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A Study of Dispense Needle for Die Attach Voids Mitigation

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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

The need of data storage devices and new technologies continues to grow with more robust and stable functioning capability. With that, improvement and utilization never stop for a seamless output. One device that is currently on new product introduction is a quad-flat no-leads (QFN) utilizing a tapeless leadframe technology. The new device used highly conductive glue with metal spacer and has experienced gross glue voids defect parts per million (ppm). Glue voids were measured for cumulative voids criteria, with values higher compared to the specification. The study used analysis of variance (ANOVA) on the dispense needle diameter and revealed the effect levels of needle diameter on cumulative voids reduction. For subsequent works, the configuration could be applied for packages with similar requirement.

Keywords: Die attach process; QFN; dispense needle; glue voids.

1. INTRODUCTION

Semiconductor technologies such as the quad-flat no-leads (QFN) leadframe technology are continuously development and improved to support varying customer requirements. Common direction of semiconductor companies is to increase the production yields and quality while

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minimizing the wastage and assembly rejections during manufacturing. For this study, a 5 x 5 mm semiconductor package with a die size of 2 x 2 mm is identified to be critical due to the high occurrence of die attach glue voids or the presence of gap or empty spaces inside the adhesion material that is created before or after the die attach cycle. When glue is subjected to higher temperature, resins or volatile material escapes from the glue at a certain degree of temperature reducing its mass. With the reduction of mass, the behavior of the glue is to collapse or reduced its volume. since the die is sitting on top of the spacer, it is stopped from moving together with the direction of the shrinkage and empty spaces is created in this manner. Figs. 1 and 2 illustrates the glue voids during die attach curing cycle.

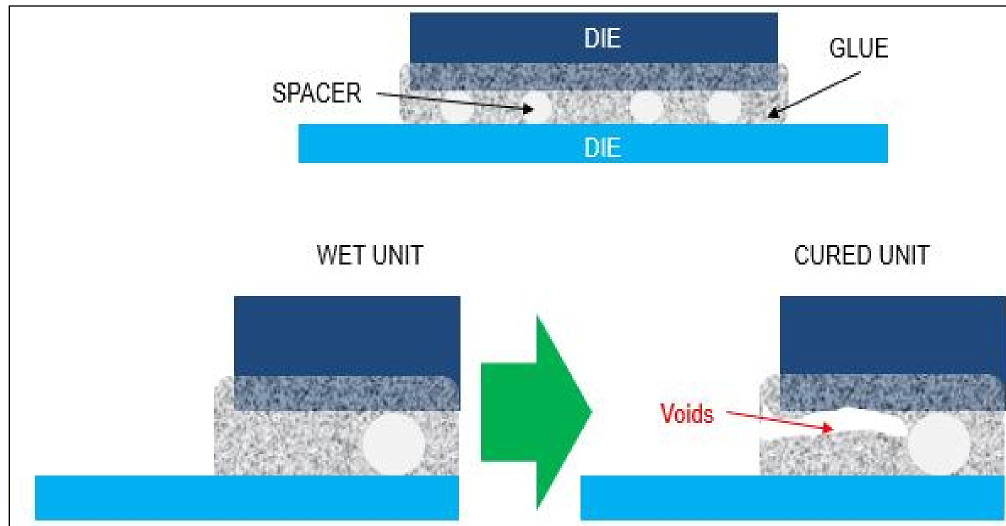

Fig. 1. Glue voids formation

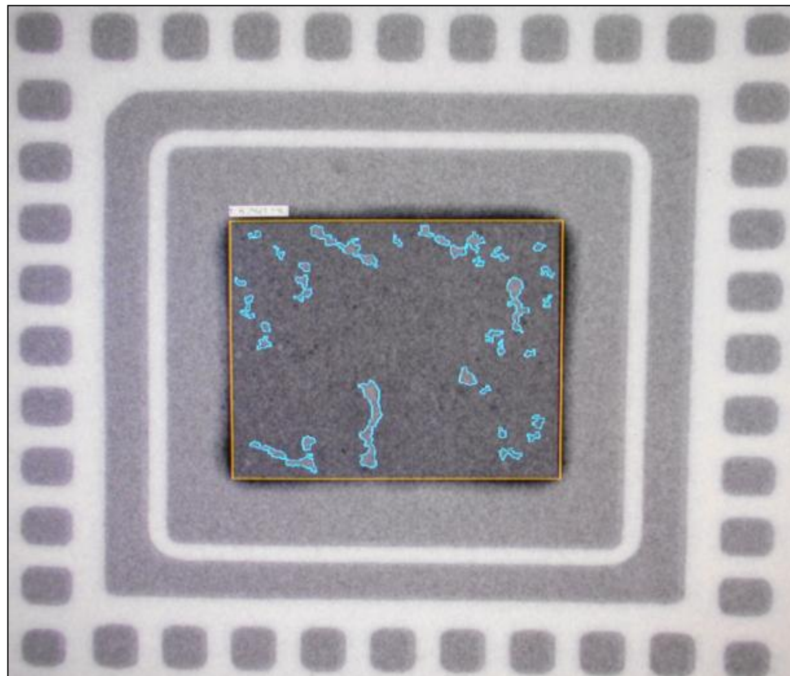

Fig. 2. Actual die attach glue voids

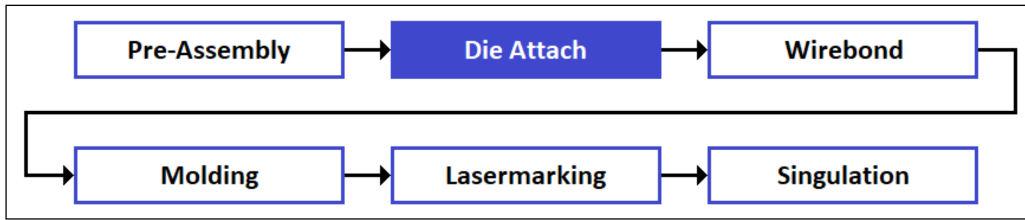

Fig. 3. Assembly process flow

2. LITERATURE REVIEW

A typical assembly process flow is given in Fig. 3 highlighting the critical process in focus. Important to note that process flow changes with the product and the technology [1-2]. Moreover, with new and continuous technology trends and breakthroughs, challenges in assembly manufacturing are inevitable [3-5].

Die attach or diebond is the process of attaching a semiconductor die either on a leadframe or in the substrate carrier. The method of attaching the die to a carrier is formed using the sequence: 1) the ejector needle ejects-up the semiconductor die from the wafer tape; 2) the rubber tip picks the die from the needle; 3) the picked die is placed on the already dispensed substrate and leadframe; 4) the bonding height is determined by the bonding parameter together with the dispense configuration [6]. Glue die attach uses the epoxy glue as the main adhesive to attach the die. The dispensing of glue on the pad of leadframe or substrate is done using a volumetric type dispenser. Based on the standard operating procedure, the shaped and condition of the glue is determined by the interaction of dispensing parameter, indirect material and glue type [7].

Delamination in semiconductor plastic packages often happens in many interfaces within the package itself, which is mainly caused of the coefficient of thermal expansion (CTE) between interfaces of two materials within the package [8]. Die attach delamination in a quad flat no-lead single row is the separation of die attach adhesive to silicon die and leadframe paddle. Die attach delamination will reduce the total contact area of silicon die to the leadframe die paddle and it will increase the package thermal resistance that could lead to early thermal shutdown of the device which uses and expose paddle dissipate heat [8].

3. METHODOLOGY

In this study, dispense needle diameter was evaluated in the design of experiment (DOE). Using the defined test vehicle, the evaluation would define the correct needle diameter that can be used in succeeding evaluations. This will be measured using a control limit for cumulative voids as defined by the internal specification and work instruction [9]. The defined needle diameter will be used and implemented to die attach machine platforms for succeeding studies.

The data gathering flow is described in Fig. 4. The 8” wafer is taped to protect the front side layer during back lap or wafer back grinding. The wafer will be grinded into 280 µm final die thickness. The diced wafer is transferred to die attach for set-up and optimization, then the bonded unit will be measured according to the required metrics.

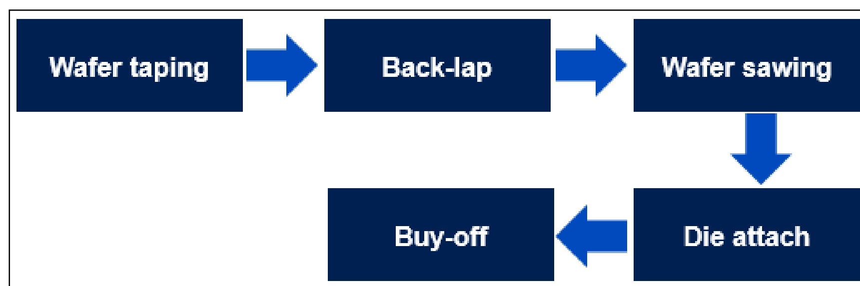

Fig. 4. Data gathering flow

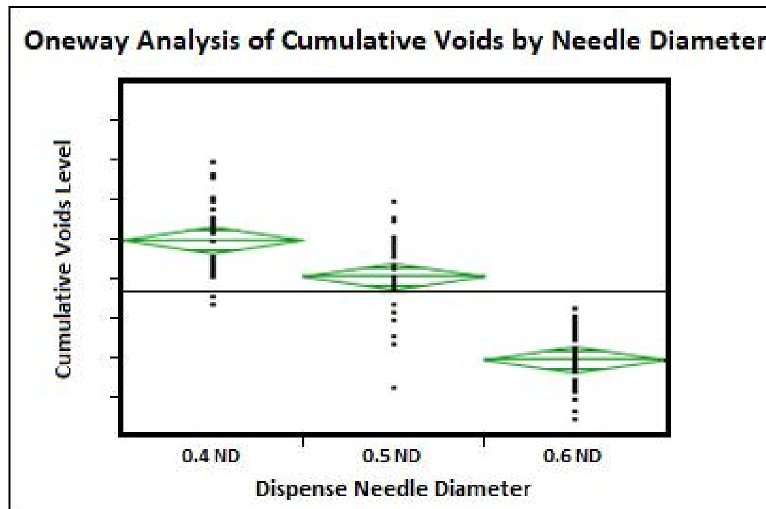

Fig. 5. Statistical analysis of varying needle diameter in terms of cumulative voids

4. RESULTS AND DISCUSSION

The experiment is focused on the response of the die attach dispense needle on the glue voids. Analysis of variance (ANOVA) in Fig. 5 indicates that dispense needle diameter is correlated in the amount of glue and the shape of the dispensed epoxy on leadframe. Note that actual values are intentionally not shown for confidentiality. By varying the diameter of the needle, a reduction in cumulative voids by 66% was achieved. However, 0.6 needle diameter (ND) is highlighted with rejection on epoxy contamination due to fillet height and epoxy splattering therefore 0.5 ND is fixed and recommended as the ideal dispense needle. Needle diameter is correlated to the size, shape and volume of the dispensed glue (epoxy pattern). The greater the volume, a higher BLT range is achieved. In this specific problem, a higher BLT than the spacer diameter provides allowances during the shrinkage of the glue. The bondhead assembly of the die attach machine uses contact sensor during the die attach process. As soon as the bondhead reaches the peak height of the glue, it triggers the sensor. A higher BLT can be achieved if there is higher volume of the glue.

Based on the evaluation, 0.6 ND showed the best result in terms of voids reduction. However, as earlier stated, there are epoxy contamination seen in the study using 0.6 ND which is not acceptable in process point of view. Note that he contamination on the needle such as dried epoxy residue may block the passage of the epoxy during dispensing which may result to intermittent epoxy response. it is advisable to achieve consistent shape of the dispensed glue to maintain even BLT height. In this case, 0.5 ND showed a balance response between voids reduction and no epoxy contamination. Practically, 0.5 ND is the best option.

5. CONCLUSION AND RECOMMENDATIONS

The study discussed the improvement done to mitigate the occurrence of cumulative voids on small package with highly conductive glue with spacer. Varying the diameter of the dispense needle provides a reduction in cumulative voids by 66%. Through implementing correct target criteria, the occurrence of voids is brought down to zero. In addition, the applications of the new control in die attach positively affected other responses such as die shear strength improvement and passing package reliability result.

For succeeding works and studies, the configuration could be considered as a reference in handling specific semiconductor packages at diebond process. A comparison of this study should also be made with other works in the same field. Discussions and learnings shared in [10-13] are helpful to improve the assembly processes particularly the die attach process. It is also recommended that the die attach process observe proper electrostatic discharge (ESD) controls. Works highlighted in [14] are useful to help ensure appropriate ESD check, controls, and improvement.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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