OPTIMIZATION OF 2DID MARKING PROCESS THROUGH DUPLICATE ELIMINATION

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ABSTRACT

Duplicate 2DID markings on lead frames in semiconductor manufacturing pose significant challenges, including confusion, production delays, and quality issues. In 2023, such duplicate markings were identified as the top two contributors to Line Stop Issues in the Final Test ICAR Issues, with five occurrences recorded. This recurring problem prompted an investigation utilizing the DMAIC (Define, Measure, Analyze, Improve, Control) methodology to identify root causes and implement corrective actions.

The analysis revealed that the primary root cause was a weakness in the program sequencing of the Laser marking machine – 2D01, leading to the assignment of identical 2DID codes to different lead frames. To address this software controlling the marking process was enhanced to incorporate validation checks ensuring each lead frame receives a unique 2DID. Additionally, process control improvements were implemented, including manual verification steps and training for operators and quality control personnel. Monitoring was instituted to track the effectiveness of these corrective actions.

The implementation of these measures has led to improved manufacturing efficiency, reduced production delays, and enhanced product quality, demonstrating the effectiveness of the DMAIC methodology in addressing complex issues in semiconductor manufacturing.

Fig. 1. Identical 2DID codes to different Lead Frames

1. 0 INTRODUCTION

1.1 Purpose of the Study

The Final Test (FT) process is the last quality assurance gate in semiconductor manufacturing, ensuring that only fully functional and compliant devices reach end customers. Among the many quality control measures in FT, two-dimensional identification (2DID) marking plays a critical role in maintaining traceability, enabling process accountability, and supporting product recalls or failure analysis when needed.

A significant number of abnormalities were recorded in the FT process of Large-Scale Integration (LSI) devices. Based on data shown on Figure 2 "Duplicate 2DID Marking" were identified a priority issue—not due to frequency alone, but because of its high impact on traceability and downstream operations.

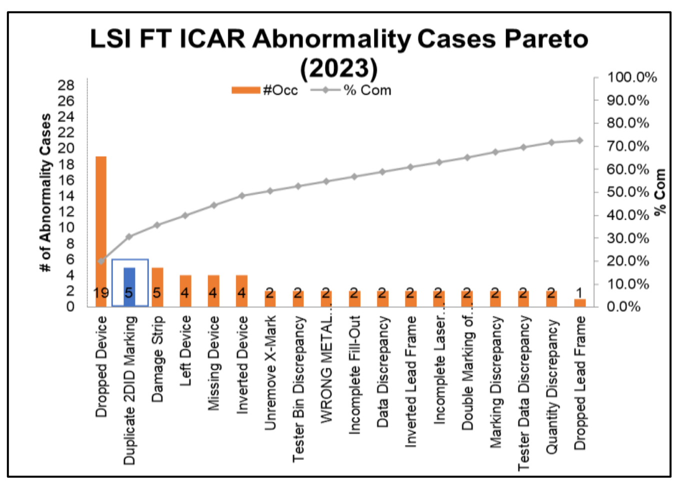

Fig. 2. Duplicate 2DID Marking as top 2 abnormality case in LSI Final Test Abnormality Cases

This paper was initiated to address the growing concern over duplicate 2DID occurrences and reinforce the reliability of identification and traceability systems within the FT process.

1.2 Objectives

This paper aims to:

- Investigate the root causes of the "Duplicate 2DID Marking" abnormality in LSI Final Testing,
- Assess its impact on production and quality systems, and
- Propose targeted corrective and preventive actions (CAPA) to eliminate recurrence and enhance overall FT process reliability.

1.3 Scope

This study focuses exclusively on abnormalities recorded in the Final Test stage of LSI device manufacturing, as reported in the 2023 ICAR system. It does not include earlier process stages such as wafer fabrication, assembly, or burn-in testing unless they are found to directly contribute to the 2DID marking issue.

The analysis is limited to defects impacting 2DID marking integrity, and the proposed solutions are specific to equipment, software, and procedural controls within the FT environment.

2. 0 REVIEW OF RELATED WORK

Not Applicable.

3.0 METHODOLOGY

3.1 Define Phase

A 4M analysis revealed that 100% of the abnormality cases were attributed to machine-related factors, with no contribution from material, method, or manpower. Given this result, the project will focus exclusively on machine-induced causes of duplicate 2DID generation. The primary goal is to eliminate recurrence by identifying failure modes within the marking equipment and associated systems that compromise device traceability.

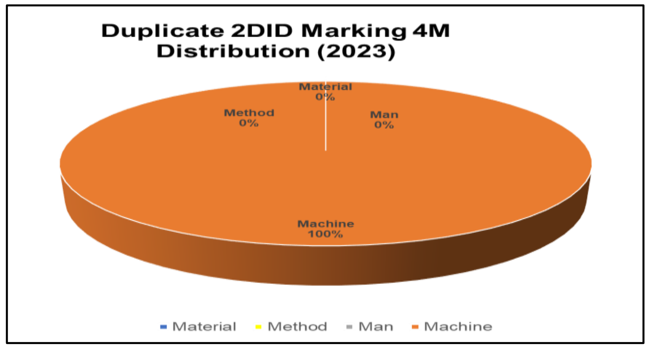

Fig. 3. Duplicate 2DID Marking 4M Contribution at LSI-FT 2023

3.2 Measure Phase

Analysis of 2023 ICAR data shows at Figure 4 a rising trend in Duplicate 2DID Marking abnormalities, with a maximum of two incidents recorded in both Q3 and Q4. The quarterly average stands at 1.25 cases. This upward trajectory indicates a recurring issue, primarily attributed to machine-related factors, as established in the Define Phase.

Given the consistency of occurrence in the latter half of the year, this project targets the complete elimination of machine-induced duplicate 2DID marking abnormalities by Q1 2024. Metrics tracked include frequency of abnormalities per quarter and system-generated marking trace logs, which will serve as baselines for measuring improvement.

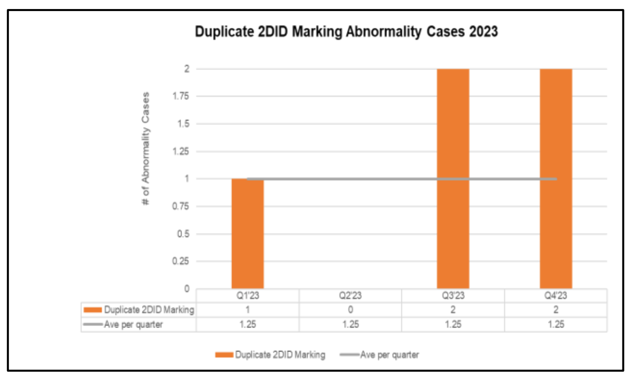

Fig. 4. Duplicate 2DID Marking is evidently increasing with a maximum of 2 cases per quarter.

3.3 Analyze Phase

This phase involves a systematic analysis of the available data, including process logs, equipment alarms, and historical marking records, to uncover process gaps or failure points. Identifying the root cause will enable the development of targeted improvements to eliminate recurrence and strengthen the traceability integrity of the marking process.

3.3.1 Duplication of 2DID Markings on two separate Strip

The duplicated code was physically found on two different strips, as shown in Figure 5. The mark history logs show two entries with the same 2DID, suggesting that the duplication was not detected by the system. Machine log records were reviewed, and no marking errors or hardware malfunctions were found.

No alarms related to marking malfunction were triggered; only unrelated errors like Misoriented Lead Frame were logged and no maintenance activities or interruptions were reported during the time of duplication occurred (See Figures 6 and 7).

Fig. 5. Actual Strips Marking vs Mark History at Machine PC

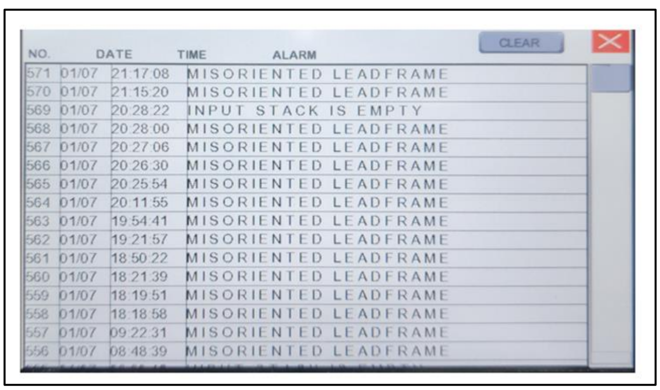

Fig. 6. Machine Alarm History

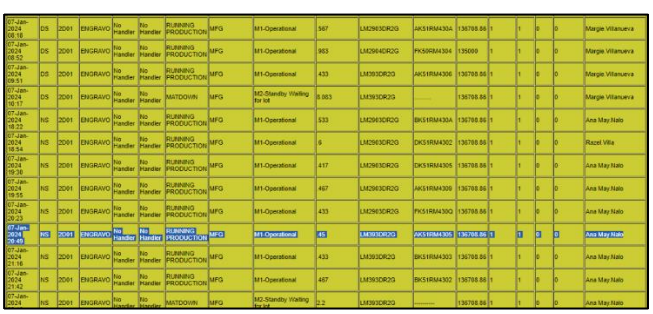

Fig. 7. Recorded History of Activities done in the Machine

3.3.2 Root Cause Analysis

To systematically uncover the root cause, structured problem-solving tools such as 5 Why-Why Analysis and Hypothesis Validation were used. This approach breaks down the issue into multiple contributing factors to help identify the most likely origin of the problem. Specifically on the machine side as shown in Figure 2, which indicates that the machine is the sole contributor to the duplicate 2DID marking. The analysis focused on potential failures in the marking system logic, strip handling, and ID tracking processes. Determining the true root cause is essential for developing effective corrective and preventive actions in the subsequent Improve phase.

Hypothesis	Component	Hypothesis Validation		Remarks
		Valid	Invalid	
Laser Module Problem	Cable		X	No issues in cable connection, all cables are in good condition
	Hardware		X	Laser hardware working in manual trigger
	PC		X	PC working/booting
	Software	X		Insufficient control verification of code marking

Fig. 8. Hypothesis Validation to Find the Most Probable Root Cause

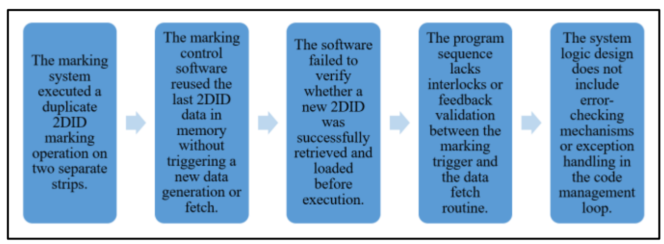

Fig. 9. Why-Why Analysis

This analysis points to a systemic software design flaw in the laser marking process. The absence of data integrity checks and a real-time validation mechanism allowed the same 2DID to be used more than once, even though the hardware and cabling systems were fully functional. (See Figure 8 and 9)

4.0 RESULTS AND DISCUSSION

4.1 Improve Phase

This phase outlines the corrective and preventive measures implemented to address the validated root causes identified during the analysis phase. The actions are designed to eliminate the underlying issues and prevent recurrence, thereby enhancing process reliability and system integrity.

4.1.1 Enhancing of machine Software program

The software enhancement included the integration of a real-time verification logic that flags duplicate codes prior to marking. This system now checks the equipment's temporary registry and halts duplication by skipping codes already recorded during post-vision inspection.

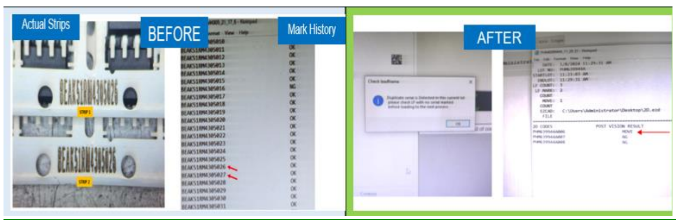

Fig. 7. Before Implementation of Corrective Actions vs After the Implementation

4.2 Control Phase

To sustain the improvements achieved during the Improve Phase, a Control Plan was established to monitor the updated software performance and ensure long-term stability of the 2DID marking process. Standard procedures were revised, and updated OCAPs (Out of Control Action Plans) were implemented to guide operators in handling potential marking anomalies. Minimal changes and updated instructions were disseminated to all relevant personnel to reinforce awareness and compliance. Regular performance checks were scheduled, and the system was monitored to confirm that duplicate marking incidents no longer occurred. As a result, the corrective measures have been fully integrated into the production process, ensuring consistent product quality and preventing recurrence of the issue.

5.0 CONCLUSION

The implementation of the updated software program effectively addressed the root cause of the duplicate 2DID marking issue specifically, the weakness in the program's control sequence logic. The corrective action introduced robust verification logic that cross-checks each 2DID code before execution, thereby preventing duplication at the source. Key results include the following:

- Successful installation and validation of the new program across 10 qualification lots, all yielding 100% pass rates.
- Improved software logic has been integrated into the standard operating process, supported by updated OCAPs and personnel training.
- No recurrence of duplicate 2DID code marking observed post-deployment (starting January 2023) up to present.

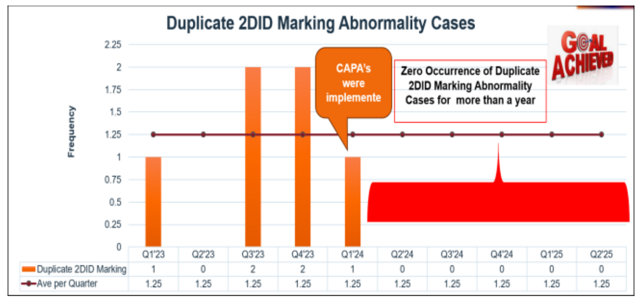

Fig. 8. Corrective and Prevention Action Effectiveness

In conclusion, the corrective actions implemented during the Improve phase have led to the complete elimination of the defect, enhanced system robustness, and ensured long-term process reliability.

6.0 RECOMMENDATIONS

The corrective actions implemented to address Duplicate 2DID Marking may be replicated and customized for other equipment or device platforms where similar traceability challenges exist, supporting continuous improvement efforts across related processes.

7.0 ACKNOWLEDGMENT

The authors extend sincere appreciation to Sir Andrey Lagazon and Sir Alfredo Nessia Jr., along with the Final Test Equipment Engineering team, for their support and collaboration throughout the development of this paper. The author also wishes to express deep gratitude to Sir Philip Bonifacio and Sir Louie Dizon for their mentorship and invaluable guidance during the conduct of the study.

8.0 REFERENCES

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9.0 ABOUT THE AUTHORS

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Christian Tinsay is graduate of Bachelor of Science in Mechatronics Engineering at Bulacan State University. Joined On Semiconductors Philippines, Inc. in 2016 as a Manufacturing Equipment Engineer. Currently, he is responsible for test equipment hardware development. Develop new or modified process formulations, definition of processing or handling equipment requirements and specifications, review of processing techniques and methods applied in the manufacture, fabrication and evaluation of semiconductors.

10.0 APPENDIX

Appendix A – Document and Standardization - OCAP