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.



BUSINESS RESULTS	
\$ CORA Expenses - Adherence to CORA Target Contribution to Gross Margin - Direct Variation (at Budget Fx rate) DV sequential continuous mprovement coupled with adherence to CORA Direct Variance Target Time to Unit cost - Adherence to target for NPI Unit cost trend (Mature devices) - Relentless cost reduction efforts	≤100% Qn+1 DV% better than Qn DV% 100% -3.0%
inishing yield loss - Yield loss (PPM)	3250

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.











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	Cycl e time	Cost	Quality	Feasibility	*Total	Remarks	Decision
Selection criteria	Sc 1- Lo 2 - R 9 R	ale :1-3-9 w Reduction - Medium eduction 9 – High eduction	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 bo	tter
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



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.

and the second second										
Evaluated By	Louiseano, Mera	elle N.								
Date	22-Jun-2920					-				Mariables Control Chart
Gage ID Hemilier	SSS004IDMT00	95				_			<u> </u>	warmones control chart
Manufacturer/Model	OOP Smart Sco	çe			0.0991	0.1009	0.0995	0.1009	0.1011	XBar of Data
Location	B1F1/Frank of La									
Deptritection	Assy Mig/ Proce	res Combod			0.1002	0.0069	0.1004	0.0006	0.1003	0.00
Parameter(s)			941	(Limit(a)	0.1008	0.0990	0.1008	0.1008	0.1008	UCL-8.18072287
Package : DFN:Mems			LSL	USL				_		1 annu
Reasured : X-axis					0.1007	0.0990	0.1008	0.1000	0.1008	
-amage Crister (A)			U MM	U.US MIN	0.1001	0.0000	0.000	0.1000	0.1000	
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LCL		0.0904		0	0.1902	0.1001	0.1004	0.1000	0.1902	
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corney										au •
landard Used		Ga	rge Block		0.1003	0.1001	0.0000	0.0996	0.1000	
rue Vatue	0.5	101/10	1 mm	7 mm	0.0907	0.0004	0.1000	0.1000	0.0004	Matter The closer care advised and a loss the same
Auf		1001	0.9999	7.0001						none: The sigma was calculated using the range.
		ingen 1	0.0001	0.0001	0.0997	0.1000	0.1002	0.1001	0.0993	
FOD>(Q	0.3	0103	0.5749	0.7390	0.0004	0.0000	0.0000	0.0000	0.1000	R of Data
agniticani bias /		90	No	190	0.0000	0.0000	0.1000	0.0000	0.1000	(
searity Summary:					0.1008	0.0992	0.1008	0.1010	0.1008	URL-6 and and
Standards Used		Gau	pe Dhock		0.0004	0.1000	0.0000	0.0000	0.1000	0.002 -0
Free Values	0.1 mm	0.5 mm 1	3	7	0.0000	0.1000	0.1000	0.0000	0.1000	
or Each Standard					0.0995	0.0991	0.1010	0.1009	0.0995	3 62005-1//
X	0.1001	0.5000 0.1	999 3.000	2 7.0001						2 AV01 AV02 AV02 AV02 AV02 AV02 AV02 AV02 AV02
Significant Litearity?	NO				0.0996	101009	10,0666	10.1907	0.0996	
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atimate of Variance	Variation	To Total Variation	 % Toterance 	% Contribution						
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neraction	0.00180419	1.29	0.6	0.0	2.000	2.1981			1.100	
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Tratio	0.06481				0.0966	0.1002	0.0000	0.0000	0.1004	
an able b	Man									
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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:

					Y	alidation 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	s Statement Alternative Hypothesis	Statistical Test	Beta	Alpha	Delta	Sample Size
Strip Warpage	mm	Cotinuous	Process	Discrete	With Precut Without Precut	но: µwp = µwop	на: µwp < µwop	2 means test	0,1	0.05	2.7	10 strips
Damaged Substrate	ррм	Discrete	Process	Discrete	With Precut Without Precut	Ho: Pwp = Pwop	на: Рwp < Рwop	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	на: Рwp < Рwop	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	на: Рwp < Рwop	2 proportion test	0,1	0.05	0.006	713
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

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 precut 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)

Respo	nse	Process Step	Practical Problem	Test Plan	Hypoth	esis Sta	tement		Conclusion
Test Failure – (O/S) Instrip Test			Will precut strip result to lower test failure in terms of O/S (open / Short) compared to strips without precut?	2 Proportio Test	n Ho: I Ha: I	There is No significant difference between with precut and non precut strip in terms of O/S Test Result			
Two			 Contingency Analysis of O/S By Strip Condition (Mosair Plat) 	•	 Contingency 	Table			
Props	Inputs	Comments	1.00		Count Total %	Fail	Pass	Total	1
α.	0.05	Typically.05	0.75 -		Col % Row %				
β	0.10	Typically 10 or 20	01.6%	Paul	2 With Precut	0.28	2840	285	6 D
P ₂	0	0 <pt<pg<1< th=""><th></th><th></th><th>Without Precut</th><th>0.56</th><th>2838</th><th>285</th><th>6</th></pt<pg<1<>			Without Precut	0.56	2838	285	6
P1	0.006	0 <pg<pg<1< th=""><th>0.25</th><th></th><th></th><th>0.32</th><th>49.68</th><th>50.00</th><th>D</th></pg<pg<1<>	0.25			0.32	49.68	50.00	D
N	713	Sample N from each populat	0.00 With Precut Without Pr	ecut	Total	0.63	99.37 5678 99.40	5713	2
			Step Condition	Те	ests				
D of	10				N DF -LogLike	RSquare 0	100 103		
Practice	al Concl	usion:		10	est ChiSquare I kelhood Ratio 0.118	0.7308			
At 95 Precut 0.431	% confide t and Nor 9. No pre	nce level , there a precut strip in t cut is comparable	is no significant difference betwee erms of O/S test result with P value e with POR.	en n e of b	bler's sctTest Prob Alternat et 0.4309 Prob(Cot oph 0.6987 Prob(Cot Tail 0.6538 Prob(Cot	ive Hypothe In Past) is gre In Past) is diff	sis vater for Strip ferent across	Condition a Candition a Strip Condit	With Recut than Without Recut Without Precut than With Precut Son

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:

					Va	idation Plan	and Results							
	1157	v i		True	Levels of X, if	Hypothesi	6 e e 1							
Y (or mini Y)	Unit of Measure	T treated as	x	nature of X	discrete or converted into discrete	Null Hypothesis	Alternative Hypothesis	Test	Beta	Alpha	Delta	Size	p-value	Decision
Strip Warpage	m	Cotinuous	Process	Discrete	With Precut Without Precut	Ho: xwp = xwop	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 D/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	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

devices Updated By: Christopher Dela	Cruz	PCMS/MR8# P1C7-FW2-xxxxx-xxxx Date: November 2019							
Process/Potential Problem	Cause	Control Measures In Place	Risk Factor	Further Control Measures/Actions					
llish Strie Warnage	No Proved & Country tops	Installed jig at handler conveyor to cater strip with high warpage during offloading of strips to magazine. Can cater up to 4mm Strip warpage.	Red	Visual inspection of strips prior loading to Hatina handler to check	Eric Espino / Chris Del				
nigh solp marpage	no meta a cominy tape	Modification of Test Nest Tool clamping height. Able to cater 4mm strip warpage.	Hed	for strips with high warpage. Measure warpage as needed.	Target : ww-46'19				
Damaged Substrate	High Strip Warpage / Nest tool clamper unable to cater high warpage	Modification of Test Nest Tool clamping height. Able to cater 4mm strip warpage.	Hed	Visual inspection of strips prior loading to Halina handler to check for strips with high warpage. Measure warpage as needed.	Eric Espino Target : ww46'19				
Test Failure (Noise & O/S)	Strip Hold stability on Nest tool	Modification of Test Nest Tool clamping height. Able to cater 4mm strip warpage.	Hed	Visual inspection of strips prior loading to Hatina handler to check for strips with high warpage. Measure warpage as needed.	Eric Espino / Test PE Target : ww46'19				
fest Handler Error	High Strip Warpage	Installed jig at handler conveyor to cater strip with high warpage during officiating of strips to magazine. Can cater up to 4mm Strip warpage.	Hed	Visual inspection of strips prior loading to Hatina handler to check for strips with high warpage. Measure warpage as needed.	Test Operator / PE Target : ww4219				
effinition votential Problem Suuse Sontrol Measures Already in Plac tisk Level	Anything on the change that State in what manner can the order of the state of the state of the state of the state of the state of the HEGH on known serious interaction MEDICUM - no serious situation of NECEL CALLE - any remain	It has the potential to cause harm on fin the change influence the potential pro- thas reduced the change of occurrent at shadnen exists supported by data, no k scie, not encugh data to evaluate risk less ton exists, science data avariable to suppo- ixists, all data avitale, high confidence of ing risk non-issue, all data is avaitable all	al product, equipment and pro- blem. co of problem nown or viable solution of fix not yet available, outcom fix, wait mode for further risk a achieving negligible risk situat tuble is headthy, process in co	cessing flow. e cannot be predicted assessment, outcome not predictable on, outcome predictable whol and stable.					
Further Control Measures	What more can you manned	no further risk evaluation is necessary wabby do to reduce the likelihood of the pr	oblem from baonening						

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

# 1 2 H 3 ^C 4	Risks identified High Test Rejects High Strip Warpage Crumpled/Damaged Strip Handler Error	Potential risk resulting from Strip planarity on nest tool No Precut and Coverlay Nest Tool Clamper unable to clamp high warpage on strip	Prob. 6 6 3	Impact 3 3	Class B B	Considered Action Run 1 good strip to check for SBL Limit and QA Test Yield Measure and compare warpage reading of Control and evaluated strip	Who Chris Chris	When WW1948 WW1948	Status DONE DONE	Prob. 1	Impact 3	Class C
1 1 2 H 3 C	High Test Rejects High Strip Warpage Crumpled/Damaged Strip Handler Error	Strip planarity on nest tool No Precut and Coverlay Nest Tool Clamper unable to clamp high warpage on strip	6 6 3	3 3	Class B B	Run 1 good strip to check for SBL Limit and QA Test Yield Measure and compare warpage reading of Control and evaluated strip	Chris	WW1948 WW1948	DONE	Prob. 1	3	Class
1 2 H 3 C 4	High Test Rejects High Strip Warpage Crumpled/Damaged Strip Handler Error	Strip planarity on nest tool No Precut and Coverlay Rest Tool Clamper unable to clamp high warpage on strip	6 6 3	3	8	Run 1 good strip to check for SBL Limit and QA Test Yield Measure and compare warpage reading of Control and evaluated strip	Chris Chris	WW1948 WW1948	DONE	1	3	с
2 H	High Strip Warpage Crumpled/Damaged Strip Handler Error	No Precut and Coverlay Nest Tool Clamper unable to clamp high warpage on strip	6	3	в	Measure and compare warpage reading of Control and evaluated strip	Chris	WW1948	DONE	1		
3 C	Crumpled/Damaged Strip Handler Error	Nest Tool Clamper unable to clamp high warpage on strip	з								`	c
4	Handler Error			· ·	в	Run 10 good strips to check for process performance	Chris	WW1948	DONE	1	3	с
· · ·		High Strip warpage	6	з	8	Runs 1x lot to check for process performance	Chris	WW1948	DONE	1	з	с
	Maximum	of [Prob. X Impact]	1	8	в						3	
DMS re Curren	LIST (eference of Current Fi nt Class (if existing)	OF IMPACTED FMEA (If any): IEA		Title: NA B							Refe	rence
Legend	d:	ange										
	Probability: None Lov Possible Probable More probable Bure	0 1 3 6 9 10	Impact: None Low Notable Seruitive High isk Catastrophic	0 1 3 6 9 10		Class: hacceptable A Major B Minor C	RIPACT 9	в				
Note: 1-	Annual state and some Weather	s A/R should be taken relevant eff	ective action	is to decreas			0	<u>n</u> nn				

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.





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.





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.



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

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9.0 ABOUT THE AUTHORS



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