DESIGN MODIFICATION OF INPUT PUSHER ASSEMBLY OF LASER MARKING MACHINE
(Case study at Integrated Circuit Assembly Manufacturing)

Arif Rahman Hakim,
Mechanical Department of Engineering Faculty of University of Riau Kepulauan Batam

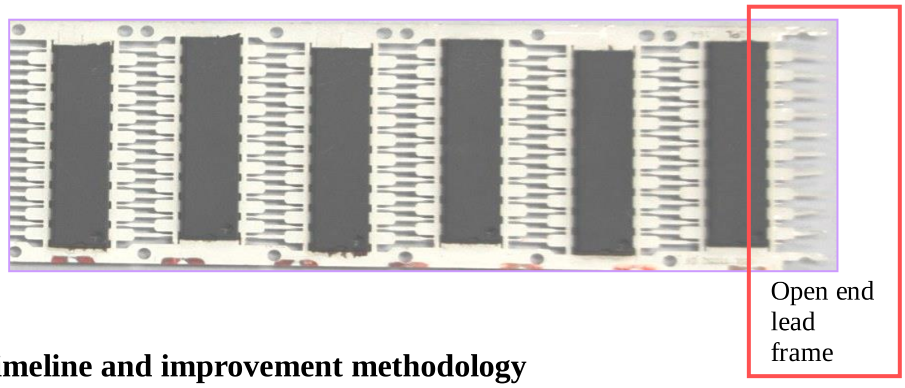
ABSTRACT
Laser marking process is one of the process step in Integrated Circuit (IC) assembly manufacturing. This process is to mark the IC unit with the device information, assembly information and product brand. One type of lead frame used for IC assembly is open end lead frame which causing the individual lead on end unit prone to damage due to hard mechanical contact. At laser mark process, the lead frame will be pushed into the laser chamber by using a solid input pusher. The existing design of input pusher will push the lead by making contact with the edge of the lead frame. Production section keep observing the damage lead problem occurred when process the open end lead frame. Damage lead was 54% of the defect occurred at laser mark process. This problem causing low yield and high rework. Team has been established to analyze the problem and found the solution.
Through investigation and analysis, team found the root cause of the problem and takes the appropriate corrective action. Design modification of input pusher from the previous design which was solid type to be U-type significantly reduces the damage lead at laser mark process. Initial observation showed that the new design able to reduce 98% of damage lead.
Key word : Design modification

Introduction

Integrated Circuit (IC) is a vital electronic component that being used widely in electronic application. This component is used in consumer product, telecommunication, computer and automotive industry. Global competition and market driven has motivated the multinational company which produce IC to sub contract the IC assembly manufacturing to the Asian country. One of the country selected by the industry to be off shore site of assembly manufacture is Batam island of Indonesia.

There is one IC assembly manufacture located in Batamindo Industrial Park Muka Kuning, Batam. This is one of top 10 IC assembly subcontractors in the world. In this factory, ICs are assembled starting from wafer chip up to the final IC component. The process step to assemble the IC is started from wafer saw process. At this process wafer will be sawn to be single chip called as die. The single die then attached to a copper lead frame using conductive epoxy glue. To strengthen the bonding, the work piece will be cured at 125^{o}C. The next process is to connect the die to the lead frame using gold wire by ultra sonic welding. This process is called as wire bonding. All these processes are classified as front line production. Wire bonded die then goes to molding process where the work piece will be covered by using epoxy mold compound plastic that categorized as thermo set plastic. The process then continued by solder plating process where the copper lead frame will be coated by tin (Sn).For device identification, the IC package will be marked using laser process. The information written on the package contains device name, manufacturing code and product brand. After completion of laser marking process, the work piece will be trimmed and formed to be single IC unit, then the final IC component are ready to ship to the customer, the owner of the product.

In this paper, it will be elaborated the process of laser marking. At this process, work piece will be loaded into the input track of the machine then the work piece will be pushed into the laser chamber using a pusher assembly called as input pusher. Inside the laser chamber, a laser system will mark the IC package. Then finally, the marked work piece will be pushed out of the chamber and unloaded to the carrier bag. Production section observing quality issue of the product such as marking defect, package defect and lead defect. Production data showed that the lead defect contributed 54% of total defects. This quality issue is concentrated on open end lead frame type.



Timeline and improvement methodology

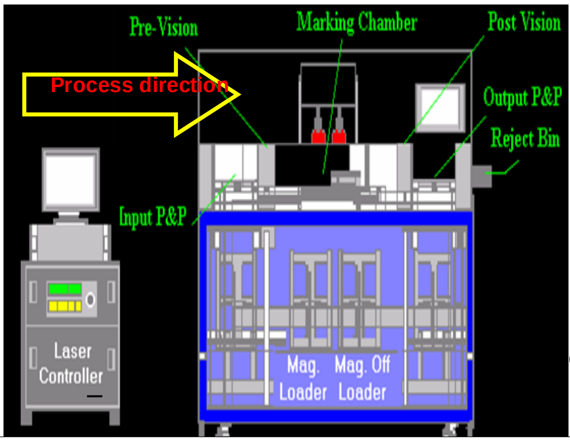
To address the quality problem, a cross functional team has been established. The team members are from process engineering, equipment engineering, quality assurance, production.

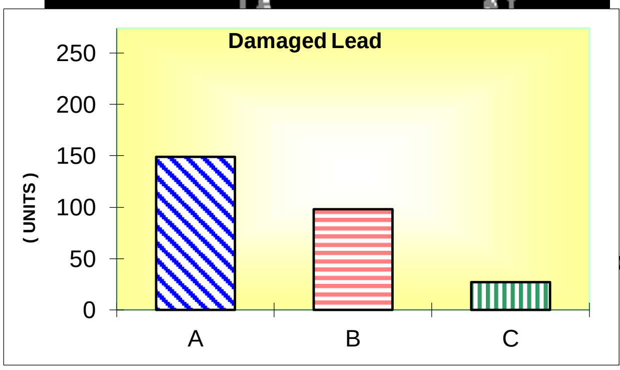
Table 1. Timeline for improvement

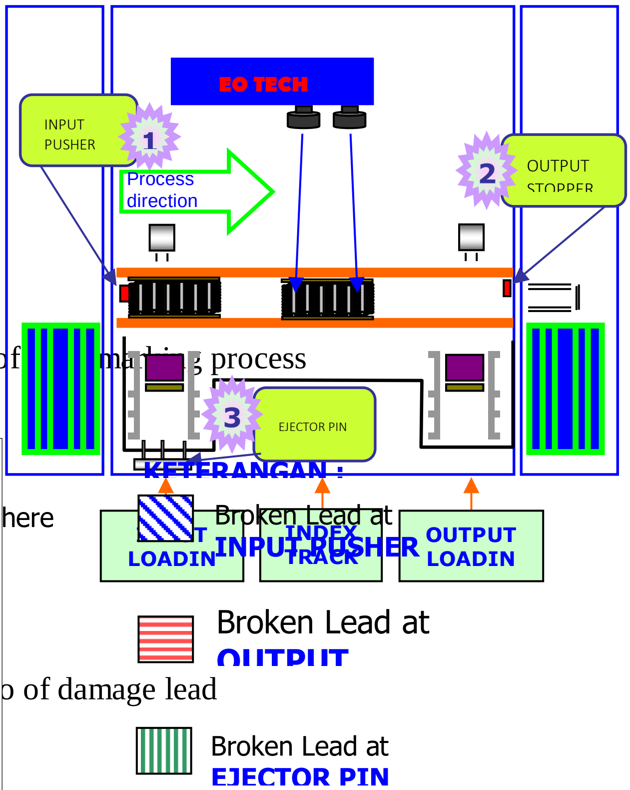
Activities	Method	June 2011		July 2011	
		w3	w4	w1	w2
1. Problem identification	Production data analysis. Process observation.	◆—◆			
2. Problem analysis	Brainstorming. Team discussion	◆—	—◆		
3. Potential cause verification	Simulation.		◆—	—◆	
4. Solution development	Brainstorming, discussion. Benchmarking, Simulation.		◆—	—◆	
5. Solution effectiveness	Simulation.			◆—	—◆
6. Solutions implementation	Action				◆—◆

Problem identification

Data for the quality problem at laser marking process collected for last one month indicated that damaged lead is top defect. Further observation and analysis showed that 54% of damaged lead occurred at pusher section.







Analysis the problem

Referring to pareto of the damage lead (fig. 3), team did further analysis of input pusher assembly. Team use fishbone diagram to find the potential cause of problem that will be verified as root cause of the problem.

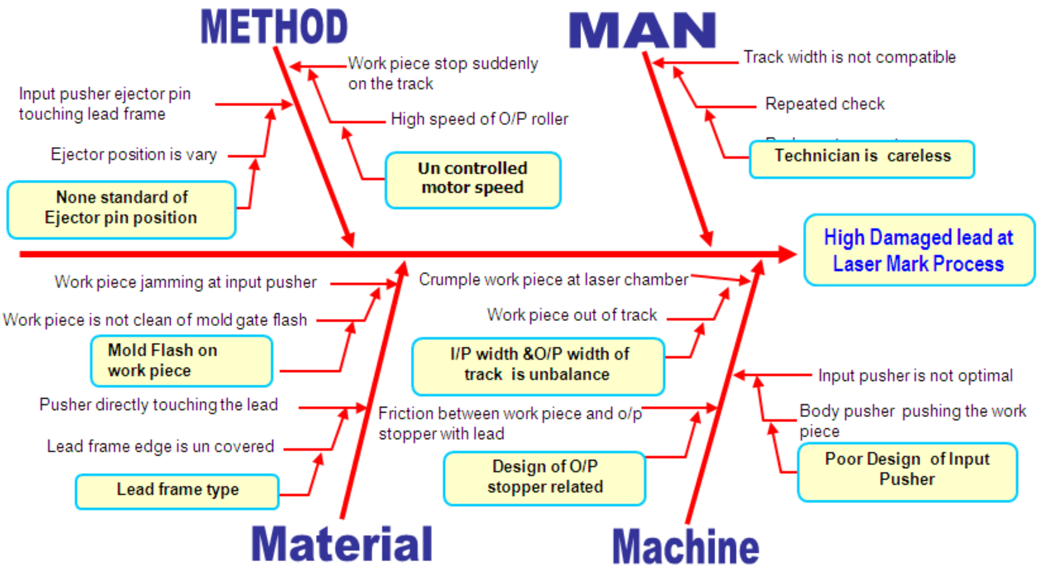


Fig 4. Fish bone diagram

Verification on the potential causes derived from fishbone diagram revealed that few potential causes are not confirmed.

Table 2. Potential causes verification

NO	POTENTIAL CAUSE	Verified by	Result
1	Technicians are careless when checking the track width.	Adi	Not confirmed
2	Poor design Input Pusher	Tarno	Confirmed
3	Unbalanced width of i/p & o/p track	Sugi	Not confirmed
4	Poor design of out put stopper	Adi	Confirmed
5	Mold flash on work piece	Tarno	Not confirmed
6	Type of lead frame which is open lead frame	Sugi	Confirmed
7	None standard position of Ejector Pin	Sugi	Confirmed
8	Uncontrolled out put roller motor	Tarno	Not confirmed

Original design of input pusher directly touches the lead frame edge. If the work piece having abnormal mold gate end flash as poor quality of molding process, then the work piece will abnormally bent that called as side bent. This condition can disturb the smoothness of work piece sliding on the track such as high frictions. To keep the work piece moving, the input pusher will push the work piece with higher forces. Due to the input pusher touching the lead with higher force, therefore the lead contacted with pusher will damage.

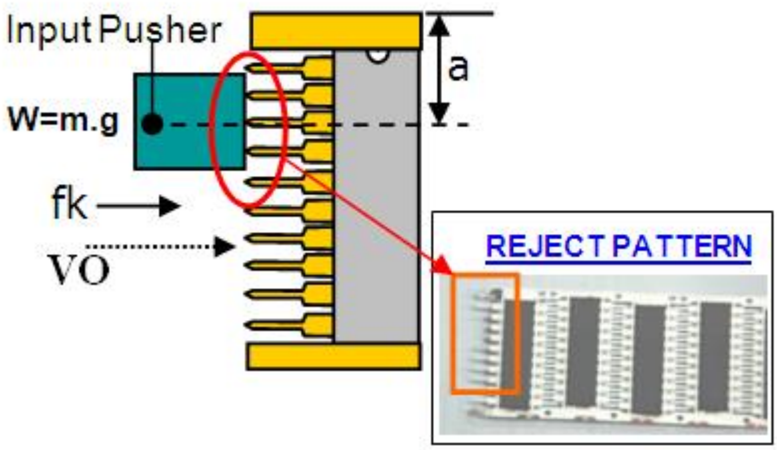


Fig. 5 Input pusher directly contact with lead

Out put stopper is a machine part that has function to stop the movement of the work piece on the track. If work piece moves to fast on track, it will hit the stopper hardly and this prone to cause damage lead.

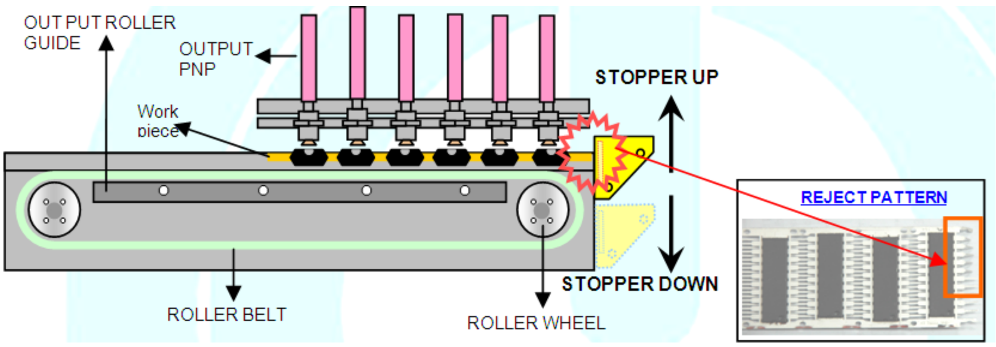


Fig 6. Work piece hit the stopper hardly

The stopper mechanism moving up and down. Original design of out put stopper having flat surface facing to the lead. This design provide high possibility of the lead to be damage when there is hard contact.

Corrective action

Four out of eight potential causes were verified and confirmed causing the problem. Team conducts brainstorming to develop corrective actions.

1. None standard position of ejector pin is confirmed as potential cause. To address this potential causes, standard position of ejector pin is defined and classified as critical item to check when doing the machine set up. The work document is revised to document the standard position. All technicians are required to use the work document as guideline when set up the machine.
2. Type of lead frame with open end is confirmed. However, modification of lead frame requires high cost since vendor involvement is required. Then team considered this potential cause as the last potential cause to address.
3. Team focus to poor design of input pusher and out put pusher which are confirmed as potential causes. Then, the corrective actions to improve the design are considered.

Methodology in improving the design of input pusher and out put pusher:

Upon the confirmation of poor design of input pusher and out put pusher, team develop ideas for modification of the existing design.

1. Modification of input pusher.

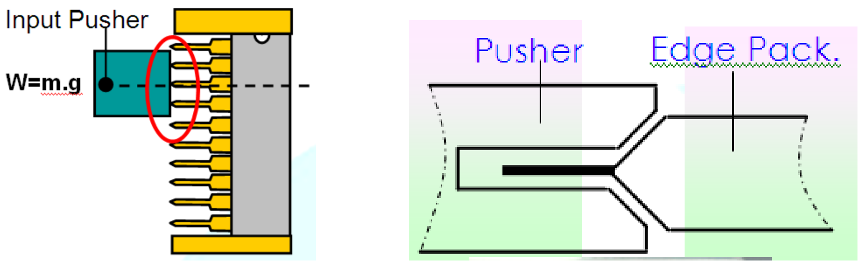
   There are 2 alternatives of design modification for input pusher;

Table 2. Alternative design for improvement of input pusher.

Alternative modification	Correlation to the potential cause	Effectiveness verification
ALTERNATIVE 1		
Redesign input pusher to be U-shape	With this design, pusher will not directly contact with the lead edge.	Computer simulation indicate this design is effective
ALTERNATIVE 2		

Enlarge the cross section of input pusher.	With this solution, then pusher is wider enough to push more leads that resulting in to less force transmitted the lead.	This modification still have direct contact between pusher and the leads and prone to damage the lead in case the work piece jamming.

Team selects the first alternative as corrective action for input pusher.



a). Original design b). Modified design

Fig 7. Difference between original design and modified design

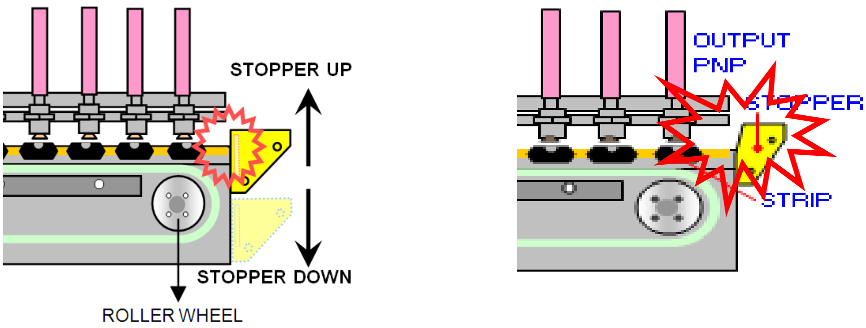
2. Modification of out put pusher.

Two 2 alternatives of design modification for out put pusher were developed.

Table 3. Alternative design for out put stopper.

Alternative modification	Correlation to the potential cause	Effectiveness verification
ALTERNATIVE 1		
Change the flat surface of the stopper to be chamfer and make the stopper wider.	Wider cross section of the stopper and champer design will reduse the possibility of lead damage when there is hard collision between work piece and stopper.	Computer simulation shows that the possibility of damage lead can be reduced.
ALTERNATIVE 2		
Change stopper material from stailess steel to be teflon	Teflon will reduce the impact when collision happen.	If the stopper design still the same with the existing design, the change of material will not significantly reduce the damage lead.

Upon verification and further discussion, team decides to combine the two alternative of design modification for out put pusher. Teflon will be used to replace the stainless steel and stopper surface will be chamfered.



a) Original design   b) Modified design

Fig 8. Difference between original design and modified design of output stopper.

Solution effectiveness

Upon verification of effectiveness of design modification of input pusher and output stopper, production data has been collected. Comparison between previous data (before design modification) and new data (after design modification) will be used to justify the effectiveness of the solution.

Further data collection is required to confirm the effectiveness of design modification. The previous data is monthly average of damage lead defect while the new data were collected for one week period only. However, the available data may be used for initial review of the effectiveness. Data showed that the damage leads are reduced significantly.

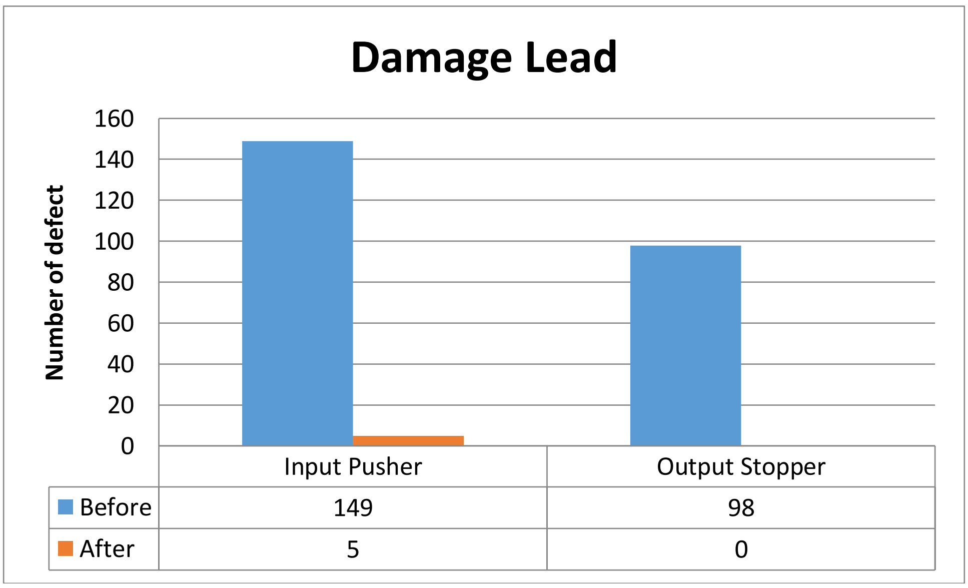


Fig 9. Comparison before and after

Conclusion

Modification of input pusher and output stopper of laser marking machine has been taken as solution to reduce damage lead problem during laser marking of Integrated Circuit assembly manufacturing.

In this case, modification of input pusher and output stopper has reduce 98% of damage lead.

Reference

1. Imai, Masaaki, Kaizen, The Key to Japan's Competitive Success, The Kaizen Institute, Ltd. 1996.
2. Ingle, Kathryn A., Reverse Engineering, Mc Graw Hill, 1994.
3. Japan Human Relation Assosiation, 1980, The idea book, Improvement through TEI (Total Employee Involvement), Productivity, Inc. 101 Merritt 7 Corporate Park.
4. Pitta, Dennis A, University of Baltimore, Baltimore Maryland USA, Product Innovation and Management in a Small Enterprice, Journal of product and brand management, Emerald Group Publishing, 2008.
5. Shingo, Shigeo, Zero Quality Control: Source Inspection and the Poka Yoke System, Productivity Press, 1986.
6. Shingo, Shigeo, Non-Stock Production: The Shingo System for Continous Improvement, Productivity Press, 1988.