OVER REJECTION DOWNTIME REDUCTION THROUGH MAGNETIZED CLEANING BRUSH

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ABSTRACT

This paper will discuss how over rejection downtime was reduced by addressing defective probe pins that affect testing results during production.

Using DMAIC approach, the team defines, measures, and analyzes how probe pins are damaging. The analysis led to replacing the cleaning methodology and materials wherein improper and excessive cleaning method with incorrect cleaning material use will result to defective probe pins.

1. 0 INTRODUCTION

Instrip Film Frame Testing is one of the high-volume production lines for our company STMicroelectronics, Inc. Instrip Film Frame Testing is the same as Final Testing where the process is to performed test on packaged device to ensure that the assembly process was correctly performed and to verify that the device meets published specification.

During testing, probe pins should be in good condition to have good bin test result. If the probe pins are damaged. It will induce contact-related problems or over rejection.

The focus of the proposed improvement is to reduce the over rejection downtime due to damaged probe pins. *See Fig 1. Over Rejection Trend*.

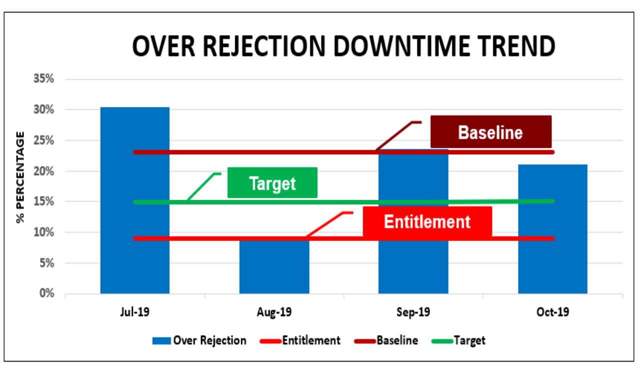

Fig. 1: Over Rejection Trend from July-October 2019

Over rejection validated when it happens, *shown in Fig. 2.*

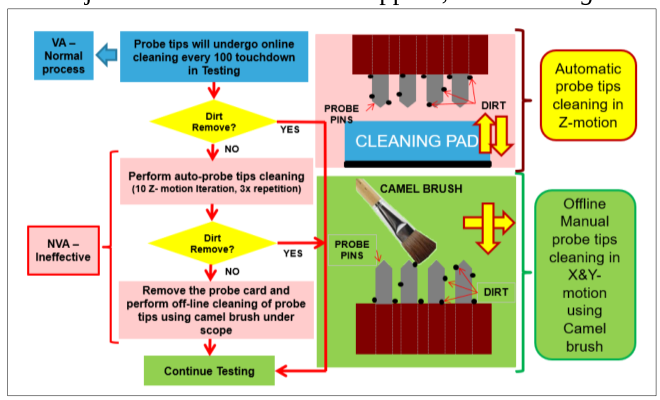

Fig. 2: Over Rejection Validation Flow

Analyzing Over Rejection Downtime using Process Mapping when consecutive rejection happens, *shown Fig.3.*

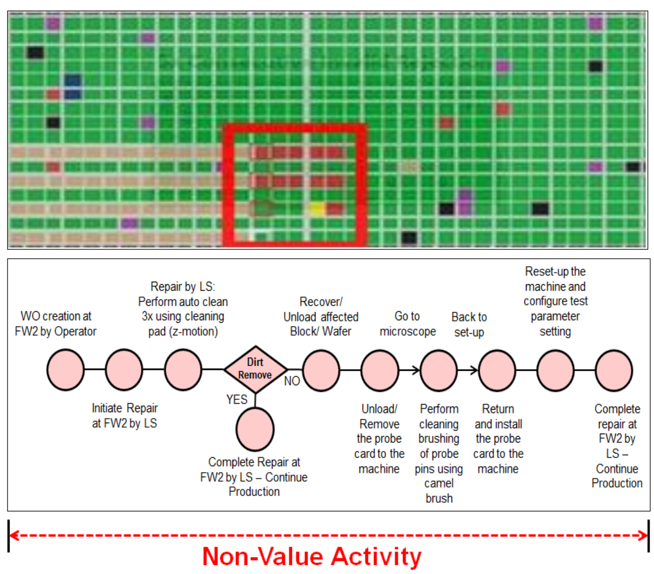

Fig. 3: Over Rejection Process Map Flow
Above shows how the 2D code scanning sequence flows.

Looking at the downtime occurrence of over rejection, defective probe pins is found to the highest contributor. *See Fig 4. Over Rejection Downtime Trend Contributor.*

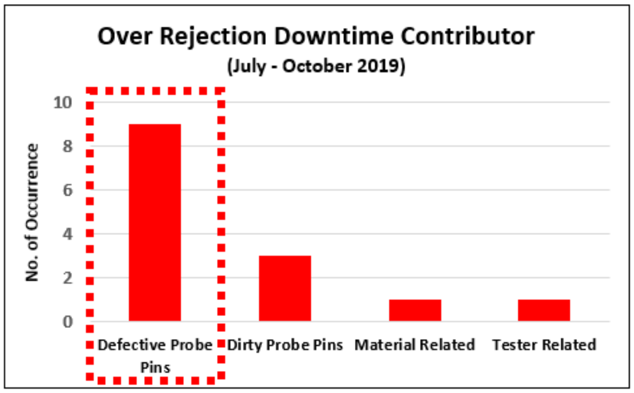

Fig. 4: Over Rejection Downtime Trend Contributor

Defective Probe Pins induce 9x occurrences.

Analyzing the defective prober pins. *Shown below is Fig. 5: %Defective of Probe Pins trend.*

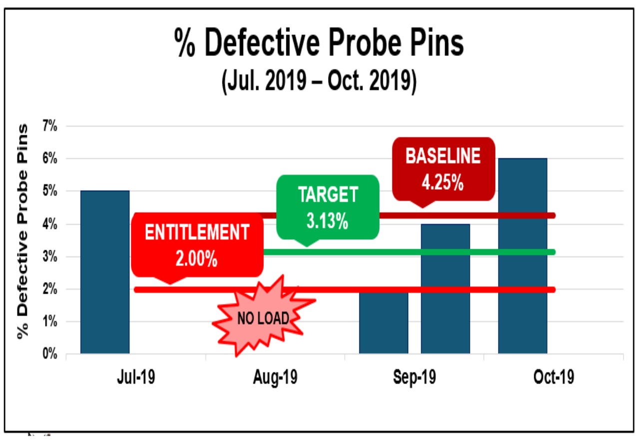

Fig. 5: Over Rejection Downtime Trend Contributor

Top contributors that induce the probe pins to be defective are Maximum Z- Over Travel, Probe Card Z-Height, Probe Pin Cleaning Method and Material use.

1.1 Maximum Z-Over Travel

It is the amount of travel (chuck vertical movement or z movement) after initial touchdown of the probes to contact to the device contact pad.

It is adjusted manually with no restriction, *as shown Fig 6. Maximum Z-Over Travel Settings Menu.*

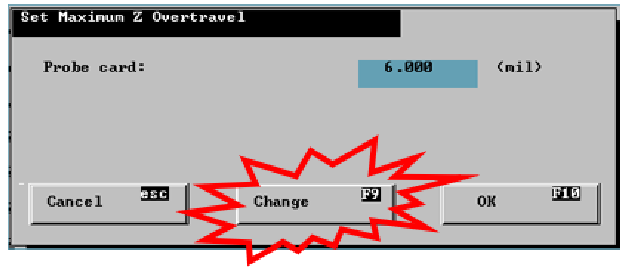

Fig 6: Maximum Z-Over Travel Settings Menu

1.2 Probe Card Z-Height

It is an actual Z-height of the probe pins that the machine measures. Due to no restriction, it can alter manually. *Shown in Fig 7. Probe Card Setting Menu.*

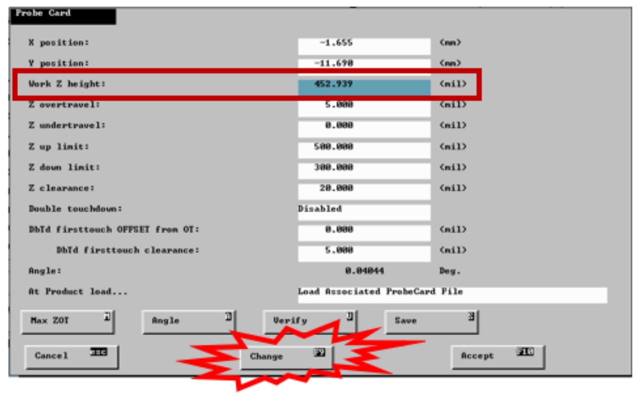

Fig 7: Probe Card Setting Menu

1.3 Probe Pin Cleaning Method and Material

Using abrasive cleaning material. Probe pin where clean in z-motion method. Dirt accumulates in the probe pin hole that causes the probe pin to be defective. *Shown in Fig.8 Cleaning Material and Method.*

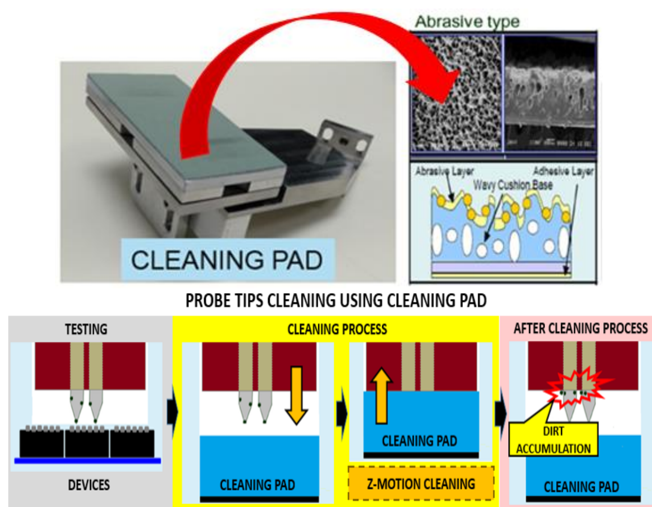

Fig. 8: Cleaning Material and Method

2. 0 REVIEW OF RELATED WORK

Upon checking, no related study on other site using same model of Instrip Film Frame probers. This is reference of ST Microelectronics, Calamba.

3.0 METHODOLOGY

2.1 Define Phase

The Macro Map below *(Fig. 9)* shows that the project scope focuses on the Film Frame Testing.

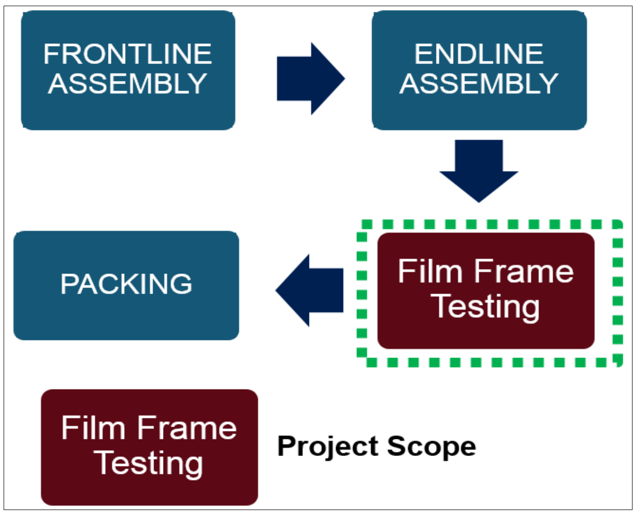

Fig 9: Macro Map

2.1.1 Detailed Process Flow under Film Frame Testing

Under Film Frame Testing, *as shown below is Fig.10 The Detailed Process Flow.*

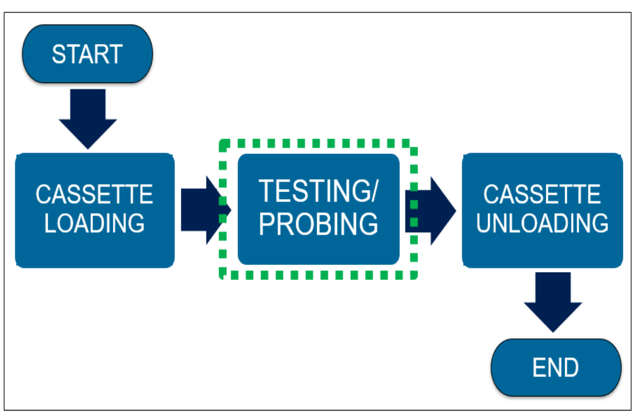

Fig 10: Film Frame Testing Detailed Process Flow

2.2 Measure Phase

Using Input / Output (I/O) Worksheet, we were able to identify 9 Key Process Input Variables (KPIV's) in Testing/ Probing process flow. 2 KPIV's tag as "**Not Our Control**", *as shown in Table 1*.

Table 1: Identifying Input Variables

				Process Inputs (KPIVs)				
0	Process Step	VA/ NVA	SOP	Type of Input	Input	Characteristic of Input (KPIV / X)	C/N	Specification
1	Testing/ Probing	VA	DMS 8224956	Equipment / Infrastructure	Forcer Motor	Motor Speed	Controllable	No error
2		VA	DMS 8328737	Equipment / Infrastructure	Max Z-up Over Travel	Height	Controllable	6mils Maximun Over Travel Height
3		VA		Raw Material / Information	Strip	Thickness	Controllable	±2 Tolerance Thickness
4		VA		Raw Material / Information	Strip	Mold Flash or Foreign Materials Present	Not Controllable Noise	No Mold Flash or Foreign Materials Present
5		VA		Raw Material / Information	Strip	Wrinkled Tape	Not Controllable Noise	No Wrinkled Tape
6		VA	DMS 8328737	Equipment / Infrastructure	Probe Card Z-height	Height	Controllable	>450 mils Minimum Height
7		VA	DMS 8328737	Equipment / Infrastructure	Z Clearance	Height	Controllable	20 mils
8		VA		Equipment / Infrastructure	Probe Tips Cleaning Material	Effectiveness	Controllable	0 rejection
9		VA		Equipment / Infrastructure	Aggressive Touchdown Life span	OS Rejection	Controllable	200K

Then we use the Cause & Effect Matrix, wherein from 7 KPIV's, they were trimmed down to 3 based on the rating of the relation between the I/O variables, *shown in Table 2*.

Table 2: Cause & Effect Matrix

				1							
			Is Y Continuous / Discrete?	Over Rejection							
			Specification Limits (for Y)	Damage Probe Pins							
			Customer Priority	10							
S.No	Process Step	Input	Characteristic of Input (KPIV / X)		Total	Is X Continuous / Discrete?	Operating Range (for X)	Unit of Measure (UOM)	Count 3's	Count 9's	X Selected / Discarded?
1	Testing/ Probing	X & Y Motor	Motor Speed	1	10	Discrete	Pass/ Fail		0	0	Discard the X
2		Max Z-up Over Travel	Motor Z- Height	9	90	Continuous	Certification	Training	0	1	Select the X
3		Device/ Block Thickness	Alignmnet Result	1	10	Discrete	Pass/ Fail		0	0	Discard the X
6		Probe Card Z-height	Motor Z- Height	9	90	Continuous	Pass/ Fail		0	1	Select the X
7		Z clearance	Competency	1	10	Continuous	Certification	Training	0	0	Discard the X
8		Probe Tips Cleaning Material	Over rejection	9	90	Discrete	Pass/ Fail		0	1	Select the X
9		Aggressive Touchdown Life span	Over rejection	1	10	Discrete	Pass/ Fail		0	0	Discard the X

Out of 3 KPIV's, 2 KPIV's were proceed quick win to validation, *shown in Table 3*.

Table 3: Quick Wins

S.No	Process Step	Input	Characteristic of Input (KPIV / X)	CnE Score		QUICK WINS	
				Score	Decision	Controlled	Decision
2	Testing/ Probing	Max Z-up Over Travel	Motor Z- Height	90	Select the X	Yes	Reject the X
6		Probe Card Z-height	Motor Z- Height	90	Select the X	Yes	Reject the X
8		Probe Tips Cleaning Material	Over rejection	90	Select the X		Select the X

2.2.1 Quick Wins for Maximum Z-Over Travel

Remove "Change" button to avoid altering the setting, *shown in Fig.11 below.*

Process	Finding/s	Action	Remark
Max Z-up Over Travel Setting	Already implemented max z-up over travel setting per set-up. But we have restriction on machine password and some Technician altered the max z-up over travel settings. Administrative problem	Remove the "CHANGE" button in the machine screen to prevent the max z-up over travel setting alteration.	Complete W1917 Done in all probers

Fig 11: Set Maximum Z- Over Travel Menu

2.2.2 Quick Wins for Probe Card Z-Height

Remove "Change" button to avoid altering the z-height setting of the probe pins, *shown in Fig. 12 below.*

Process	Finding/s	Action	Remark
Probe Card Z-height Setting	Prober/ machine will validate/ measure the correct probe card z-height setting. But we have restriction on machine password and some Technician altered the probe card z-height setting. Administrative problem	Remove the "CHANGE" button in the machine screen to prevent the probe card z-height setting alteration.	Complete W1917 Done in all probers

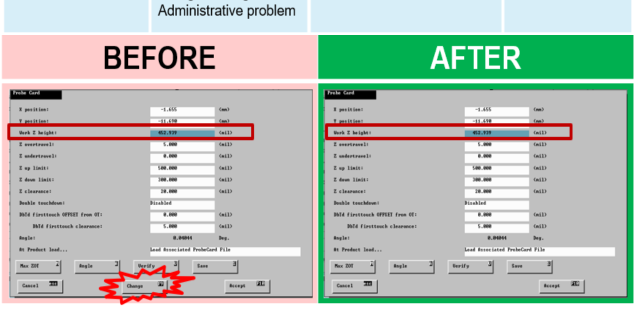

Fig 12: Probe Card Setting Menu

2.3 Validation Phase of the Potential X's

We proceeded to validate the 1 remaining X's.

2.3.1 Cleaning Method and Material Validation

Using cleaning materials, we validate "Abrasive" and "Brush" Cleaning Materials.

2.3.1.1 Abrasive Cleaning Material (Current Set-up)

For Abrasive cleaning materials, cleaning method is z-motion (z-up/ down). *Shown in Fig.13.*

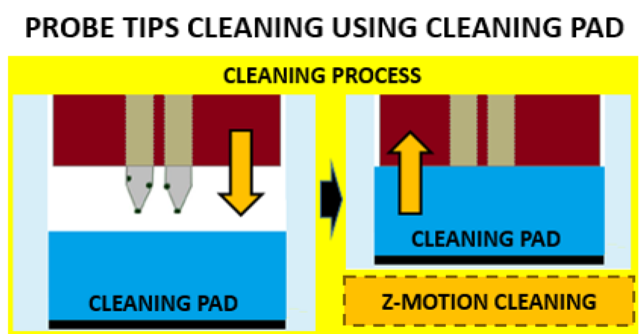

Fig 13: Abrasive Cleaning Materials

2.3.1.2 Brush Cleaning Material (Propose Set-up)

For Brush cleaning materials, cleaning method is x and y motion (left & right movement). *Shown in Fig.14.*

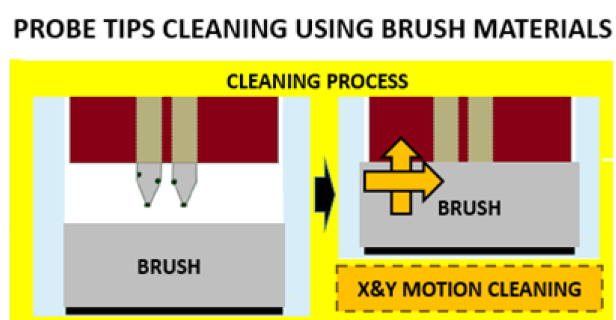

Fig 14: Brush Cleaning Materials

2.4 Analyze Phase

Table 4 shows the validation plan to analyze if there is a significant difference.

Table 4: Validation Plan Table

Validation Plan and Results

Y (or mini Y)	Unit of Measure	Y Treated as	X	True nature of X	Range of X, if continuous	Levels of X, if discrete or converted into discrete	Hypothesis Statement: Null Hypothesis	Hypothesis Statement: Alternative Hypothesis	Graphical Analysis	Statistical Test
Probe Tips Cleaning Material	% Over Rejection	Discrete	Over Rejection	Discrete		CleaningPad BrushMaterials	PCleaningPad = PBrush Materials	PCleaning Pad ≠ PBrush Materials		2 Proportion Test
		Discrete	Damage Probe Pins	Discrete		Cleaning Pad Brush Materials	PCleaningPad = PBrush Materials	PCleaning Pad ≠ PBrush Materials		2 Proportion Test

The sample size was generated based on attribute sampling formula to perform the statistical test, *shown in Fig. 15.*

GENERAL ATTRIBUTE SAMPLING FORMULA:

$$n = Z^2_{\alpha/2}\left(\frac{pq}{\delta^2}\right) = 1.96^2\left[\frac{0.5\,(0.5)}{0.10^2}\right] = 96$$

Fig 15: Probe Card Setting Menu

Shown below is Table 5 The Final Validation plan table with sample size using cleaning pad and brush materials.

Table 5: Final Validation Plan Table with Sample Size

Validation Plan and Results

Y Treated as	X	True nature of X	Range of X, if continuous	Levels of X, if discrete or converted into discrete	Hypothesis Statement: Null Hypothesis	Hypothesis Statement: Alternative Hypothesis	Graphical Analysis	Statistical Test	Beta	Alpha	Sample Size
Discrete	Over Rejection	Discrete		CleaningPad BrushMaterials	PCleaningPad = PBrush Materials	PCleaning Pad ≠ PBrush Materials		2 Proportion Test	0.1	0.05	100
Discrete	Damage Probe Pins	Discrete		Cleaning Pad Brush Materials	PCleaningPad = PBrush Materials	PCleaning Pad ≠ PBrush Materials		2 Proportion Test	0.1	0.05	100

> Probe Pins Cleaning Material - 2 Proportion Test
> Damage Probe Pins - 2 Proportion Test

2.4.1 Probe Pins Cleaning Material Statistical Test

Shown on Fig. 16, using 2 Proportion Test in online auto cleaning due to the occurrence of over rejection during Testing/ Probing. The result shows that at 95% confidence level, there is **SIGNIFICANT DIFFERENCE** between cleaning pad and cleaning brush materials in occurrences of over rejection.

Process Function	Process Step	Practical Problem	Test Plan	Hypothesis Statement	Conclusion
Testing/ Probing	Probe Pins Auto Online Cleaning	Is there an Improvement on Over Rejection occurrences using Cleaning Pad and Cleaning Brush Material.	2 Proportion Test	Ho: PCleaningPad = PCleaningBrush Ha: PCleaningPad ≠ PCleaningBrush	Significant Difference Reject Ho

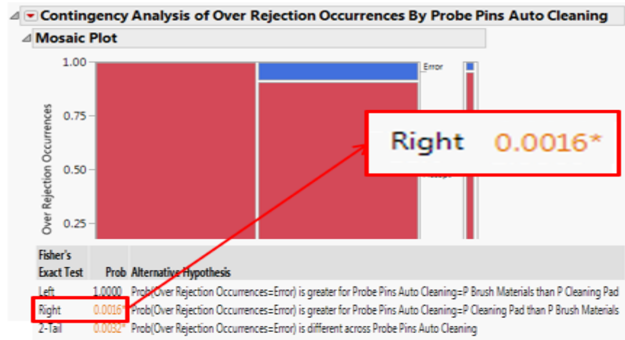

Fig. 16: Cleaning Material – 2 Proportion Test Result

2.4.2 Damage Probe Pins Statistical Test

For the damage probe pins, at better than 95% confidence level, there is **SIGNIFICANT DIFFERENCE** between cleaning pad and cleaning brush materials in occurrences of damage probe pins during testing and auto online cleaning. *See Fig. 17.*

Process Function	Process Step	Practical Problem	Test Plan	Hypothesis Statement	Conclusion
Testing/ Probing	Probe Pins Auto Cleaning	Is there is an Improvement on Damage Probe Pins using Cleaning Pad and Cleaning Brush Material.	2 Proportion Test	Ho: PCleaningPad = PBrushMaterials Ha: PCleaningPad ≠ PBrushMaterials	Significant Difference Reject Ho

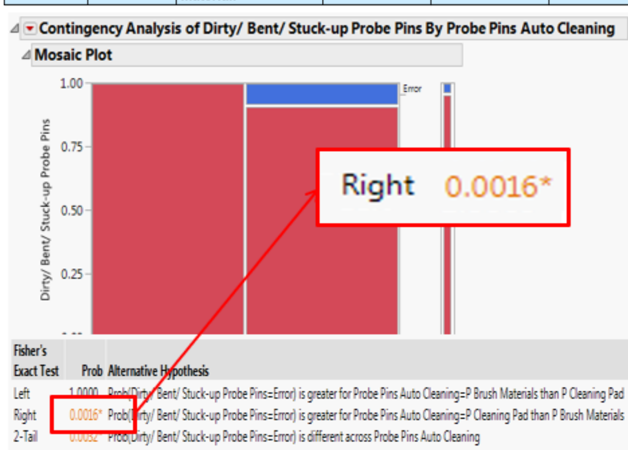

Fig. 17: Damage Probe Pins – 2 Proportion Test Result

2.5 Improve Phase

Corrective and Preventive actions were summarized using potential problem analysis as shown in *Table 6.*

Table 6: Corrective and Preventive Action

Item	Problem	Validated KPIV/Cause	Preventive Action	Permanent Action	Responsible/ Completion Date	Status
1	High downtime occurrences of over rejection in all devices running on EG4090F probers from July to September 2019 affecting the OPS1 Integrated Line Cost and Delivery.	Over Rejection Occurrences Damage Probe Pins	Replaced the cleaning materials from cleaning pad to cleaning brush materials in all EG4090F prober	Include the PM schedule of cleaning brush materials cleaning, inspection and replacement in the Equipment PM schedule.	Frielan	Done WW2005

Find below is Fig. *18 Cleaning Brush Materials and Method.*

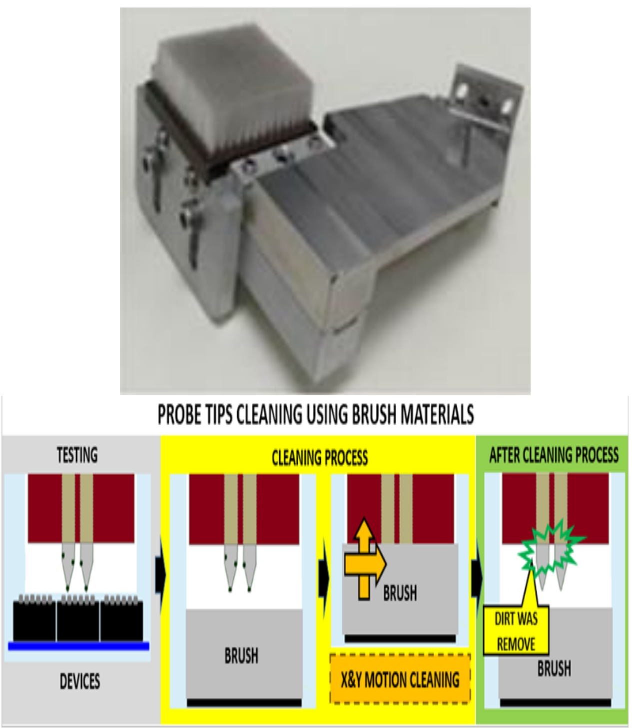

Fig. 18: Cleaning Brush Materials and Method

3.0 RESULTS AND DISCUSSION

After the improvements were made, Over Rejection trend has improved from July 2019 to November 2019. *See Fig 19.*

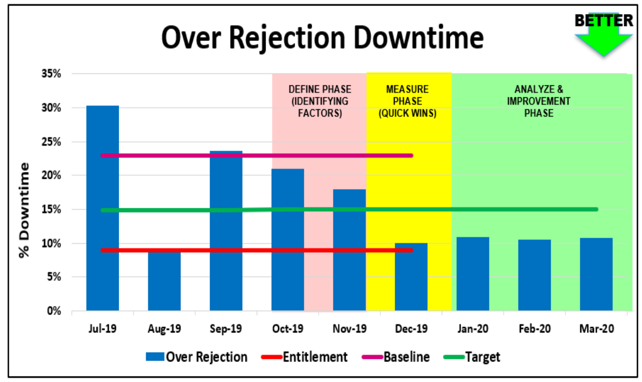

Fig. 19: Over Rejection Occurrences Improve from the average of 23% to 10%.

Defective probe pins trend improved by 3% from July 2017 to November 2019. *See Fig 20.*

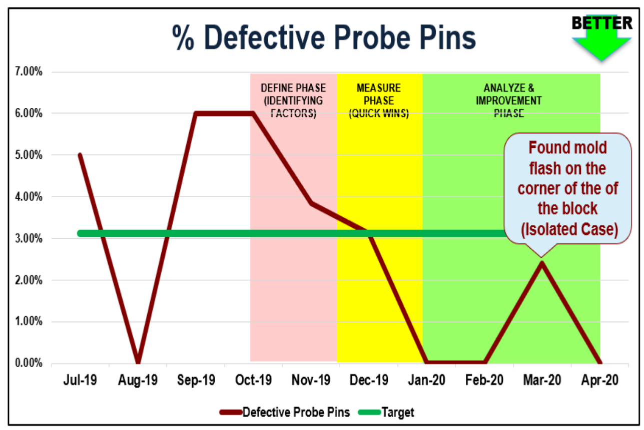

Fig. 20: Defective Probe Pins Trend

4.0 CONCLUSION

After implementing and completing all actions, encountered over rejection errors were reduced and same with the probe pins consumption, thus improving machine performance.

5.0 RECOMMENDATIONS

It is recommend to fan-out these learnings to other machines. Future studies are recommended for plans to zero-out the occurrences of over rejection and probe pin damage.

6.0 ACKNOWLEDGMENT

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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.

7.0 REFERENCES

1. Electroglas EG4090 Film Frame Maintenance Manual

8.0 ABOUT THE AUTHORS

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