

# Die Attach Process Defect Mitigation through Design Improvement on Anvil Block Tooling

Rennier S. Rodriguez<sup>1\*</sup>, Frederick Ray I. Gomez<sup>1</sup> and Bryan Christian S. Bacquian<sup>1</sup>

<sup>1</sup>New Product Development & Introduction, STMicroelectronics, Inc., Calamba City, Laguna, Philippines 4027

## ABSTRACT

Process improvement through modification in the design of indirect material is one potential direction to improve the productivity during assembly manufacturing. In this paper, an augmented design of anvil block is presented to reduce the crumpled strips, leadframe bending and dents, uneven bonding of die, localized insufficient epoxy, and misaligned die encountered during the conversion and setup stage. The implementation of the augmented design improves the current assembly practice through eliminating the replacement of anvil block that is the cause of misalignment on the indexer handler of the die attach machine. Through this design, the selection of appropriate vacuum hole setup can be through the sliding insert only without pulling out the anvil block from the machine.

*Keywords: Anvil block; assembly; die attach process; leadframe; QFN.*

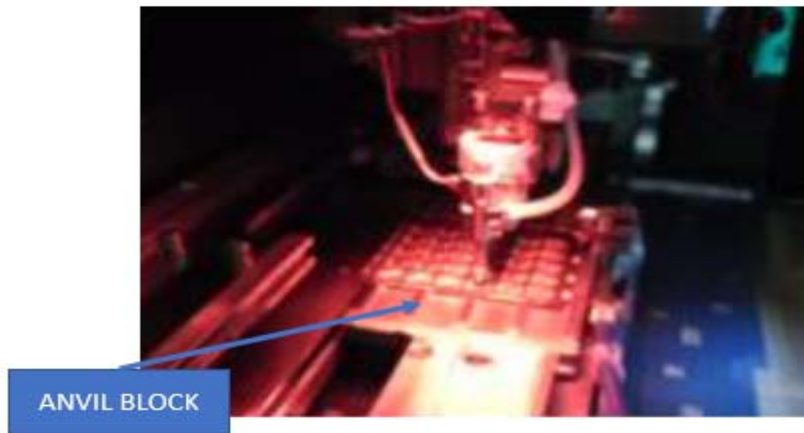
## 1. INTRODUCTION

The application of machine for integrated circuit manufacturing reduced the risk of human intervention while increasing the efficiency of production and in-process controls. Latest die attach machine nowadays has a 50% placement capability improvement from the previous version of equipment with additional capability to automatically inspect and monitor the quality of all the units. Moreover, this translate to a 50-100% improvement, depending of the size of the package undergoing build, for unit per hour output with increased of production yield greater than 99.5%.

However, to attain the optimum performance of the equipment, a setup or machine conversion must be performed properly. The pre-requisite to produce a “machine recipe” for a certain package setup are: 1) programming of wafers and leadframe or substrate which requirement actual dimension, thickness, and position of the references and unit; 2) actual teaching of sensor and pattern recognition based from the leadframe and wafer programs; and 3) indirect material (or IDM) which pertains to the pickup tool, ejector needle assembly and anvil block tooling. Note that with new and continuous technology trends and breakthroughs, challenges in assembly manufacturing exist [1-4].

During IDM setup, in this case the anvil block as shown in Fig. 1, human intervention and judgement is required to complete the job for the device in focus which is a quad-flat no-leads (QFN) leadframe package. The process technician needs to perform the installation of the IDM to the machine based from the package or device requirement. IDM such as anvil block is dedicated according to the dimension and pitching of the leadframe as required by

41 the package (i.e.  $5 \times 5 \text{ mm}^2$ ,  $5 \times 7 \text{ mm}^2$ ,  $6 \times 6 \text{ mm}^2$ ). Upon installation, a manual calibration and  
42 planarity are required on the leadframe handler of the machine. The height of the bondhead  
43 assembly for every unit in a single row is required to be taught in the machine.  
44

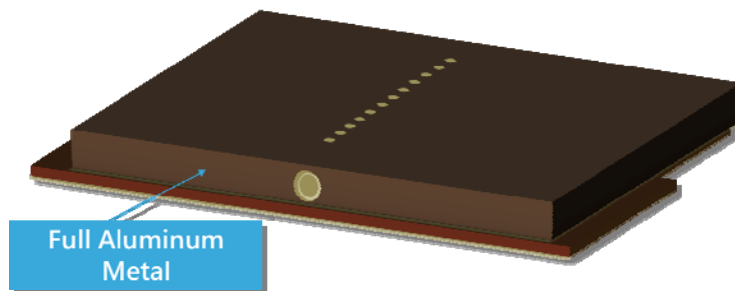


45  
46 **Fig. 1. Actual anvil block**  
47

48 Human interventions in the part of setup procedure are the causes of common assembly  
49 defects such as crumpled strips, leadframe bending and dents, uneven bonding of die,  
50 localized insufficient epoxy, and misaligned die. Opportunity is seen through modification of  
51 the anvil block tooling to provide a design that limits the replacement of anvil block thus  
52 reduced the cycle time of setup and conversion as well. This paper discussed the design of  
53 a flexible anvil block that can cater multiple packages. the design has a sliding process plate  
54 equipped with multiple vacuum holes that can be change depending on the requirement of  
55 the package. Through application of the design, anvil block is not required to be removed on  
56 the machine which secures the planarity between the indexer handler and positively impact  
57 the cycle time of setup and conversion on the machine.  
58

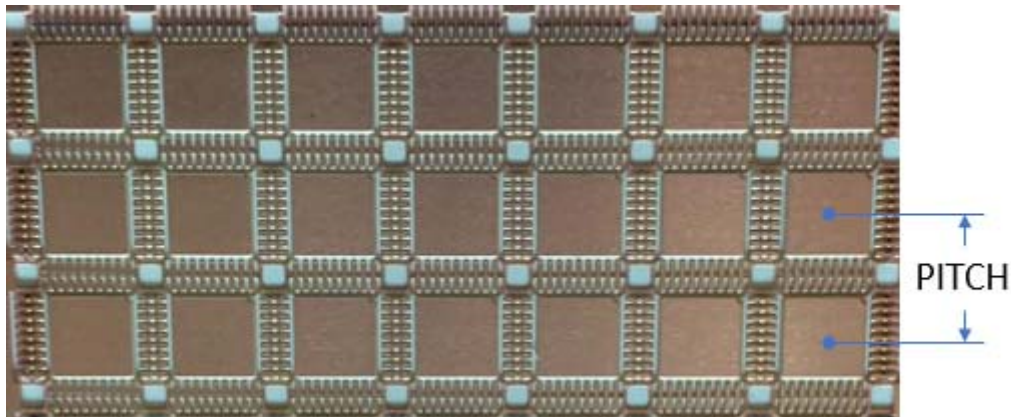
## 59 **2. PROCESS DESIGN AND METHODOLOGY**

60  
61 Die attach machine requires anvil block during dispensing and bonding to hold properly the  
62 leadframe during the process. Anvil blocks are made from metal plates drilled with a defined  
63 array of vacuum hole that is connected to the vacuum supply as illustrated in Fig. 2. The  
64 array of vacuum hole is equivalent to the leadframe pitch or the distance of every device or  
65 unit in a leadframe strip as shown in Fig. 3. In production practices, changing the leadframe  
66 design or pitch requires a dedicated anvil block design.  
67



68  
69 **Fig. 2. Three-dimensional model of anvil block**  
70

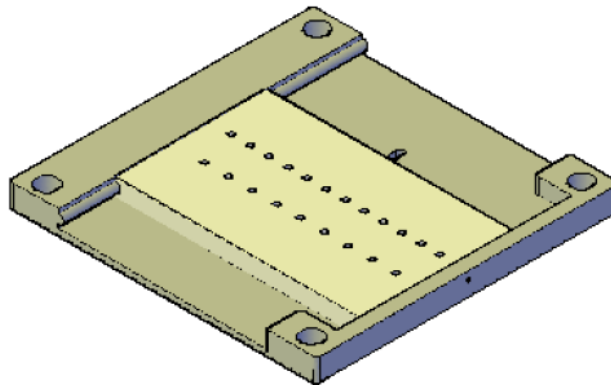
71



**Fig. 3. Unit pitch in a leadframe strip**

72  
73  
74  
75  
76  
77  
78  
79  
80  
81

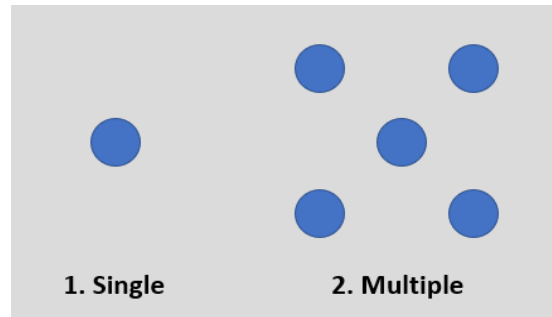
The augmented design of anvil block as shown in Fig. 4 is presented to remove the calibration and planarity procedure same as to reduce the conversion and setup cycle time. The anvil block will not be removed from the indexer, instead the sliding insert can be shifted to select the appropriate vacuum hole array. The sliding insert is composed of multiple vacuum hole that ranges from the different leadframe pitch design.



**Fig. 4. Three-dimensional model of the improved anvil block design**

82  
83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93

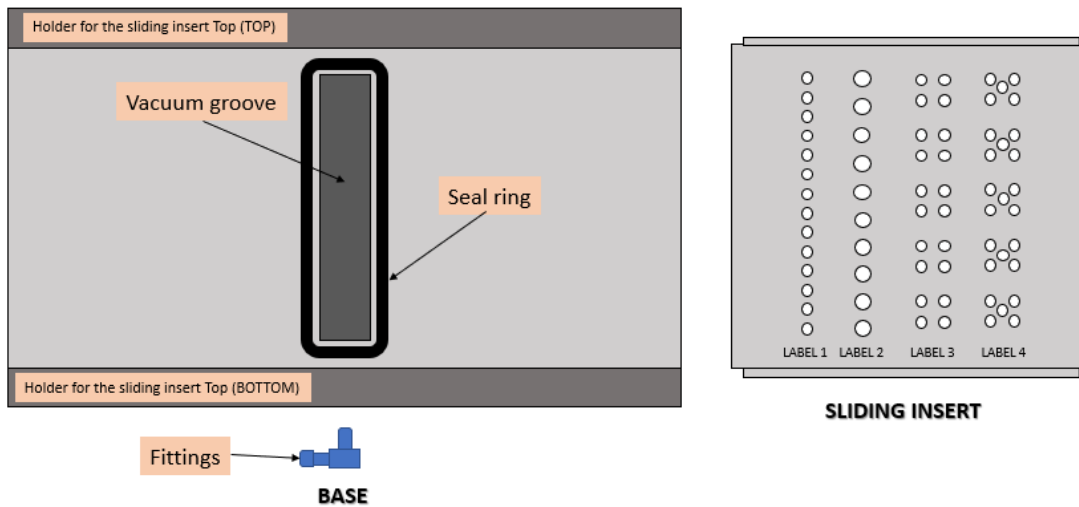
The vacuum hole is located underneath the leadframe pad wherein the diameter and the design of the hole can be modified depending on the size of the pad. Fig. 5 illustrates the different designs of vacuum hole: 1) for single vacuum hole design, the leadframe pad size ranges from 1 to 2.5 mm; and 2) multiple vacuum hole design is implemented to leadframe pad size greater than 2.5 mm. The advantage of compatible vacuum hole setting is to avoid the leadframe from moving when the glue is dispensed on top of the pad. Even glue dispense provides low tilting of the silicon die during die attach process.



**Fig. 5. Vacuum hole design**

94  
95  
96  
97  
98  
99  
100  
101

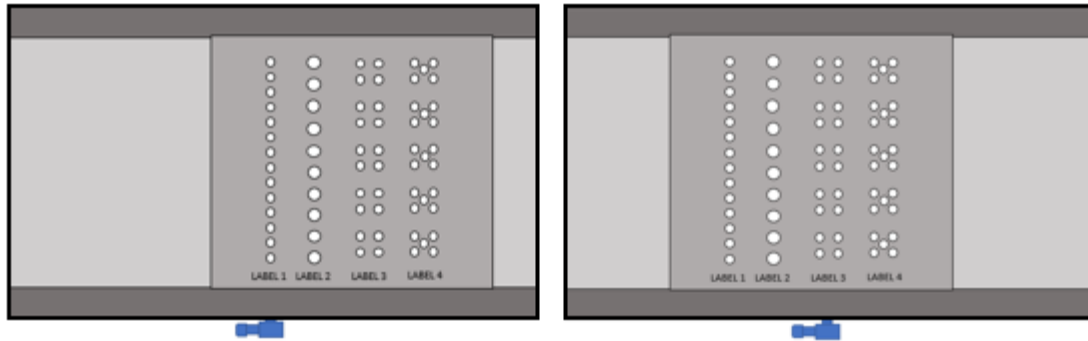
The augmented design of anvil block as depicted in Fig. 6 is composed of two parts: 1) the base assembly, which connects the vacuum supply to the sliding inset; and 2) the sliding insert which is composed of multiple vacuum hole array.



102  
103  
104  
105  
106  
107  
108  
109  
110  
111  
112

**Fig. 6. Augmented design of anvil block**

When the vacuum is supplied to the fittings and vacuum groove, the rubber sealing ring eliminates the escape or leak between the base assembly and sliding inset. The seal ring also avoids loose contact between the sliding insert and base when sliding the insert or selecting the appropriate design of vacuum hole. Note that anvil block and vacuum holes vary with the product and design. Moreover, assembly process flow depends with the product and the technology [5-8].



**Fig. 7. Selectable vacuum holes depending on package design requirement**

The implementation of the improved design of anvil block tooling reduced the cycle time of conversion by 20%. The calibration and planarity check performed during setup is removed and instead calibration is performed quarterly or every preventive maintenance schedule. Through reduction of human intervention, assembly rejections encountered during setup are mitigated.

### 3. CONCLUSION AND RECOMMENDATIONS

The paper discussed a process solution and improvement with the augmented anvil block tooling that significantly improved the handling of QFN leadframe strip during die attach process. The improved anvil block design helped reduce, if not eliminate, the assembly defect during die attach process such as crumpled strips, leadframe bending and dents, uneven bonding of die, localized insufficient epoxy, and misaligned die. Cycle time during setup is also improved.

Although the paper focused on the improvement in the anvil block tooling to address the die attach process related defects, continuous process and design improvement is important to sustain high quality performance of semiconductor products and its assembly manufacturing. Works and learnings discussed in [2, 9-10] are helpful in improving the assembly processes particularly the die attach process.

For future works, it would be useful to show production data or at least the evaluation data before and after implementation of the improved design, for better comparison. Pareto chart of typical defects could be added to highlight the top defects that could be addressed by the anvil block design improvement. Finally, procedure or instruction should be documented for proper use and setup of the tool.

### ACKNOWLEDGMENT

The authors would like to thank the New Product Development & Introduction (NPD-I) team and the Management team for the great support.

### REFERENCES

1. 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.

- 154 2. Xian TS, Nanthakumar P. Dicing die attach challenges at multi die stack packages. 35th  
155 IEEE/CPMT International Electronics Manufacturing Technology Conference. Malaysia:  
156 2012;1-5.
- 157 3. Sumagpang Jr. A, Rada A. A systematic approach in optimizing critical processes of  
158 high density and high complexity new scalable device in MAT29 risk production using  
159 state-of-the-art platforms. Presented at the 22nd ASEMEP Technical Symposium,  
160 Philippines; June 2012.
- 161 4. Liu Y, Irving S, Luk T, Kinzer D. Trends of power electronic packaging and modeling.  
162 10th Electronics Packaging Technology Conference. Singapore. 2008;1-11.
- 163 5. Harper C. Electronic packaging and interconnection handbook. 4th ed., McGraw-Hill  
164 Education, USA; October 2004.
- 165 6. May GS, Spanos CJ. Fundamentals of semiconductor manufacturing and process  
166 control. 1st ed., Wiley-IEEE Press, USA; May 2006.
- 167 7. Nenni D, McLellan P. Fabless: the transformation of the semiconductor industry.  
168 CreateSpace Independent Publishing Platform, USA; April 2014.
- 169 8. Doering R, Nishi Y. Handbook of semiconductor manufacturing technology. 2nd ed.,  
170 CRC Press, USA; July 2007.
- 171 9. Rodriguez R, Graycochea Jr. E, Seguido R, Gomez FR. Die attach process optimization  
172 with enhanced epoxy control on leadframe package. Journal of Engineering Research  
173 and Reports. 2020;14(2);32-37.
- 174 10. Abdullah Z, Vigneswaran L, Ang A, Yuan GZ. Die attach capability on ultra thin wafer  
175 thickness for power semiconductor. 35th IEEE/CPMT International Electronics  
176 Manufacturing Technology Conference. Malaysia: 2012;1-5.