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Optimization of Epoxy Dispense for Rectangular Die

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I. INTRODUCTION

An epoxy bond is formed by attaching the die to the leadframe with the use of epoxy glue. A drop of epoxy is dispensed on the package and the die placed on top of it. The package needs to be heated at an elevated temperature to cure the epoxy properly. This process uses adhesives such as polyimide, epoxy and silver-filled glass as die attach material to mount the die on the die pad. The mass of epoxy on the die peripheral of the die is known as the Epoxy Coverage area after die bonded, this provide mechanical strength along die edge as shown in Figure 1. Common criteria or requirement for epoxy coverage is 100%. The problems in achieving and controlling the Epoxy Coverage and Inadequate corner coverage can lead to delamination at the corners.

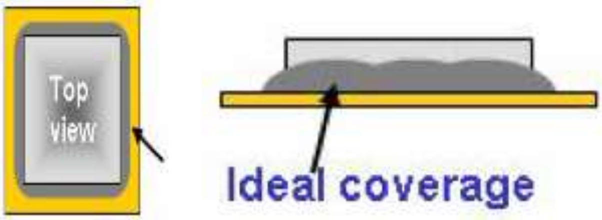

Fig. 1. Epoxy Coverage for Rectangular Die

This paper aims to share and discuss the study of actual experimental for Epoxy dispense for Rectangular Die as part of control to achieve good epoxy coverage. Double-Y and Double-Y plus are the standard dispense patterns automatically selected based on rectangular die size and aspect ratio as shown in figure 2. The default pattern size for Double-Y and Double-Y + typically provides sufficient fillet coverage around the die.

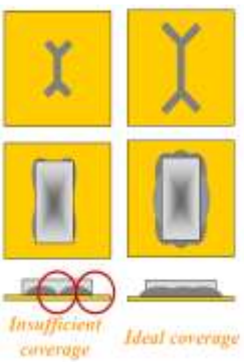

Fig. 2. Double-Y Epoxy Dispense Pattern for Rectangular die

The challenge for Rectangular die size is to have the adhesive spread to assume the shape of the die during the die placement process. There are many approaches to this problem and it can consume considerable process engineering time for critical applications.

II. PROBLEM IDENTIFICATION

Due to the poor wettability of the Ag-based epoxy on the roughened leadframe which results in insufficient epoxy coverage at the chip corner, a full coverage underneath the chip and a consistent linear epoxy fillet height formation is needed.

Rectangular Die Size has been a challenge during Die bond process as manufacturing concern. Fillet height with maximum 75% of die thickness proves to a challenge to consistently achieve. Initial evaluation performed show majority of the samples having fillet height formation >75% die thickness up to 100% as shown in figure 3.

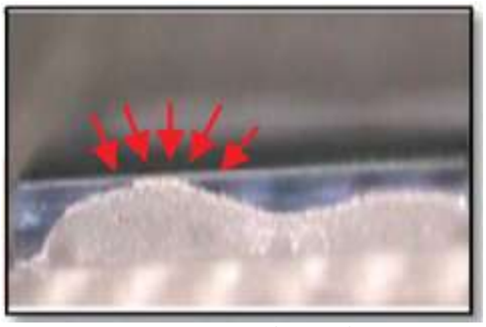

Fig. 3. Failure mechanism for high fillet height

Attempts to reduce the epoxy volume, to compensate for the high fillet height, will result in insufficient epoxy coverage at the chip corner as illustrated in figure 4.

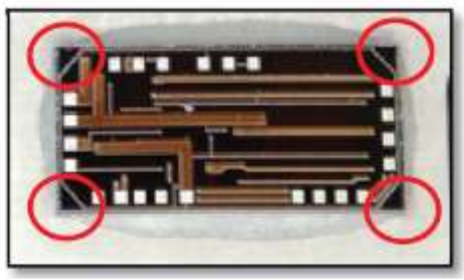

Fig. 4. Failure mechanism for Insufficient Epoxy Coverage

The occurrence of high fillet height is very detrimental as it can cause the following reliability problem for back-end assembly. Epoxy component bleed out creeping up to top of the die cause surface contamination which is rejected during visual inspection screening as manufacturing yield loss. The

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surface contamination will result in Non-stick on pad (NSOP) once it reaches the critical metalized area intended for wire bonding. Delamination on top of die is also a potential risk in the reliability performance of the device as shown in figure 5.

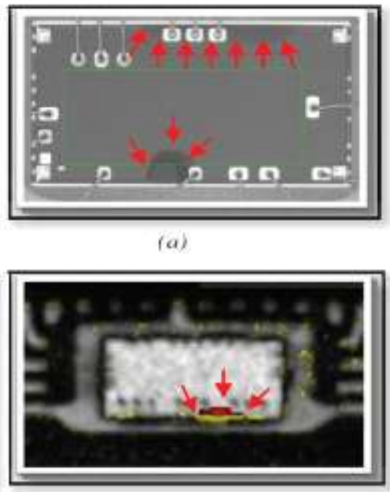


Fig. 5. High epoxy fillet height impact on assembly
(a)Die surface contamination, (b) Delamination on top of die

III. EVALUATION ASSEMBLY PROCESS IMPROVEMENT

To achieve this, the epoxy dispense scale is varied at 80%, 90% and 100% to determine the optimum pattern scale that can satisfy the target epoxy response as illustrated in figure 6. The die is pressed down onto the dispensed epoxy glue gradually at a target height until the epoxy glue covers the periphery of the due. 30 samples pattern scale are prepared. The fillet comparison and other functional tests (BLT), die tilt, voids are also checked no assembly variation.

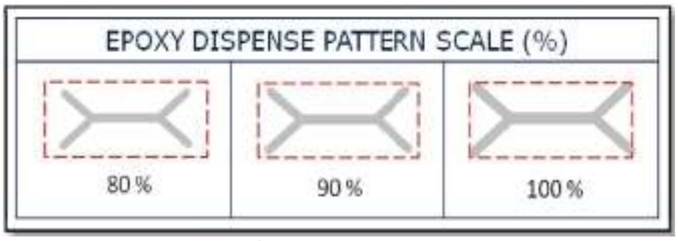


Fig. 6. Schematic Diagram of dispense pattern scales at 80%, 90% and 100%

Epoxy Pattern Scale Assessment Table 1 shows the fillet height response at 80%, 90% and 100% epoxy dispense scale. The fillet height for 90% and 100% show a complete and a consistent epoxy glue coverage as compared to the 80% epoxy dispense scale. The epoxy glue coverage on the corners of the die for the 90% and 100% are complete, whereas minimal epoxy coverage with mountain like formation are observed at the corners and peak of the die, respectively, for the 80% epoxy dispense scale samples. The increase in the epoxy volume near the corners of the die provides a uniform epoxy distribution resulting to a consistent epoxy fillet he and 100% epoxy coverage at the die corners.

TABLE 1. Epoxy Glue Coverage at die sidewall at varying dispense ratio

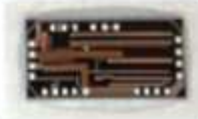
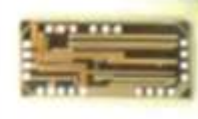
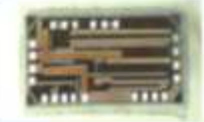
Epoxy Dispense Scale	Fillet height	Epoxy Coverage
80%		
90%		
100%		

Figure 7 shows the asymptotic relationship dispense scale and component overtravel. The die needs to be pressed further down ~0.90 mm into the epoxy dispensed at 80% pattern scale. The travelled distance is needed to attain the required epoxy coverage along the periphery of the die, otherwise, insufficient epoxy coverage observed. A lower travel distance at 0.49 mm and .40mm is needed for 90% and 100% dispense scale, respectively to obtain good epoxy coverage along the die and start plateau at 0.40mm. This shows that the wetting resistance generated by the roughened μPPF with EBO was compensated by the increase in the dispense scale as minimal distance is applied to obtain a consistent fillet height and epoxy coverage along the die during die bond process.

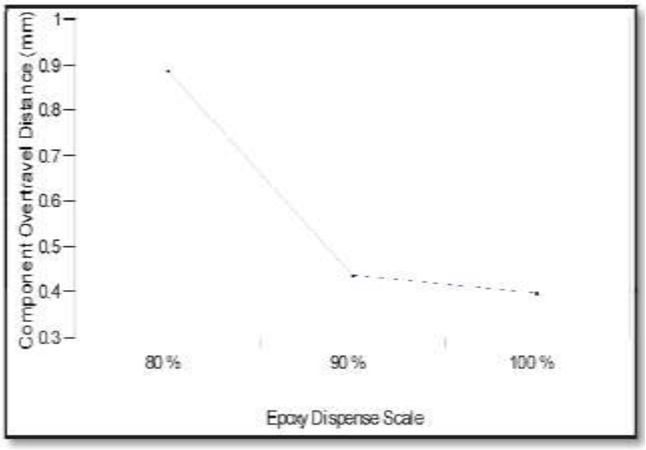


Fig. 7. Asymptotic relationship of epoxy glue pattern scale and component overtravel.

Although a consistent epoxy glue fillet height is established at 90% and 100% dispense patter scale, it still fails the target fillet height which is less than 75% of die thickness. This indicates that further optimization on the die bond parameter is required to obtain a favorable die process.

After the optimum epoxy dispense scale is identified from Table 1, it is then set as a fixed input parameter on the next assessment. Utilizing SAS JMP software, a design of experiment (DOE) is set-up to identify the optimized parameter range that can satisfy the target die bonding function into the fillet height response.

TABLE 2. DOE Matrix

Leg #	Dispensing Height (mm)	Pattern Spindle Speed (mm/s)	Component Placement Overtravel (mm)
1	0.05	3.70	0.40
2	0.07	4.30	0.60
3	0.07	3.70	0.20
4	0.05	4.00	0.60
5	0.07	4.00	0.40
6	0.09	4.30	0.40
7	0.07	4.30	0.20
8	0.05	4.30	0.40
9	0.07	4.00	0.40
10	0.09	4.00	0.60
11	0.09	4.00	0.20
12	0.07	4.00	0.40
13	0.07	3.70	0.60
14	0.09	3.70	0.40
15	0.05	4.00	0.20

Figure 8 shows the prediction plot for the fillet height, statistical analysis show the component overtravel is a significant factor at P-value 0.0015, its interaction with the dispensing height at P-value 0.0305 is slightly significant.

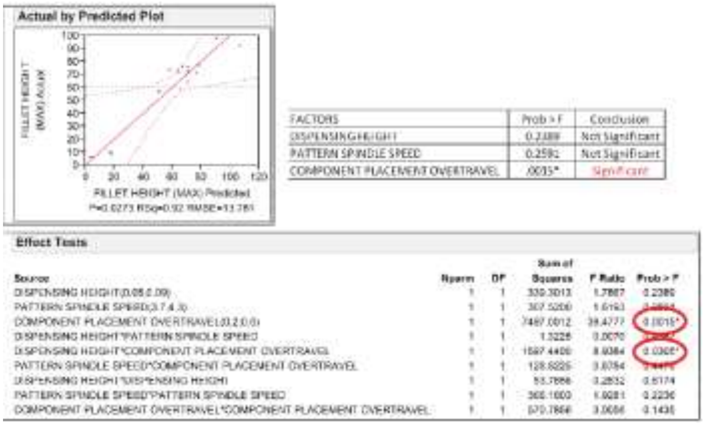


Fig. 8. Epoxy fillet height prediction plot.

Although the pattern spindle speed is not significant based on statistical analysis, a workable parameter is still needed to ensure consistent epoxy coverage. The pattern spindle speed generated in figure 9. At 3.7 mm/s showed an incomplete dispense pattern, it was increased gradually until a full and consistent glue pattern formation was achieved at 3.9 mm/s.


(a) (b)

Fig. 9. Epoxy pattern formation at (a)3.7mm/s and (b) 3.9 mm/s

Base on the contour profiler set at 3.9 mm/s figure 10 the die bond process parameter window, indicated by a small red box, was deternmined.

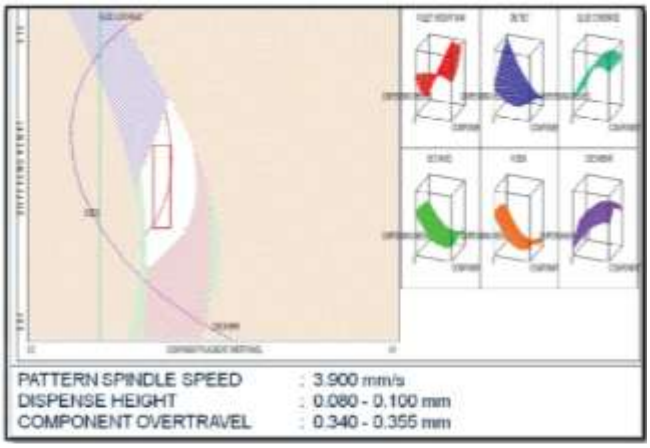


Fig. 10. Die bond process parameter based on 3.9 mm/s spindle speed contour profile

IV. CONCLUTION & RECOMMENDATIONS

The studies show that a suitable epoxy pattern is the key to ensure that the epoxy dispensed on the substrate can evolve to the final shape of the chip after the initial squeezing during the DA process. For rectangular die Double-Y with 100% pattern scale is recommended to obtain consistent epoxy fillet less than 75% and 100% epoxy coverage at the die corners.

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