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Optimization for Die Attach Film Delamination on Nickel-Palladium-Gold Die Pad

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Author's contribution

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

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ABSTRACT

In the Semiconductor Industry, the delamination performance of integrated circuit packaging is being aggressively improved. However, this task is complicated and difficult, as the defective failure is highly dependent on the compatibility of the material characteristics that may affect the entire Integrated Circuit package system under certain stress levels, both mechanical and thermal. This research work aims to study Die Attach process optimization in DAF adhesive for Nickel-Palladium-Gold Die Pad leadframe to achieve maximum reliability performance under IPC / JEDEC Moisture Sensitivity Level 1 (MSL1) at 260°C reflow. Strategic optimization of the Die Attach process is needed to ensure robust reliability. And one of the solutions is to apply the Scrubbing method, which is a machine feature used at a constant temperature to aid in the wetting of adhesives and the removal of voids.

Keywords: Delamination; die attach; die attach film.

1. INTRODUCTION

Microelectronic device packages consist of multi-layered composites with geometric inconsistencies, including cross-sections, corner and corners, and are often exposed to extreme non-uniform thermal cycling during the installation, testing, storage and operation of packages. The bipolar cross-sections are invariably a small connection, which determines

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the thermo-mechanical protection of most micro-electronic device packages due to its internal thermal-mechanical property discontinuities and geometric discontinuities. This is according to the article entitled Delamination and Reliability Issues in Packaged Devices [1].

Basically, the sites with geometrical discontinuities are the stress concentration points where the stress and displacement fields exhibit singular behavior. Fig. 1 shows the interfaces of types of delamination based on IPC/JEDEC Standard for Moisture/Reflow Sensitivity Classification in an IC chip package [2].

During device testing, most devices with a small delamination are not easily recognizable but can cause product durability and functional failure for some field applications particularly after the application of external mechanical stresses. If the alleged fault units need to be recalled as a customer's refund, the manufacturer of the semiconductor will face significant cost impacts.

Delamination is a function of the package materials and the reflow stresses. The semiconductor manufacturer cannot control the latter but must focus on selecting new material to eliminate delamination or implement mitigation techniques to provide sufficient reliability for the application in the presence of delamination. There are several mitigation techniques to improve the reliability or delamination performance without having to change the materials. Some of the techniques can be used individually or combined and consist of ways to improve mold compound adhesion to the die pad, eliminate top side die delamination, or improve the strength of the stitch bond. This is according to Semiconductor digest new and industry trends [3].

Once the IC chip package encapsulated, the Scanning Acoustic Microscope (SAM) in transmission mode was applied in all the units for delamination after the reliability test. In the transmission mode, show minor- to total-pad delamination on units in the SAM image in Fig. 2. Representative cross-section photo in Fig. 3, shows thin gap between mold compound and die pad interface.

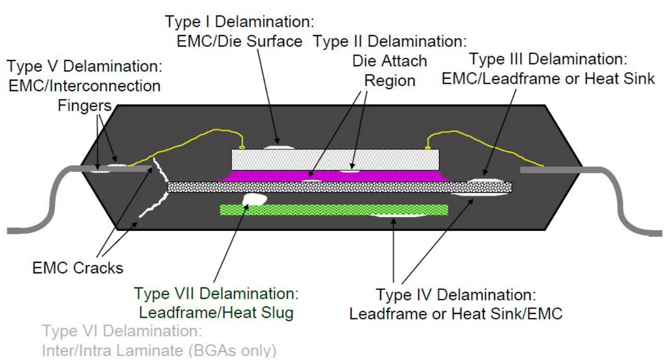

Fig. 1. Types of delamination based on AWW/JEDEC [2]

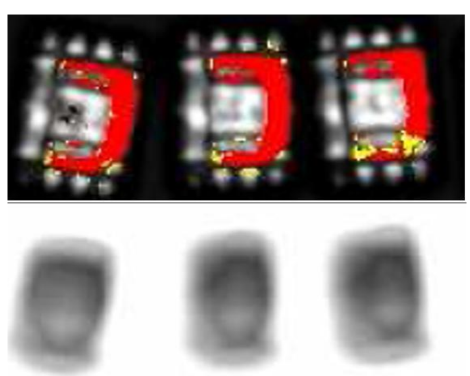

Fig. 2. SAM image of delamination

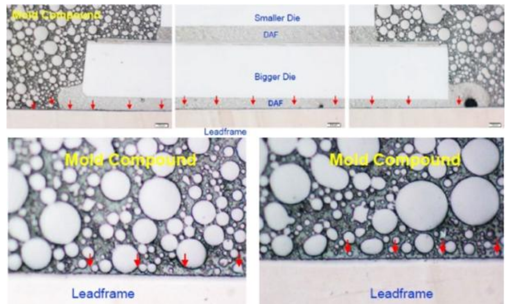

Fig. 3. Cross section analysis

2. EXPERIMENTAL DETAILS

The process optimization in Die Attach is inevitable to ensure process robustness and package reliability when using DAF. The major process difference as compared to the conventional die attachment process is heat bonding. The experiment is performed to optimize the settings of the die attachment using the die bonder. Three main process parameters are used in experiment design (DOE) using statistical JMP software. Parameters are: (a) Scrub Cycle, (b) X & Y Scrub Amplitude, (c) Bond Time / Delay with the guidance to Response Surface Methodology: Process and Product Optimization Using Designed Experiments [4].

Scrubbing is a machine feature that is used at constant temperature to aid in the wetting of adhesives and in the removal of voids (Fig. 4). A scrub may be activated, and this will cause the bondarm to vibrate at a user selected frequency and amplitude. Scrub assisted automatic die attachment is not common process that relies on "scrubbing" the die in the pad to break the gap or help to minimize the gap [5-7]. The scrub method involves moving the die back and forth cyclically, from left to right or horizontally. If the number of scrubbing and displacement cycles is programmable, this option offers a lot of flexibility. Force is applied over time, with either a linear or an orbital motion in the X, Y and sometimes Z directions. Surface variations in the lead frame cause friction during the scrub, and this combination of strength, friction and high temperature forces the welding material into the base material and forms an intermetallic bond. The Scrub motion performs three actions: 1) breaks the oxide layer, 2) drives out voids, and 3) forces adhesive into die.

The aim of this DOE study is to optimization the bond parameter to increase the adhesion thru scrubbing mechanism of Die Attach Film into Die Pad Leadframe Nickel Palladium-Gold, as seen in Fig. 4 using Die Attach. ESEC Manual; 2008 as reference [8]. The output response of this experiment is the interfacial delamination between the DAF and the leadframe interface. Scanning Acoustic Microscope (SAM) is used for delamination checking. The following is a summary of the Experimental Design (DOE) table of responses and measuring technique as provided in Table 1.

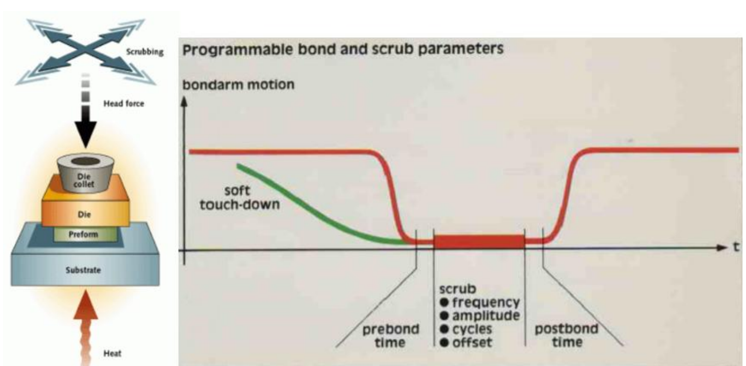

Fig. 4. Bond scrubbing mechanism

Table 1. DOE evaluation matrix

Run	Variable			Response							
	Scrub Cycle	Both XY Scrub Amplitude	Bond Delay	Green Peel Test	Void	TSAM	Squeeze out			HDS	PAC Failure Mode
	(Spec: 2-6 cycles)	(Spec : 30-50um)	(Spec:200-400ms)	Spec: Rejected if >10% un-wet	Spec: rejected if single >5%; Total: 10%	Spec: Rejected if DA delam >10%	Spec: Rejected if >100um outside die perimeter			Spec: >0.4kg/mm2 (non-destructive)	Spec: Rejected if >10% adhesive to paddle
				ss: 10pcs	ss: 10pcs	ss: 10pcs	ss: 2pcs			ss: 10pcs	ss: 10pcs
							Ave	Min	Max		
*A1 – ctrl	4	30	200	5	0	5	127	110	151	P	5
A2	2	30	200	0	0	0	55	51	62	P	0
A3			400	0	0	0	74	67	80	P	0
A4		50	200	0	0	0	92	76	101	P	0
A5			400	0	0	0	89	66	104	P	0
A6	4	40	300	0	0	0	109	103	119	P	0
A7	6	30	200	0	0	0	132	119	143	P	0
A8			400	0	0	0	130	123	139	P	0
A9		50	200	0	0	0	160	141	177	P	0
A10			400	0	0	0	162	141	180	P	0

3. RESULTS AND DISCUSSION

The findings are evaluated with JMP statistical tools in order to decide the most appropriate parameter to reduce the delamination of the DAF and the Leadframe interface. Scrub Cycle and XY scrub amplitude factors are important factors from the findings of Fig. 5 DOE Parameter Estimates. There are significant factors that particularly affect Delamination and DAF Squeeze Out response. All other responses are not affected by the identified DOE factors which can be considered statistically non-significant (P-value > 0.05) as shown in Fig. 5.

Fig. 6. show the DOE prediction profiler provide the predicted values of response given different setting. In reference to A Practical Guide to Design, Analysis and Applications [9].

Based on JMP Contour Profile in Fig. 7, the process window identified (XY Scrub Amplitude: 25um – 35um; Scrub Cycle: 1 – 2 cycles) met all bond quality requirements (Green Peel, Void, TSAM, Squeeze Out, HDS, HDS Failure Mode).

Once the process window has been validated, all the quality will be met. After the Reliability Test, all assembled sample units were checked for delamination using a Scanning Acoustic Microscope (SAM) operating in transmission mode [10-12]. Show No delamination of the units in the SAM image in the transmission mode in Fig. 8. The representative cross-section photo shown in Fig. 9, shows No delamination or separation of DAF to leadframe noted for the cross-section inspection of the unit.

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	3.8061224	21.32868	0.18	0.8642
Scrub Cycle	17.125	2.169024	7.90	0.0002*
XY Scrub Amplitude	1.1102041	0.413406	2.69	0.0363*
Bond Delay	-0.00898	0.041341	-0.22	0.8352

Fig. 5. DOE parameter estimates

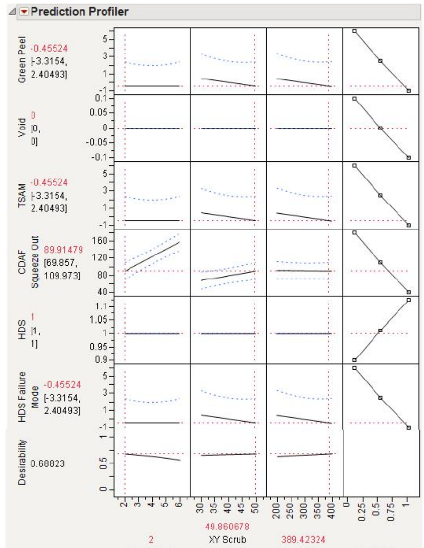

Fig. 6. DOE prediction profiler result

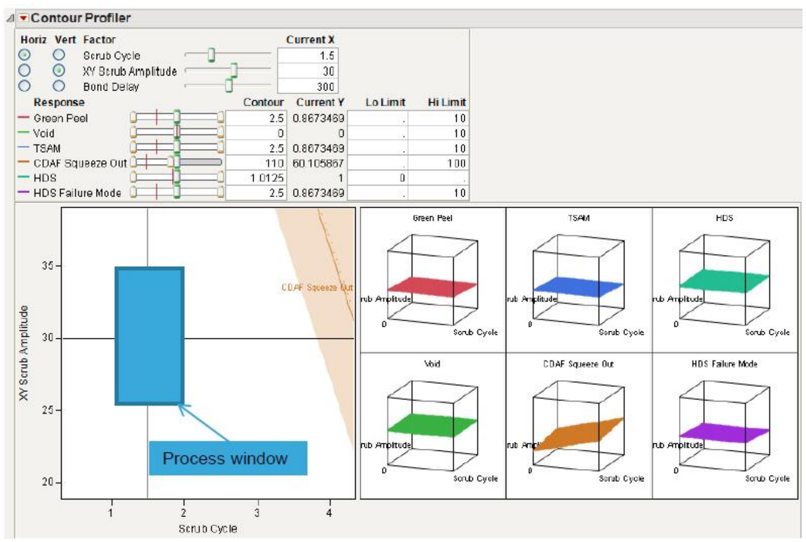

Fig. 7. DOE contour profiler

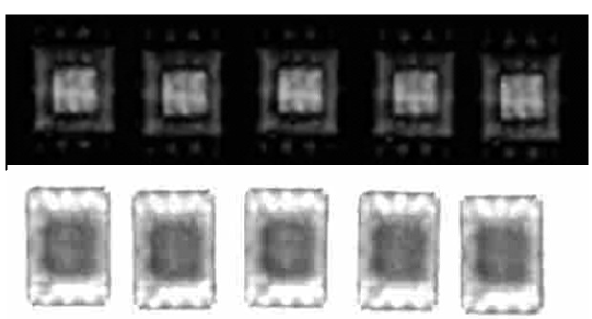

Fig. 8. Bond Line thickness (BLT) verification result

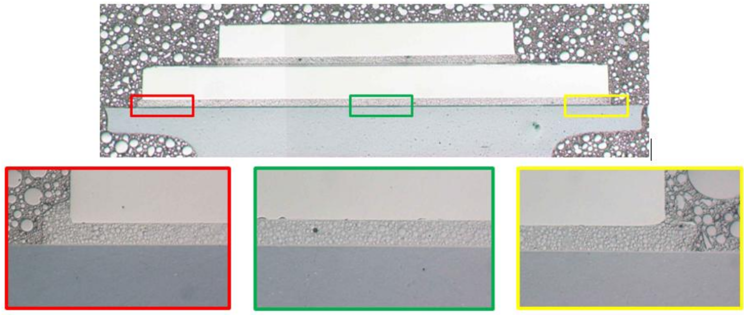

Fig. 9. Cross section verification result

4. CONCLUSION

Delamination is not the desired result for packages as it may have an impact on device reliability. However, due to package construction, cost pressures and package reliability performance requirements, some devices are bound to do so. There are several techniques that can be used to improve delamination performance or to improve reliability. Optimizing the Scrub Cycle and XY Scrub Amplitude of the Die Attach equipment beyond the usual method of testing the process limits. Scrub Cycle and XY Scrub Amplitude are the most significant parameters for increasing package reliability performance. These parameters are often used and set up, but the goal can be achieved with the proper evaluation of the machine parameter.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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