



# Die Attach Machine Selection for Glue Voids Reduction Performance

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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 paper is focused on the glue voids reduction of quad-flat no-leads (QFN) devices evaluated on different die attach machine platforms. The evaluation was narrowed-down into two main die attach machines with the objective of attaining the best performance in terms of reducing or eliminating the glue voids. Glue voids were quantified and only die attach Machine B was able to satisfy the specification. The study used analysis of variance on the two machines and presented the effect of machine selection on glue voids reduction. For future works, the selected die attach machine could be used for devices with critical requirement.

**Keywords:** Die attach process; leadframe; glue voids; assembly; QFN.

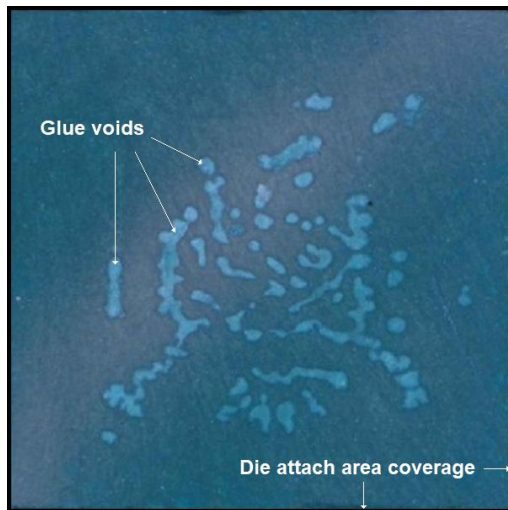
## 1. INTRODUCTION

Quad-flat no-leads (QFN) leadframe packaging technologies are continuously developed and improved to deliver high quality and robust

products for various applications. A common direction of semiconductor manufacturing companies is to increase the production yields and maintain high quality while minimizing the wastage and assembly rejections. With new and

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continuous technology trends and breakthroughs, challenges in assembly manufacturing are inevitable [1-4]. In this paper, a QFN device is identified to be critical due to the high occurrence of glue voids. When the glue is subjected to higher temperature, resins or volatile materials escape 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 reduce its volume. Due to many factors in the process, equipment and materials, glue voids could be unnecessarily formed. Voids or gaps inside the glue are created before and/or after the die attach process cycle. A sample image of glue voids is shown in Fig. 1 in reference to the region of interest which is the silicon die area or the die attach area coverage.



**Fig. 1. X-ray image example of glue voids**

## 2. REVIEW OF RELATED LITERATURE

Assembly process flow for QFN device is shown in Fig. 2 highlighting the assembly process in focus. Important to note that assembly process flow changes with the product and the technology [5-6]. Also as previously mentioned, new technologies and breakthroughs bring along its many challenges.

Die attach assembly process is the method of attaching a silicon die or multiple dice on a leadframe 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 leadframe; 4) the bonding height is determined by the bonding parameter together with the dispense configuration. Glue diebonding uses the epoxy glue as the main adhesive to attach the die. The dispensing of glue on the pad of leadframe is done in a cross pattern 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.

Glue voids occurrence are critically monitored as this may lead to package delamination. Delamination in semiconductor 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 [7]. Die attach delamination in QFN is the separation of die attach adhesive to silicon die and leadframe die paddle. Die attach delamination would reduce the total contact area of silicon die to the leadframe die paddle and would increase the package thermal resistance that could lead to early thermal shutdown of the device.

## 3. METHODOLOGY

The QFN device was evaluated on two different die attach machine platforms for glue void occurrence performance. Machine A is an older version that can only meet the glue's bond line thickness criteria of less than 25  $\mu\text{m}$  with a dispensing technology of volumetric dispense. In contrast, Machine B is capable to achieve a higher bond line thickness with the pneumatic dispensing technology wherein the volume of epoxy could be controlled through pressure.

The data gathering flow is defined in Fig. 3. The wafer is taped to protect the front side layer during backlap process. The wafer is then grinded to 280  $\mu\text{m}$  final die thickness. The sawn dice of 2.2 x 1.9  $\text{mm}^2$  die size taped in wafer ring are later transferred to die attach station for setup and optimization. The bonded units are then subjected to x-ray imaging for glue voids measurement.

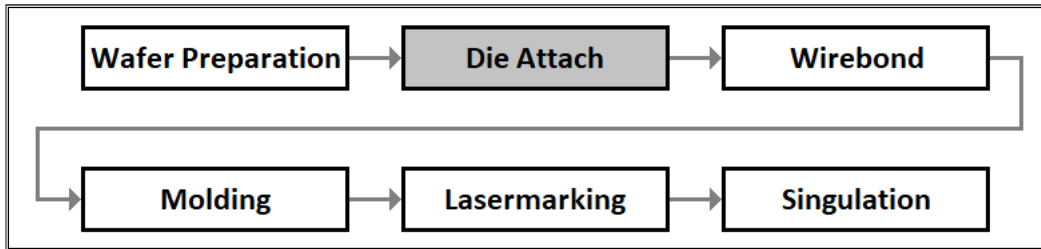


Fig. 2. Assembly process flow highlighting the process in focus

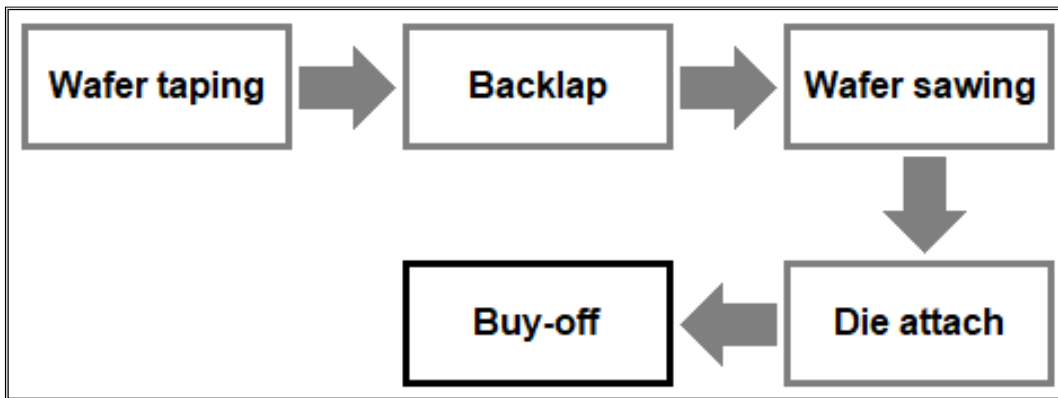


Fig. 3. Data gathering flow

#### 4. RESULTS AND DISCUSSION

Glue voids are gaseous elements trapped inside the unit level after die attach process. Using x-ray inspection machine, large amount of glue voids is seen on Machine A, while Machine B produced an average of 0.8% voids only. Fig. 4 shows the analysis of variance on the glue voids

occurrence of the two machine platforms with 30 samples each. The All Pairs Tukey-Kramer test is used to show and find means that are significantly different to each other. And visually it shows in the graph that there is significant difference on the two die attach machines with regards to the glue voids occurrence reduction performance.

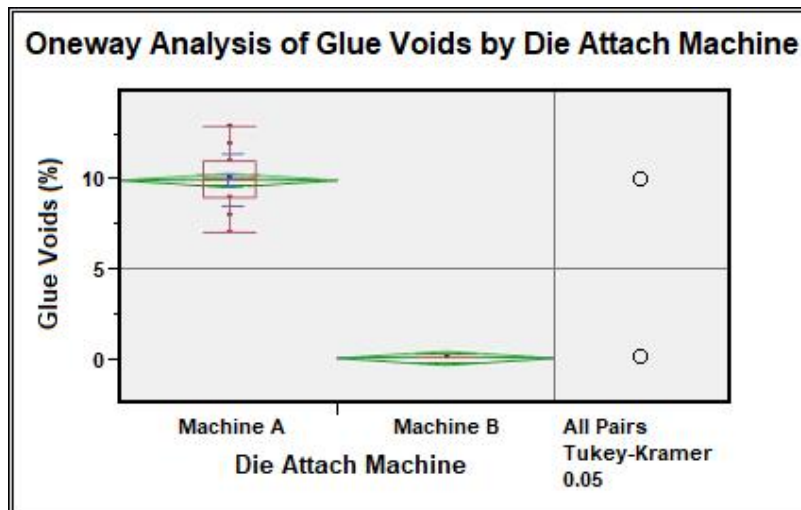
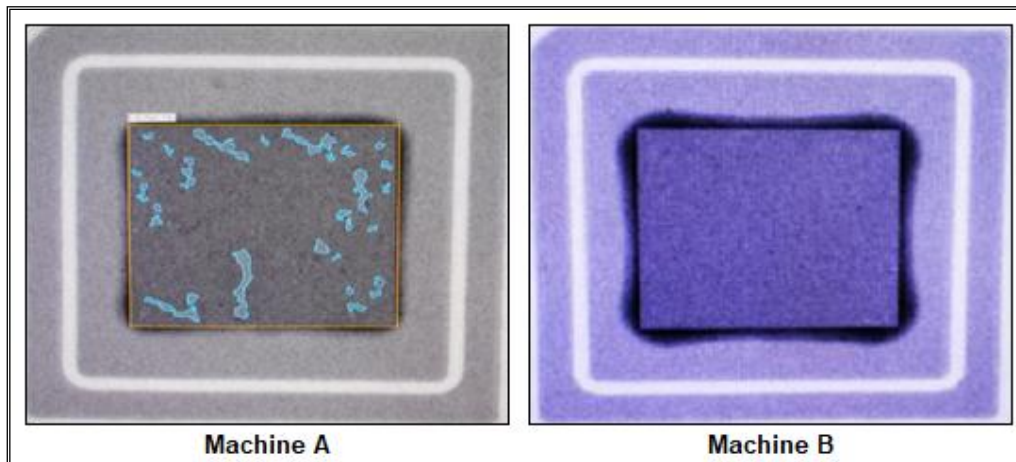


Fig. 4. Statistical analysis of glue voids occurrence on two die attach machines



**Fig. 5. Glue voids x-ray image result comparison**

Based on the results, Machine A failed on controlling the glue voids with 9.87% mean versus the target specification of 5% for glue voids defined in the assembly internal specification [8]. Note that glue voids are measured or quantified automatically by the built-in measuring tool of the x-ray visual inspection machine. Normally, the measurement is based on the amount of anomalous or non-conforming contrast of pixels with respect to the region of interest as highlighted in Fig. 5. Machine B was able to eliminate the glue voids as seen also in the x-ray image comparison with Machine A.

## 5. CONCLUSION

The paper discussed the evaluation of different machine platforms to realize an acceptable or minimized glue void occurrence on QFN devices. In this study, it has been shown that Machine B has significant improvement in the glue voids reduction performance, capable of zeroing out the glue voids occurrence. Machine B is also capable of processing glue with higher bond line thickness. Higher bond line thickness creates more clearance for the shrinkage of the glue, therefore, eliminating the glue voids and realizing a robust package.

## 6. RECOMMENDATIONS

Based on the study, Machine B platform and its configuration could be used as a reference in handling QFN packages with critical requirement at die attach assembly process. Works and learnings shared in [1,9-11] are helpful to improve the assembly processes particularly the die attach process. Die attach machines could

also be evaluated based on the reliability performance of the device. Future studies could include the thermo-mechanical strains due to CTE mismatch which occur when the glue is subjected to high temperature.

## 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.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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