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Die Attach Pre-bond Inspection Innovation for Roughened Leadframe

Michael D. Capili[1*]

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

Author's contribution

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

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Short Research Article

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ABSTRACT

This paper studies the challenges and behavior of epoxy material between the roughened Leadframe during the Die Attach process. Die bond on the roughened die-attach paddle (DAP) of epoxy has been a challenge for its manufacturability in terms of maintaining the target epoxy volume. The study on the roughened Leadframe utilizing the Pre-bond inspection parameter causing machine inspection cannot fully detect the epoxy pattern. The uneven contrast of pad's, causing pre-bond inspection problem. Hard to teach / set-up epoxy inspection due to the contrast between leadframe die pad vs. epoxy. The roughened leadframe property has different surface contrast causing Frequent "Bond Align" and epoxy inspection error on the Roughen leadframe. This occurrence leads to risks of insufficient epoxy which is detrimental to product reliability (delamination on die bottom) and can cause manufacturing yield loss due to insufficient epoxy coverage. Using the Design of Experiment (DOE) methodology and its applicable statistical tools, the author to come up with error-proofing solutions to resolve and reduce the Insufficient Epoxy. The innovative and breakthrough solutions implemented were the installation of ultra-bright light with double sidelights in pre-bond inspection which is the key in reducing defects rate.

Keywords: Die attach; insufficient epoxy; pre-bond inspection; roughened leadframe.

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

1. INTRODUCTION

The processability of the epoxy on the surface of the roughened leadframe needs to be established due to this significant difference in contrast between the leadframe die pad vs. epoxy when compared to the Copper leadframe which has a major impact in the quality of the chip assembly [1-5]. Today, roughened leadframes is mainly used that can help improve adhesion of the die attach, wire bonds, and mold compound, and improve the solderability of the leadframe [6-8]. Another technique to improve adhesion is to change the plating finish. One can roughen the nickel layer through a chemical etch before depositing the palladium [9-11].

2. MATERIALS AND METHODS

2.1 Problem Identification

The study on the roughened leadframe utilizing the Pre-bond parameter for Ag-based epoxy on standard Ag-plated DAP Cu leadframe causing Pre Bond-Inspection Machine cannot fully detect the epoxy pattern, due to dark background image cause by rough leadframe, as shown in Fig. 1.

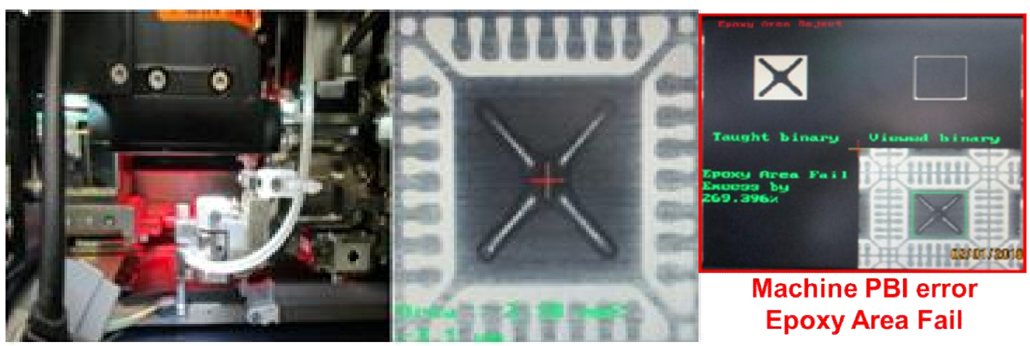


Fig. 1. Die attach pre bond-inspection machine cannot fully detect the epoxy pattern due to roughened leadframe

The uneven contrast of pad's, causing pre-bond inspection problems as shown in Fig. 2. From row 1 to 8 the inspection show passed result, while the remaining 3 rows from 9 to 11 show PBI error failed due to the darkening of the pad. Hard to teach / set-up epoxy inspection due to no contrast between leadframe die pad vs. epoxy. Roughen leadframe property has different surface contrast causing Frequent "Bond Align" and epoxy inspection error on Roughen leadframe.

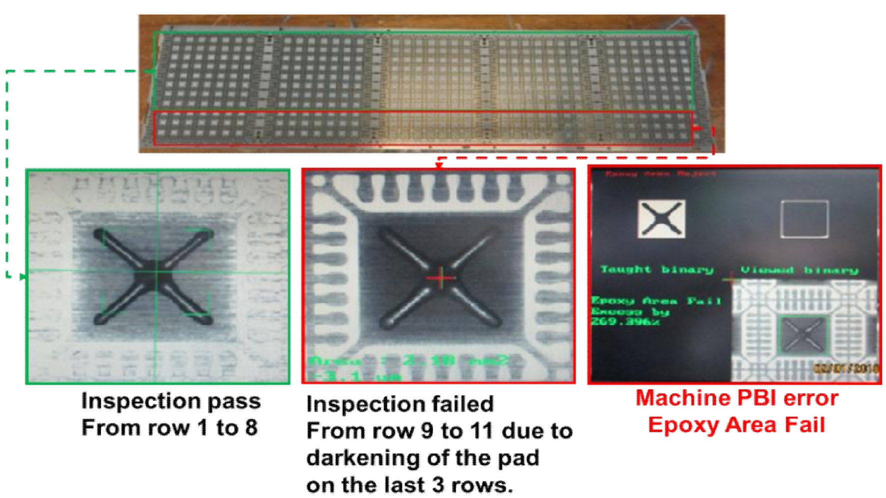


Fig. 2. Roughened leadframe causing die attach pre bond-inspection error, cannot fully detect the epoxy pattern

2.2 Process Mapping

A Detailed process mapping was performed in the Die Attach process, there are 6 steps to complete the Die attach process and Epoxy Dispense & Pre-bond Inspection were identified as critical steps.

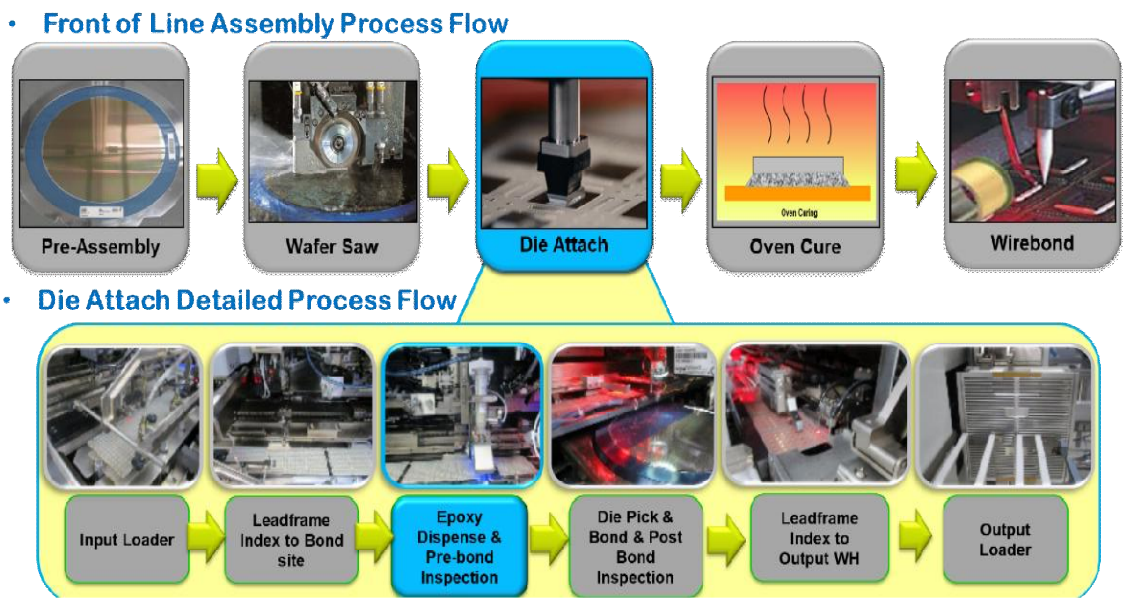


Fig. 3. Die attach process mapping

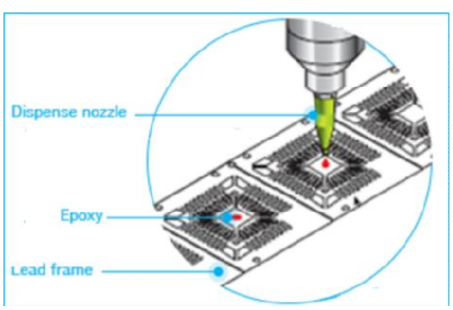
2.3 Understanding Epoxy Dispense Process and Pre-Bond Inspection

Epoxy Dispensed through dispensing needle or nozzle by controlled epoxy volume on the leadframe. The location of the dispensing is controlled with a visual control system, called Pre-Bond inspection in the die attach equipment.

Pre-bond inspection is a machine feature for Epoxy volume checking, wherein the actual dispense epoxy pattern is being checked prior bonding of die vs the Taught epoxy pattern. If between the green and red lines of epoxy pattern, it is an acceptable area. PBI can detect excessive epoxy and insufficient epoxy, the machine will automatically alarm and stop.

2.4 Pre-Bond Inspection Assembly

Current machine PBI Module Assembly lighting composed of white Coaxial illumination with indirect Red Ring light with Luminous Intensity 800 mcd (millicandelas).



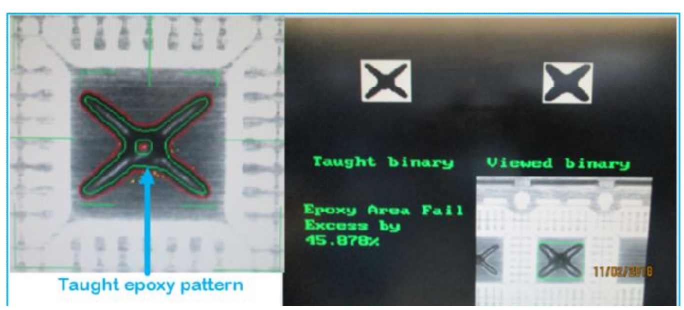


Fig. 4. Epoxy dispense process

Fig. 5. Pre-bond inspection

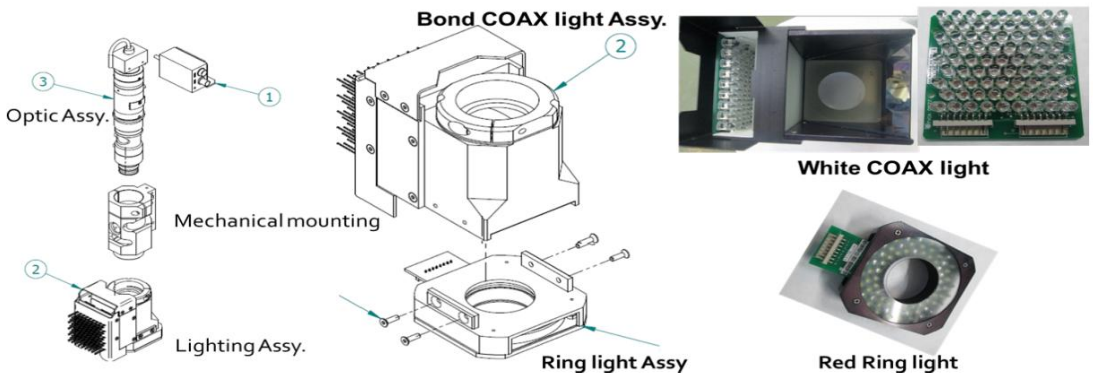


Fig. 6. Pre-bond inspection assembly

2.5 Validation of Causes

Validation on potential causes was statistically analyzed using the appropriate statistical tool to check its significance to insufficient epoxy defect.

Using Attribute Measurement System Analysis (MSA) to validate the accuracy and effectiveness of current PBI detection control, showed that the current machine PBI setting is not effective and unacceptable. Machine Inspection cannot fully detect the epoxy pattern in the roughened leadframe from row 9 to 11 due to the darkening of the pad.

The unacceptable result of Attribute MSA in Pre-bond inspection was potentially due to the planarity issue on the machine anvil block. To validate the hypothesis, an evaluation of different Anvil Block planarity measurements (10, 15, 20 microns) with the response to PBI detection was performed using a statistical tool, two proportion tests. The results shows there is No Significant difference, all proportion is equal in all measurements of Anvil Block planarity, inaccurate Pre-bond issue is still present.

Table 1. Poor detection of pre-bond inspection

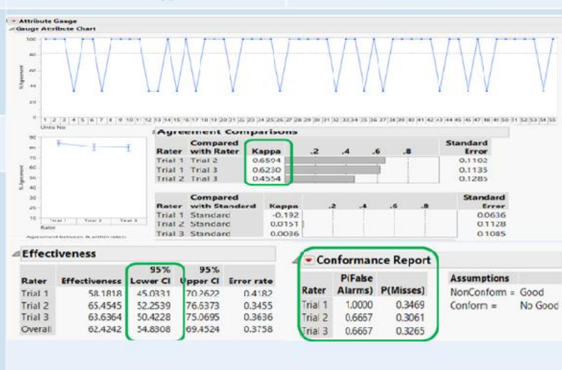
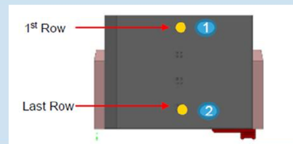
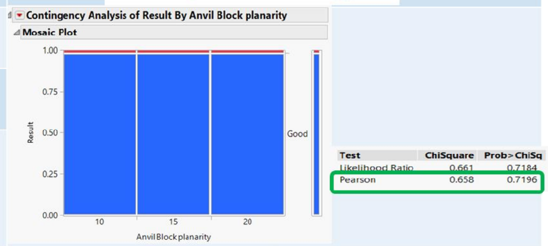
Practical Problem	Does current Pre-Bond Inspection setting is effective detection control?		
Y (Key Output)	Insufficient Epoxy	X (Key Input)	Pre-bond Inspection
Unit of Measurement	PPM	True Nature of X	Continuous
Nature of Y	Discrete	Level of X	Polarized lighting Coaxial Light Setting: 50 Ring Light Setting: 50
Null Hypothesis	Ho: Acceptable	Alternative Hypothesis	Ha: Unacceptable
Method of Validation	Validate to determine whether the Pre-Bond Inspection vision system can be still reliable to capture insufficient defect.		
Statistical Test	Attribute Measurement System Analysis		
Statistical Result	Kappa is at <0.75 indicating weak PBI inspection Effectiveness is < 90% Unacceptable. Over-rejection P(FA) is at 66% (≤ 5%) showing not all good units are accepted. Under Rejection P(Miss) is at 34% (≤2%) showing not all good units are being rejected..		
Controllability	CONTROLLABLE	Decision	TRUE CAUSE

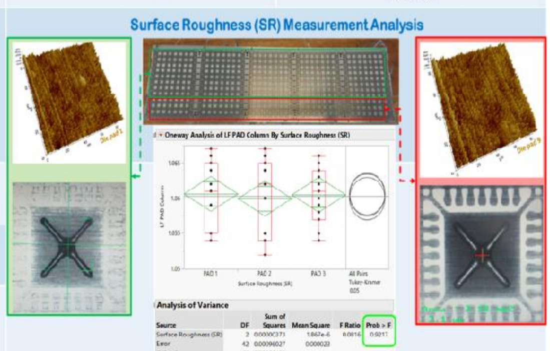
Table 2. Anvil block planarity

Practical Problem	Does different Anvil Block planarity will improve PBI result?		
Y (Key Output)	Insufficient Epoxy	X (Key Input)	Anvil Block Planarity
Unit of Measurement	PPM	True Nature of X	Continuous
Nature of Y	Discrete	Level of X	Planarity (µm): 10, 15, 20 microns
Null Hypothesis	Ho:P10=P15=P20	Alternative Hypothesis	Ha:P10≠P15≠P20
Method of Validation	Check the anvil block planarity in response to Poor PBI Detection. Perform the Evaluation on different Anvil Block planarity measurement (10, 15, 20 microns) and check the PBI response.		
Statistical Test	2-proportion		
P-value	**0.719**		
Statistical Result	@ 95% confidence level there is No Significant difference, All proportion are equal in all measurement of Anvil Block planarity, Pre-bond issue is still present.		
Controllability	CONTROLLABLE	Decision	NOT TRUE CAUSE

Validation of Leadframe roughness were also performed, measuring all pad surface roughness (SR) was measured using a Non-Contact atomic force microscope. And using ANOVA Statistical Comparison of Pad 1 to Pad 11 surface Roughness shows @ 95% confidence level there is No Significant difference. Leadframe roughness measurement comparison result on Pad 1 to Pad 11 is all the same.

After all statistical validation of potential causes, Poor detection of Pre-Bond Inspection remain are found to be statistically Significant and Valid True Cause.

Table 3. Leadframe roughness

Practical Problem	Does Leadframe surface roughness measurement are different per Pad Column?		
Y (Key Output)	Insufficient Epoxy	X (Key Input)	Anvil Block Planarity
Unit of Measurement	PPM	True Nature of X	Continuous
Nature of Y	Discrete	Level of X	Pad 1, 9 and 11
Null Hypothesis	Ho:µPad1=µPad9=µPad11 S Ratio	Alternative Hypothesis	Ha:µPad1≠µPad9≠µPad11 S Ratio
Method of Validation	We measure all surface roughness (SR) measurements were measured using Non-Contact atomic force microscope. SR response was quantified using S ratio integrated over the whole surface.		
Statistical Test	Analysis of variance (ANOVA)		
P-value	**0.921**		
Statistical Result	@ 95% confidence level there is No Significant difference, on surface roughness from Pad 1 to Pad 11.		
Controllability	CONTROLLABLE	Decision	NOT TRUE CAUSE

2.6 Review Related Literature

Research related to Science Principles of Light and Shadow was done, to understand further the science beyond the Pre-bond inspection and to come up with new ideas in finding an alternative solution.

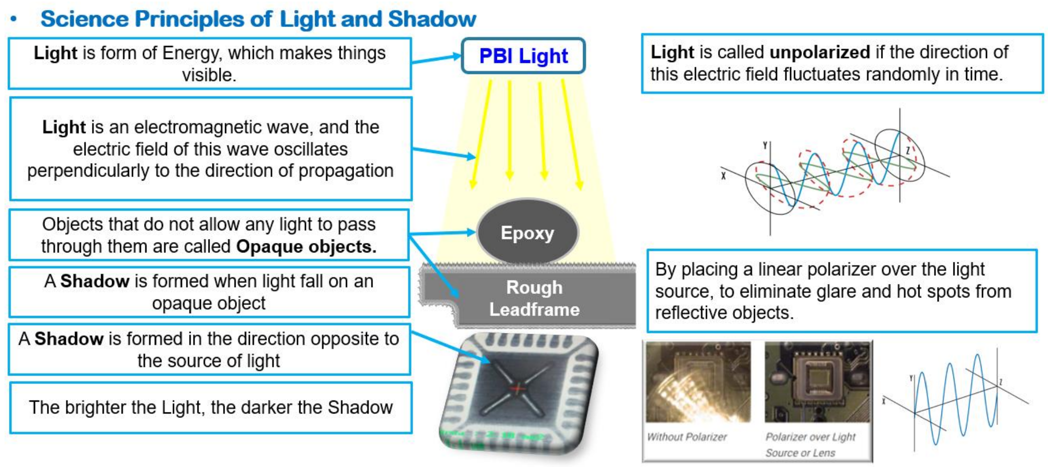


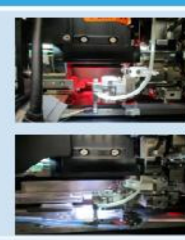
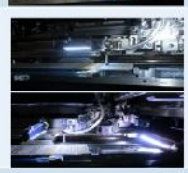
Fig. 7. Science principles of light and shadow

With that new ideas come up, to solve the issue to un-balance contrast on the Leadframe, a brighter source of light is needed. The same solution to separate the epoxy image to the dark image of the roughened Leadframe pad. For brighter the Light, the darker the Shadow, a sidelight as a reflector that will focus on the shadow to remove it is needed.

3. RESULTS AND DISCUSSION

Using Design of Experiments (DOE) to evaluate the suitable setting of PBI base on the idea come up in review related literature. Considering the 4 Factors; Type of Light, additional sidelight, Coaxial Light setting, and Ring light setting.

Table 4. DOE matrix

#	Factor	Nature of X	Level	
1	Type of Lighting	Discrete	White Light: Luminous Intensity 800 mcd Ultra Bright: Luminous Intensity 1,200 mcd	
2	Side Light	Discrete	Single Side Light Double Side Light	
3	Coaxial L Setting	Continuous	Low 50 High 100	
4	Ring L Setting	Continuous	Low 0 High 50	

Each factor has 2 levels and each leg has 1 repetition. The total number of Legs is 32 runs and 1 control leg. And base on DOE Interaction Plot, to improve the Yield, the plot shows I need to use of Ultra Bright Light with double sidelight for PBI. Epoxy can be clearly distinguished from the pad, remove the dark shadow.

To verify the DOE result, Attribute Measurement System Analysis was performed to validate the accuracy of the new setting of Pre-bond inspection. The MSA report indicates that the New PBI detection control with Ultrabright light with double sidelight is effective and acceptable.

Table 5. Suitable optimal setting of pre-bond inspections

Best Solution # 4	Evaluate suitable optimum setting of Pre-bond Inspections (PBI) using DOE	
Y (Key Output)	Insufficient Epoxy	X (Key Input)
Unit of Measurement	PPM	
Null Hypothesis	Ho:F1=F2=F3=F4 no significant factor	
Alternative Hypothesis	Ha: at least one factor is significant	
DOE Summary	No. of Factor: 4 No of Runs:16 Repetition: 1 Control Leg:1 No. of Legs: 32	
Statistical Test	Design Of Experiments (DOE)	
Statistical Result	Significant Factor: Side Light & Type of Lighting with P value < 0.05	
Controllability	**CONTROLLABLE**	

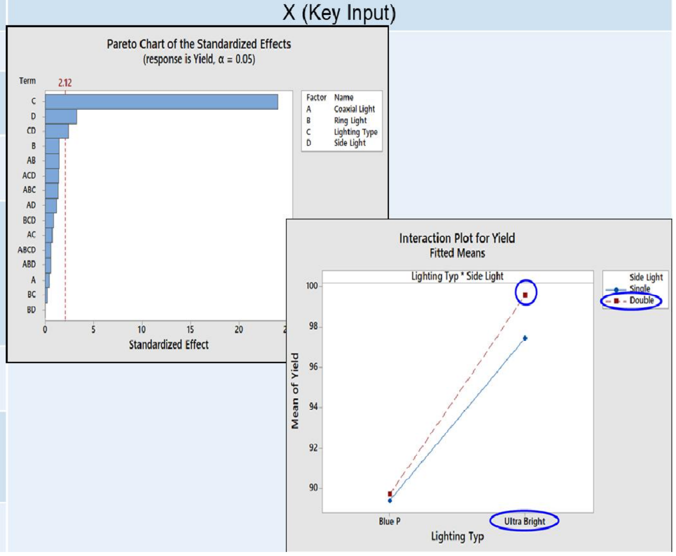
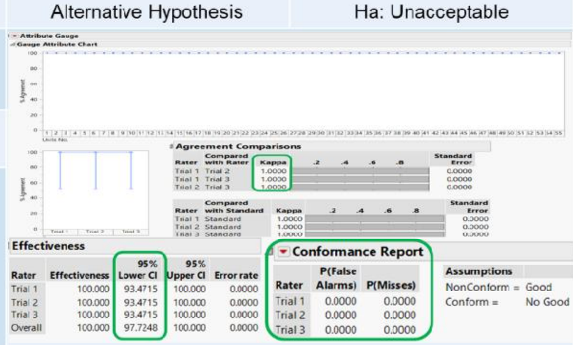


Table 6. New pre-bond inspection settings

Practical Problem	Does New Pre-Bond Inspection setting is effective detection control?		
Y (Key Output)	Insufficient Epoxy	X (Key Input)	Pre-bond Inspection
Unit of Measurement	PPM	True Nature of X	Continuous
Nature of Y	Discrete	Level of X	Ultrabright light with double side light
Null Hypothesis	Ho: Acceptable	Alternative Hypothesis	Ha: Unacceptable
Method of Validation	Validate if the New Pre-Bond Inspection vision system can be still reliable to capture insufficient defect.		
Statistical Test	Attribute Measurement System Analysis		
Statistical Result	Kappa is greater than 0.75 indicating Good PBI inspection. Effectiveness is greater than > 90% acceptable. Over-rejection P(FA) is less than < 5% showing all good units are accepted. Under Rejection P(Miss) is less than < 2% showing all good units are being rejected.		
Decision	**ACCEPTABLE**		



4. CONCLUSION

With the use of Science Principles of Light and Shadow, the issue on un-balance contrast in the Leadframe causing inaccurate detection of Pre-bond inspection was solved. And thru the use Design of the experiment and other statistical tools, an error-proofing solution to use Ultra Bright Light with double sidelight for Pre bond inspection was attained or implemented. Epoxy can be clearly distinguished from the pad, removed the dark shadow and it was validated thru attribute measurement system analysis.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Quentin Brook. Lean six sigma and Minitab: The complete toolbox guide for business improvement; 2014.
2. Paul A. Tipler. Physics for Scientists and Engineers, Vol. 1: Mechanics, Oscillations.
3. Born Max, Wolf Emil. Principles of optics: Electromagnetic theory of propagation, interference and diffraction of light.
4. Joseph Goodman. Introduction to Fourier Optics.
5. Raymond H. Meyers, Douglas C. Montgomery, Christine M. Anderson Cook. Response surface methodology: Process and product optimization using designed experiments, Wiley; 4 Editions.
6. Dan Hart, Bruce Lee, John Ganjei. Increasing IC leadframe package reliability. MacDermid Inc. Waterbury, CT, USA.
7. Christopher Henderson. Info Track Issue 54 of Semitracks Inc. Newsletter; 2013.
8. Die Attach Manual by ASM Pacific Technology. Available:www.asmpacific.com
9. Tadatake Sato, Kenichi Tashiro, Yoshizo Kawaguchi, Hideki Ohmura, Haruhisa Akiyama. Pre-bond surface inspection using laser-induced breakdown spectroscopy for the adhesive bonding of multiple materials National Institute of Advanced Science and Technology (AIST), 1-1-1 Umezono, Tsukuba, Ibaraki, Japan.
10. Digital Microscope Guide Vol. 4 Illumination Methods by Keyence Corporation. Available:www.keyence.com
11. Mitsui Leadframe by Mitsui High-tec, Inc. Fukuoka Japan. Available:www.mitsui-high-tec.com

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