PROCESS SIMPLIFICATION THROUGH ELIMINATION OF PRE-CUT, COVERLAY AND DE-TAPE PROCESS FOR MEMS INSTRIP PACKAGES

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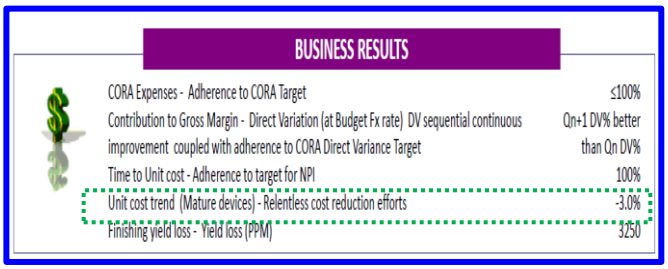
ABSTRACT

This paper will discuss how our project supported cost improvement as one of the organizational goals of the company last 2019. Project focuses on analyzing the IDM spending and process simplification at assembly plant. Calamba has two process bricks for MEMS devices , MEMS with FT1 (Instrip test) and FT2 (Singulated test). MEMS Instrip requires a special process called Pre-cut. Comparing the two MEMS package group, MEMS Instrip has a higher cost in terms of process flow which Pre-cut process incurred additional cost for saw blade and coverlay tape.

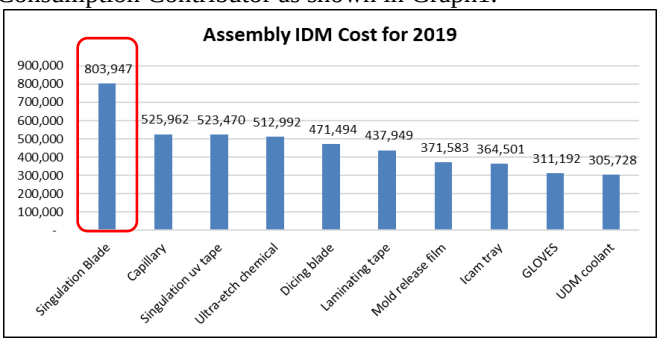
Pre-cut process removal significantly improved the Cycle time and indirect material consumption (saw blade and coverlay tape). Details of the journey will be further appreciated as we read and understand the story behind the success of this project.

1. 0 INTRODUCTION

Our project supported BEM&T – Calamba 2019 Top Page thru relentless cost reduction effort which was one of the plant top priority highlighted in blue box below.

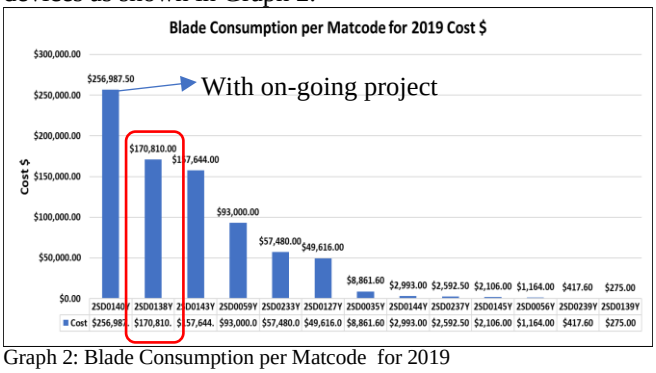


In 2019, the Singulation blade is the Top Assembly IDM Cost Consumption Contributor as shown in Graph1.



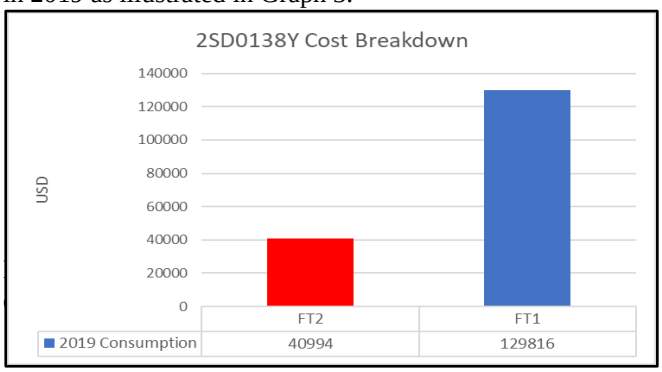
Graph 1: Assembly IDM Cost for 2019

2SD0138Y is the material code for saw blades used in MEMS product. It is the Top 2 blade consumption which is used for Pre-cut and Full-cut process dedicated to MEMS devices as shown in Graph 2.



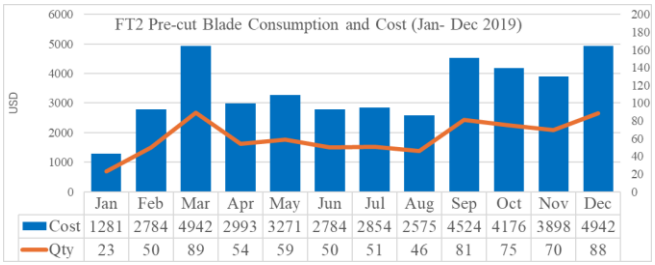
Graph 2: Blade Consumption per Matcode for 2019

Breakdown showed a total of 41K USD or 24% of 2SD0138Y blade is used for Pre-cut process alone for FT2 in 2019 as illustrated in Graph 3.



Graph 3: 2SD0138Y Cost Breakdown

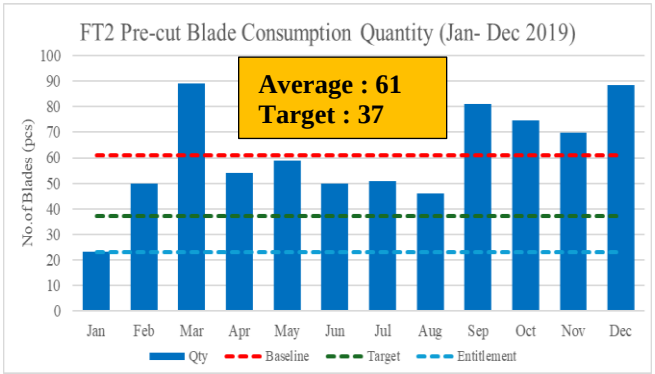
Below are the 2019 monthly cost & consumption quantity of FT2 Pre-cut blade (2SD0138Y blade) as shown in Graph 4.



Graph 4: FT2 Pre-cut Blade Consumption and Cost 2019

Increasing volume in Instrip MEMS packages and new banner of products being developed by NPI projected to run on 2020 means an increase in IDM consumption per process. The challenge is to reduce pre-cut blade consumption observed from January to December 2019 for MEMS Instrip.

Our objective is to reduce pre-cut blade consumption for MEMS Instrip packages from an average of 61 pcs/month to 37 pcs/month or 60% reduction by February' 2020 as shown in Graph 5.

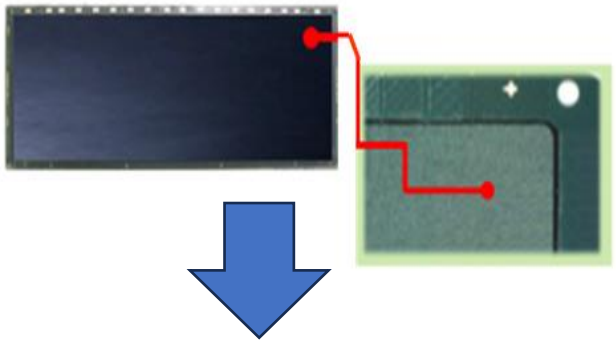


Graph 5: Target Consumption Quantity per month

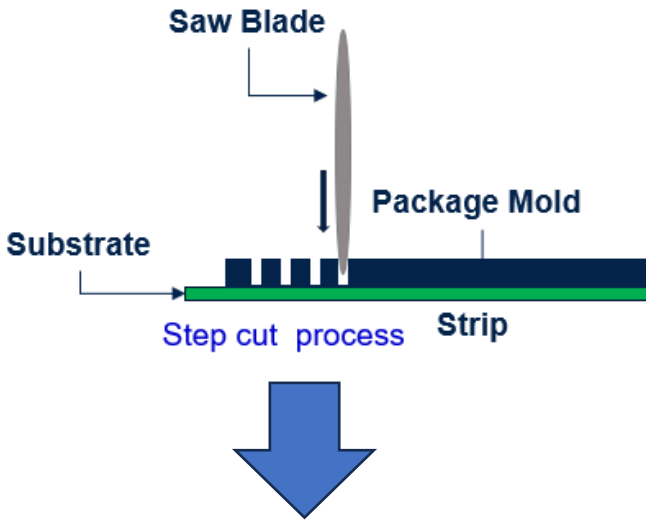
Understanding the Pre-cut Process:

Pre-cut process function is to relax the molded strips and manage the warpage that could influence electrical testing alignment and response during trimming at FT1 Instrip testing.

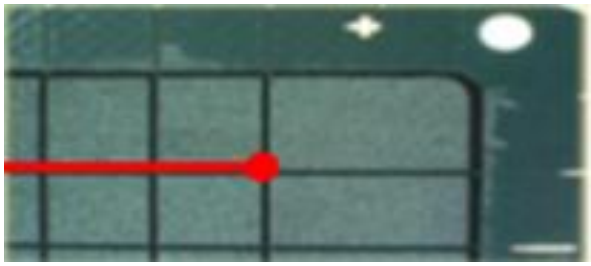
1) Molded Strip will undergo pre-cut process (Input)



2) Pre-cut Process using Saw Blade to partially cut the molded part of the strip.



3) Molded strip is partially cut.



4) Pre-cut strip will now undergo coverlay taping process.

Coverlay Taping Machine

5) Pre-cut Strip with Coverlay Tape (Output Strip)

2. 0 REVIEW OF RELATED WORK

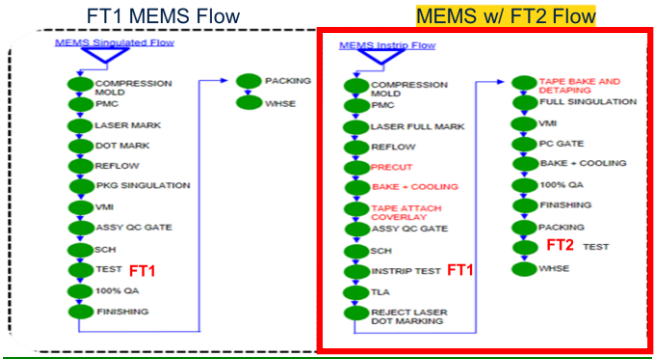
Checking from other previous studies related to pre-cut, only specific MEMS product for Instrip test is using this coverlay material, other devices don't require this as part the process. Further checking was benchmarked to ST Malta where we have the same set-up however, there was no study on how to reduce pre-cut blade consumption on this product.

3.0 METHODOLOGY

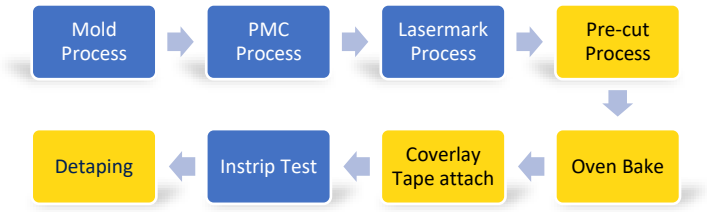
3.1 Understanding the MEMS Process Flow

Below shows comparison between Singulated (FT1 only) and Instrip Testing (FT1 + FT2) as shown.

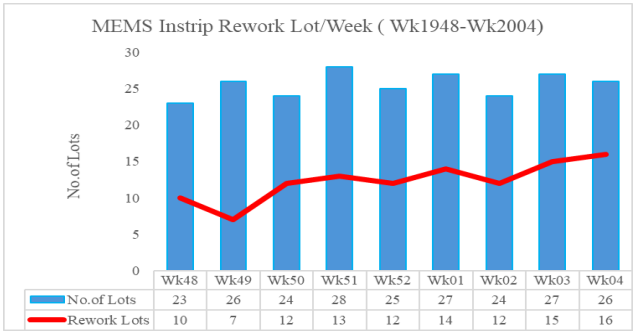
Only MEMS Instrip devices have the Pre-cut Process flow



Shaded in yellow are the four additional process steps required for FT2 MEMS Instrip compared to FT1 MEMS which is the focus of this study. These steps at FT2 MEMS Instrip device do not have significant purpose but rather incurred negative effect in processing.

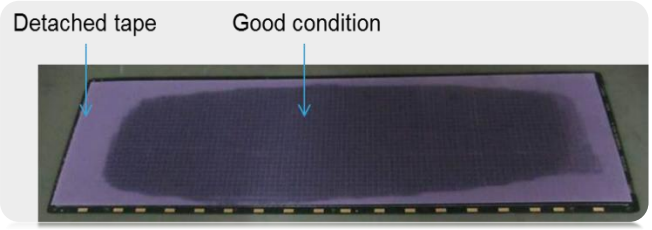


Graph 6 shows an average of 48% of rework lot for Instrip MEMS due to detached coverlay tape. Detached coverlay tape happens when lot was staged for about above 8 hours prior testing. This detached coverlay tape will be endorsed back to coverlay taping for re-conditioning also known as rework which is a Non-Value Adding Activity.



Graph 6: MEMS Instrip Rework Lot/Week

Shown is a sample illustration of strips being reworked due to detached coverlay tape on molded strip.



The following options were identified and assessed based on impact on Cycle time, Cost, Quality and Feasibility. Among the options, removal of Pre-cut process removal was chosen based on the scoring with highest points.

Table 1: Selection Criteria

Option	Cycle time	Cost	Quality	Feasibility	*Total	Remarks	Decision
Selection criteria	Scale :1-3-9 1- Low Reduction 2 – Medium Reduction 9 – High Reduction		Scale :1-3-9 9 – Low Impact 1- High Impact	Scale :1-3-9 9 – Feasible w/ <10k investment 3 – Feasible w/ >10k investment 1- Not feasible		*The higher the better	
Removal of Precut Process	9	9	9	9	36	Removing precut process is directly proportional to decrease the use of precut blades	GO
Rejuvenated blade to be use for precut process	1	1	3	9	14	Blade rejuvenation is additional cost for the supplier to perform the rejuv activity.	NO GO
Extend blade life for precut process	9	9	3	9	30	Blades use from precut process already maximized through Blade life extension project for other devices.	NO GO

Risk Assessment was performed to identify impact on Pre-cut process removal. Risk identified will be validated to confirm impact of change.

Table 2: Risk Assessment

RISK ASSESSMENT Form - Skip Precut process

#	Risks identified	Potential risk resulting from	Before Action		
			Prob.	Impact	Class
1	High Test Rejects	Strip planarity on nest tool	6	3	B
2	High Strip Warpage	No Precut and Coverlay	6	3	B
3	Crumpled/Damaged Strip	Nest Tool Clamper unable to clamp high warpage on strip	3	3	B
4	Handler Error	High Strip warpage	6	3	B
Maximum of [Prob. X Impact]			18		B

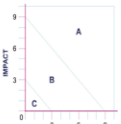
LIST OF IMPACTED FMEA (If any):	Title:	Reference
DMS reference of Current FMEA	NA	
Current Class (if existing)	B	
Max Class for the current change	C	

Legend:

Probability:	
None	0
Low	1
Possible	3
Probable	6
More probable	9
Sure	10

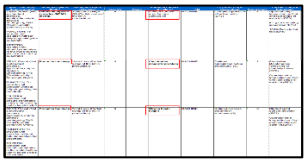
Impact:	
None	0
Low	1
Notable	3
Sensitive	6
High risk	9
Catastrophic	10

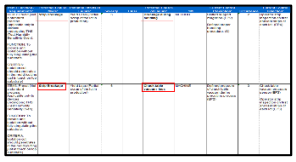
Class:	
Inacceptable	A
Major	B
Minor	C



Note:
1- Any risk classified as A/B should be taken relevant effective actions to decrease occurrence frequency or enhance detectac
2- After actions taken, the maximum of [Prob. X Impact] should be not greater than 20 (Class A). IE Prob X Impact ≤ 20, C Prob X Im

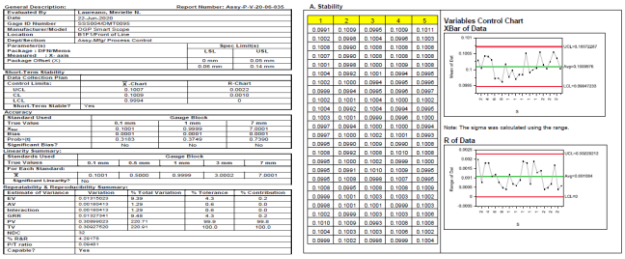
FMEA review was performed. The characteristics identified were already included in substrate FMEA.





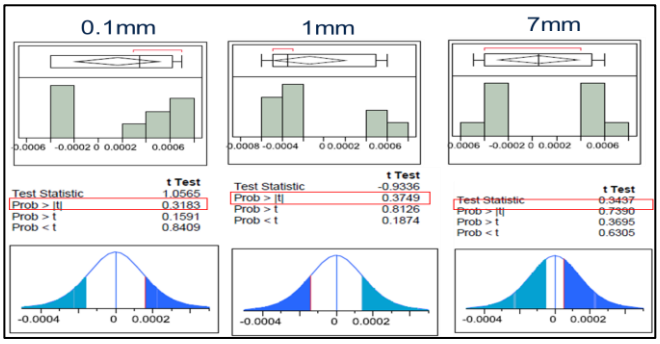
Before we proceed to the validation, we checked the MSA – (measurement system analysis) on warpage to ensure that there will be no measurement issue. The equipment used for warpage is smart scope.

For Stability MSA – all points are in control limit and these indicates that the measurement system can be use anytime.

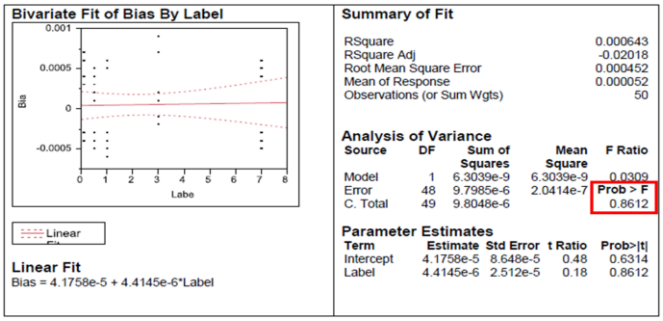


All point are in control limits and these indicate that the Measurement system can be use anytime.

MSA - Bias



Bias across the measurement range is not significant (Prob ItI > 0.05)



Equipment bias is Linear across the process range. (Prob ItI > 0.05)

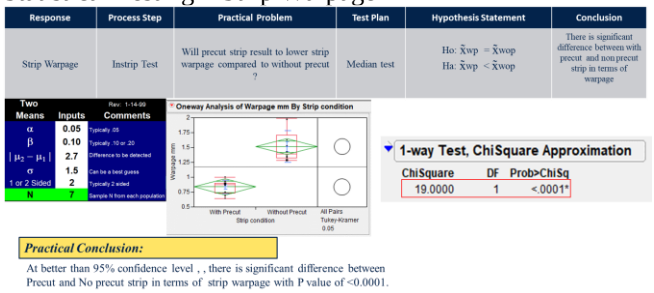
Focus will only be on Eliminating Pre-cut process.
Detached coverlay issue is associated with pre-cut process and can be eliminated, thus, also eliminate rework at assembly. Pre-cut blade for singulation can be reduced by removing pre-cut process. It also eliminates the use of coverlay tape and oven bake process.

Validation Plan:

Validation Plan											
Y (or mini Y)	Unit of Measure	Y treated as	X	True nature of X	Levels of X, if discrete or converted into discrete	Hypothesis Statement: Null Hypothesis	Hypothesis Statement: Alternative Hypothesis	Statistical Test	Beta	Alpha	Delta	Sample Size
Strip Warpage	mm	Cotinuous	Process	Discrete	With Precut Without Precut	Ho: μwp = μwop	Ha: μwp < μwop	2 means test	0.1	0.05	2.7	10 strips
Damaged Substrate	PPM	Discrete	Process	Discrete	With Precut Without Precut	Ho: Pwp = Pwop	Ha: Pwp < Pwop	2 proportion test	0.1	0.05	0.0001	50 strips
Test Failure _Noise	Percentage	Discrete	Process	Discrete	With Precut Without Precut	Ho: Pwp = Pwop	Ha: Pwp < Pwop	2 proportion test	0.1	0.05	0.001	4281
Bin 6 O/S	Percentage	Discrete	Process	Discrete	With Precut Without Precut	Ho: Pwp = Pwop	Ha: Pwp < Pwop	2 proportion test	0.1	0.05	0.006	713
Handler Error	# of occurence	Discrete	Process	Discrete	With Precut Without Precut	Ho: Pwp = Pwop	Ha: Pwp < Pwop	2 proportion test	0.1	0.05	0.05	85 strips

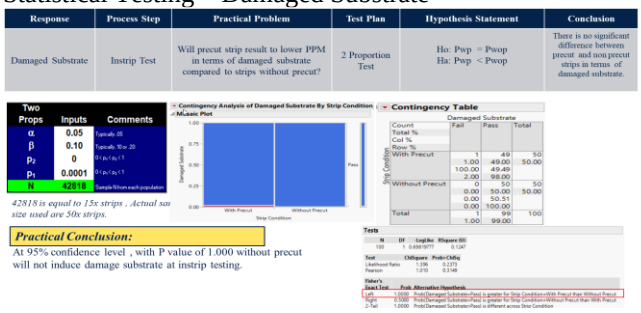
There are 5 responses identified for this project that need to validate, strip warpage, damaged substrate, test failure, handler error.1 continuous and 4 discrete to be validated with and without pre-cut. We used 10% Beta risk and 5 % Alpha Risk . We determine the critical difference to arrive at this sample size.

Statistical Testing – Strip Warpage



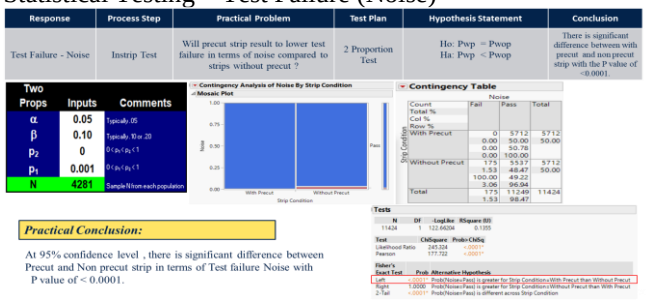
At better than 95% confidence level, **there is significant difference between Pre-cut and No pre-cut strip in terms of strip warpage** with P value of <0.0001.

Statistical Testing – Damaged Substrate



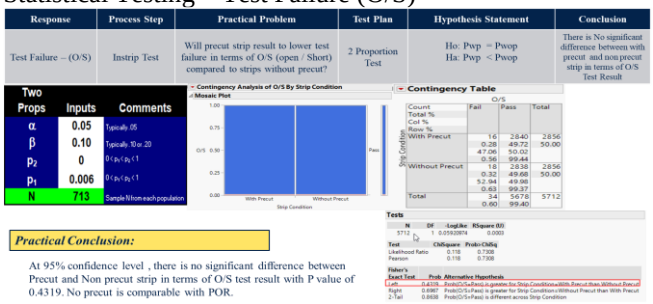
At 95% confidence level , with P value of 1.000 without pre-cut will not induce damage substrate at Instrip testing.

Statistical Testing – Test Failure (Noise)



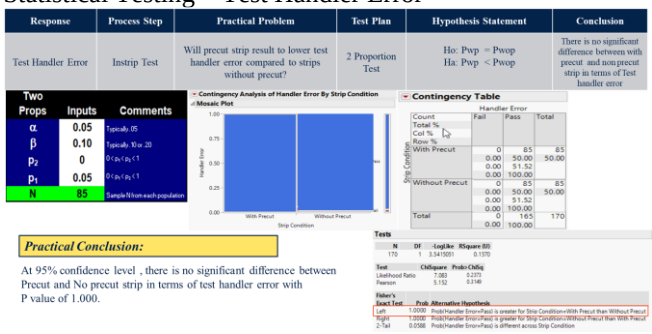
Remarks: At 95% confidence level , ***there is significant difference*** between Pre-cut and No pre-cut strip in terms of Test failure Noise with P value of < 0.0001.

Statistical Testing – Test Failure (O/S)



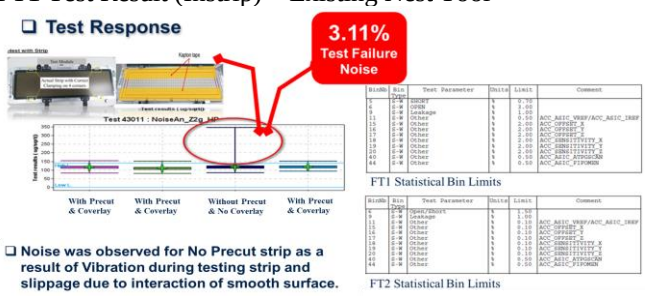
At 95% confidence level , there is no significant difference between Pre-cut and No pre-cut strip in terms of O/S test result with P value of 0.4319. No pre-cut is comparable with POR.

Statistical Testing – Test Handler Error

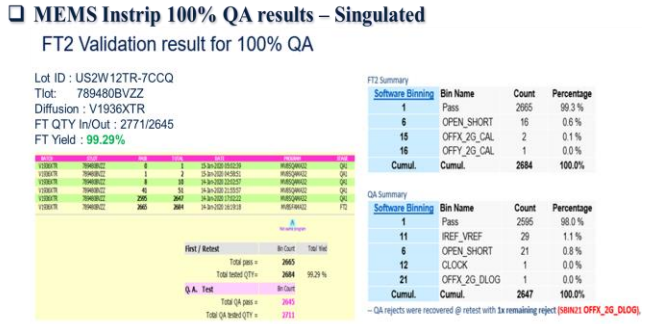


At 95% confidence level , there is no significant difference between Pre-cut and No pre-cut strip in terms of test handler error with P value of 1.000.

FT1 Test Result (Instrip) – Existing Nest Tool



No Pre-cut FT2 & QA Test Result



FT2 & QA Test Result Passed with 99.29% Yield vs 98% Yield Target.

Validation Result:

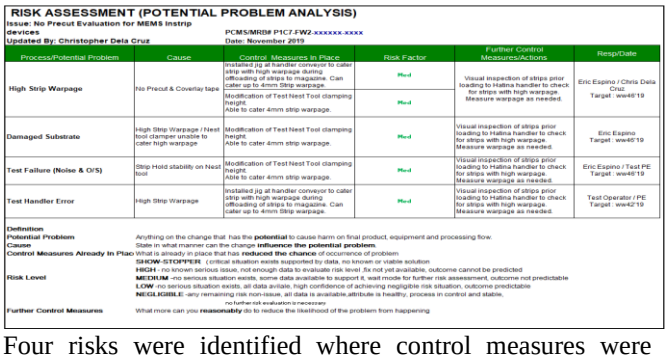
Validation Plan and Results

Y (or mini Y)	Unit of Measure	Y treated as	X	True nature of X	Levels of X, if discrete or converted into discrete	Hypothesis Statement		Statistical Test	Beta	Alpha	Delta	Sample Size	p-value	Decision
						Null Hypothesis	Alternative Hypothesis							
Strip Warpage	mm	Continuous	Process	Discrete	With Precut Without Precut	Ho: $\bar{X}$wop = $\bar{X}$wop	Ha: Pwp < Pwop	Median Test	0.1	0.05	2.7	10 strips	0.0001	X is significant. Hence, accept Ha
Damaged Substrate	PPM	Discrete	Process	Discrete	With Precut Without Precut	Ho: Pwp = Pwop	Ha: Pwp < Pwop	2 proportion test	0.1	0.05	0.0001	50 strips	1.000	X is not significant. Hence, accept Ho
Test Failure _Noise	Percentage	Discrete	Process	Discrete	With Precut Without Precut	Ho: Pwp = Pwop	Ha: Pwp < Pwop	2 proportion test	0.1	0.05	0.001	4281	0.0001	X is significant. Hence, accept Ha
Bin 6 OFS	Percentage	Discrete	Process	Discrete	With Precut Without Precut	Ho: Pwp = Pwop	Ha: Pwp < Pwop	2 proportion test	0.1	0.05	0.006	713	0.4319	X is not significant. Hence, accept Ho
Handler Error	# of occurrence	Discrete	Process	Discrete	With Precut Without Precut	Ho: Pwp = Pwop	Ha: Pwp < Pwop	2 proportion test	0.1	0.05	0.05	85 strips	0.0294	X is significant. Hence, accept Ho

Based on the validation result only Strip Warpage and Test Failure (noise) is significant from the change with P value of 0.0001 which affected by the removal of pre-cut process.

Next action is to determine the nature of problem at Test process.

Table 3 : Potential Problem Analysis

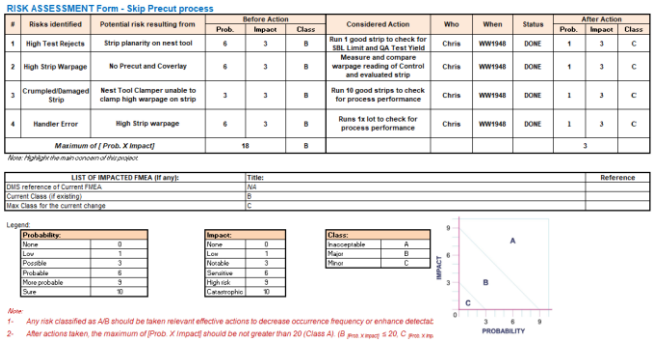


Four risks were identified where control measures were reviewed and implemented.

Corrective Action on Noise Test Failure and Strip Warpage was the modification of nest tool holding the strip which has direct impact on testing and to cater 3mm strip warpage.

This improvement project was presented in the 2023 ANTS Symposium. This resulted in reducing Test Noise Failure and improving clamping capability from 1mm to 3mm.

Table 4: Quality Risk Assessment – Result

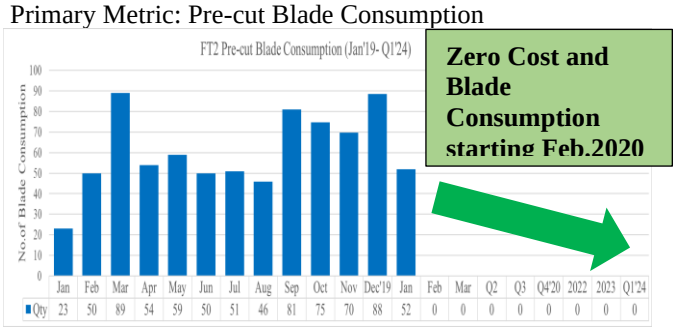


After the actions were done, the impact for the risk assessment decreased from 18 to 3 or from major to minor class.

4.0 RESULTS AND DISCUSSION

After removal of Pre-cut process, below are the results and impact of this project which leads to Cost savings and Cycle time reduction as shown in Graph 7 and 8 respectively.

Primary Metric: Pre-cut Blade Consumption

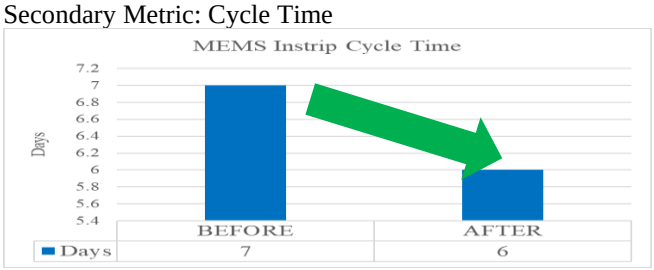


Graph 7: FT2 Pre-cut Blade Consumption 2019-2024

After the project implementation, no more cost incurred from pre-cut blade from Feb'2020 to date. This Project leads to cost savings of USD 100.23K from Feb.2020 to Jan.2021 alone.

Cycle time reduction for MEMS Instrip devices reduces from 7 days to 6 days.

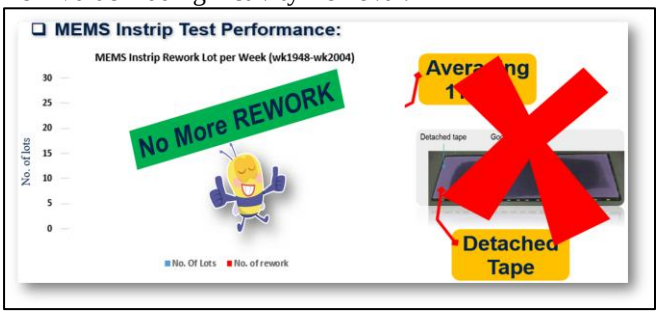
Secondary Metric: Cycle Time



Graph 7: MEMS Instrip Cycle Time (Before and After)

Zero rework on detached coverlay after Pre-cut process elimination that resulted in removal of Non-Value Adding Activity.

Non-Value Adding Activity Removal.



5.0 CONCLUSION

With the use of data analysis tools, proper risk assessment and management during this project, Pre-cut process elimination was made possible and implemented without compromising quality and productivity.

6.0 RECOMMENDATIONS

It is recommended to fan-out this improvement on upcoming device variant originally requiring pre-cut process which was already fanned-out to other device variants.

7.0 ACKNOWLEDGMENT

The authors would like to acknowledge the following: Assembly Process Engineering and Production team, Test Product Engineers for the technical guidance and feasibility study.

8.0 REFERENCES

1. Equipment and Process FMEA
2. FW2 Process Plan
3. Assembly IDM Cost
4. ST Calamba Tope Page

9.0 ABOUT THE AUTHORS

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Sotero Malabanan is a Sr Technician Specialist in the End of Line. BS Electrical Engineering from Alejandro Colleges, Quezon City. He acquired his Semiconductor knowledge at STMicroelectronics for 19.4years.He is a certified Six-Sigma Green Belt practitioner and currently a Process Engineer Support for Singulation and VMI process.