# Glass Die Ink Marking Media Selection for a Robust Glass Attach Process

**Jerome Dinglasan[1*], Aiza Marie Agudon[1] and Frederick Ray Gomez[1]**

[1]*Back-End Manufacturing & Technology, STMicroelectronics, Inc., Calamba City, Laguna, 4027, Philippines.*

***Authors' contributions***

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

***Article Information***

*Original Research Article*

## ABSTRACT

Glass material used on a semiconductor device for isolating currents are one of the new breakthroughs of the modern world. Challenges are inevitable due to its complex characteristics and unique appearance. The study focuses on the phenomenon of reject glass die unrecognized, picked and bonded by die attach machine on good units of the semiconductor quad-flat no-leads (QFN) device in focus. This QFN device utilizes glass die as interposer on two active dice that separates the dielectric current of each die. During die attach process, machine photo recognition system failed to recognize and detect the glass die reject marking due to its unique transparent design and will be attached on good units. Thus, resulting to gross rejection and low process yield. Practical solutions to prevent the said phenomenon are simulated and determined by performing selection of variables like the contrast of the reject mark related to the product structure and compatibility through statistical analysis. The improvement drives to promote process robustness and scrap reduction that will help the manufacturing to be competitive through innovative resolutions on problems.

*Keywords: Die attach process; glass die; ink marking; QFN; photo recognition system.*

---

*\*Corresponding Email: jerome.dinglasan@st.com;*

## 1. INTRODUCTION

Semiconductor companies had been dedicated to continually drive its manufacturing process into innovation and robustness. Different methods and techniques of continuous improvement are introduced in a way that all aspects of manufacturing are met and sustained. Good manufacturing indicators from process yield, equipment efficiency, up to optimal quality performance and customer satisfactory products are considered. Among these semiconductor products is the quad-flat no-leads (QFN) device in focus that has been produced by manufacturing plants for power and industrial applications. Singulated die from silicon wafer with circuit embedded is mounted on a leadframe and will be interconnected by a gold and copper wire to distribute required current flow. Then encapsulation will follow to secure and protect the product during its application on electronic power and industrial devices.

This product also includes glass die, that serves as an insulator, and restricts the electric current of another silicon die. As seen in Fig. 1 the product's structure is design with die-to-die stack-up, or die is placed on top of another die as a design to serve its specified purpose. This product undergoes multiple dice attach processes from their aliases named power die, (1) mother die, (2) glass die (3) and daughter die (4). Included also on the structure is a glass die between the mother and the daughter die.

During die attach of glass wherein die attach machine picks the glass from the wafer and place it on the top of die 2, certain issues were encountered by the production line that result to gross rejection and machine downtime. This is caused by reject glass used and attached on good units. reject glass die on wafer have ink marking that serves as an indicator of bad die. Markings were placed prior use on assembly by the glass wafer manufacturer because of the glass wafer's yield. The yield is defined as the good units remained after inspecting or testing all units from the wafer. Bad dice will be not removed instead will be marked using a black marker as a default color. This practice has been used on different manufacturing plants on their assembly process. With the unique transparent appearance of the glass die, this reject marking induces recognition problems on the die attach machine's photo recognition system (PRS). Studies and learning related to PRS system are discussed in [1-5]. Moreover, works and discussions on the glass die are shared in [6-10].

The actual appearance of the black marking that can be distinguished by naked eye is shown in Fig. 2. But in the machine, it is almost unrecognizable as the marking blends on the glass die contrast as seen in Fig. 3. Therefore, it will be recognized as good glass die and will be picked and attached on the good units. to resolve this phenomenon, an experiment will be considered, and statistical analysis will be performed to address the occurrence of picking reject glass to be placed on good units.
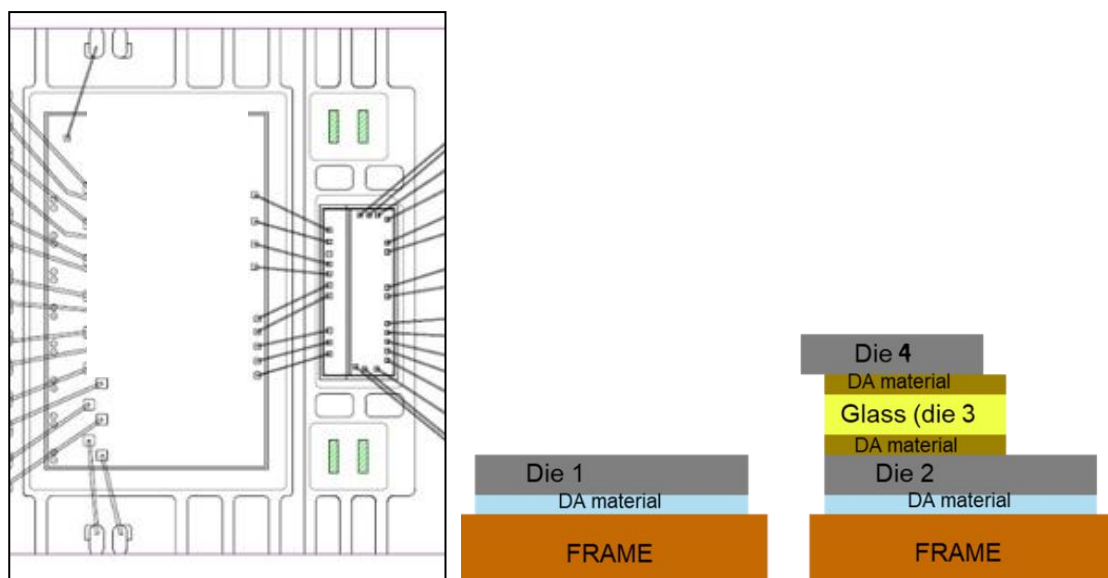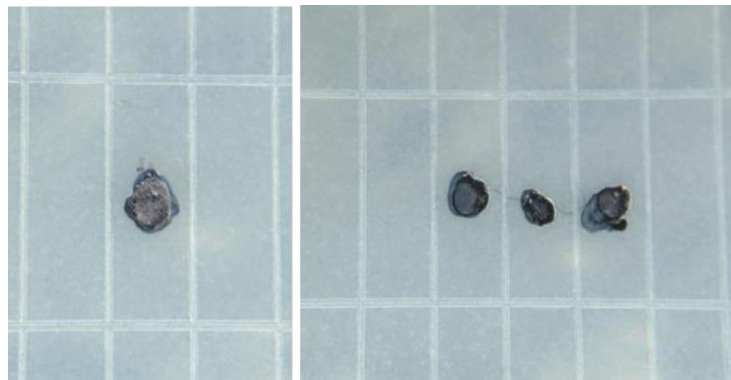


**Fig. 1. QFN product design in focus**

☐ Actual images of inkdot markings

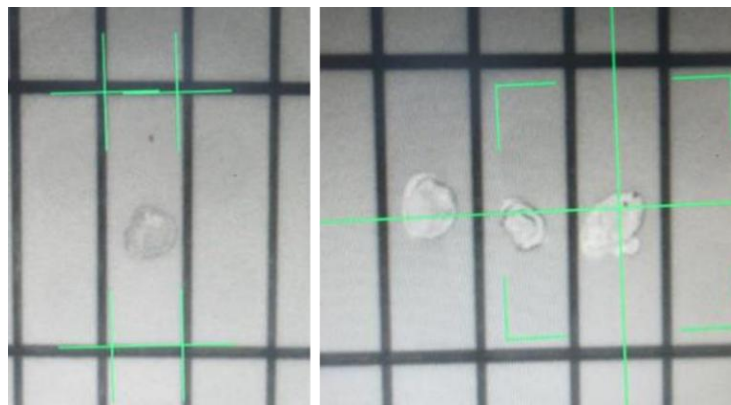**Fig. 2. Glass die markings as viewed on low power microscope**



**Fig. 3. Glass die markings as viewed on die attach machine PRS**

## 2. METHODOLOGY OF THE EXPERIMENT

To address the said phenomenon of bad glass die attached on good units due to PRS failure, we have considered different selection of marking color. This is to match its contrast with the transparent glass die via machine's PRS detection. Fundamental requirements were also considered like electrostatic discharge (ESD) compliance and cleanroom protocol requirements. Discussion on the fundamentals of ESD and ESD controls could be found in the ESD Association references and previous works [11-12].

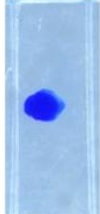Narrowing the selection down, included on the available resources are markers with black, silver, and blue colors. An experiment was planned for every sample marker to determine the appropriate color and contrast detectable by the machine PRS. Table 1 shows the markers' fundamental characteristics and its acceptable requirements. Table 2 on the other hand gives visual appearance applied on glass die and PRS vision thru the machine.

This marked glass die samples therefore will be set up on the die attach machine PRS vision. Same illumination set up, and ink mark detection sensitivity level will be applied. A continuous PRS detection will be performed and acceptance response per marking color sample will be recorded and put into scientific resolve.

**Table 1. Marker sample details**

| Sample | Color | Tip Size | ESD Safe | Cleanroom Safe | Health Hazard |
|--------|-------|----------|----------|----------------|---------------|
| Marker A | **Black** | 1-2 mm | Yes | Yes | Yes |
| Marker B | **Blue** | 1 mm | Yes | Yes | Yes |
| Marker C | **Silver** | 1 mm | Yes | Yes | Yes |

**Table 2. Marker sample application**

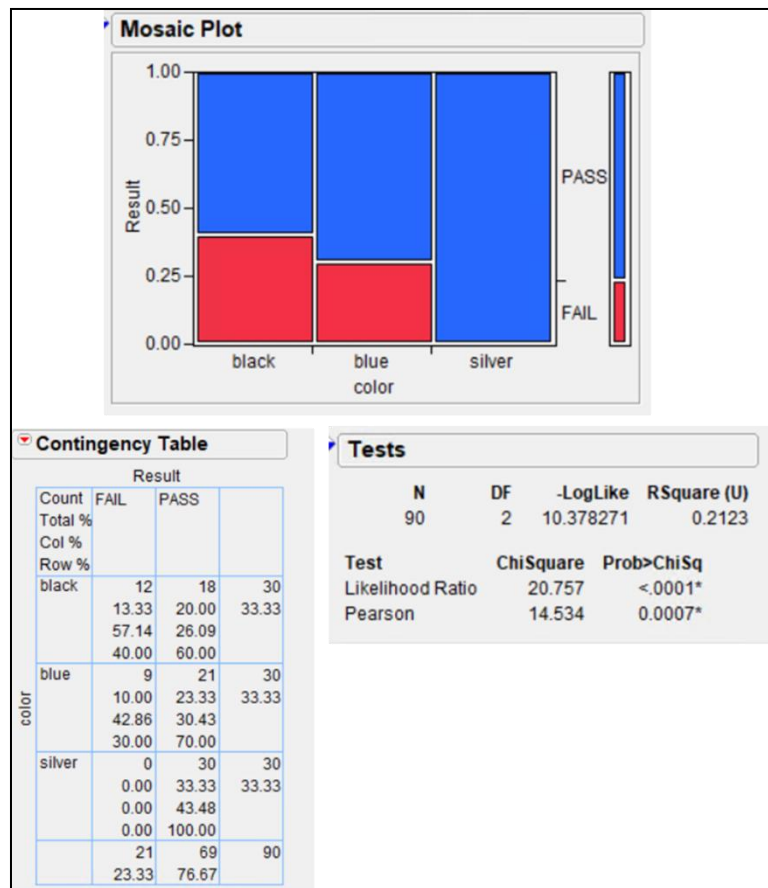| Sample | Color | Actual application | PRS Appearance | Number of Samples |
|---|---|---|---|---|
| Marker A | **Black** | | | 30 |
| Marker B | **Blue** | | | 30 |
| Marker C | **Silver** | | | 30 |



**Fig. 4. Statistical analysis of data from the experiment**

## 3. RESULTS AND DISCUSSION

The experiment conducted targets to resolve the phenomenon of ink marked glass die on good units using statistical analysis. From sample units that has been inked with 3 different markers and put into machine PRS recognition, admirable results had observed. Based on mosaic plot of 2-proportion test in Fig. 4, it has been noted that there is significant difference on the 3 variables. The silver ink marking color tested and simulated on glass die using machine PRS can be considered to use, having better than 95% confidence level with higher probability of passing results.

## 4. CONCLUSION AND RECOMMENDATIONS

As statistically analyzed and determined from the experiment, it is practically appropriate to consider the silver color marker to be used as ink marking for bad glass die. With the help of statistical tools, the best medium was selected, factoring out other options that doesn't gave promising results. The silver contrast of the selected marker gives better compatibility and clear recognition of the machine PRS that will prevent erroneous picking of bad dice during die attach. Comparing with the other markers, the silver marker can be considered as practical solution to prevent gross rejection and promote drastic process yield improvement. Noted also from the evaluation the similar ideas that can be explore and applied on the same technical details of the product and application, as the practicality of the said solution is not limited on this type of product and will drive for a continuous development and process robustness.

## DISCLAIMER

The company name used for this research is commonly and predominantly selected in our area of research and country. There is absolutely no conflict of interest between the authors and company because we do not intend to use this company as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the company rather it was funded by personal efforts of the authors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Salcedo MR, et al. Enhanced die attach process defect recognition on qfn leadframe packages. Journal of Engineering Research and Reports. 2021; 20(3):92-96.
2. Oh HW, et al. Gerber-character recognition system of auto-teaching program for pcb assembly machines. SICE 2004 Annual Conference. Japan. 2004;1:300-305.
3. Kim HT, et al. Automatic focus control for assembly alignment in a lens module process. 2009 IEEE International Symposium on Assembly and Manufacturing. South Korea. 2009;292-297.
4. Pulido J and Gomez FR. Enhanced wirebonding technique on qfn device with critical die reference. Journal of Engineering Research and Reports. 2021;20(3):57-61.
5. Chan YK, et al. Image based automatic defect inspection of substrate, die attach and wire bond in IC package process. International Journal of Advances in Science, Engineering and Technology. 2018;6(4):53-59.
6. Malay R, et al. Active and passive integration on flexible glass substrates: subtractive single micron metal interposers and high performance IGZO thin film transistors. IEEE 65th Electronic Components and Technology Conference (ECTC). 2015;691-699.
7. Shorey AB, et al. Glass solutions for wafer level packaging. International Wafer Level Packaging Conference (IWLPC). 2019;1-6.
8. Apriyana AAA, et al. Design and development of single-qubit ion trap on glass and Si substrates with RF analysis and performance benchmarking. IEEE Transactions on Components Packaging and Manufacturing Technology (CPMT). 2020;10(7):1221-1231.
9. Gablan AG, et al. Improved die attribute recognition via colored glass wafer. Journal of Engineering Research and Reports. 2021;20(6):104-108.
10. Shorey A, et al. Glass substrates for carrier and interposer applications and associated metrology solutions. SEMI Advanced Semiconductor Manufacturing Conference (ASMC). 2013;142-147.
11. ESD Association. Fundamentals of ESD, device sensitivity and testing. USA; 2011.

12. Gomez FR and Mangaoang Jr. T. Elimination of ESD events and optimizing waterjet deflash process for reduction of leakage current failures on QFN-mr leadframe devices. Journal of Electrical Engineering, David Publishing Co. 2018;6(4):238-243.