Journal of Engineering Research and Reports

20(9): 13-17, 2021; Article no.JERR.69827
ISSN: 2582-2926

Resolution of Low IMC on Multi-Stacked Dice Device with Different Bond Pads

Freddie B. Folio[1], Roy B. Guingab[1], Frederick Ray I. Gomez[1] and Jonathan C. Pulido[1*]

[1]New Product Development & Introduction, Back-End Manufacturing & Technology, STMicroelectronics, Inc., Calamba City, Laguna, Philippines.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JERR/2021/v20i917370
Editor(s):
(1) Guang Yih Sheu, Chang-Jung Christian University, Taiwan.
Reviewers:
(1) P. Narasimman, Kings College of Engineering, India.
(2) Ilgaitis Prūsis, Riga Technical University, Latvia.
Complete Peer review History: http://www.sdiarticle4.com/review-history/69827

Original Research Article

Received 24 April 2021
Accepted 29 June 2021
Published 30 June 2021

ABSTRACT

The continuing advances of die technology of integrated circuits (IC) miniaturization bringing more complexity in the product. At unusual conditions one may encounter new challenges intrinsic to the structure of the package. The study aims to qualify a product such as multi-stacked dice configurations with baseline reference using same die technology. The only difference is the substrate layout in which defined for the electrical purpose. The challenge is to understand and resolve low intermetallic coverage (IMC) on each die which may lead to manufacturability and reliability problems over time.

Keywords: Bond pad; intermetallic coverage; multi-stacked dice; wirebond.

1. INTRODUCTION

During the evaluation stage wirebond process parameters were challenged. The change of substrate becomes critical as it not comparable to the existing device already manufacturable. Using the problem definition tree, possible root cause was being scrutinized. Fig. 1 shows the low intermetallic coverage or intermetallic compound (IMC) measured on the device in

**Corresponding author: Email: jonathan.pulido@st.com;*

focus. The intermetallic formation between bondwire (or simply wire) of either Gold (Au), Silver (Ag) or Copper (Cu) material to the Aluminum (Al) bond pad is one of the critical factors in measuring the reliability and integrity of wirebonding [1-4]. Worth to note that with the continuing technology trends, challenges in semiconductor assembly manufacturing are inevitable [5-8]. Among the risk factors affecting the low IMC, the main contributors attributed to the failure were identified. First, the amount of heat transfer from heat block to the surface of the bond pad and second, the type of capillary that will match to the device material changes. The new device encountered low IMC that led to the risk mitigation and solution formulation to successfully qualify the product.

2. METHODS AND RESULTS

The target IMC shall be observed accordingly in each die depending on the temperature setpoint given in Table 1. The impact of increasing temperature shall be evaluated. In line with this, the warpage level after strip heat application shall also be also observed and prior the evaluation decision point.

The hypothesis of the capillary structure also affects the IMC performance. There is an alternative capillary available aside from the current control. In Table 2, the other type were included in the evaluation and will observe the intermetallic performance.

Based on the comprehensive data collection at different temperature controls. The impact of bonding temperature has significant effect to the Die 3 IMC performance. Fig. 2 describes the intermetallic at different temperature potential with a p-value (probability value) of 0.0151. In terms of the effect, the lower temperature at 170 degrees Celsius (deg C) has lower effect on intermetallic readings. As temperature increases, IMC increases for capillary A which is the control parameter.

The other capillary potential solution using different bond site temperature are shown in Fig. 3. The impact of temperature were also observed on Die 3. There is a significant effect on the IMC response in each parameter. At p-value of 0.0057, the variation on the spread and location of IMC are visible favorable at 180 deg C. It was observed to have better performance comparing to the other temperature set point.

	IMC		
	Die 1	Die 2	Die 3
1	81.5	75.8	73.7
2	85.5	79.5	72.4
3	83.3	72.5	71.2
4	80.6	76.9	77.3
5	72.8	75.8	68.2
6	79.4	78.5	67.8
7	81.3	76.4	69.4
8	78.6	72.8	79.2
9	79.6	71.8	66.7
10	86.2	70.3	75.3
11	83.7	70.7	64.5
min %	72.8	70.3	64.5
max %	86.2	79.5	79.2
average %	81.1	74.6	71.4
requirement per BPD %	75	70	70
Remarks	Failed	Passed	Failed

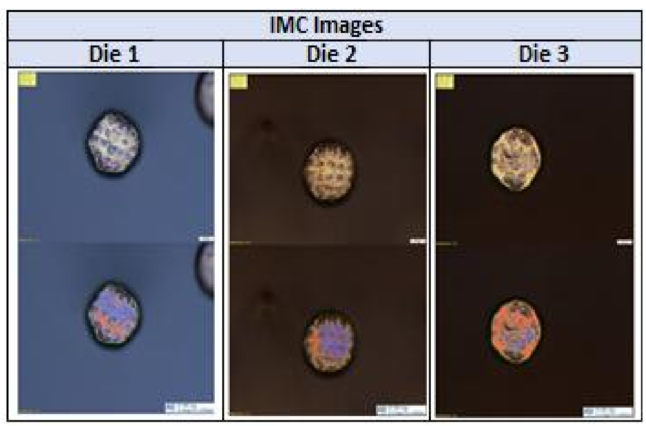

Fig. 1. IMC failure of the device

Table 1. IMC matrix for wirebond heat block temperature

Die	Temperature		
	170 deg C	180 deg C	190 deg C
Die 1	•	•	•
Die 2	•	•	•
Die 3	•	•	•

Table 2. IMC matrix for type of capillary

Die	Capillary	
	Capillary A (control)	Capillary B (new)
Die 1	•	•
Die 2	•	•
Die 3	•	•

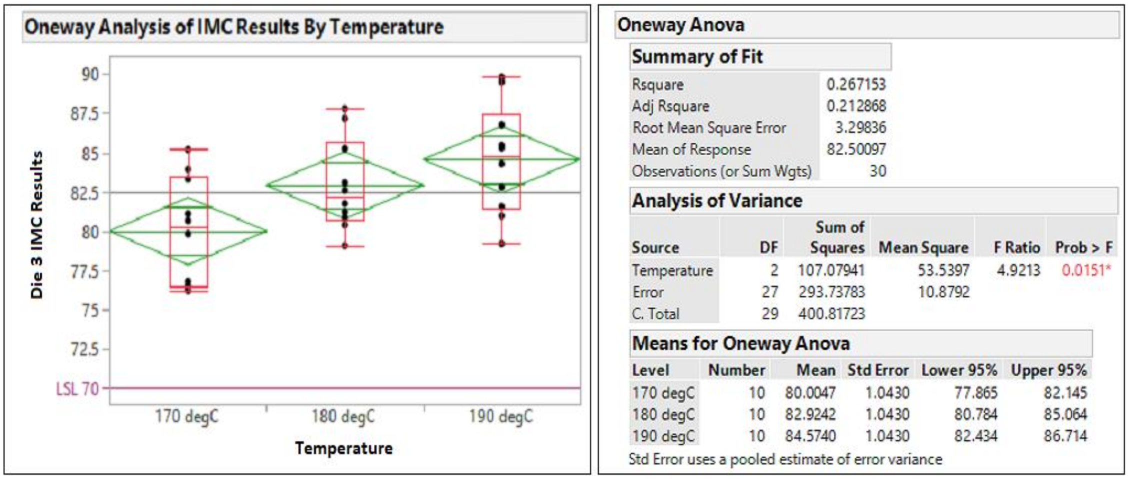

Fig. 2. Capillary A – Die 3 IMC data at different temperature

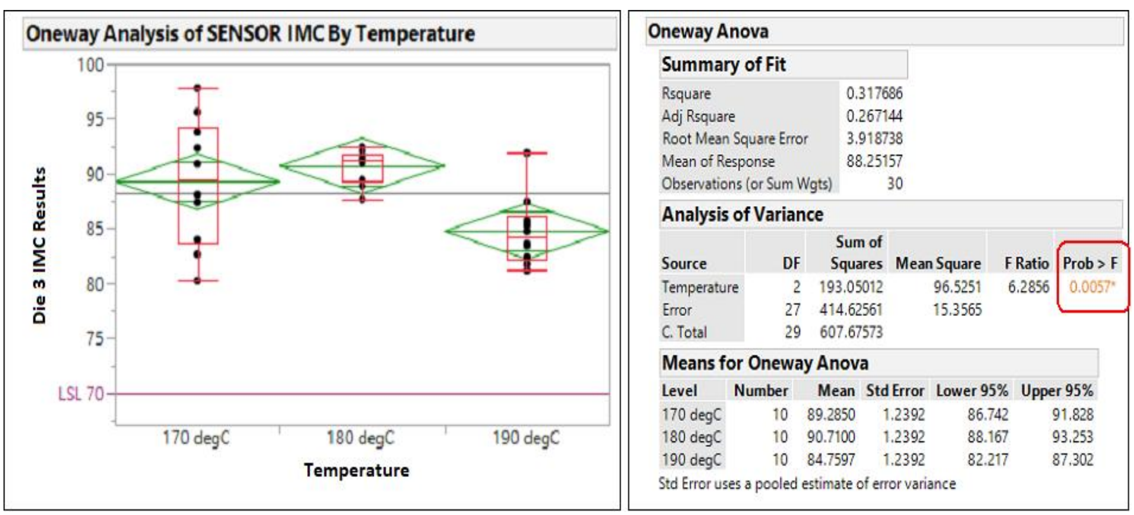

Fig. 3. Capillary B – Die 3 IMC data at different temperature

To determine and identify what will be the best solution to the problem, a statistical comparison between the two capillaries at maximum IMC requirement were analyzed. Fig. 4 describes the best temperature application for the two types of capillary.

Looking at the parameters, it is better to apply the capillary B without any failures on the performance. For the point of manufacturing process control, the higher performance is better. In this case, variation of the location and the spread of IMC data were considered. And the drawbacks of implementing higher side on the unmolded strips may pose threat such as strip warpage in the future. Looking at Table 3, all data favored capillary B.

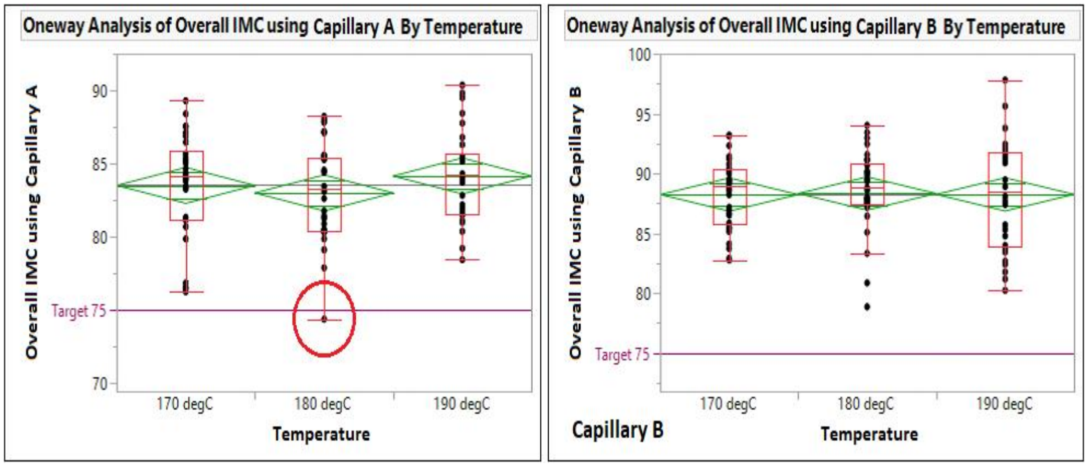

Fig. 4. Capillary A and B overall IMC performance

Table 3. IMC matrix for wirebond heat block temperature and type of capillary

Die	Temperature			Capillary	
	170 deg C	180 deg C	190 deg C	Capillary A	Capillary B
Die 1	Passed	Passed	Passed	Passed	Better
Die 2	Passed	Passed	Passed	Passed	Better
Die 3	Passed	Passed	Better	Passed	Better

3. CONCLUSION

Package robustness can be attained with minimal variability if the key factors involved are thoroughly assessed. For this product, lower IMC response were attributed to the type of capillary and temperature setpoint. The data gathering and statistical analysis made the team concluded for the better parameter to apply. Learnings from the challenges are documented and deployed to the manufacturing group to promote sustainable manufacturing excellence. Moroever, works and studies discussed in [9-12] are useful in reinforcing robustness and optimization of the semiconductor device during wirebond process.

ACKNOWLEDGEMENT

The authors would never get tired of sharing the sincerest gratitude to the New Product Development & Introduction (NPD-I) team, and the Management Team (MT) for the continuous support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Hong SJ, et al. The behavior of FAB (free air ball) and HAZ (heat affected zone) in fine gold wire. Advances in Electronic Materials and Packaging 2001 (Cat. No.01EX506). South Korea. 2001;52-55.
2. Descartin M, et al. Non-continuous IMC in copper wirebonding: Key factor affecting the reliability. 6th International Conference on Electronic Packaging Technology (ICEPT). China. 2015;403-407.
3. Sia J, et al. Elimination of intermetallic coverage over-etching on aluminum pad. Journal of Engineering Research and Reports. 2021;20(7):153-156.
4. Tan CE, et al. Challenges of ultimate ultra-fine pitch process with gold wire & copper wire in QFN packages. 36th International Electronics Manufacturing Technology Conference. Malaysia. 2014;1-5.
5. Nenni D and McLellan P. Fabless: The transformation of the semiconductor industry. CreateSpace Independent Publishing Platform, USA; 2014.
6. Saha S. Emerging business trends in the semiconductor industry. Proceedings of PICMET '13: Technology Management in the IT-Driven Services (PICMET). USA. 2013;2744-2748.

7. Liu Y, et al. Trends of power electronic packaging and modeling. 10th Electronics Packaging Technology Conference. Singapore. 2008;1-11.
8. May GS and Spanos CJ. Fundamentals of semiconductor manufacturing and process control. 1st ed., Wiley-IEEE Press, USA; 2006.
9. Tran TA, et al. Fine pitch probing and wirebonding and reliability of aluminum capped copper bond pads. IEEE 50th Electronic Components and Technology Conference (ECTC). USA. 2000;1674-1680.
10. Pulido J, et al. Wirebond process improvement with enhanced stand-off bias wire clamp and top plate. Journal of Engineering Research and Reports. 2020; 9(3);1-4.
11. Dresbach C, et al. Local hardening behavior of free air balls and heat affected zones of thermosonic wire bond interconnections. European Microelectronics and Packaging Conference. Italy. 2009;1-8.
12. Moreno A, et al. Enhanced loop height optimization for complex configuration on QFN device. IEEE 22nd Electronics Packaging Technology Conference (EPTC). Singapore. 2020;182-184.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/69827