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# Flux Shorting Mitigation on Semiconductor BGA Device through Process Design Enhancement

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***Authors' contributions***

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

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## ABSTRACT

With the new and upcoming technologies in semiconductor industry, packages like the ball grid array (BGA) are getting more challenging to process due to inherent issues that come along. Process improvement through modification in the design of indirect material is one key direction to improve the productivity during assembly manufacturing. In this paper, an enhanced design of dipping plate is presented to solve the issue of flux shorting due to out-of-specs dipping plate at ball attach process. The study used a side by side comparison to prove that the new design is better than that of the out-of-specs indirect material. With the new enhanced design of dipping plate and the optimized flux depth parameter, flux shorting occurrence was successfully mitigated.

*Keywords: BGA; flux shorting; semiconductor package; solder ball.*

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## 1. INTRODUCTION

Ball attach is one of the most challenging process in semiconductor industry for integrated circuit (IC) assembly that is responsible in attaching a conductive material which is solder through screen printing technology. Nowadays, continuous technological breakthrough on integrated circuit assembly machine offers reliable solution to recurring production issues. One of the major assemblies reject especially in ball attach process was flux shorting and this is caused by out of specs dipping plate. With the new design of indirect material, which is dipping plate as base material, a big challenge exists to run or to process this type of technology especially in ball attach process. Dipping plate is a type of indirect material wherein the ball is formed and attached through screen printing and the ball will place underneath the package. Nevertheless, this paper presents a solution to successfully process this type of new technology in integrated circuit assembly manufacturing by modifying the dipping plate with a higher stand of height to totally separate the flux to prevent shorting issue. To guarantee its integrity during processing, stencil printing is incorporated with criteria such as ball height, ball diameter and visual inspection. This stencil printing criteria is performed after machine setup and conversion to ensure the product is reliable when subjected to reliability tests. Fig. 1 shows the defect manifestation of flux shorting. The defect would provide path for possible electrical shorting between the solder balls and eventually damaging or affecting the functionality of the device.

## 2. LITERATURE REVIEW AND PROBLEM IDENTIFICATION

A complete assembly process flow for the semiconductor ball grid array (BGA) device in focus process starting pre-assembly to singulation process is shown in Fig. 2. Highlighted is the process where the issue was encountered. Worthy to note that assembly process flow varies depending on the product and its technology [1-4]. Also, with the continuing technology development and state-of-the-art platforms, challenges in semiconductor industry are unavoidable [5-8].

Flux shorting is the top major assembly reject in ball attach process and this was seen during the development of the package. This flux shorting is caused by an out of specification dipping plate or the height of the dipping is at lower side. Fig. 3 shows the defect manifestation using the out of specification dipping plate. Actual ball size of the package is 250 microns in diameter and pitch of 500 microns.

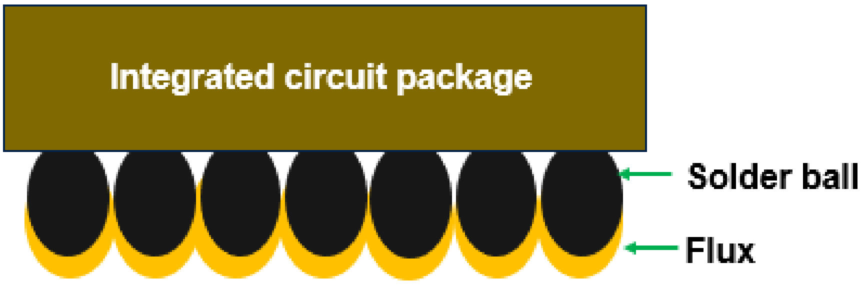


Fig. 1. Flux shorting defect

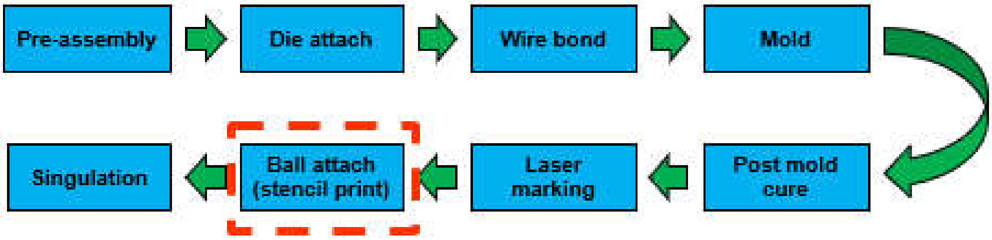


Fig. 2. BGA assembly process flow

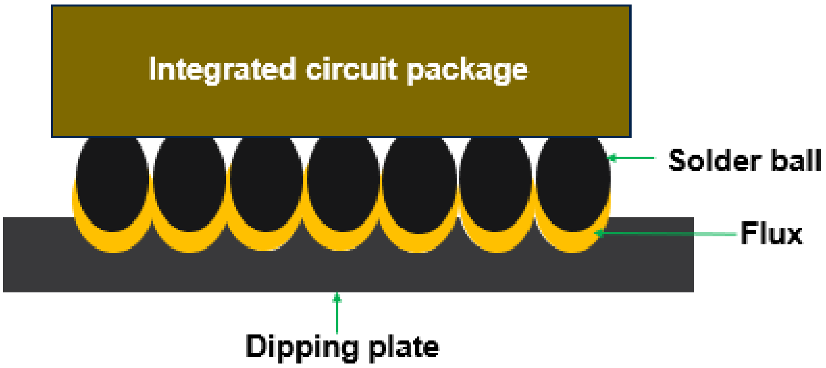


**Fig. 3. Defect manifestation using the out of specification dipping plate**

The dipping plate is serves as a carrier wherein the ball is formed through stencil printing process. This package is used a conductive solder paste material and issue is occur during ball attach using stencil process. A parameter optimization was also done to process this type of new technology in ball attach process and a 100% visual inspection is implemented to cater all the balls in a substrate to make sure that there is no reject, however, the issue of flux shorting still occurs.

## 3. METHODS AND DISCUSSION OF RESULTS

An improved and enhanced process solution in ball attach process was formulated by extensively optimizing the height of the dipping plate. Fig. 4 shows the process of ball attach through stencil printing.

With this improvement, no flux shorting occurred after implementing the enhanced dipping plate with a higher height compared to the out of specification dipping plate. Fig. 5a shows the modified dipping plate while Fig. 5b gives the unit after dipping process and showing no flux shorting.

One of the advantages of the solution is the unit per hour (UPH) is increased because this will skip the 100% visual inspection on the actual unit. Cycle time faster and this is a good achievement to make the delivery of units will move firm as well. This can also have a good reliability results when the package is subjected to board level reliability because units have no flux shorting. A medium to large scale of validation was done to see the difference on the improvement done. Fig. 6 shows the results of the flux depth evaluations done, with the optimized flux depth achieved at 12.5 microns for successful flux shorting mitigation.

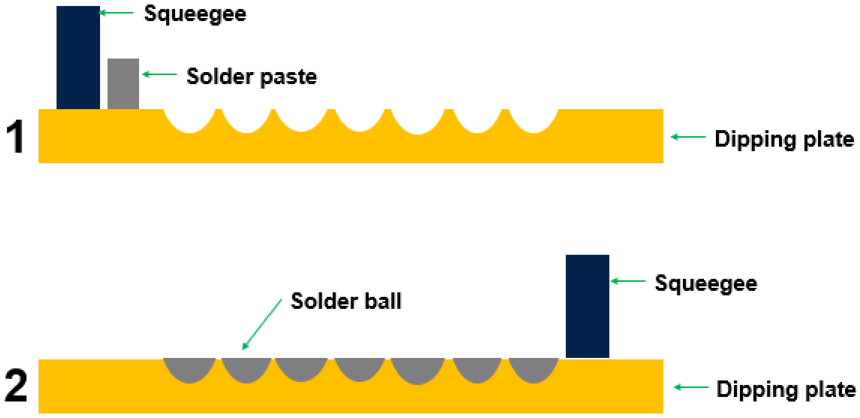


**Fig. 4. Ball attach process using stencil printing**

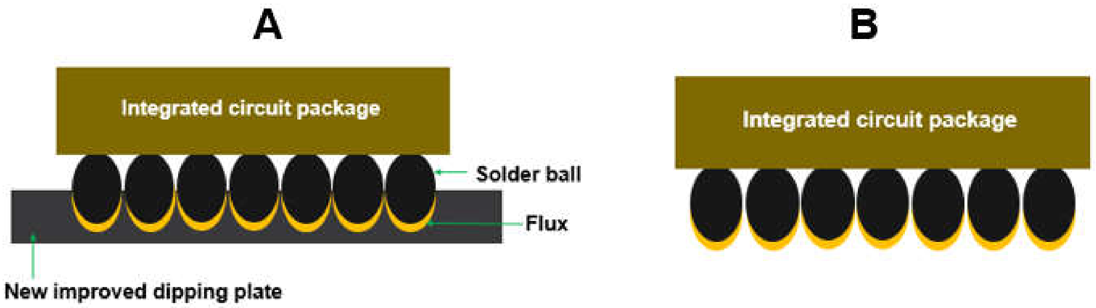
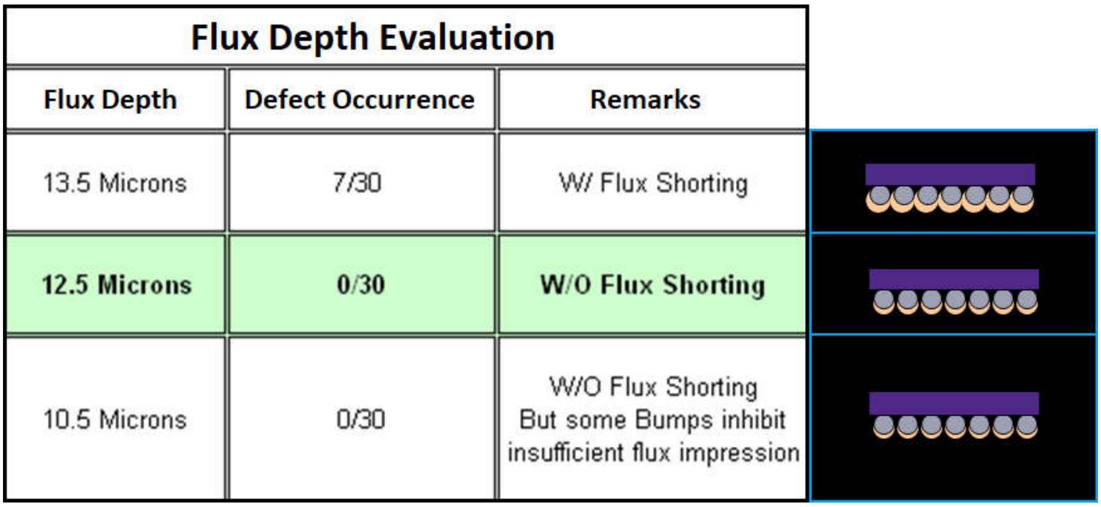


**Fig. 5. a) Modified dipping plate; b) Unit without flux shorting**



| Flux Depth Evaluation | | | |
|---|---|---|---|
| Flux Depth | Defect Occurrence | Remarks | |
| 13.5 Microns | 7/30 | W/ Flux Shorting | |
| **12.5 Microns** | **0/30** | **W/O Flux Shorting** | |
| 10.5 Microns | 0/30 | W/O Flux Shorting<br>But some Bumps inhibit<br>insufficient flux impression | |

**Fig. 6. Evaluation results**

## 4. CONCLUSION AND RECOMMENDATIONS

This paper discussed a process solution and improvement in addressing the flux shorting issue at ball attach process through stencil printing assembly. By modifying the dipping plate with a higher height and formulating the optimized flux depth, flux shorting defect was successfully mitigated. The improved solution with the minimal or low side dipping plate used in ball attach process could be used in other works with similar requirement.

Comparison of existing works and other studies is recommended for added analysis. Important to note that continuous process improvement is imperative to sustain the high quality performance of semiconductor products and its assembly manufacturing. Studies and works discussed in [9-12] are helpful in improving the manufacturability of semiconductor products through process optimization and comprehensive evaluations.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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