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Understanding and Controlling Resin Bleed Out

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I. INTRODUCTION

Die attach pastes, which consist of resin, curing agent, catalyst, filler and additives, have been extensively used to attach die onto lead frames in various electronic packages. One of the issues commonly encountered during package assembly is Resin bleed-out (RBO), or epoxy bleed out (EBO). Resin Bleed Out is a surface phenomenon whereby fractions of the organic resin or reactive diluents migrate along the surface of the substrate or up the side of the semiconductor chip due to surface energy difference between the resin & the substrate. The movement of the low viscosity polymer molecules is by capillary action.

RBO is the separation of some formulation ingredients in the paste from the bulk paste (see Figure 1). Depending on die attach paste formulations and lead frame surface chemistry and morphology, bleeding ingredients can be solvents, reactive diluents, low-molecular-weight resins, catalysts, and additives like adhesion promoter. Resin bleed out tends to occur on high energy surfaces such as metal lead frames without any organic coating. Bleed out can occur once die attach pastes are dispensed on to lead frames or during thermal curing. As microelectronics continue to move towards smaller form factor, higher reliability and higher performance, control of RBO becomes increasingly critical for packages where there is a very little clearance between die and die pad edge, or between one die and another in multi-chip modules (MCMs).

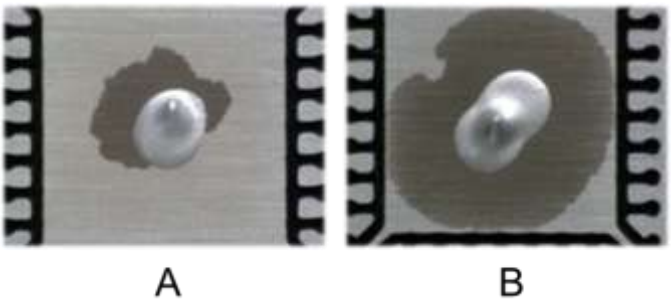

Figure 1. Example of Resin bleed-out (RBO)
(A) Minor RBO (B) Severe RBO

II. PROBLEM IDENTIFICATION

How resin bleed-out occurs? When die attach paste is dispensed onto a solid surface like lead frame surface, the paste will typically wet the surface partially. The adhesive force between die attach paste and lead frame surface causes the paste to spread while the cohesive force within the bulk paste will hold the ingredients together and avoid contact with a lead frame surface. So the degree of wetting will depend on the balance between adhesive force and cohesive force. Bleed-out occurs when the adhesive force of some formulation ingredients to the substrate is stronger than the cohesive force within the paste. The driving force for bleed out is to minimize the surface energy of the substrate by wetting. Impact of resin bleed-out Resin bleed-out can cause several issues if it is not well controlled.

What Are the Risks of Bleed Out?

• If the formulation ingredients bleed from the periphery of the die attach pastes and covers the wire bonding area, then issues like non-stick on pad (NSOP) and weak wire bond can occur. It can also be an issue if bleeding occurs from the die attach fillet along die edge to the die top, contaminating the bond pad on die top surface.

• Resin bleed-out may affect the adhesion of mold compound to die pad or mold compound to die top surface, both of which can lead to delamination. In particular, die top delamination is strictly not allowed in wire-bonded packages because it can cause the ball bond to be mechanically lifted, thereby leading to electrical failures during temperature cycling.

• As the formulation ingredients bleed out of the bulk paste, the composition of die attach paste under die may change accordingly. This can impact the adhesion of die attach to lead frame adversely, leading to an adhesive failure.

What Are Some Potential Causes of Bleed Out?

Bleed out may occur for many reasons including: thermodynamics of wetting (surface free energy), bulk material properties and curing schedule.

Surface Free Energy - Epoxy adhesives are typically formulated to have higher surface energy than their respective substrates and adherents. This positive differential ensures good wetting and stronger bonds. When the reverse occurs, a resin bleed often results due to the epoxy having more of an affinity to the surface, than itself. This is especially true with Au plated electronic parts, as described in the surface contaminants portion of this tip.

Viscosity of Adhesive - In general, lower viscosity adhesives will bleed more than high viscosity pastes, due to capillary and thermodynamic work of adhesion forces which increase wetting across the surfaces. Differences in densities, wide ranges in molecular weight distribution and type or lack of rheological fillers, can contribute to resin bleed.

Curing Schedule - Do not delay the cure or "stage" the adhesive while on a substrate. This will increase the chances of bleed out. The cure temperature should always be the highest that the substrate will allow; since the faster the epoxy

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adhesive cures, the lower the probability of resin bleed. As a rule of thumb, higher/faster cure = less resin bleed.

Surface Contaminants - In the manufacturing of electro-plated parts (particularly gold), the plating bath can often be a source of contamination. During this process, the parts are exposed to organic and inorganic agents within the plating bath. These materials can become entrapped within the plating material as it is being deposited. Even after a solvent cleaning process which parts go through prior to shipment, these contaminants can remain within the plating.

In addition, any solvent residue remaining on the parts can increase the potential of resin bleed down the road. It is also believed that higher porosity substrates may contribute to resin bleed by changing the surface wetting properties, promoting resin bleed through increased capillary transport.

III. Assembly Process Improvement

There are several approaches to control or eliminate resin bleed-out. These approaches include modifying formulation by selecting appropriate anti-EBO, using die attach film (DAF)/B-stage epoxy, controlling surface roughness, creating mechanical barrier, and lowering the surface energy of lead frames by surface coating.

• *Modifying formulations*. Generally, anti-bleeding agents are added to die attach pastes to reduce or eliminate RBO. Different anti-bleeding agents may have different working mechanisms. Some anti- bleeding agents are added to enhance the cohesiveness of the pastes while others are added to form a thin layer with a surface energy lower than the pastes themselves on a lead frame surface. Therefore, tailoring die attach adhesives with appropriate anti-bleeding agents is critical to prevent RBO on different types of lead frames, while maintaining high adhesion to metal lead frames to achieve high reliability.

• *Die Attach Film/B-stage Epoxy*. The simplest and most effective way to eliminate RBO is to use die attach films or B-stage materials. However, there are limitations associated with this approach. These can include high material cost and capital investment, difficulty to achieve high adhesion and thus high reliability, and limited thermal performance of these materials.

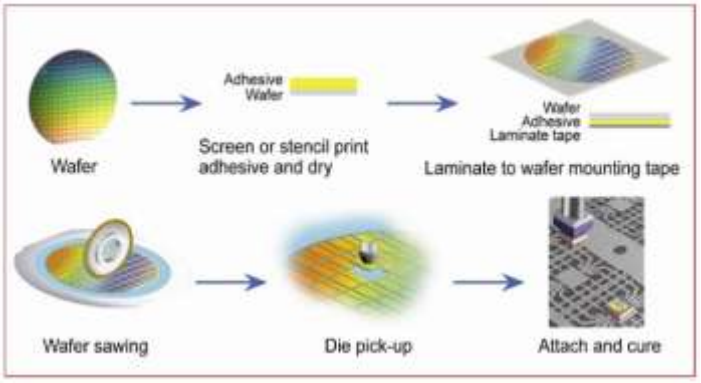

Figure 2. Die Attach Film

• *Mechanical barriers*. In some cases, grooves on lead frames are designed in between die attach area and wire bond area to reduce resin bleed-out, as shown in figure 3. This is a simple and cost-effective process. However, this approach may not work well if the bleeding is severe. Similarly, some low surface energy insulating film around a chip can be printed to confine the un-cure pastes to the space defined by the printed pattern.

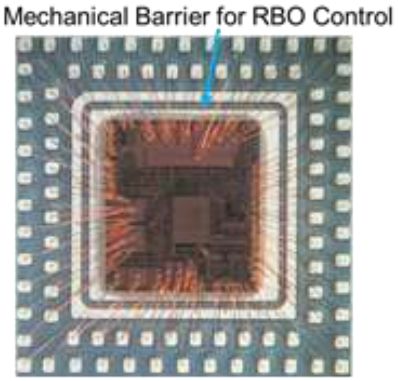

Figure 3. Example of Mechanical Barrier for RBO

• *Plasma Cleaning* involves the removal of impurities and contaminants from surfaces through the use of an energetic plasma created from gaseous species. Gases such as argon or oxygen, are commonly used. However, if the plated part to be treated is easily oxidized, such as silver or copper, inert gases such as argon and helium are preferred. The plasma activated atoms and ions behave like a molecular sandblast and can break down organic contaminants.

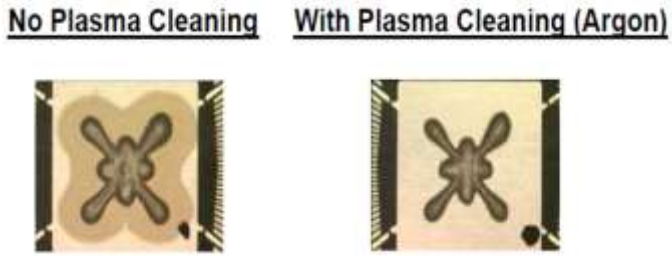

Figure 4. Result of Plasma Cleaning

IV. Conclution & Recommendations

This article provides an understanding of how bleeding occurs, the impact of bleeding, and methods to control bleeding. Bleeding is the result of the interaction between die attach pastes and metal lead frames. In terms of die attach pastes, the most effective way to control RBO seems to be the surface coating with anti-RBO without affecting other performances like delamination, or combining this method with others to provide an even better solution.

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