# LEADFRAME TAPE DE-REEL PREVENTION AT WIREBOND MACHINE THROUGH SENSOR INTEGRATION

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## *ABSTRACT*

Sensor technology plays a major role in the Semiconductor Industry, it can accelerate processes, increase productivity, and prevent losses. This technical paper will discuss how we prevented the Lead frame tape De-reel at Reel-to-Reel Wirebond process by integrating detection control through sensor with latching relay and lever roller at input/output module. Using Problem Solving Methodology, the team was able to identify and analyze the root causes on how the lead frame tape de-reel happened during wirebond process including how the solution prevented the defect through error proofing concept.

## 1. 0 INTRODUCTION

Micromodule device is one of company's high volume production lines. The volume ramp-up is very challenging. Department KPI should be met by putting all controls in the line to meet target Yield.

Yield graph shows that it's not consistently meeting the target of 99.80% versus actual yield from Oct'19 to Mar'20 as shown in Fig.1

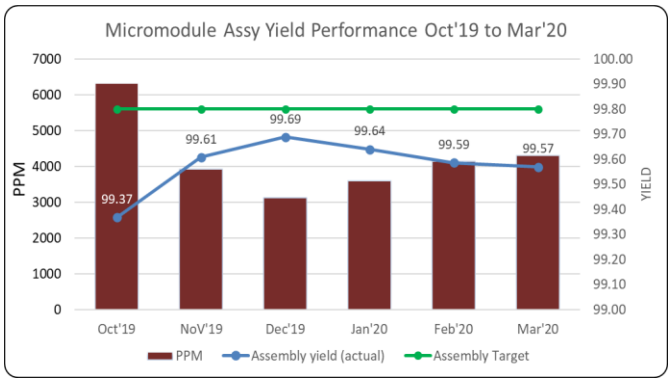


Fig. 1. Micromodule Assy Yield from Oct 2019 to Mar 2020

Analyzing the Yield detractor, it shows that crumpled Lead frame tape due to de-reeled lead frame at Wirebond process is the top defect in pareto chart as shown in Fig.2

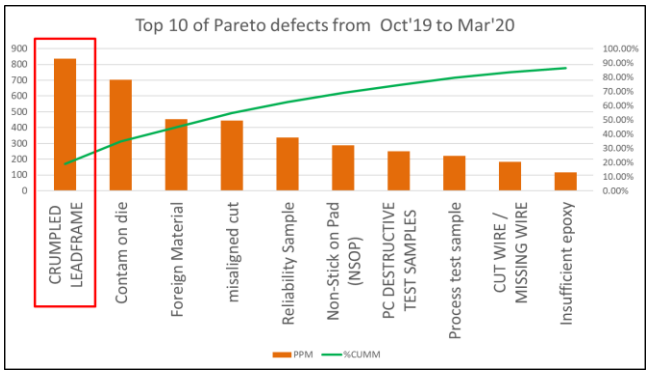


Fig. 2. Pareto of defect from Oct 2019 to Mar 2020

Figure 3 shows PPM trend of lead frame De-reel at Wirebond averaging 21038 PPM for Micromodule devices from October 2019 to March 2020. The target is to reduce the crumpled leadframe PPM level to 19892 PPM.

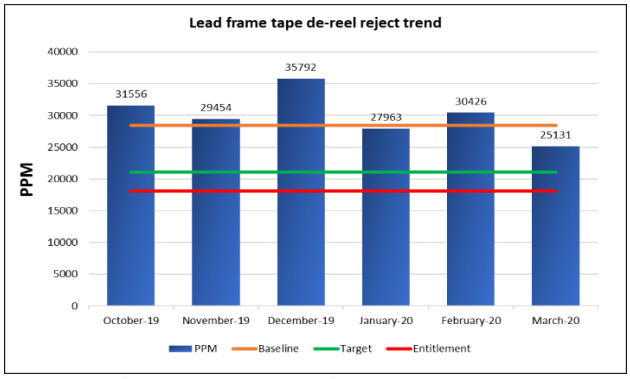


Fig. 3. Lead frame tape de-reel PPM from Oct 2019 to Mar 2020

## 2.0 REVIEW OF RELATED WORK

"Not Applicable"

## 3.0 METHODOLOGY

### *3.1 Analyzing the Process Flow*

Fig. 4 is the Process macro map of Micromodule device from Assembly to Final test where Wirebond is the focus of this project and the main source of Yield top defect.

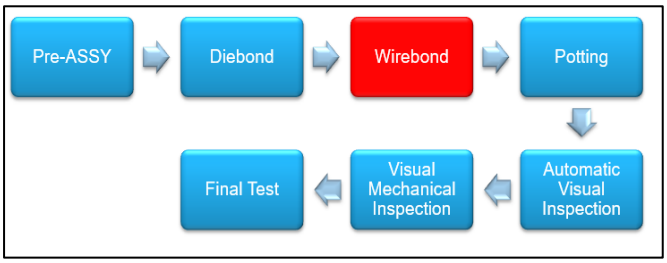


Fig. 4. Micromodule Process Macro Map

Fig. 5 is the process flow of Wirebond Reel-to-Reel from lot preparation to unloading of wirebonded units at metal reel where de-reel happened during wirebond process.

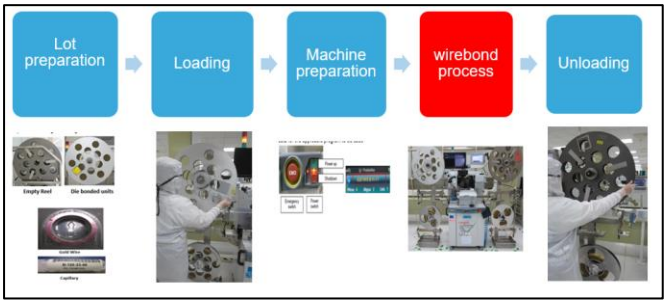


Fig. 5. Detailed Reel to Reel Process Flow

### *3.1.1 Reel to Reel Wirebond Process*

Reel to Reel wirebond machine with Input and Output spooler. Lead frame tape with un-bonded units is connected to input yellow spacer, while the bonded units is connected to output yellow space as shown in Fig.6

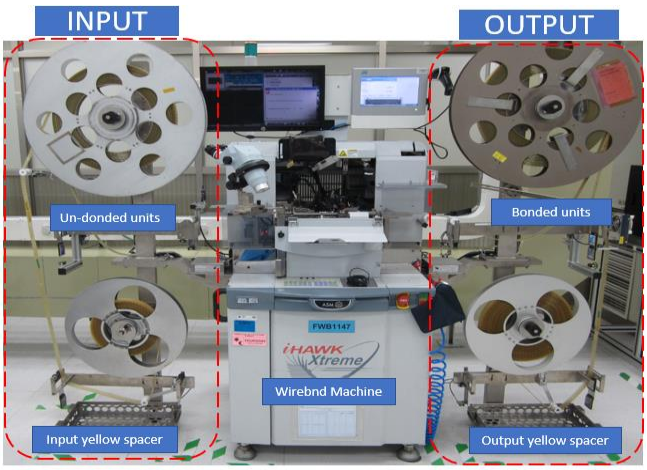


Fig. 6. Reel to Reel iHawk Xtreme Wirebond Machine

### *3.1.2 What is de-reel at Wirebond?*

Fig. 7 shows the event of de-reel lead frame tape at Wirebond. This scenario happens at input/output of spooler, where the sensor encounters malfunctioning resulting to continues stepper motor movement. This machine malfunction will cause the lead frame tape to slide into the floor where bonded and unbonded units hit the hard surface.

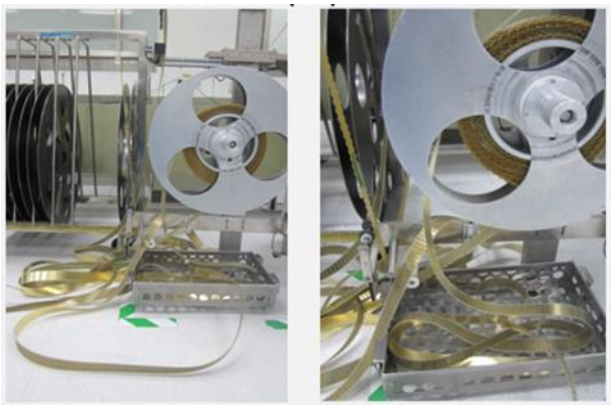

Fig. 7. De-reel Lead Frame tape event at Wirebond

The assembly defect manifestation was encountered after de-reel at Wirebond which is failed at Final test and potential customer complaint as shown in Fig.8

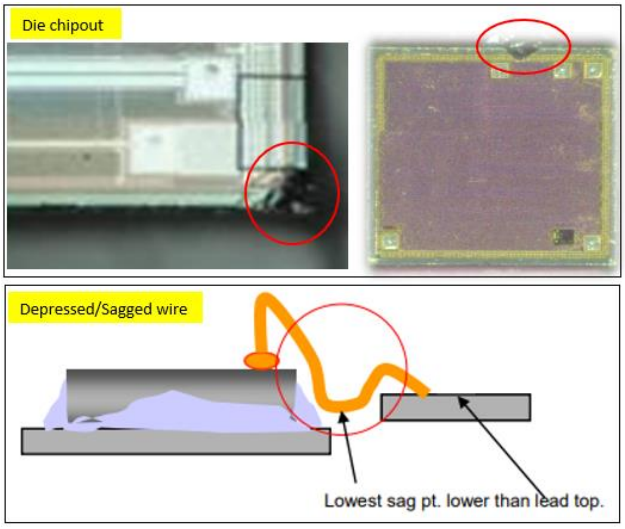


Fig. 8. Lead frame tape de-reel defects.

## *3.2 Identification of Potential Rootcause*

Fig.9 is the Cause-and-Effect diagram of De-reel Lead frame tape at Wirebond. Team identified 9x potential root causes that contribute to the problem or defect.

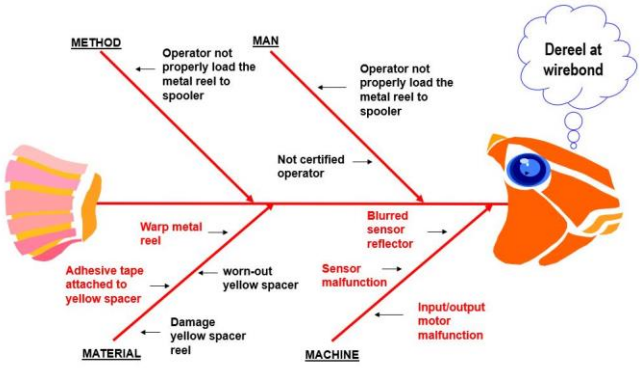


Fig. 9. Cause and Effect diagram.

Table 1 shows the validation of potential root causes which identified at cause-and-effect diagram. The team identified 5 potential root causes namely blurred sensor reflector, sensor malfunction, input/output motor malfunction, adhesive tape attached to yellow spacer and warp metal reel which are all true cause and within control.

Table 1. Root causes validation

| Potential Cause | Method of Validation | Result of Validation | Conclusion (True Cause/Not True Cause) | Controllability |
|---|---|---|---|---|
| Blurred sensor reflector | Visual simulation | Verified that reflector at FWB1105 is blurred | True cause | Within Control |
| Sensor malfunction | Visual simulation | Verified that sensor is possible to malfunction due to short circuit | True cause | Within Control |
| Input/output motor malfunction | Visual simulation | Verified that input/motor is prone to malfunction due to manual rotate of stepper motor | True cause | Within Control |
| Warp/damaged metal reel | Visual inspection and digital caliper | Some of metal reel have damaged on the gap that sometimes will cause crumpled to LF, affected by warp is failed on target gap measurement | True cause | Within Control |
| Adhesive tape attached to yellow spacer | Visual inspection | Most of yellow spacer have many spliced and the attached tape is not totally adhere to yellow spacer | True cause | Within Control |
| Operator not properly load the metal reel to spooler | Visual inspection | All in-process metal reel is properly load | Not true cause | No Control |
| worn-out yellow spacer | Visual inspection | All worn out yellow spacer is already pull out in the line | Not true cause | Within Control |
| Damage yellow spacer reel | Visual inspection | All damaged yellow spacer is already pull out in the line | Not true cause | Within Control |
| Not certified operator | Certification badge | All operator at WB is certified | Not true cause | Within Control |

## *3.3 Solution Formulation*

Table 2 shows 5 identified valid causes of Lead frame tape de-reel at Wirebond process. The authors list down all the alternative solutions for the valid causes for which 2x alternative solutions (1. Use lever type roller to improve sensor sensitivity 2. Use additional sensor with latching relay) was identified with highest rating based on effectiveness of measure under the criteria of risk, ease and cost. Risk is potential to create problem if implementing the solution. Ease of implementation is about how easy it is to implement the solution. While the Cost is referred to the expenses associated to execution of solution.

Table 2. Selection of Best alternative Solutions.

| Valid Cause | EP Level | Alternative Solutions | Action Category | Validation | | Measures for Effectiveness | | | | Decision |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Method | Results | Risk | Ease | Cost | Rating | Rank | Go / No Go |
| Blurred sensor reflector | 3 | Use lever type roller to improve sensor sensitivity | Bench | Installed lever type roller | 12 out 12 of machine already installed lever type roller | 5 | 5 | 5 | 15 | 1 | Go |
| Sensor malfunction | 1 | Use additional sensor with latching relay | Innovative | Installed additional sensor with latching relay | 3 out 12 of machine already installed sensor with latching relay | 5 | 5 | 5 | 15 | 2 | Go |
| Input/output motor malfunction | 4 | Motor response checking during PM | Bench | Include at PM checklist | Not yet included | 3 | 3 | 3 | 9 | 6 | No go |
| Adhesive tape attached to yellow spacer | 1 | Use additional sensor with latching relay | Innovative | Installed additional sensor with latching relay | 3 out 12 of machine already installed sensor with latching relay | 5 | 5 | 5 | 15 | 3 | Go |
| | 4 | Remove tape at yellow spacer prior use | | Conduct awareness across all shift | Done on deployment but still have de reel due to other reason | 5 | 1 | 5 | 11 | 4 | No go |
| Warp metal reel | 4 | Pull out all warp metal reel and conduct monthly checking of metal reel | Innovative | MH perform inventory and checking of metal reel condition | 8 out of 104 pcs of metal reel is defective | 3 | 3 | 5 | 11 | 5 | No go |

Potential Problem Analysis was used to determine the risks prior the implementing of best solution to ensure that the best solutions will not incur new problems as shown in table 3

Table 3. Potential Problem Analysis

| Best solution | Potential Problem | Potential Cause | Preventive/ Contingency Acton | EP Level | Responsible | Target | Sta |
|---|---|---|---|---|---|---|---|
| Use lever type roller to improve sensor sensitivity | Stuck-up lever type roller | Misaligned aluminum holder | Include checking of lever type roller at PM checklist | 3 | J. Andal/B. Zamora | WW2015 | Do |
| Use additional sensor with latching relay | Sensor malfunction | • Frequent use<br>• Short circuit | • Provide spare of photoelectric sensor<br>• Include checking of sensor at PM checklist | 2 | J. Andal | WW2015 | Do |
| | Malfunction of 24V relay | | • Provide spare of 24V relay<br>• Include checking of 24V relay at PM checklist | 2 | J. Andal | WW2021 | Do |
| | No 24V supply of sensor | Defective 24V machine power supply | • Include checking of 24V machine power supply at PM checklist<br>• Install another relay for machine power supply for zero volts detection | 2 | J. Andal | WW2021 | Do |

## *3.4. Description of Best Solution*

Figure 10 shows the location of installed reflective sensor at input and output module of Wirebond machine. This sensor has a latching relay set-up, the spooler motor automatic turn-off once the sensor sense Lead Frame tape on a required limit.

The machine will not run/start until the "press reset" was not activated refer to fig 11. A lever type roller was installed at the lower part of metal reel to improve sensor sensitivity.

With this sensor installed, de-reel event was prevented and falling lead frame tape on the floor was eliminated.

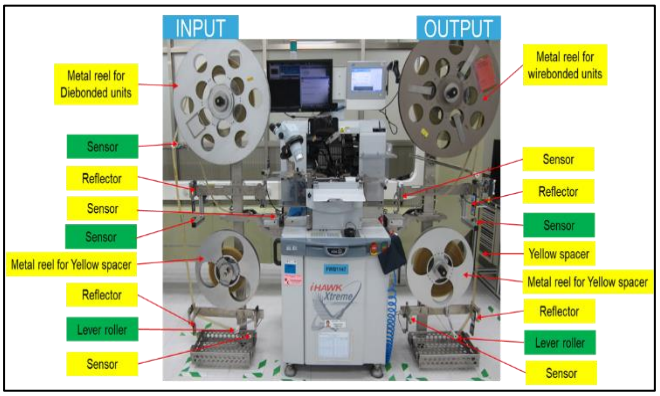


Fig. 10. Location of sensor and lever as additional control


Fig. 11. Press reset motor activation button

## *3.5 How does a reflective object sensor work*

When light from the Emitter strikes the sensing object, the object reflects the light, and it enters the Receiver where the intensity of light is increased. This increase in light intensity is used to detect the object. Sensing distance ranging from several centimeters to several meters as shown on Fig 12.

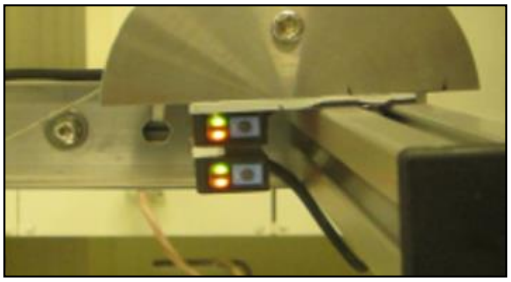

Fig. 12. De-reel Lead frame Sensor

## *3.6 How does lever roller work*

The lever roller provides enough tension on the output spacer and improves the detection of spacer on the reflective sensor line of sight as shown on Fig 13.

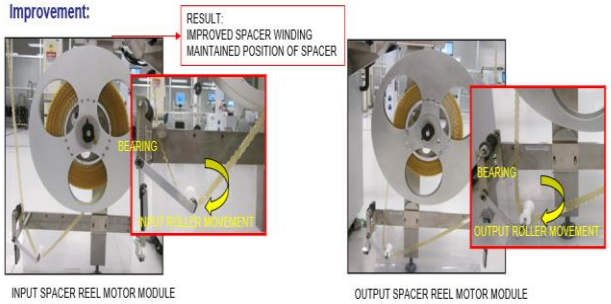


Fig. 13. Lever roller at input/output

## *3.7 Electrical wiring diagram at input/output*

Figure 14 shows that when any of two sensors are triggered or activated the relay will be activated on latching state, cutting the input motor supply and will prompt *LF reel sensor check failed*.

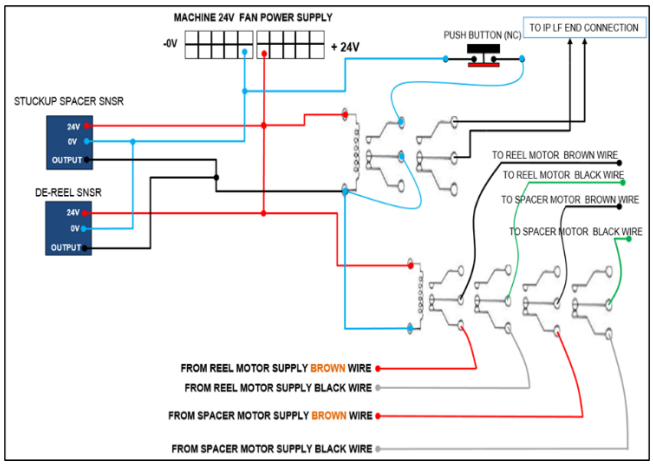


Fig. 14. Input Wiring diagram.

Figure 15 shows that when the sensor is triggered or activated the relay will be activated in a latching state, cutting the output motor supply and will prompt *output LF error*.

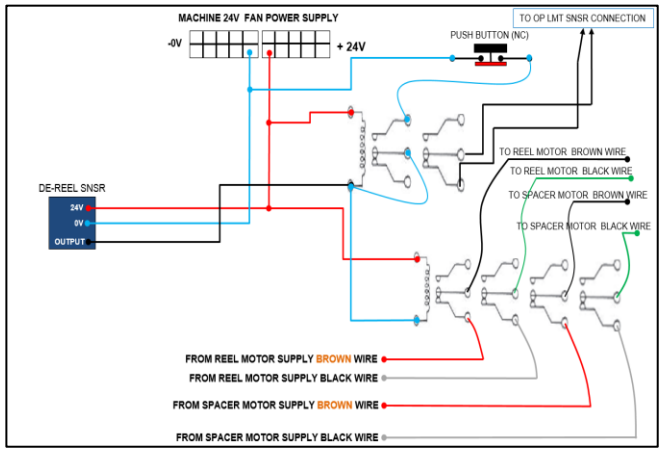


Fig. 15. Output Wiring diagram.

## *3.8 Solution Implementation*

Table 4 shows the implementation plan of the best solution identified by the team. Using PDCA (Plan Do Check Act), we will be able to check the over-all status of activity to implement the best solution.

First best solution is installation of lever type roller to improve sensor sensitivity was identified 3 steps on how to execute the activity. Those are design creation of lever type roller, in-house fabrication of lever type roller and lastly Installation/evaluation. Implementation is 100% done according to the plan.

Second best solution is installation of additional sensor with latching relay was identified with 4 steps on how execute the activity. Those are design electrical wiring diagram, Gathering materials, installation/evaluation, and lastly implementation of additional sensor with latching relay to all machines. Implementation is 100% done according to the plan.

Table 4. Implementation Plan

| PLAN | | DO | | | | | | | | | CHECK | ACT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Best Solution | Steps (How) | Implementation Date (When) | | | | | | | | Resp. (Who) | Result Monitoring (How) | Learning (What you learned from the action) | Status |
| | | Plan vs. Actual | Mar-20 | | | Apr-20 | | May-20 | | | | | |
| | | | Wk | Wk | Wk | Wk | Wk | Wk | Wk | Wk | | | |
| Use lever type roller to improve sensor sensitivity | Design creation of lever type roller | Plan | 10 | | | | | | | | J. Andal | Brainstorming and suggested best design for lever type roller | Team communication | 100% done |
| | | Actual | 10 | | | | | | | | | | | |
| | In-house fabrication of lever type roller | Plan | 11 | | | | | | | | J. Andal | 100% completion of fabrication | Project execution | 100% done |
| | | Actual | 11 | | | | | | | | | | | |
| | Installation and evaluation | Plan | | 12 | | | | | | | Team | Monitoring the effectiveness of lever roller | Always set a another best action | 100% done |
| | | Actual | | 12 | | | | | | | | | | |
| Installed additional sensor with latching relay | Design electrical wiring diagram | Plan | | | 13 | | | | | | J. Andal | Checked functionality of design wiring diagram | Learned reading of Electrical wiring diagram | 100% done |
| | | Actual | | | 13 | | | | | | | | | |
| | Gathering materials | Plan | | | | 15 | | | | | J. Andal | With available materials | Material preparation | 100% done |
| | | Actual | | | | 15 | | | | | | | | |
| | Installation and evaluation | Plan | | | | | 16 | | | | J. Andal/B. Zamora | Installed and evaluate the effectiveness of additional sensor | Project execution | 100% done |
| | | Actual | | | | | 16 | | | | | | | |
| | Implementation of additional sensor with latching relay to all machine | Plan | | | | | | 18 | 19 | 20 | J. Andal/B. Zamora | 3 WB installed sensor with latching relay have no occurrence of dereel | Project execution | 100% done |
| | | Actual | | | | | | | 19 | 20 | | | | |

## 4.0 RESULTS AND DISCUSSION

Graph shows at fig 16 that after the implementation of best solution, the lead frame tape de-reel event at Wirebond was eliminated starting April 2020 to June 2022.

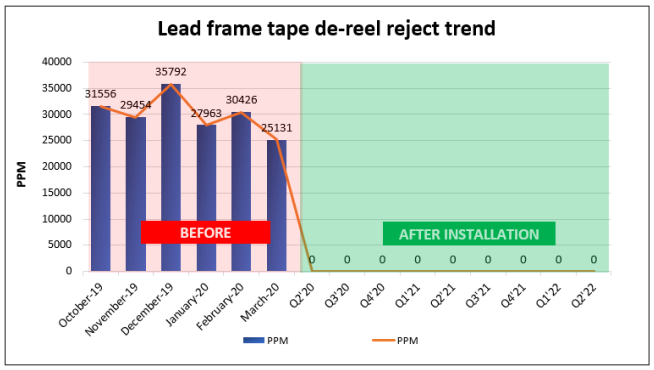


Fig. 16. De-reel event trend after installation

The IE Certified Annualized cost saving for this project from April 2020 to March 2021 was calculated at 73.62KUSD for all Micromodule devices as shown at table 5.

Table 5. Annualized Cost Savings

YIELD IMPROVEMENT / SCRAP REDUCTION PROJECT

| Project | Dereel problem at Wirebond PPM | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Actual | | | | | | Forecasted | | | | | | |
| Monthly Forecast Savings | Apr'20 | May'20 | Jun'20 | Jul'20 | Aug'20 | Sep'20 | Oct'20 | Nov'20 | Dec'20 | Jan'21 | Feb'21 | Mar'21 | T |
| Input Volume (K) | 13,061 | 13,603 | 6,379 | 12,118 | 15,340 | 11,884 | 10,977 | 6,071 | 5,950 | 6,399 | 7,285 | 4,971 | 114 |
| Defect rate (%) | | | | | | | | | | | | | |
| Baseline | 2.34% | 2.34% | 2.34% | 2.34% | 2.34% | 2.34% | 2.34% | 2.34% | 2.34% | 2.34% | 2.34% | 2.34% | |
| Actual/Target | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 1.64% | 1.64% | 1.64% | 1.64% | 1.64% | 1.64% | 1.64% | |
| Improvement | 2.34% | 2.34% | 2.34% | 2.34% | 2.34% | 0.70% | 0.70% | 0.70% | 0.70% | 0.70% | 0.70% | 0.70% | |
| Scrap qty reduced (K) | 305.47 | 318.14 | 149.18 | 283.42 | 358.78 | 83.38 | 77.02 | 42.6 | 41.75 | 44.89 | 51.11 | 34.88 | 1,7 |
| Device Cost | 0.0409 | 0.0428 | 0.0419 | 0.043 | 0.0427 | 0.0419 | 0.0366 | 0.0351 | 0.0345 | 0.0345 | 0.0345 | 0.0345 | |
| Savings (K$) | | | | | | | | | | | | | |
| Monthly | 12.49 | 13.6 | 6.25 | 12.18 | 15.34 | 3.5 | 2.82 | 1.49 | 1.44 | 1.55 | 1.76 | 1.2 | |
| Cumulative | 12.49 | 26.09 | 32.34 | 44.52 | 59.86 | 63.35 | 66.17 | 67.66 | 69.1 | 70.65 | 72.42 | 73.62 | |

| RESPONSIBILITY MATRIX | IE | Project Owner |
|---|---|---|
| CCRP Release # | n/a | B. Zamora |
| Actual + Forecasted Savings (K$) | 73.62 | |

IE CERTIFIED!

### *4.1 Team Learnings:*

Table 6 shows the team learnings that need to improve.

Table 6. Team Learnigs

| What Went Well | What Needs to Be Improved | Action Plans | RESP | Target Date | Status |
|---|---|---|---|---|---|
| Eliminate dereel at input and output module of Wirebond machine | Parts maintenance of implemented project | Include proper maintenance at PM checklist | J. Andal B. Zamora | WW2021 | Done |
| Prevent broken coupling due to manual rotation of metal reel during end of lot | 100% installation of dereel prevention project | Stick to timeline activity installation | J. Andal B. Zamora | WW2022 | Done |

### *4.2 Standardization:*

The team list down all needed documents activities to sustain the improvements, applicable documents were updated. Then successfully deployment to the shopfloor personnel was executed. Table 6 shows the summary of documents and activities that have been updated.

Table 7. Documentation

| Activity | Responsible | Target Implementation | Status |
|---|---|---|---|
| Update Wirebond work instruction | Bernard Zamora | WW2023 | Done |
| Providing OPL on how to use dereel prevention project | Bernard Zamora | WW2022 | Done |
| Line training for dereel prevention project | Julius Andal / Eric espino | WW2021 | Done |

## 5.0 CONCLUSION

After installing the reflective sensor with latching relay and lever roller at input/output module, the lead frame tape de-reel event at reel-to-reel Wirebond process was eliminated.

## 6.0 RECOMMENDATIONS

It is recommended to fan-out these learnings to other machines. Future studies are recommended for plans to zero-out the occurrences of de-reel event at Wirebond.

## 7.0 ACKNOWLEDGMENT

We would like to thank Mr. Leonel Jay Manuel and all the Integrated Lines Team for their sincerest appreciation and full extended support.

To our colleagues for providing us with the tools necessary to complete this project.

To our beloved family, friends, and colleagues who wholeheartedly supported them to make this project fruitful and successful.

## 8.0 REFERENCES

ASM iHawk Eagle Extreme Wirebond Maintenance Manual

## 9.0 ABOUT THE AUTHORS

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