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

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Authors' contributions

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

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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

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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 the package (i.e. 5x5 mm^2, 5x7 mm^2, 6x6 mm^2). Upon installation, a manual calibration and planarity are required on the leadframe handler of the machine. The height of the bondhead assembly for every unit in a single row is required to be taught in the machine.

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

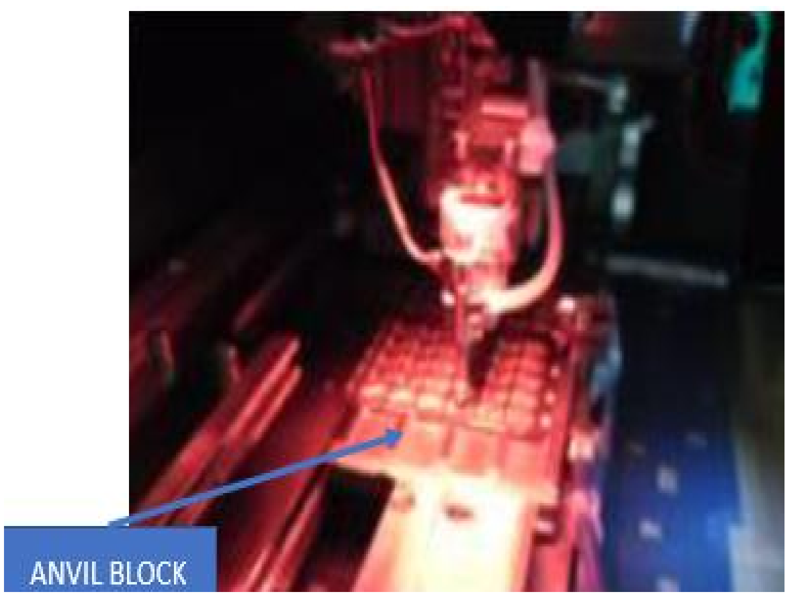

Fig. 1. Actual anvil block

2. PROCESS DESIGN AND METHODOLOGY

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

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.

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.

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.

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 insert. 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].

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.

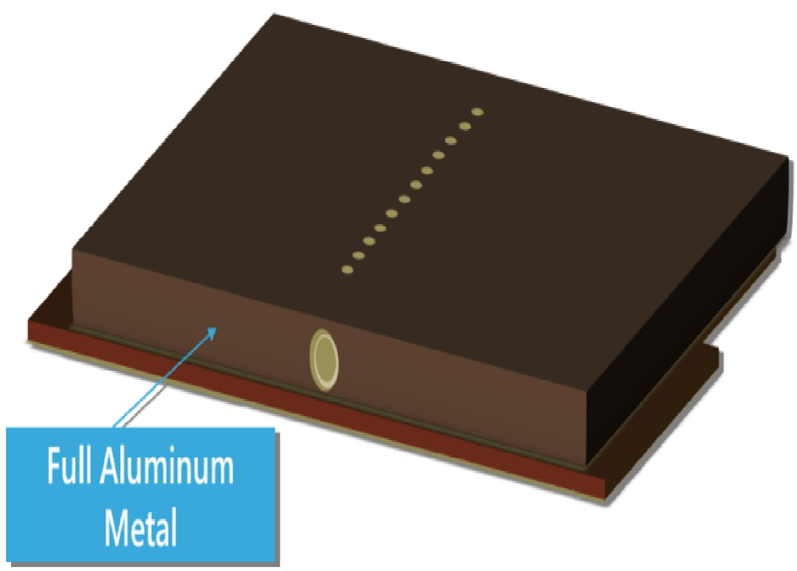

Fig. 2. Three-dimensional model of anvil block

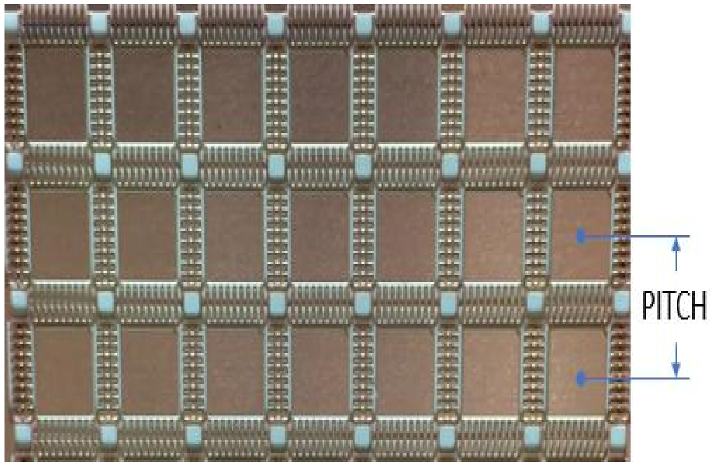

Fig. 3. Unit pitch in a leadframe strip

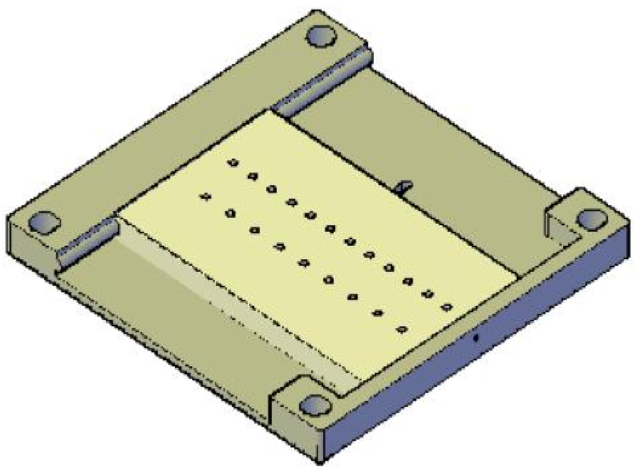

Fig. 4. Three-dimensional model of the improved anvil block design

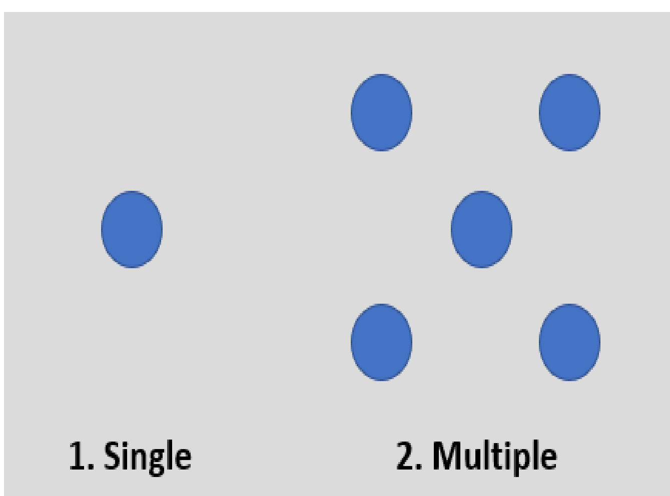

Fig. 5. Vacuum hole design

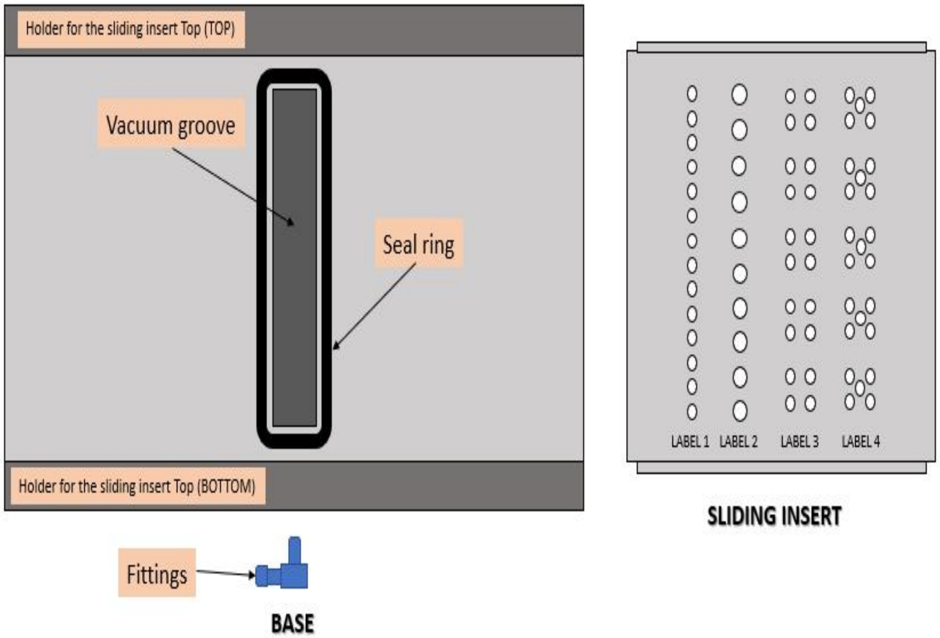

Fig. 6. Augmented design of anvil block

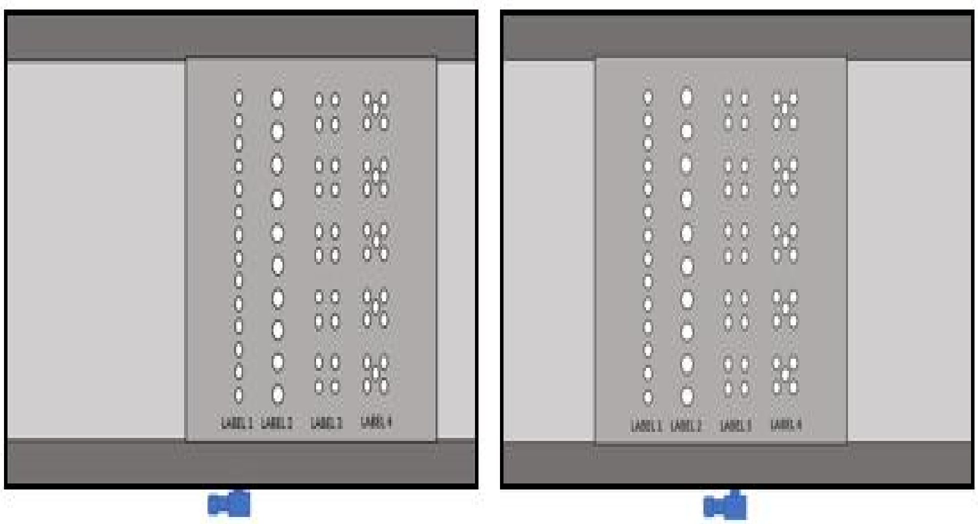

Fig. 7. Selectable vacuum holes depending on package design requirement

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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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