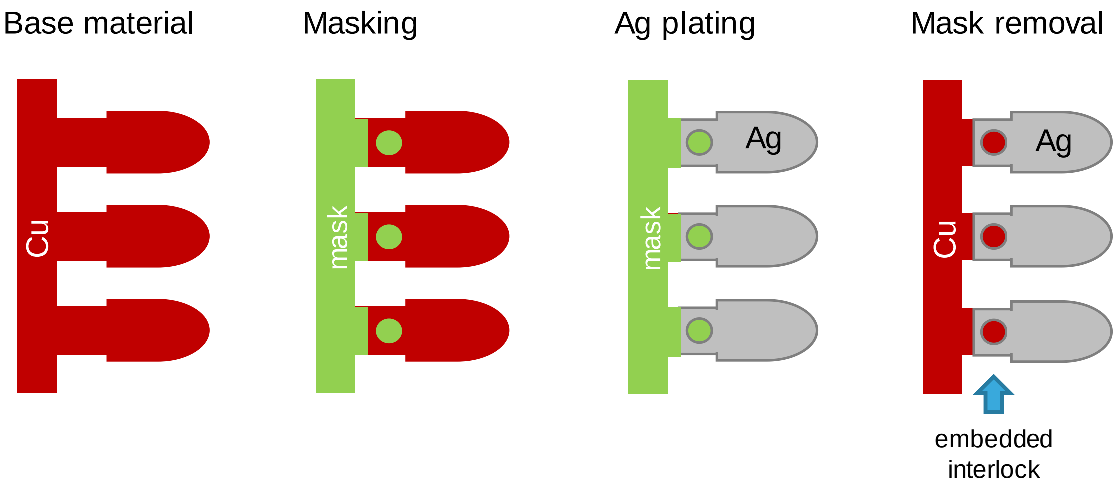

Fig. 4. Embedded interlock process flow.

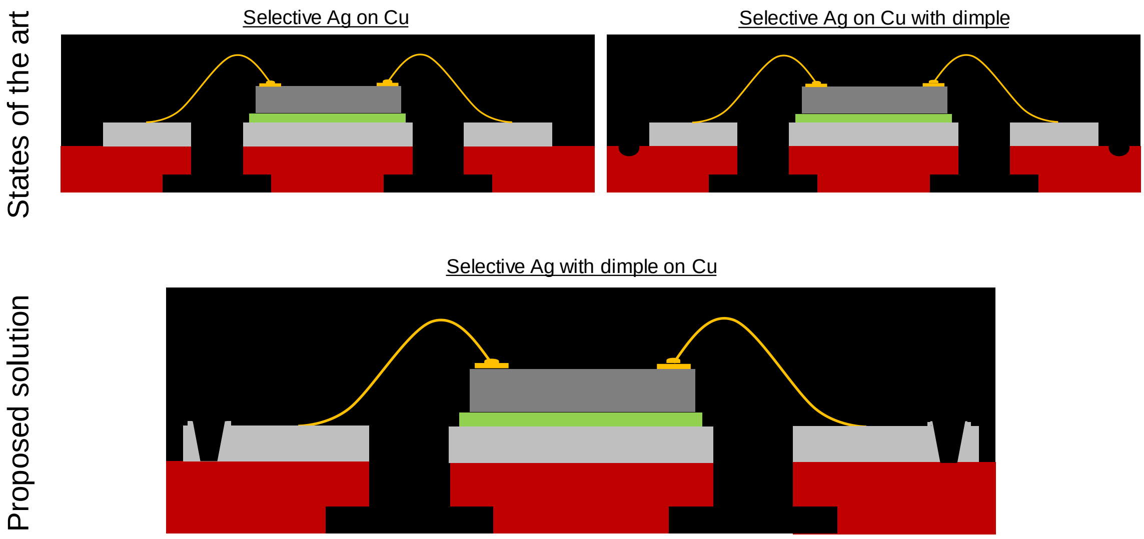

Fig. 5. Package cross-sectional construction using selective Ag on Cu, Selective Ag on Cu with dimple and the selective Ag with dimple on Cu.

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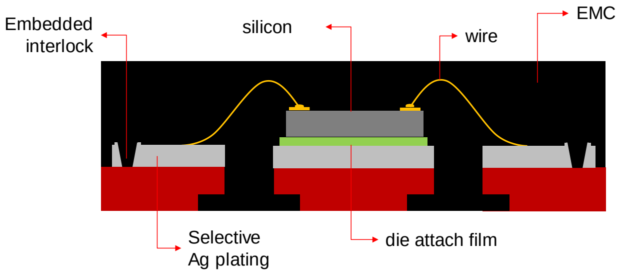

Fig. 6. Cross-sectional package construction showing the different components of the assembly.

III. Conclusion

The introduction of the embedded interlock on the plated layer provides mechanical interlock feature, larger contact surface area and minimized exposed Cu surface, which will prevent delamination along the EMC-to-carrier interface.

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