Journal of Engineering Research and Reports

17(4): 44-50, 2020; Article no.JERR.61327
ISSN: 2582-2926

Managing Epoxy Tailing in Die Attach thru Design of Experiment

Michael D. Capili[1*]

[1]STMicroelectronics Inc., Calamba Philippines LISP 2 Calamba City, Laguna 4027, Philippines.

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JERR/2020/v17i417196
Editor(s):
(1) Dr. P. Elangovan, SRM TRP Engineering College, India.
Reviewers:
(1) Abdelaali Fargi, University of Monastir, Tunisia.
(2) Shilpi Birla, Manipal University Jaipur, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/61327

Original Research Article

Received 25 July 2020
Accepted 03 October 2020
Published 26 October 2020

ABSTRACT

Die attach epoxy dispensing is an automated factory environment that creates some special challenges. A robust production process begins with an understanding of the adhesives in their fluid state and which important parameters must be controlled. One of the most common problems encountered with adhesives in Die attach process is epoxy tailing. Tailing in this sense means the peak of the dispensed material falls away from the center of the dot when the nozzle finishes dispensing. Dispensing requirements, techniques, and equipment resulting from this experience are discussed. Guidelines for optimizing quality is given. In this research, epoxy-associated defects are eliminated by optimizing the Break tail parameter using the Design of Experiment (DOE) methodology. The DOE prediction profile result shows that the tailing parameters recommended is Broken tail delay: 200 ms and Break tail offset is 350 counts. This study is applicable for silver filled conductive adhesive epoxy with greater than 9K Viscosity and greater than 4 Thixotropic Index.

Keywords: Break tail parameter; die attach; epoxy; epoxy tailing.

1. INTRODUCTION

Die attach, also known as die bonding, is the process of attaching (or bonding) a die (or chip) to a substrate, leadframe or another die. This process can take on many forms and can be applied in many different ways. The common die attach material is Epoxy. Epoxy Dispensed

**Corresponding author: Email: michael.capili@st.com;*

through dispensing needle or nozzle by controlled volume on the substrate. The location of the dispensing is controlled with vision control system in the die attach equipment [1] as illustrated in Fig. 1.

2. EXPERIMENTAL DETAILS AND METHODOLOGY

The excessive flow between the dispensing patterns can result in epoxy tailing as seen in Fig. 2 due to unoptimized dispensing parameters. This can cause several problems with epoxy, such as epoxy lead, epoxy splatter, and epoxy bridging. In this research, a validation the relationship of the Break Tail parameter and Epoxy tailing issues using the Design of Experiment (DOE) methodology [2].

A long epoxy tail at the tip of the dispensing needle is observed at the current break tail parameter. This happens when the dispensing needle moves up faster and breaks the tail at a certain distance at one point. This may cause epoxy dripping / splatter during indexing and needle movement [3].

Validate the relationship of the Break Tail parameter and Epoxy tailing issues thru DOE method. Break-Tail Offset is the height of the upward motion of the dispenser nozzle prior to the break-tail delay & eventual index to the next pad site. Break-Tail Delay is the time the dispenser nozzle stays on the actual dispense site before moving to the next pad site [4].

2.1 DOE Factorial Screening

One of the solutions is to optimize the Epoxy Dispense Break Tail Parameter. Below is the methodology of evaluation using Design of Experiment (DOE) [2] shown in Fig. 4.

Below is the summary of Design of Experiment (DOE) methodology shown in Fig. 5. The input variables are the tail break parameters, Tail Break parameter are composed of Tail Break Delay is the duration of time before the dispenser moves to the next pad from the Z-ready Position. And Break Tail Offset is the initial height/step before the dispenser move to the Z-ready Position which is the height of the dispenser in idle position.

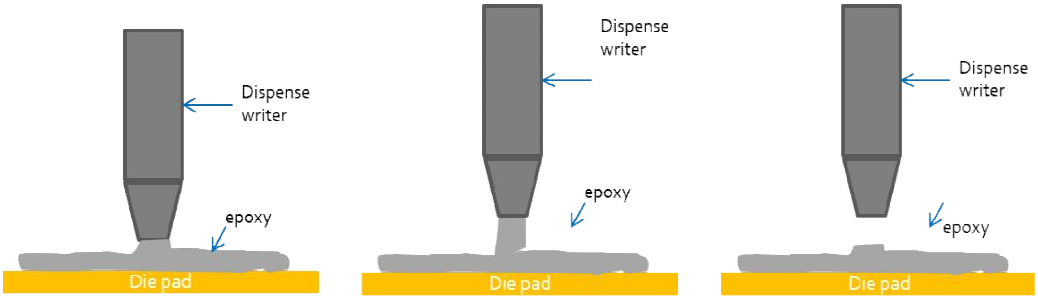

Fig. 1. Epoxy dispense

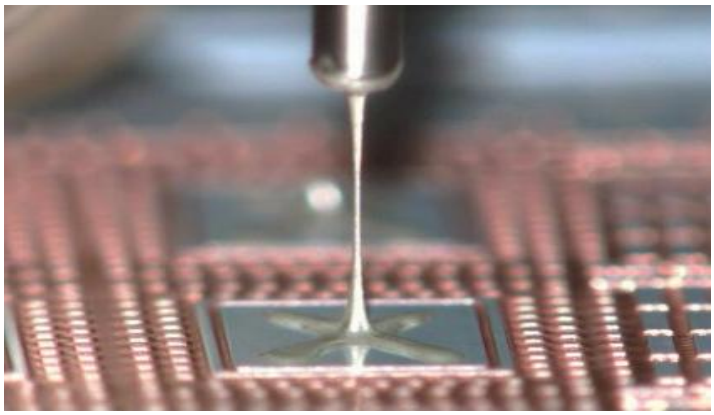

Fig. 2. Epoxy tailing failure mechanism

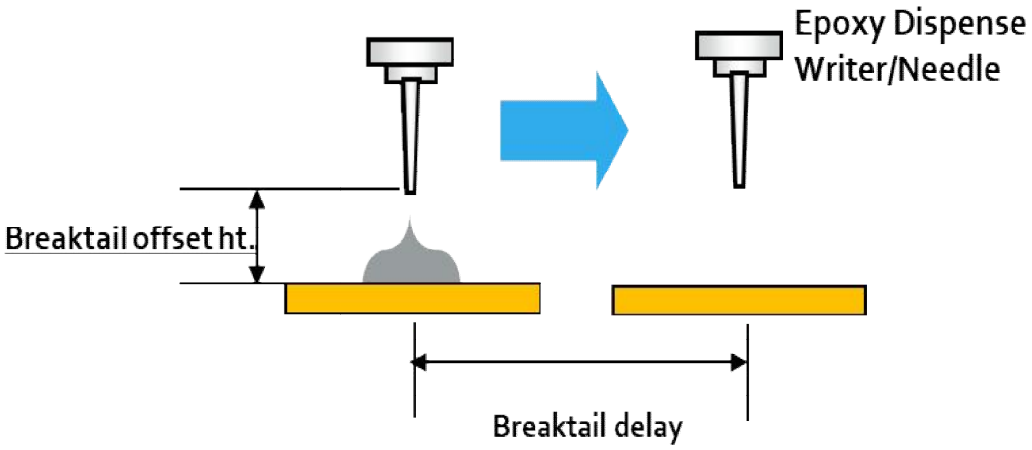

Fig. 3. Epoxy dispense break tail flow

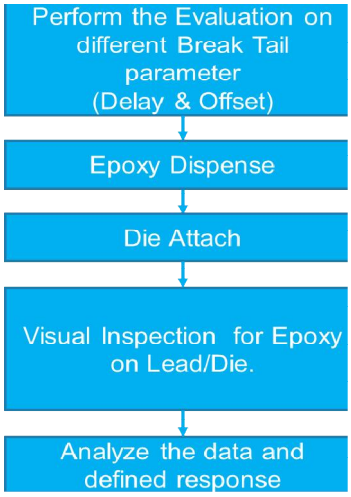

Fig. 4. Evaluation flow

Process Function	Process Step	Practical Problem	Test Plan	Hypothesis Statement	Conclusion
Die Attach Process	Epoxy Dispense	What is Optimize Break Tail Parameter that will result to less Epoxy Tailing	Design Of Experiments (DOE) RSM	Ho:F1=F2 no significant factor Ha: at least one factor is significant	P value < 0.05, accept Ha.

Factor	
Break Tail Delay	100 to 400
Break Tail Offset	100 to 600

Response
Epoxy Talling / Excess Epoxy

Constant/ Fix Parameter	
Dispense Pattern	X - Pattern
Dispense Sequence	6 - Sequence
Dispense Direction	Alternate Y Direction
Bond Direction	Alternate Y Direction
Leadframe Pitch Indexing	5mm

Design Summary

Factors:	2	Replicates:	1	Cube points:	4
Base runs:	13	Total runs:	13	Center points in cube:	5
Base blocks:	1	Total blocks:	1	Axial points:	4
				Center points in axial:	0

Point Types

α = 1.41421

Two-level factorial: Full factorial

StdOrder	RunOrder	PtType	Blocks	Break Tail Delay	Break Tail Offset	Result
12	1	0	1	250.000	350.000	1
4	2	1	1	400.000	600.000	32
9	3	0	1	250.000	350.000	7
6	4	-1	1	462.132	350.000	38
3	5	1	1	100.000	600.000	25
1	6	1	1	100.000	100.000	30
10	7	0	1	250.000	350.000	5
2	8	1	1	400.000	100.000	35
8	9	-1	1	250.000	703.553	21
11	10	0	1	250.000	350.000	3
7	11	-1	1	250.000	-3.553	39
5	12	-1	1	37.868	350.000	15
13	13	0	1	250.000	350.000	0

Fig. 5. DOE summary matrix

3. RESULTS AND DISCUSSION

Based on the statistical tool Minitab, the DOE Response Surface regression shows the p-value of the model and linear is at 0.000, indicating that the model can provide a significant linear relationship with the response [5]. And the following factors are significant; Break Tail Delay, Break Tail Offset, interaction between Break Tail Delay* Break Tail Delay, and the interaction between Break Tail Offset* Break Tail Offset shown in a graphical presentation in Fig. 7.

The Lack of Fit P-value is 0.103, indicate that there is no evidence of lack of fit or error. And the R square value of the model is at 91.33%, indicating that the model has a strong correlation with the response.

To measure multicollinearity, you can examine the correlation structure of the predictor variables. You can also examine the variance inflation factor (VIF), which measures how much the variance of an estimated regression coefficient increases if your predictors are correlated. If the VIF = 1, there is no multicollinearity but if the VIF is > 1, the predictors are correlated. On Minitab result the coefficients and collinearity have shown variance inflation factor (VIF) values for all main factors, and their interactions remain low, indicating that there is no multicollinearity [5]. The regression equation is shown in Fig. 8 as well.

Contour plots show darker regions that indicate lower epoxy on lead/die rejection. And based on the contour plot, the recommended Break tail delay range is from 100 to 300 ms, and Break tail offset ranges from 250 to 450 ms.

The Residual plot result shows that all the points on the normal probability plot are still within the line. The histogram plot has a bell shape curve but is skewed to the right. The points on the versus fits are randomly scattered along with the zero. There is no pattern in the observation order plot.

The original response to the DOE optimizing plot recommendation is as follows; Break tail delay is 213 ms and Break tail offset is 388 counts. But for simplification and standardization, I chose the close to the nearest 100. As a result, the values were manually adjusted to allowable values and the resulting optimum setting is below: Break Tail delay is 200 ms, and Break tail offset is 350 counts.

Response Surface Regression: Result versus Break Tail

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	5	2509.09	501.82	26.28	0.000
Linear	2	387.74	193.87	10.15	0.009
Break Tail Delay	1	247.83	247.83	12.98	0.009
Break Tail Offset	1	139.91	139.91	7.33	0.030
Square	2	2120.34	1060.17	55.51	0.000
Break Tail Delay*Break Tail Delay	1	1037.53	1037.53	54.33	0.000
Break Tail Offset*Break Tail Offset	1	1356.18	1356.18	71.01	0.000
2-Way Interaction	1	1.00	1.00	0.05	0.826
Break Tail Delay*Break Tail Offset	1	1.00	1.00	0.05	0.826
Error	7	133.68	19.10		
Lack-of-Fit	3	100.88	33.63	4.10	0.103
Pure Error	4	32.80	8.20		
Total	12	2642.77			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
4.37007	94.94%	91.33%	70.92%

Fig. 6. DOE response surface regression

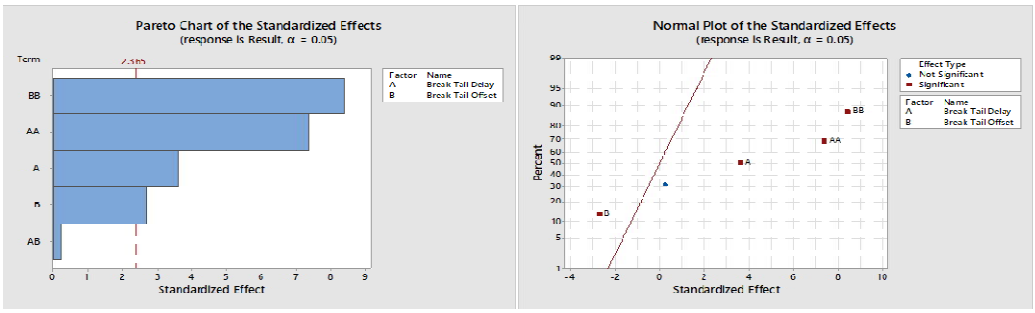

Fig. 7. Pareto chart & normal plot of the standardized effect

Coded Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	3.20	1.95	1.64	0.146	
Break Tail Delay	5.57	1.55	3.60	0.009	1.00
Break Tail Offset	-4.18	1.55	-2.71	0.030	1.00
Break Tail Delay*Break Tail Delay	12.21	1.66	7.37	0.000	1.02
Break Tail Offset*Break Tail Offset	13.96	1.66	8.43	0.000	1.02
Break Tail Delay*Break Tail Offset	0.50	2.19	0.23	0.826	1.00

Regression Equation in Uncoded Units

Result = 62.24 - 0.2389 Break Tail Delay - 0.1764 Break Tail Offset
+ 0.000543 Break Tail Delay*Break Tail Delay
+ 0.000223 Break Tail Offset*Break Tail Offset
+ 0.000013 Break Tail Delay*Break Tail Offset

Fig. 8. Coefficients and collinearity and regression equation

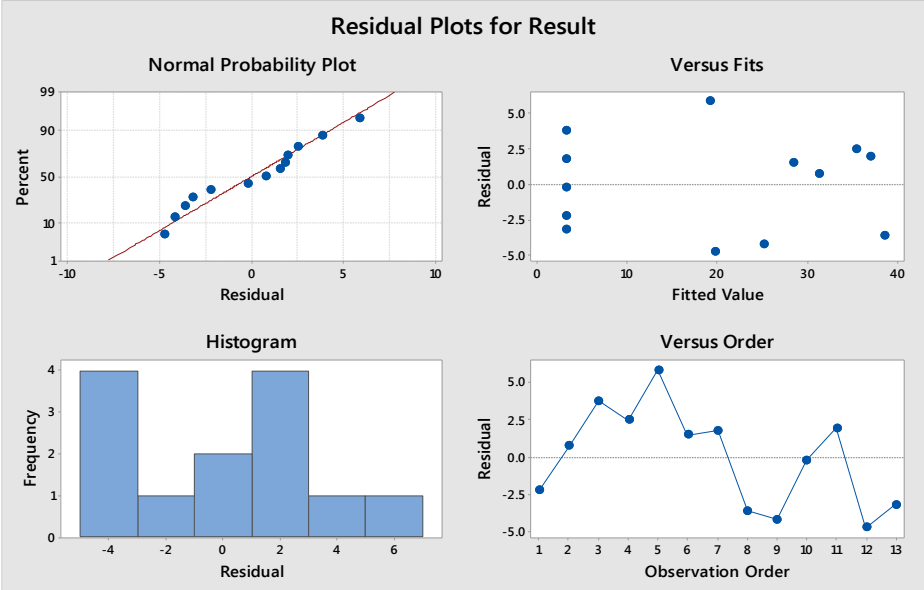

Fig. 9. Residual plots

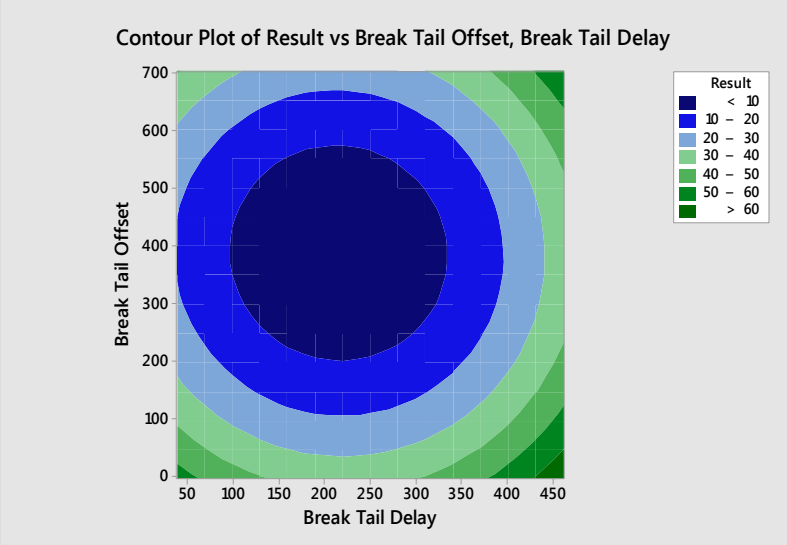

Fig. 10. Contour plots

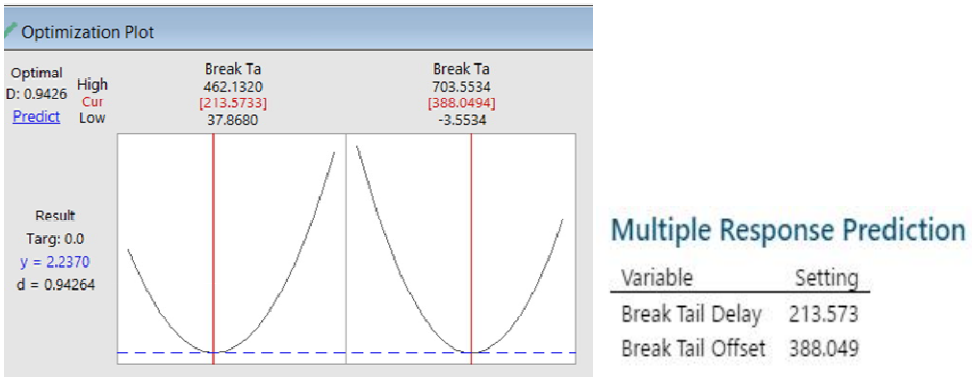

Fig. 11. DOE optimization plot

4. CONCLUSION

The practical conclusion is at the 95 % confidence level, the DOE prediction profile result shows that the tailing parameters recommended is Break tail delay: 200 ms and Break tail offset is 350 counts.

Growth is inevitable, which brings changes and challenges in assembly manufacturing like that of Die attach process complexities concerning devices. These challenges, however, can be overcome through the Design of Experiment (DOE) method which consists of rich parametric tools to optimize a process.

Simulation runs have shown that the occurrence of splattering and epoxy tailing is influenced by tail break parameters. And studies that will allow standardization of all the Die attach process Break tail parameters.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Die Attach Manual by ASM Pacific Technology www.asmpacific.com.
2. Raymond H. Meyers, Douglas C. Montgomery, Christine M. Anderson Cook. Response Surface Methodology: Process and Product Optimization Using Designed Experiments, Wiley; 4 editions.

3. Managing Stringing or Tailing in Adhesive Deposition by Steven R. Marongelli, Application Specialist/GSM Dispensing Platform Product Team Universal Instruments.
4. Novin Yap, Caloy Hennosura, Freddie Pascual, Elimination of epoxy bridging in diebond process. ON Semiconductor Philippines Inc.
5. Rehman M. Khan, Problem Solving and Data Analysis Using Minitab: A Clear and Easy Guide to Six Sigma Methodology.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/61327