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Enhanced Die Attach Process Defect Recognition on QFN Leadframe Packages

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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

Advanced packaging at the back-end semiconductor manufacturing characterizes various equipment capabilities per device requirement. High resolution imaging for inspection system during die attach process has gained its interest to feature automated selections during in-line processing. Increasing yet stringent requisites of today's applications give us leading indicators of market's demand at more functionality in a smaller and complex package. In light with the technology trend, vision inspection system is a well-known challenge. Instead of using a high magnification microscope off-line after assembly processing, leadframe inspection feature uses optical image-based system to recognize real-time feedback on lead-related defects. Such leadframe inspection activation provides good accuracy, monitoring process integrity in real-time for quad-flat no-leads (QFN) leadframe packages. This paper presents how leadframe inspection at die attach machine takes advantage of simultaneous detection of early die attach defect manifestations.

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1. INTRODUCTION

In a traditional product quality monitoring inspection, manual detection method has been uneconomical, and its detection accuracy is certainly affected by subjectivity, momentum, and proficiency of the inspector. Provided with the available resources, a practical approach that maximizes machine capability has been driven. Manufacturing managed to capitalize various equipment platform that supports its market structure industry requirement. On top of the wide range equipment from different stations, one of the significant contributors is the die attach machine in focus (hereinafter referred to as Machine X). It has been defined as fully automatic die attach machine with highly flexibility in handling wide range of die sizes, leadframes and substrates. Machine X is equipped with fast and reliable linear bond head, pre-bond/post-bond inspection system, and 2-in-1 epoxy writer system.

Despite the high machine capability performance, the team recognized an inaccurate feature wherein lead-related defect has been captured or considered as "good" or defect-free during its processing. By this current machine condition, lead-related defect was by-passed and might continue causing high rejection whenever not noticed that would bring to poor quality and yield loss.

To overcome the shortcomings of post manual inspection, leadframe inspection activation feature has been uncovered. This feature prediction model can detect any lead-related defect, comparable to works and studies in [1-7], at real-time based and will maximize its machine capability without sacrificing its capacity. Driven to support its challenging lead-related defect parts per million (ppm) level by at least 80% reduction, enabling leadframe inspection feature was then initiated. Fig. 1 shows the machine's non-detection of the defects when the feature is disabled.

Damaged leads and epoxy on leads are not recognized during processing in-line inspection and letting the unit be diebonded. Feature selection for leadframe inspection is disabled as it reflects predetermined decision no matter what pattern recognition is demonstrated. Based on Fig. 1, resolution judgement for leadframe alignment is "OK" causing the unit to proceed bonding with no defect comprehended.

2. PROCESS AND SYSTEM IMPROVEMENT

Early detection and error-proofing is a practical solution to prevent yield loss and intermittent downtimes. Machine X is capable of leadframe inspection features that enable its vision system to recognize image-based defect manifestations. Actual implementation demonstrated real-time detection of damaged leads and epoxy on leads during die attach process when the leadframe inspection is enabled. Images shared in Fig. 2 highlighted the detection of the defects during processing. A red dialog box notification will alert during processing whenever scans lead-related defects.

Material variations also contributed to diverse conformity on machine capabilities. QFN leadframe packages have been differentiated with taped and no-tape design selections. In all means, it was demonstrated on Figs. 3-4 that leadframe inspection capability of Machine X can cater both QFN leadframe with taped or no-tape packages given.

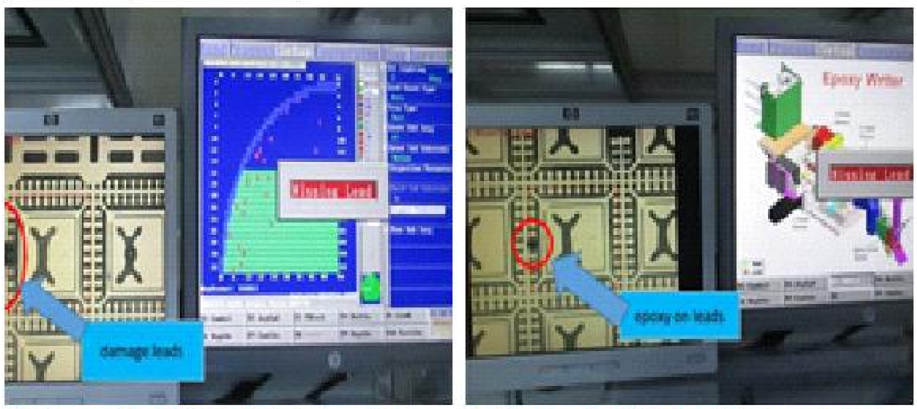
Process simulation recognized as defective leads due to imaged-based epoxy seen on leads during leadframe alignment. Machine will prompt an image showing location of defect which signaling "lead with reject" as seen in Fig .4.

Visible holes for taped leadframe can be compensated through coaxial and side light settings by making the leadframe background darker. In this setup, vacuum holes will be invisible even if it is not covered by leadframe pad. Moreover, roughened leadframe and additional installed side light for QFN with tape package leaves epoxy impression with white-image manifestation. This make distinction with much improved epoxy pattern recognition and inspection.

Leadframe inspection is Disabled

Fig. 1. Damaged leads are not detected when the feature is disabled

Leadframe inspection is Enabled



Machine prompting "Missing Lead" due to damaged lead

Machine prompting "Missing Lead" due to epoxy on leads

Fig. 2. Damaged leads are detected, skipped bonding when the feature is enabled, thus, no unit affected

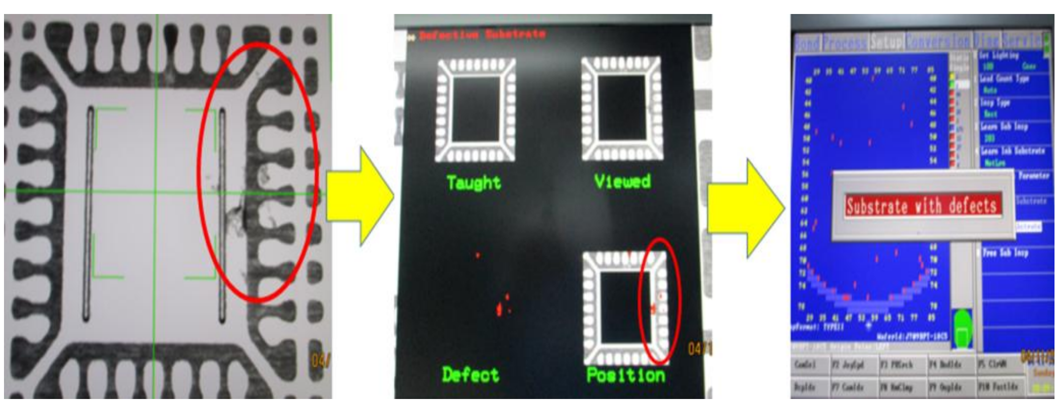


Fig. 3. Validated on no-tape QFN leadframe device

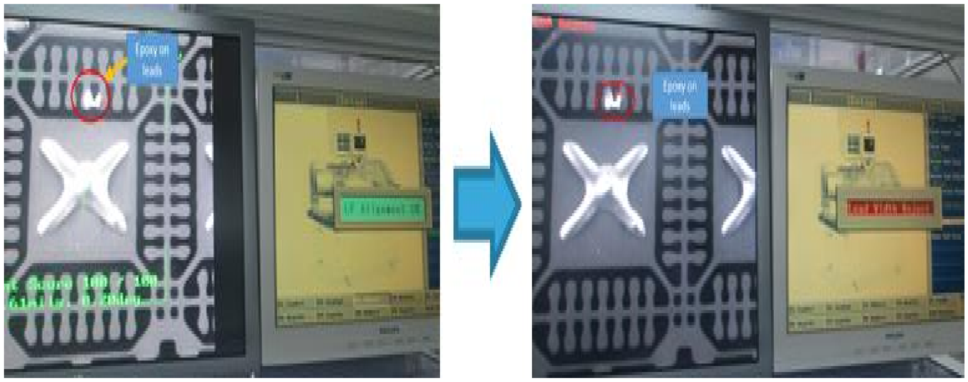


Fig. 4. Validated on taped QFN leadframe device

3. CONCLUSION AND RECOMMENDATIONS

The paper focused on the leadframe inspection activation on the die attach machine in focus for QFN leadframe packages. The feature allows real-time recognition and detection of lead-related defects. Similar manufacturing issues such as epoxy on leads or damage on leads have been addressed timely by implementing leadframe inspection activation. The real-time feedback algorithm ensures no unit is diebonded on leadframe with lead-related defects.

Maximizing equipment capability and error-proofing solution without acquiring investment supports the high-volume manufacturing performance. Man-hour inspection after processing is reduced with significant throughput gain. The machine and the leadframe inspection feature could be used on similar devices. Worthy to note that continuous process improvement is vital to sustain the high-quality performance of semiconductor products and the assembly manufacturing. Studies and learnings shared in [8-11] would help reinforce the robustness and optimization of die attach assembly 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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