



Glue Voids Reduction on QFN Device through Material and Process Improvement

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Authors' contributions

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

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ABSTRACT

The paper is focused on the glue voids reduction on critical semiconductor quad-flat no-leads (QFN) device processed on a stencil printing type of die attach machine. Process optimization through material preparation improvement was done to mitigate the silver lumps of the sintering glue which is a main contributor on the voids occurrence. Eventually, the glue voids were reduced to less than the allowed 5% limit. For future works, the learnings and configuration could be used on devices with similar requirement.

Keywords: Die attach process; glue voids; QFN; stencil printing.

1. INTRODUCTION

The process of stencil printing materialized in QFN leadframe package assembly during the epoxies has high thixotropic index characteristic which is the ability of the glue to oppose

introduction of sintering epoxies wherein the normal dispensing and bonding process is not capable to produce consistent fillet height and bond line thicknesses: the highly sintering spreading to the surface of the leadframe. In addition, this material is also very viscous which

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create uneven dispensing pattern when using standard pneumatic dispenser. This became a challenging behavior of the glue during its introduction stage. Worthy to note that with new and unending technology trends and breakthroughs, challenges in assembly manufacturing are inevitable [1-4].

The application of glue stencil printing to the construction of QFN packages is the newest technology in terms of thin silicon die bonding. The highly silver-filled glue is deposited to the leadframe or carrier through the defined stencil openings to create a desirable printing design wherein a thin silicon die can be attached through die bonding or die attach process. However, premix sintering glues is often experienced with lumps of silver flakes that are visible after the material is thawed. Thawing is a term used in material preparation that pertains to the time span where an epoxy releases the moisture from the material. The manifestation of glue scrapping is correlated to the silver lumps found on the sintering glues wherein it is the root cause of "glue voids" as exemplified in Fig. 1 within the die bonded units.

The glue voids originate from the glue canal formed when a silver lumps (with a diameter more than the thickness of the stencil) is dispensed by the squeegee during printing as illustrated in second item of Fig. 2. The trapped air or voids is formed when a silicon die is bonded on top of the printed glue since there is no exit for the entrapped air in the material thus this will be carried out until the unit is cured.

This paper discusses the series of evaluation done to eliminate the formation of silver lumps. Through different evaluation results, the application of centrifugal mixing has the significant impact in eliminating the silver lumps which is the root cause of glue voids.

2. METHODOLOGY

Glue voids is a critical reject monitored during QFN assembly due to its potential impact in the integrity and quality of the product. This reject is controlled normally less than 5% of the total area of the silicon die to limit its detrimental effect during reliability and functionality test. Specification (or spec) limits for glue voids are governed by assembly quality specification and work instruction [5].



Fig. 1. Sample image of glue voids

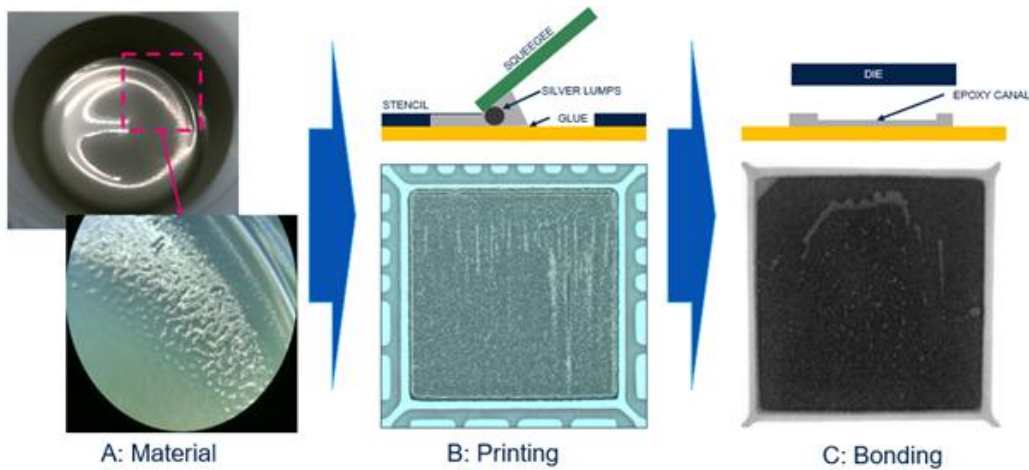


Fig. 2. Sintering glue

During the development of the QFN device in focus using printing process, glue voids is one of the die attach process challenges that became the main barrier for the device's qualification. Process mapping shown in Fig. 3 was done to analyze the defect occurrence. Important to note that assembly process flow changes with the product and the technology [6-7]. And as earlier mentioned, with new technologies and breakthroughs comes along its many challenges.

Different irregularities were found in each process step. The elimination of silver lumps during material preparation is the primary interest to be resolved since it may be the real root cause for glue voids found after die attach cure. Upon careful assessment of the matter, a centrifuge mixer is introduced during material preparation. A centrifuge mixer is a machine capable of redispersing the silver flakes through rotational motion and revolution. The purpose is to breakdown lumps of silver during thawing stage to create an even printing of glue.

A workability trial is suggested and pursued. Included in this request is to incorporate a centrifuge mixer between material preparation and printing process to assess the significant impact of the centrifuge mixer and measure its performance. On another set of trial, centrifuge mixing is not required. On Trial 1, after the glue undergone centrifuge mixing, the irregularities or silver lumps found on the incoming samples became not visible, as shown in Fig. 4. The measurement used is visual inspection only since the irregularities is obvious on naked eye.

3. RESULTS AND DISCUSSION

The two sets of jar of epoxies undergone printing and die bonding process using similar set of machine parameter and condition. As observed on the x-ray results in Fig. 5, voids is still evident on both trials however an acceptable voids with measurement of less than 5% is observed on Trial 1 (with centrifuge mixing) and voids greater than 5% is encountered on Trial 2 (without centrifuge mixing).

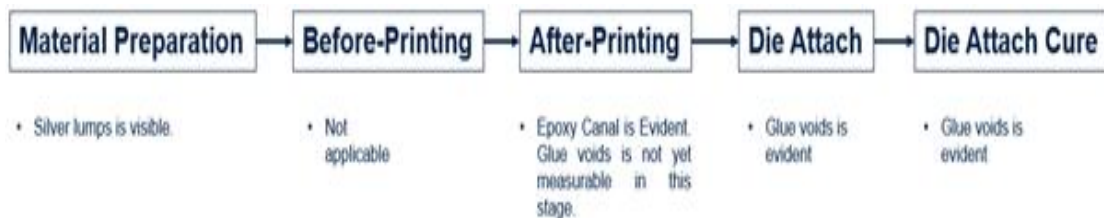


Fig. 3. Process mapping



Fig. 4. After centrifuge mixing

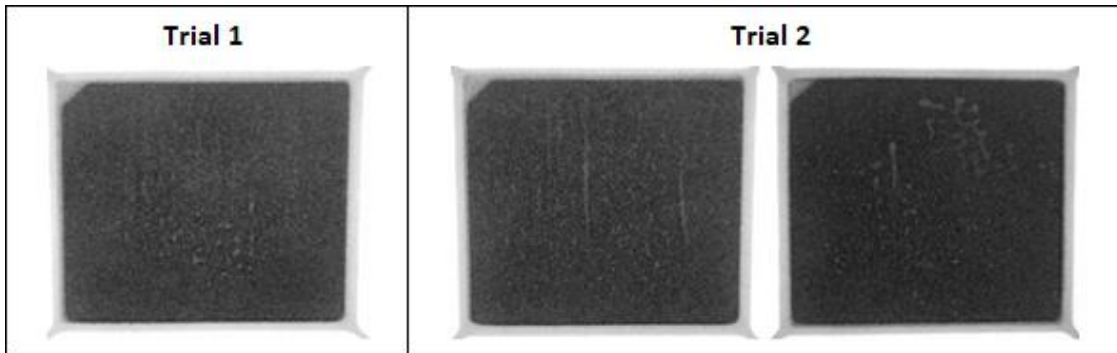
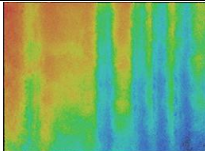
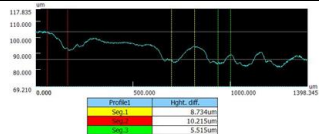



Fig. 5. X-ray photos of glue voids

Table 1. Glue canal profile

Squeegee	Glue profiler	Height difference	Scrapping signature
Installed at die attach machine			

The voids observed on Trial 2 shows similar signature with the glue canal observed before print as depicted in Table 1. The depth of the glue canal has a height difference of 8-10 microns along a single print.

From the result of both trials, using centrifuge mixing has a positive impact on the printing behavior of the glue. The irregularities such as silver lumps observed on the incoming material is significantly reduce thus it reduces the voids manifestations as well on the units. Also proven in this trial is the correlation of silver lumps and printing condition of the glue. Silver lumps is a

potential root cause of having glue voids since it produces canal on the printed glue.

4. CONCLUSION AND RECOMMENDATIONS

The work discussed the evaluations and improvement done to mitigate the occurrence of silver lumps on the sintering glue, which eventually led to the reduction of glue voids. The learnings presented on this paper could be considered as a reference for succeeding works and studies in handling critical QFN packages at die attach process.

A comparison of this study is recommended to be done with other works in the same field. Chemical characterization of the precursors used for glue making should be analyzed. Effect of centrifugation could also be studied. Other microscopy techniques such as the scanning electron microscopy (SEM) could be used for better view of voids images. Lastly, discussions and learnings shared in [8-10] are helpful to improve the assembly processes particularly the die attach process.

DISCLAIMER

The products used for this research are commonly and predominantly used 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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