SW Test Workshop
Semiconductor Wafer Test Workshop

# REDUCING PROBE NEEDLE DAMAGE ON BOND PAD USING SIX SIGMA METHODOLOGY

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ON Semiconductor®

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# Agenda

- The DMAIC Model
- What is probe damage?
- The Define phase
- MSA – Measurement of System Analysis
- Analyze Phase – Identification and validation of KPIVs
- Improve Phase
- Control –Standardization of corrective action
- Revisiting probe damage
- Conclusion / Recommendation

# SIX SIGMA

## The DMAIC Model


Define Opportunity
*(What is important?)*

**Define** the goals of the improvement activity.

Select the appropriate responses (Y's) to be improved.

" Another wafer for scrap due to probe damage. We don't have enough wafers to support delivery".


"We need to explain to the custom[illegible] why we are delayed

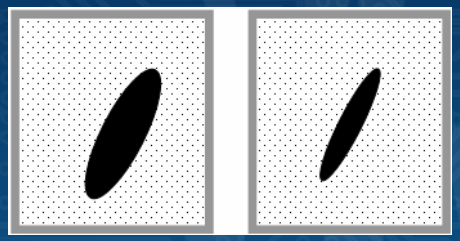
# VOICE OF THE CUSTOMERS

"What probe damage again!!! Another wafer for 100% inspection!!". When will this end? Huhuhu

# What is Probe Damage?

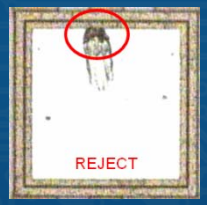
- Probe damage is defect induced during wafer probing which exposes the base metal or touches the pad perimeter / seal ring of the bond pad.

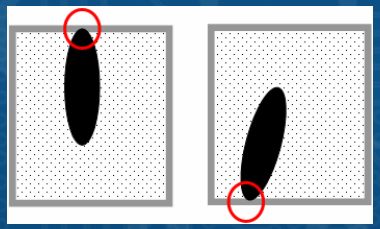
GOOD

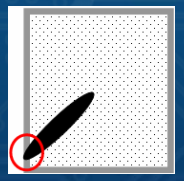



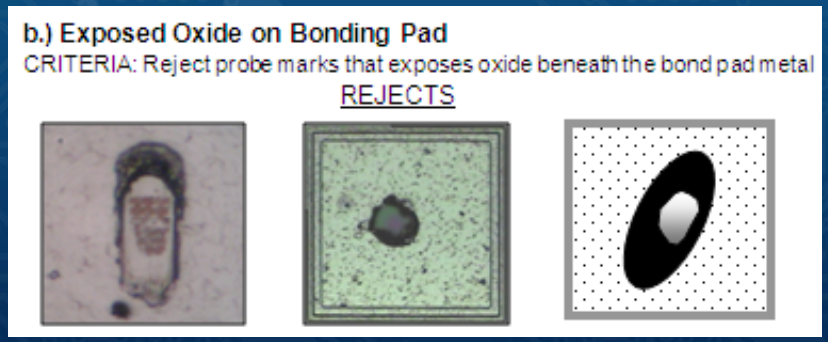
Criteria – Accept any visible gap or the operator can clearly see that there was no damage on seal ring of the bond pad vs. probe mark (including aluminum push-outs).

REJECTS

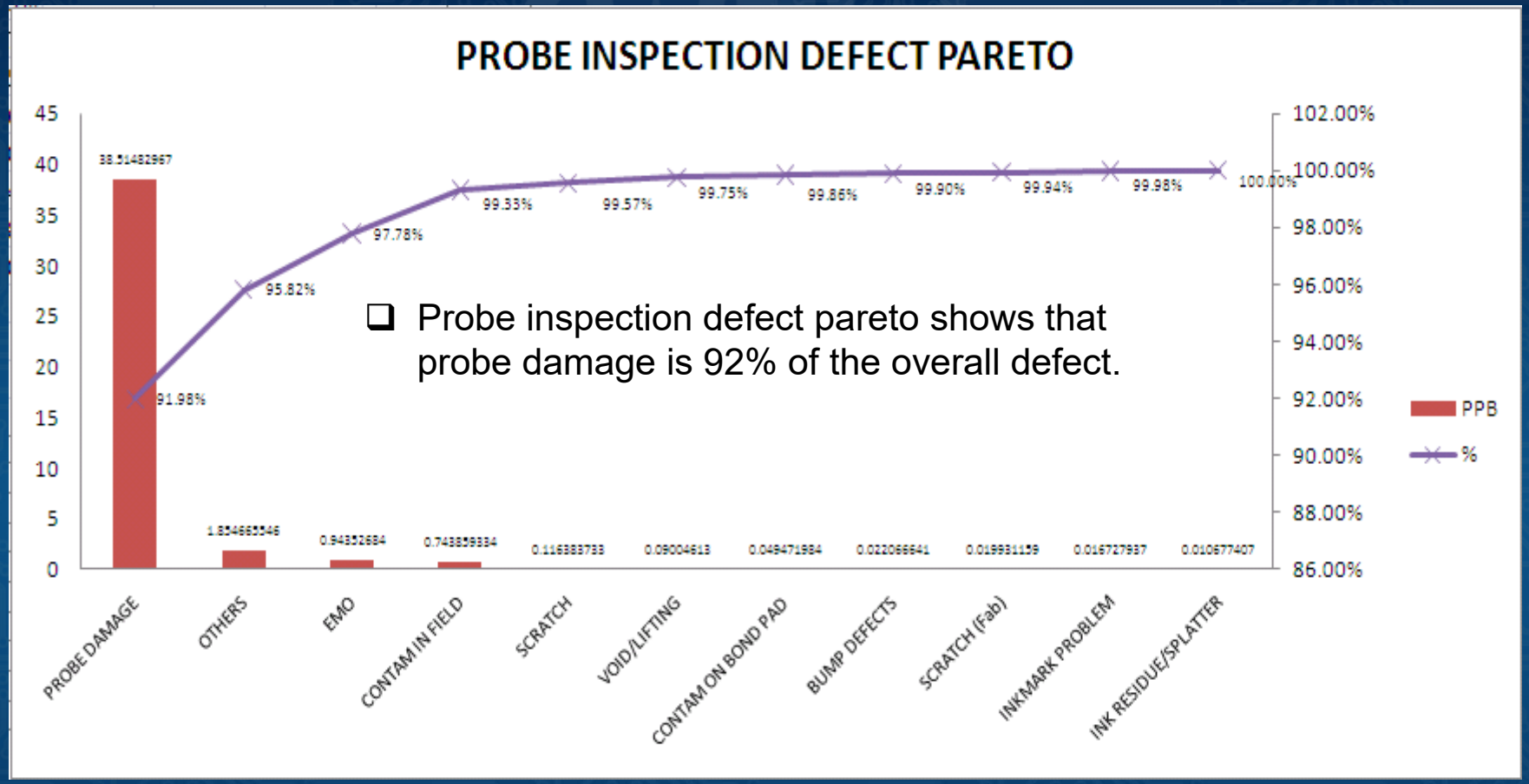






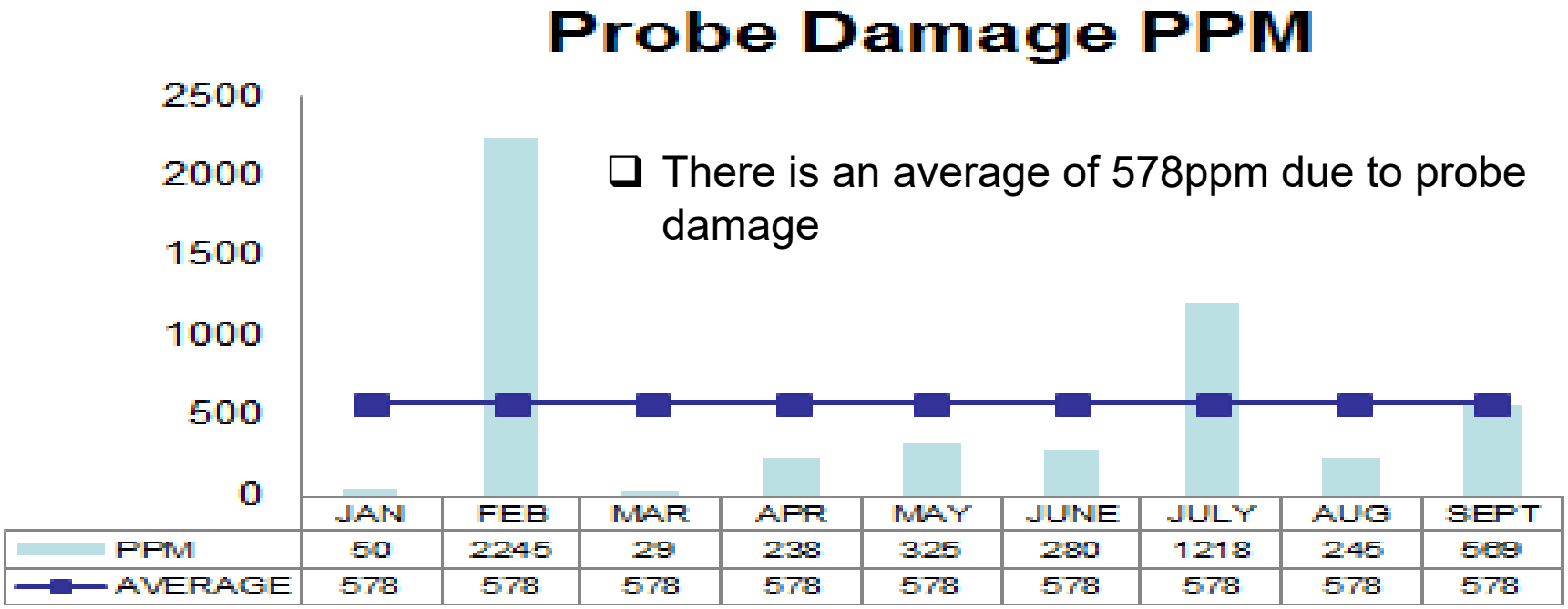
# Why Is Probe Damage a Problem?




- Probe inspection defect pareto shows that probe damage is 92% of the overall defect.

# Why Is Probe Damage a Problem?

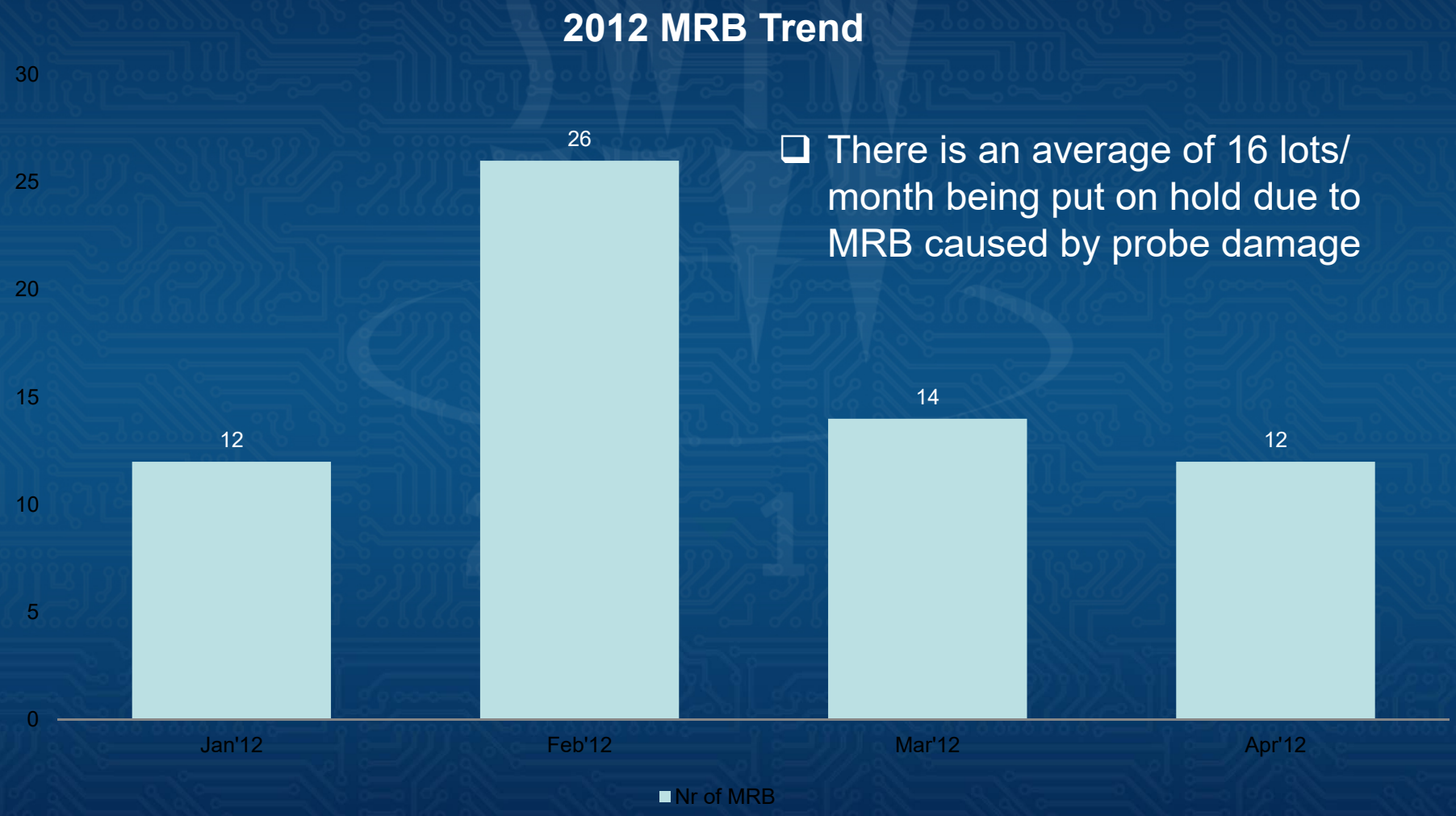
Trend Chart of Probe Damage




- There is an average of 578ppm due to probe damage

# Why Is Probe Damage a Problem?

Trend Chart of MRB Occurrence




- There is an average of 16 lots/ month being put on hold due to MRB caused by probe damage

Define

- Project Selection
- Project Description
- Project Charter
- Project Impact
- Define Phase Summary

Measure

Analyze

Improve

Control

# Project Charter - Team Composition

Leader:

Glenn Placido

Project Manager

Process Experts

Team Members:

1. Jonah Capua
2. Vangie Ocampo
3. Betong Paglinawan
4. Ryan Sangeles
5. Maan Lugar

Defines & Supports the Project

Project Champion:
Teody Estrada/
Raquel dela Cruz
Boris Bastien

**Probe Damage Reduction at Sort**

Process Owner/s:

Sherwin Gan
Enan dela Cruz
Dondon Montero

Owner of the Improvement Actions

Financial Validation & Tracking

Financial Representative:

Anna Dichoso

Define

- Project Selection
- Project Description
- Project Charter
- Project Impact
- Define Phase Summary

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Analyze

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Control

# Business Case

- Probe damage is the number 1 visual defect contributor at wafer sort. Yield and cycle time is affected due to this problem.

# Problem Statement

- Probe damage is a consistent top defect at wafer sort with an average ppm of 578. the number 1 visual defect contributor at wafer sort. Yield and cycle time is affected due to this problem. There is also an average of 16MRB per month.

# Project Metrics

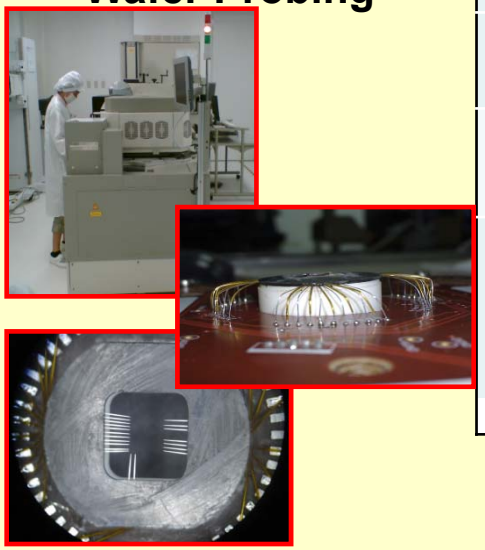
- Probe damage PPM
- Number of MRB occurrence

# Goal Statement

- Reduce probe damage PPM by 50% from 578 to 289
- To reduce MRB occurrence by 75% due to probe damage from an average of 16 per month to 4 wafers per month.

# Macro Map (SIPOC)

| Supplier | Input | Process | Output | Customer |
|---|---|---|---|---|
| Wafer fab | Unsorted Wafers | Wafer Probing | Sorted wafers | Assembly |
| Probe Card Maintenance | Probe Card | | | Customers |
| Probe card build | Probe Needle | | | |
| Equipment Maintenance | Prober | | | |



Wafer loading → WS1 → Bake (125'c) → WS2 → Inspection → Off-lin inking → Packaging

Process steps highlighted are the focus of this project

# SIX SIGMA

## The DMAIC Model


Define Opportunity
*(What is important?)*

Measure Performance
*(How are we doing?)*

**Define** the goals of the improvement activity.

Select the appropriate responses (Y's) to be improved.

**Measure** the existing system.

Gather data to measure and verify the response variable --- the problem or improvement opportunity.


- Measurement Systems Analysis
  - Final outgoing inspection (FOI), consistency and effectiveness as well as its miss rate and false alarm rate were checked.

# Summary of Attribute MSA Study

| KPOV (Output or Response Variable) | MSA Method | Criteria | Actual Result | Remark/s |
|---|---|---|---|---|
| Probe Damage | Consistency | ≥ 90% | # 1 = 96.61%<br># 2= [illegible] | Pass |
| | Effectiveness (Individual) | | [illegible].15%<br>#3= 98.31% | Pass |
| | | ≥ 90% | 94.92% | Pass |
| | | ≤ 2% | # 1 = 1.89%<br># 2= 0.38%<br>#3= 1.52% | Pass |
| | False Alarm Rate | ≤ 5% | # 1 = 0.0%<br># 2=0.0%<br>#3= 0.0% | Pass |

PASS !!!

Interpretation:
- Consistency and Effectiveness passed the Attributes MSA criteria.
  - All three operators were able to detect probe damage.

# SIX SIGMA

## The DMAIC Model


Define Opportunity
*(What is important?)*

Measure Performance
*(How are we doing?)*

Analyze Opportunity
*(What is wrong?)*

**Define** the goals of the improvement activity.

Select the appropriate responses (Y's) to be improved.

**Measure** the existing system.

Gather data to measure and verify the response variable --- the problem or improvement opportunity.

**Analyze** the system to identify the causes or gaps.

Find the relevant X's.


Define Measure Analyze Improve Control

- Identification of KPIVs
  - Based on the process mapping and fishbone diagram, the team identified 144 KPIVs that will contribute on Probe Damage.
  - The team decided to select and prioritize 78 KPIVs out of 144 identified KPIVs. The selection and prioritization was based on the impact to Probe Damage. After combining similar KPIVs, the team came up with 15 validation plans.
- Validation of KPIVs
  - After thorough validation and hypothesis testing conducted all 15 KPIVs are identified to be valid.
  - Therefore, the significant and valid KPIVs are now to be addressed in Improve Phase.

Define

Measure

Analyze

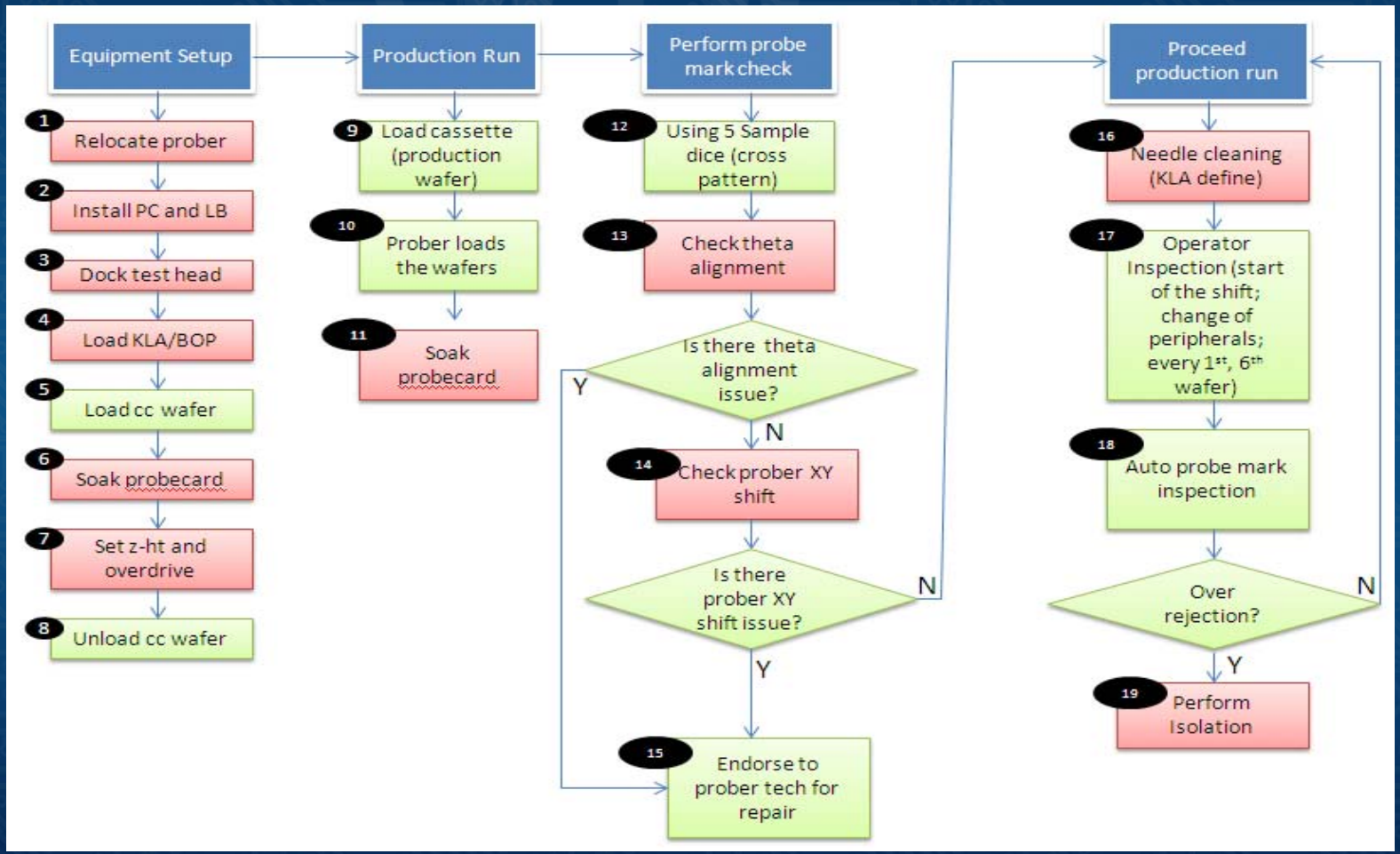
- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

Improve

Control

# Detailed Process Map

Wafer loading → WS1 → Bake (125'c) → WS2 → Inspection → Off-line inking → Packaging



Define

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- Analyze Phase Summary

Improve

Control

# SIPOC

| Supplier | Input | Process | Output | Customer |
|---|---|---|---|---|
| o ProbeCard Build<br>o Prober Maintenance<br>o FAB<br>o Loadboard Maintenance<br>o ITS<br>o Prober Maintenance<br>o Operation<br>o KLA | o ProbeCard<br>o Prober<br>o Wafer<br>o Loadboard<br>o Cleaning material<br>o Cleaning material replacement procedure<br>o Operator<br>o Cleaning Frequency | 16 Needle cleaning (KLA define)<br>↓<br>17 Operator Inspection (start of the shift; change of peripherals; every 1st, 6th wafer)<br>↓<br>18 Auto probe mark inspection<br>↓ | Probecard needle free of debris | Production |
| o ProbeCard Build<br>o Prober Maintenance<br>o FAB<br>o Loadboard Maintenance<br>o Operation<br>o Operation<br>o Prober Maintenance | o ProbeCard<br>o Prober<br>o Wafer<br>o Loadboard<br>o Inspection method<br>o Operator<br>o Maintenance troubleshooting guide during isolation and endorsement to production | 13 Perform Isolation | Gross rejection/equipment problem resolved. | Production |

Define

Measure

Analyze

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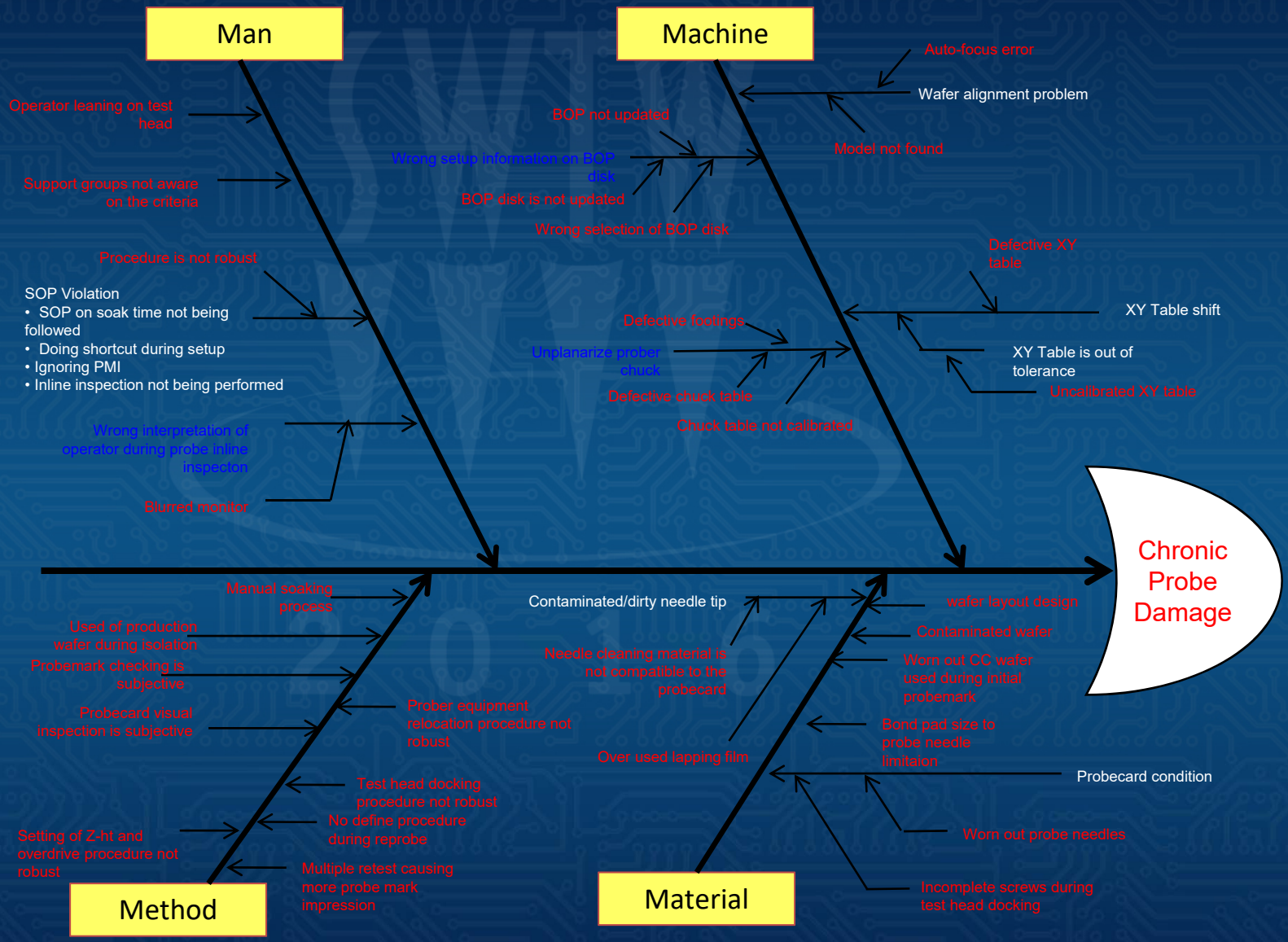
Improve

Control

# Cause and Effect Analysis



Define

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Improve

Control

# Validation Plan for Shortlisted KPIVs

## C&E Matrix

Microsoft Office
cel 97-2003 Worksh

C&E Matrix (Selected)

Identified 144 KPIVs after thorough process mapping and root cause analysis

Shortlisted 78 of 144 KPIVs after prioritization

15 Validation Plans

| No. | Process Step | Input | KPIV No. | | | Bond Damage | | | | | To | Ra | Selected / Discarded? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Importance to Customer | X | | | | | | | |
| 1 | Relocate Prober | Prober | 1 | | | | | | | | | | ected |
| | | Maintenance | 3 | | | | | | | | | | ected |
| 2 | Install Probecard and Loadboard | Prober | 4 | | | | | | | | | | ected |
| | | Probecard | 6 | | | | | | | | | | ected |
| | | Loadboard | 8 | | | | | | | | | | ected |
| | | Maintenance | 12 | | | | | | | | | | ected |
| 3 | Dock Test Head | Prober | 13 | | | | | | | | | | ected |
| | | Probecard | 15 | Physical condition | Visually good | 9 | | | | | 90 | 7 | Selected |
| | | Maintenance | 21 | Skills in test head docking | no specs.... | 9 | | | | | 90 | 8 | Selected |
| 4 | Load KLA BOP | Prober | | | | | | | | | 90 | 9 | Selected |
| | | Probecard | | | | | | | | | 90 | 10 | Selected |
| | | Maintenance | | | | | | | | | 90 | 11 | Selected |
| 6 | Soak Probecard | Prober | | | | | | | | | 90 | 12 | Selected |
| | | Probecard | | | | | | | | | 90 | 13 | Selected |
| | | Operator | | | | | | | | | 90 | 14 | Selected |
| | | Maintenance | 44 | BOP DISK | updated with label (device | 9 | | | | | 90 | 15 | Selected |
| | | Standard Wafer | 45 | Condition of standard wafer | Standard wafer replenishment procedure. | 9 | | | | | 90 | 16 | Selected |
| 7 | Set z-ht and overdrive | | | | | | | | | | 90 | 17 | Selected |
| | | | | | | | | | | | 90 | 18 | Selected |
| | | | | | length | | | | | | 90 | 19 | Selected |
| | | Probecard | 48 | Physical condition | Visually good - Probemark is acceptable as per criteria. | 9 | | | | | 90 | 20 | Selected |

Define

Measure

Analyze

- Identification of KPIVs
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  - Graphical, and/or
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Improve

Control

# Validation Plan for Shortlisted KPIVs

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 1 | Equipment (Prober) | Operational Condition of prober. | Prober XY shift will increase if prober was relocated. | Validate if XY shift will increase after prober movement. |
| 2 | Equipment (Prober) | Operational Condition of prober. | Using a defective prober footings will cause planarity problem and can induce probe damage. | Validate effect of a defective footings on probemark |
| 3 | Equipment (Prober) | Operational Condition of prober. | Card relative Z-ht and overdrive does not have effect on the probemark size. | To validate effective card relative Z-ht; and overdrive which can induce minimum probemark |
| 4 | Equipment (Prober) | Operational Condition of prober. | "Model not found" and "auto focus error" will induce probedamage if not properly corrected. | Validate effect of the ff errors, model not found, and auto focus error on the probemark. |
| 5 | Equipment (Prober) | Operational Condition of prober. | Incorrect soak time will have effect on probemark size | Validate effect of soaking on the probemark (10min auto-soak) |
| 6 | Operator | Soaking procedure. | Incorrect soak time will have effect on probemark size | Validate effect of manual soaking on the probemark (10min- PC-PREHEAT 2 HRS PROBER SOAK FOR INITIAL SETUP) |
| 7 | Method | Inspection procedure and equipment repair | Procedures is not yet robust or is not yet define during :<br>* Prober relocaton<br>* PC/LB installation<br>* test head docking<br>* Standard wafer replenishment<br>* Probemark inspection criteria<br>* Inspection of probecard needle prior use | Validate specs if being followed in actual :<br>* Prober relocaton checklist/guide prior endorsement to production<br>* PC/LB installation<br>* test head docking<br>* skills in Equipment isolation<br>* Probemark inspection criteria<br>* Inspection of probecard needle prior use |
| 8 | Probe Csrd | In good condition | Using out of spec screws in PC stifener (ELTESO PC) can induce probe damage. | Validate Effect of using out of screws can induce probe damage.. |
| 9 | BOP Disk | Updated and with label | Loading an wrong/not updated BOP disk can cause probe damage | Validate effect of using a wrong / not updated BOP disk |
| 10 | Prober | Operational Condition of prober. | Uncalibrated cleaning unit height can smash the probecard and eventually leads to probe damage. | Effect of using uncalibrated cleaning unit height |
| 11 | Cleaning material | Lapping paper | Replacing the cleaning material incorrectly will have bubbles and eventually mis-aligning the needle during needle cleaning. | Effect of wrong replacement if cleaning material |
| 12 | Cleaning material | Lapping paper | Accumulation of debris on the probe needle can cause probe damage. | Effect of debris on the probe needle. |
| 13 | Cleaning material | Lapping paper | Worn out cleaning material will not be able to sufficiently clean the probecard needle and eventually causes probe damage. | Effect of using worn out cleaning material |
| 14 | Method | Probe oprating procedure | Leaning on the test head and removal of cable on cable setup will induce probe damage. | Effect of leaning on the teast head and removal of cable while ongoing test. |
| 15 | Probecard | Visually good; planarity at +/- 0.3mils | Probecard with planarity issue can cause probe damage. | Validate effect of using probecard with planarity issue. |

15 Validation Plans

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

Improve

Control

# Validation Plan for Shortlisted KPIVs

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan | Validation Result |
|---|---|---|---|---|---|
| 1 | Equipment (Prober) | Operational Condition of prober. | Prober XY shift will increase if prober was relocated. | Validate if XY shift will increase after prober movement. | VALID |
| 2 | Equipment (Prober) | Operational Condition of prober. | Using a defective prober footings will cause planarity problem and can induce probe damage. | Validate effect of a defective footings on probemark | VALID |
| 3 | Equipment (Prober) | Operational Condition of prober. | Card relative Z-ht and overdrive does not have effect on the probemark size. | To validate effective card relative Z-ht; and overdrive which can induce minimum probemark | VALID |
| 4 | Equipment (Prober) | Operational Condition of prober. | "Model not found" and "auto focus error" will induce probedamage if not properly corrected. | Validate effect of the ff errors, model not found, and auto focus error on the probemark. | VALID |
| 5 | Equipment (Prober) | Operational Condition of prober. | Incorrect soak time will have effect on probemark size | Validate effect of soaking on the probemark (10min auto-soak) | VALID |
| 6 | Operator | Soaking procedure. | Incorrect soak time will have effect on probemark size | Validate effect of manual soaking on the probemark (10min- PC- PREHEAT 2 HRS PROBER SOAK FOR INITIAL SETUP) | VALID |
| 7 | Method | Inspection procedure and equipment repair | Procedures is not yet robust or is not yet define during :<br>* Prober relocaton<br>* PC/LB installation<br>* test head docking<br>* Standard wafer replenishment<br>* Equipment isolation<br>* Probemark inspection criteria<br>* Inspection of probecard needle prior use | Validate specs if being followed in actual :<br>* Prober relocaton checklist/guide prior endorsement to production<br>* PC/LB installation<br>* test head docking<br>* Standard wafer replenishment procedure.<br>* Probemark inspection criteria<br>* Inspection of probecard needle prior use | VALID |
| 8 | Probe Csrd | In good condition | Using out of spec screws in PC stifener (ELTESO PC) can induce probe damage. | Validate Effect of using out of screws can induce probe damage.. | VALID |
| 9 | BOP Disk | Updated and with label | Loading an wrong/not updated BOP disk can cause probe damage | Validate effect of using a wrong / not updated BOP disk | VALID |
| 10 | Prober | Operational Condition of prober. | Uncalibrated cleaning unit height can smash the probecard and eventually leads to probe damage. | Effect of using uncalibrated cleaning unit height | VALID |
| 11 | Cleaning material | Lapping paper | Replacing the cleaning material incorrectly will have bubbles and eventually mis-aligning the needle during needle cleaning. | Effect of wrong replacement if cleaning material | VALID |
| 12 | Cleaning material | Lapping paper | Accumulation of debris on the probe needle can cause probe damage. | Effect of debris on the probe needle. | VALID |
| 13 | Cleaning material | Lapping paper | Worn out cleaning material will not be able to sufficiently clean the probecard needle and eventually causes probe damage. | Effect of using worn out cleaning material | VALID |
| 14 | Method | Probe oprating procedure | Leaning on the test head and removal of cable on cable setup will induce probe damage. | Effect of leaning on the teast head and removal of cable while ongoing test. | VALID |
| 15 | Probecard | Visually good; planarity at +/- 0.3mils | Probecard with planarity issue can cause probe damage. | Validate effect of using probecard with planarity issue. | VALID |

**15 Valid KPIVs**

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

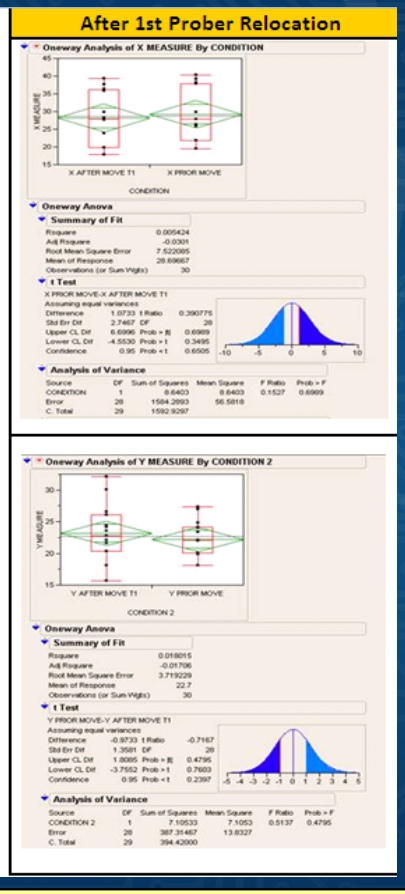
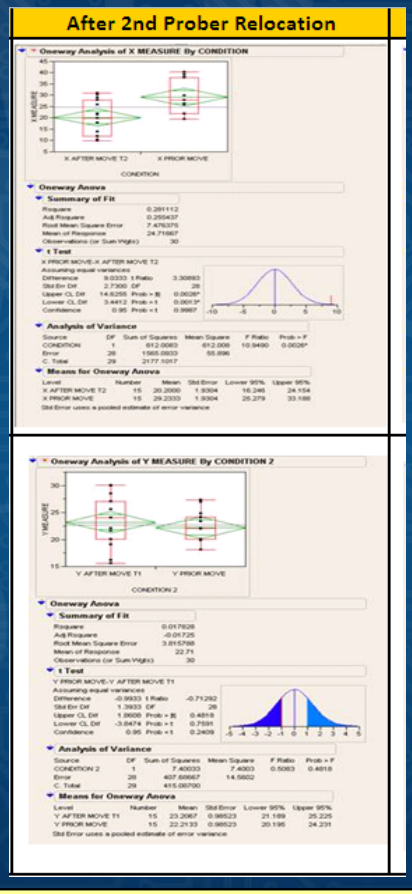
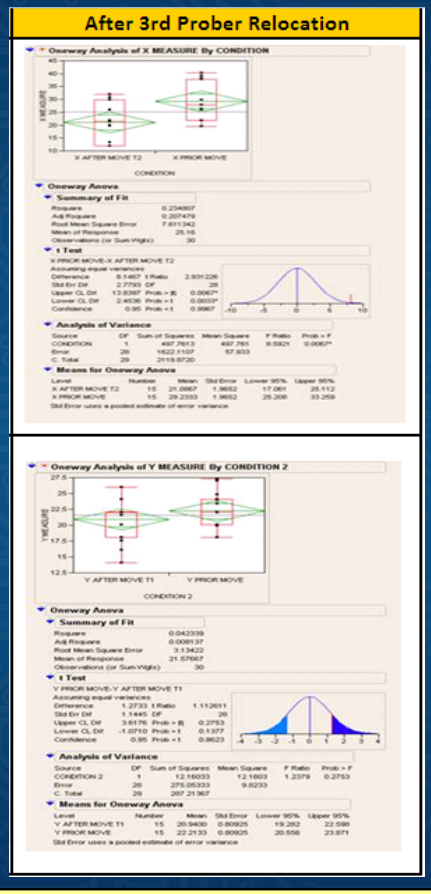
Improve

Control

# Validation Result for Operational Condition of Prober

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 1 | Wafer | Operational condition of prober | Prober XY shift will increase during equipment relocation | Using t-test validate increase on prober XY shift during prober relocation. |

Objective: To verify if shift on prober XY will increase after prober relocation.

| | After 1st Prober Relocation | After 2nd Prober Relocation | After 3rd Prober Relocation |
|---|---|---|---|
| X |  |  |  |
| Y |  |  |  |

Conclusion: The above test results showed that during the first relocation, there is no significant difference in the X and Y probe mark shifts. In the succeeding two relocations, there was no significant shift in the Y axis still, BUT for the X axis the shift now became very significant Therefore the identified KPIV is *VALID.*

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

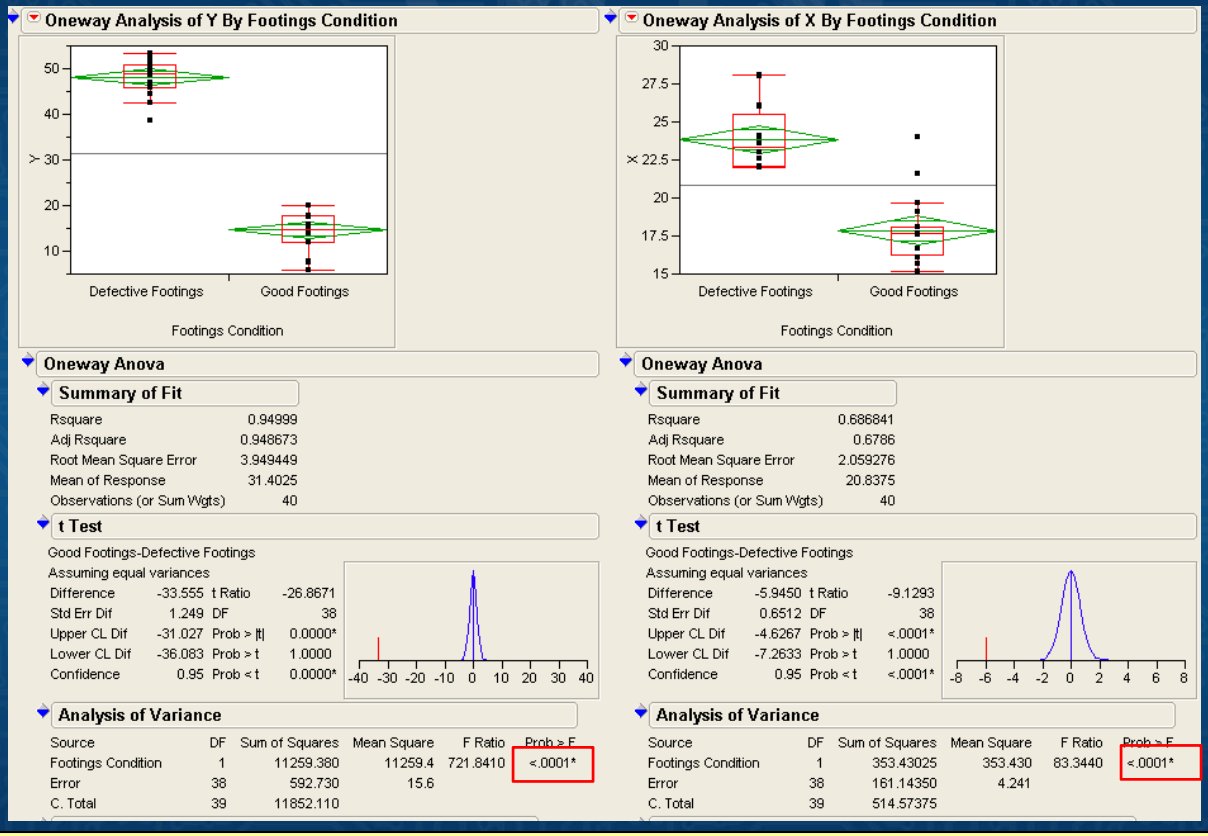
Improve

Control

# Validation Result for Operational Condition of Prober

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 2 | Wafer | Operational condition of prober | Using defective prober footings will cause planarity problem and can induce probe damage. | Using t-test validate planarity using good vs defective prober footing. |

Objective: To verify if using a defective prober footing can cause probe damage..




Conclusion: Result shows that there is a significant difference in the X and Y shifts when using good footings vs defective footings. Therefore the identified KPIV is *VALID.*

Define

Measure

Analyze

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Improve

Control

# Validation Result for Operational Condition of Prober

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 3 | Wafer | Operational condition of prober | Card relative Z ht and overdrive does not affect probemark size. | Using DOE to check effect on probe mark size of different z ht and overdrive setting |

Objective: To verify effect of card relative z ht and overdrive on probe mark size.

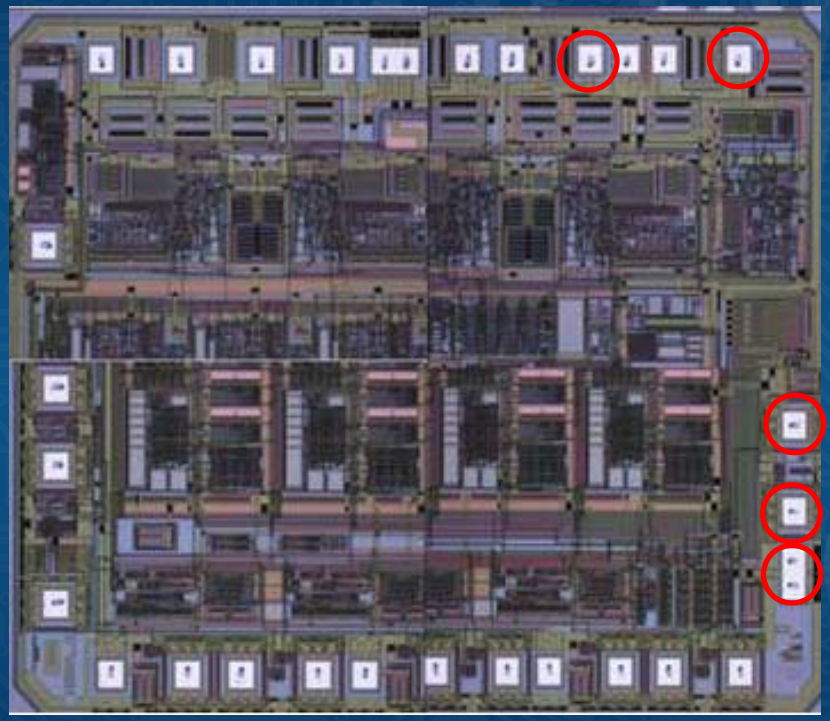

Photo at left show is the result of simulation in which the probe mark length (samples in red box) is much bigger and longer compared to a normal probe mark size.

Conclusion: Setting of card relative z height is critical as this will dictate the needle cleaning height, As Z height increases needle cleaning height also increases. This will cause probe card to smash and eventually probe damage will occur. Therefore the identified KPIV is *VALID.*

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
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- Results and Analysis:
  - Graphical, and/or
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Improve

Control

# Validation Result for Operational Condition of Prober

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 4 | Wafer | Operational condition of prober | “Model not found" and "auto focus error" will induce probe damage if not properly corrected. | Validate effect of the ff errors, model not found, and auto focus error on the probemark. |

Objective: To verify if “Model not found” and “auto focus error” will induce probe damage if not properly corrected.

Conclusion: Although “Model not found” error was not replicated during the validation, the team still consider this as valid since “Model not found” error is due to probe card vs prober theta alignment and corrective action to address will be define. Therefore the identified KPIV is *VALID.*

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

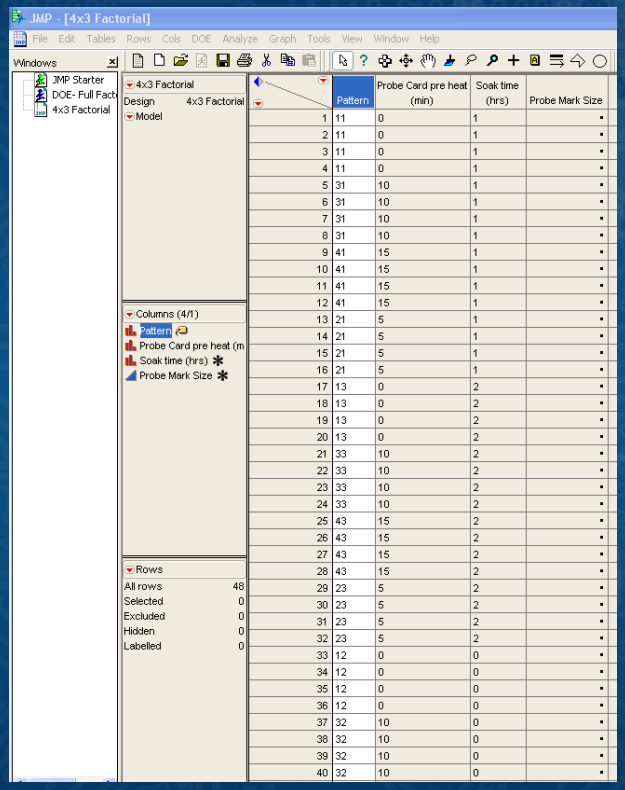
Improve

Control

# Validation Result for Soaking Procedure

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 5, 6 | Operator | Soaking Procedure | Incorrect soak time will have effect on probemark size | Using DOE validate effect of soaking on the probemark (10min- PC- PREHEAT 2 HRS PROBER SOAK FOR INITIAL SETUP) |

Objective: To verify if effect of soaking (prober soak – 2hrs; PC soak- 10min) on probe mark size and position.




| | |
|---|---|
| Device | 0HSBA |
| Temp | 155°C |
| Probing duration | 2hours |
| test time | 30sec |

| | X (µm) | Y (µm) |
|---|---|---|
| Prober shift | 2 | 2 |

| 0 prober soak/ 10mins PC soak | First Die 1 | First Die 2 | Offset (less prober shift) | Last Die 1 | Last Die 2 | Offset (less prober shift) |
|---|---|---|---|---|---|---|
| X | 6.2 | 20.3 | -12.1 | 6.2 | 24.2 | -16 |
| Y | 9.9 | 15.7 | -3.8 | 9.9 | 15.1 | -3.2 |

| | X (µm) | Y (µm) |
|---|---|---|
| Prober shift | 4 | 2 |

| 2 prober soak/ 5mins PC soak | First Die 1 | First Die 2 | Offset (less prober shift) | Last Die 1 | Last Die 2 | Offset (less prober shift) |
|---|---|---|---|---|---|---|
| X | 54.5 | 36.5 | 14 | 56.5 | 37.1 | 15.4 |
| Y | 33.1 | 31.4 | -0.3 | 29.6 | 34.9 | -3.3 |

Conclusion: Result shows that prober soak and PC soaking is required as this affects the probe mark size and position which can lead to probe damage. Probe mark size and position will increase as PC soak time increases. Therefore the identified KPIV is *VALID.*

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

Improve

Control

# Validation Result for Inspection Procedure and Equipment Setup/ Repair

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 7 | Method | Inspection procedure and equipment repair | Procedures is not yet robust or is not yet define | Check specs if procedure are existing. |

Objective: To verify if there is an existing procedure define during :

- Prober relocation – No procedure
- PC/LB installation - No procedure
- Test head docking – No procedure
- Setting z-ht and overdrive – With procedure.
- Inspection methodology to detect theta alignment problem. No procedure.
- Inspection methodology –With procedure but needs to be enhanced.
- Theta alignment problem. – With procedure but needs to be enhanced.
- Detect prober XY shift problem – With procedure but needs to be enhanced.
- Correct prober XY shift problem – With procedure but needs to be enhanced.
- Methodology after equipment repair – With procedure but needs to be enhanced.
- Probemark inspection criteria – With procedure but needs to be enhanced.
- Inspection of probecard needle prior use – With Procedure.
- Different criteria at probe card build vs production - No procedure.

Conclusion: There are no procedures define on some of the critical activities above. For those identified with procedures, further enhancement needs to be done to increase detection of the problem. Each operator/technicians have their own procedures based on their experiences thus can result to poor detection of probe damage. Therefore the identified KPIV is *VALID.*

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

Improve

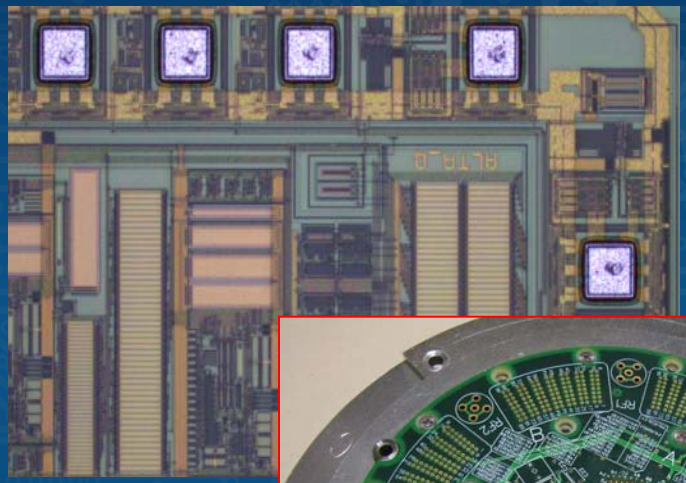
Control

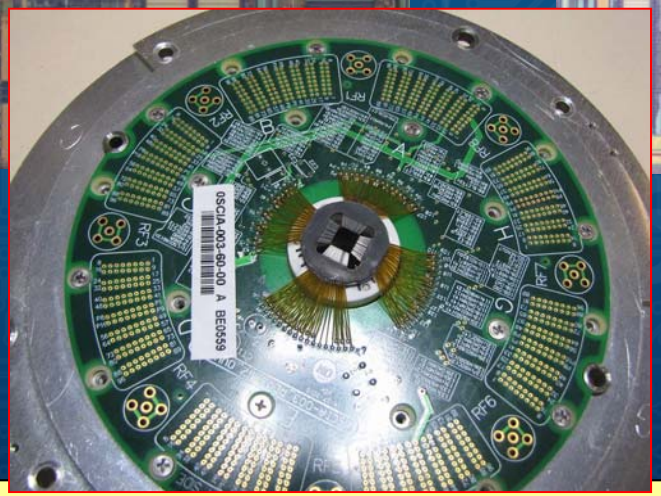
# Validation Result for Probe Card PC Stiffener Screws

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 8 | Method | Probe card in good condition. | Using out of spec screws in PC stifener (ELTESO PC) can induce probe damage. | Validate Effect of using out of screws can induce probe damage.. |

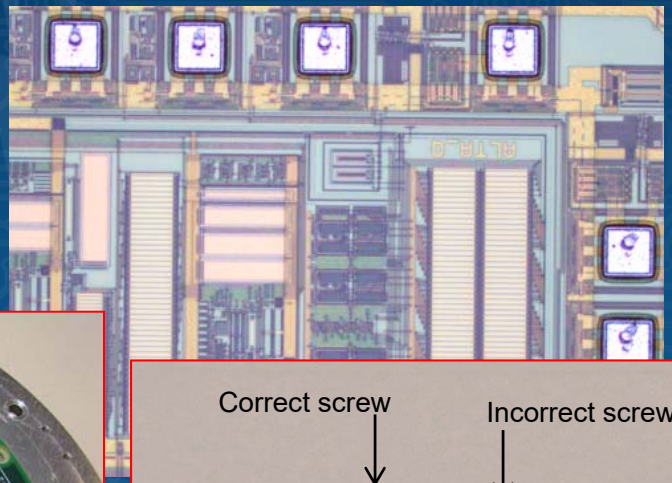
Objective: To verify if using out of spec screws in PC stiffener can cause probe damage.

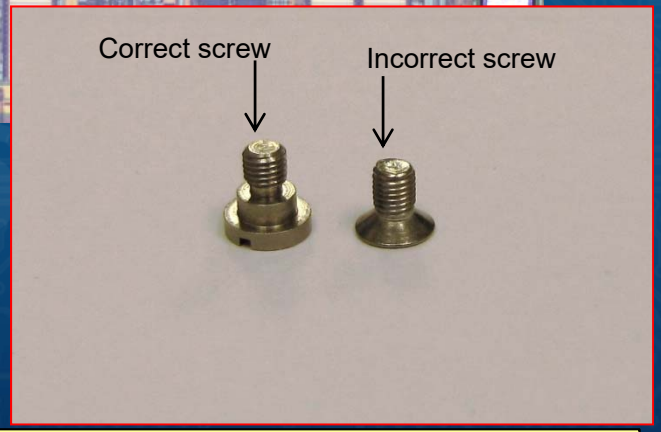
## Using PC with standard screws





## Using PC with non standard screw






Conclusion: The PCB is not mounted floating on the stiffener. The root cause of this is the fact that not the special ELTESO screws are used to mount the PCB, standard screws (see picture ELTESO screws. Left is the correct screw, right is the out of spec screw). As a result the PCB is not floating and the expansion due to the temperature is driving the needle movement. Therefore the identified KPIV is *VALID.*

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

Improve

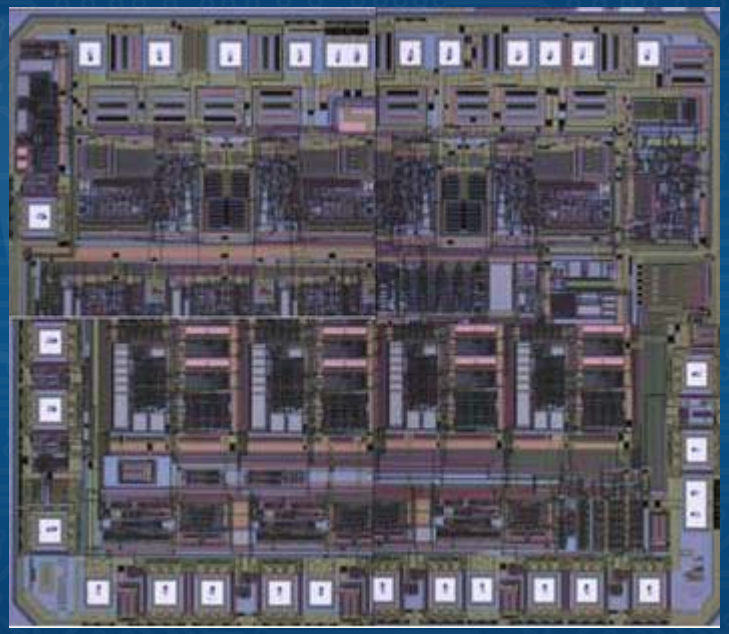
Control

# Validation Result for Updated and Labelled BOP Disk

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 9 | BOP Disk | Updated and with label | Loading of wrong/not updated BOP disk can cause smash the probecard and eventually causes probe damage | Validate effect of using a wrong / not updated BOP disk |

Objective: To verify if using wrong/not updated BOP disk can cause smash probecard and eventually causes probe damage.

Inspection result after simulation



Conclusion: Incorrectly loading a BOP disk causes smash probecard, however, during validation, probe damage was not induced. This however does not mean that this probe damage will not happen thus the KPIV is VALID.

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

Improve

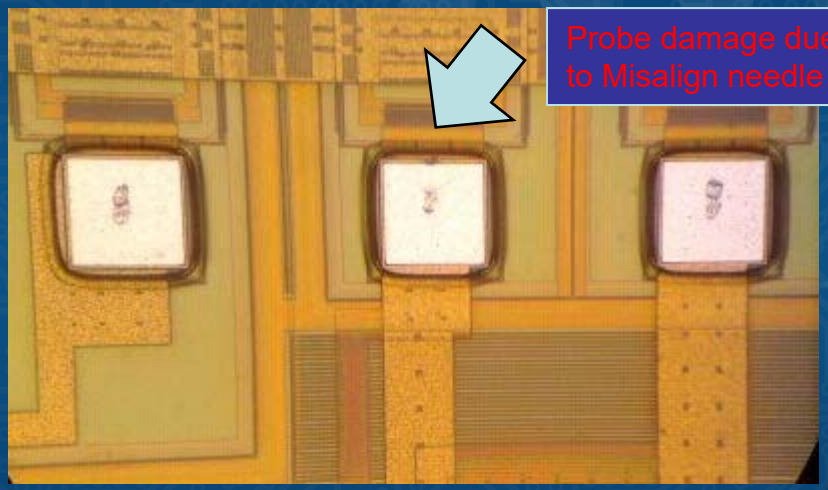
Control

# Validation Result for Frequent Tweaking of needle

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 10 | Probe Card | Probe card in good condition | Use of Sodium Hyroxide can cause weakening of probe needle which can lead to needle misalignment and eventually probe damage.. | Check historical data . |

Objective: Check historical data of probe card using sodium hydroxide and duralco epoxy.

0WICA PC with SN 081998 uses NAOH and Duralco and encountered misalign needle on the middle of the lot.




Conclusion: Sodium Hydroxide is the chemical used during needle etching. Application of this chemical is subjective and operator dependent while use of Duralco epoxy does not effectively hold the needle of the probecard. This eventually weakens the needle and will cause premature needle misalignment. The KPIV is therefore VALID.

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

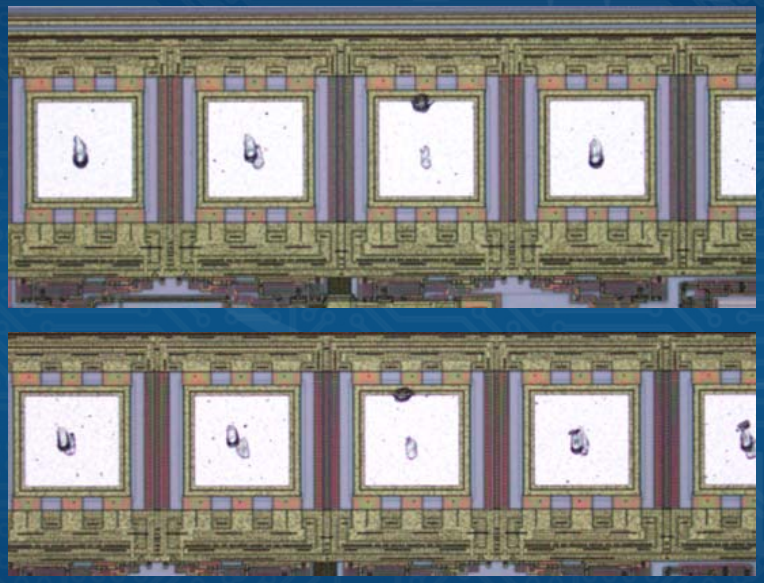
Improve

Control

# Validation Result for Replacing of Lapping Paper

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 11,12 | Cleaning material | Updated and with label | Replacing the cleaning material incorrectly and worn out cleaning materials will eventually mis-align the needle during needle cleaning. | Validate effect of bubble during lapping paper replacement can cause probe damage. |

Objective: To verify effect of wrong replacement of cleaning material and use of worn out cleaning material can induce probe damage.



Needle misaligment after needle cleaning using worn out needle cleaning material.

Conclusion: Replacing cleaning material without removing the original cleaning material will cause needle to smash due to additional 100um overdrive and consequently probe damage will occur. Using also an already worn out cleaning material will cause needle misalignment. The KPIV is therefore VALID.

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

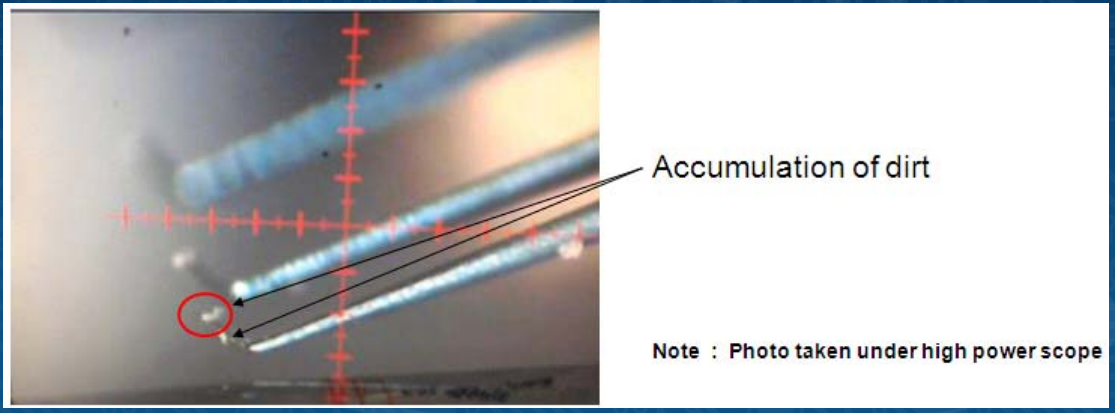
Improve

Control

# Validation Result for Accumulation of Debris on Lapping Paper

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 13 | Cleaning material | Lapping Paper | Accumulation of debris on the probe needle can cause probe damage. | Validate effect of accumulated debris on the probecard needle |

Objective: To validate if accumulated debris on the probecard needle can induce probe damage.




Conclusion: Result shows that probe damage will occur if there is an accumulated dirt/debris on the probecard needle. The size and location of the probe damage coincides with that of the debris on the probecard needle. The KPIV therefore is VALID.

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

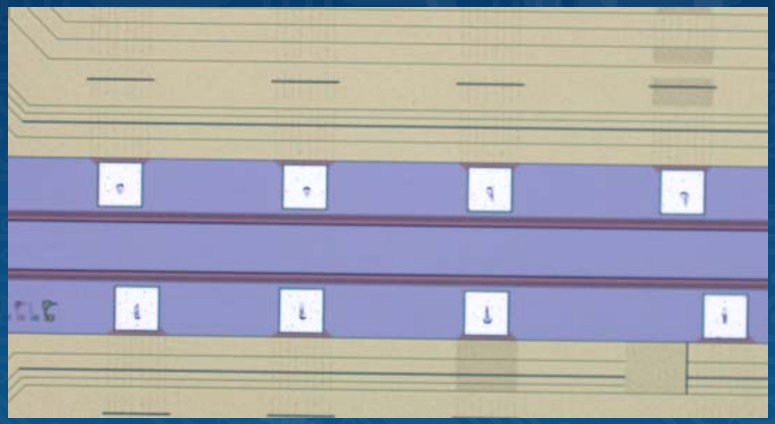
Improve

Control

# Validation Result for Probe Operating Procedure

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 14 | Method | Probe operating procedure | Leaning on the test head and removal of cable on cable setup will induce probe damage. | Effect of leaning on the test head and removal of cable while ongoing test. |

Objective: To verify if there is an effect on leaning on the test head and removal of cable while ongoing test will induce probe damage.



Before reseating of cable – No probe damage seen on the bond pad

After reseating of cable – Probe damage seen on the bond pad

Conclusion: Result shows that after reseating the cable, probe damage occurred. Therefore the identified KPIV is *VALID.*

Define

Measure

Analyze

- Identification of KPIVs
- Prioritization of KPIVs
- Validation Plan for KPIVs
- Results and Analysis:
  - Graphical, and/or
  - Statistical
- Analyze Phase Summary

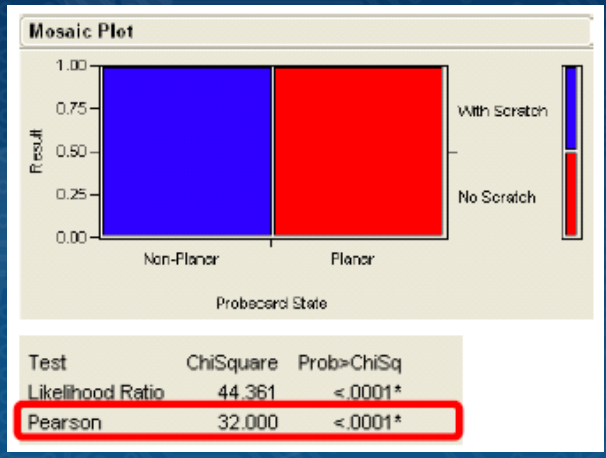
Improve

Control

# Validation Result for Probe card Planarity

| KPIV Plan No. | Input | Characteristic of Input (KPIV) | Hypothesis | Validation Plan |
|---|---|---|---|---|
| 15 | Probe card | Probe card planarity | **Probecard with planarity issue can cause probe damage.** | Validate effect of using probecard with planarity issue. |

| | |
|---|---|
| **Test Plan** | Chi-Squared Test |
| **Sample Size** | 32 samples |
| **Hypothesis Statement** | *Ho :* Probe damage (planar) = Probe damage (Non-planar)<br>*Ha :* Probe damage (planar) not = Probe damage (Non-planar) |
| **Test Result** | p-value < 0.0001 |
| **Statistical Conclusion** | Reject Ho @ 95% confidence level |
| **Practical Conclusion** | The occurrence of probedamage is significantly different between planar and non-planar probe card |

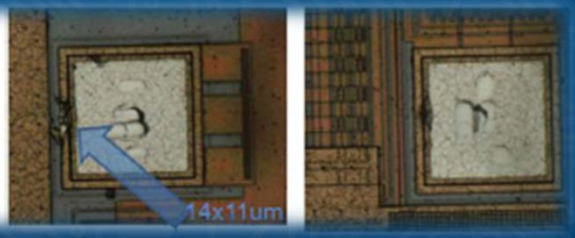



| Test | ChiSquare | Prob>ChiSq |
|---|---|---|
| Likelihood Ratio | 44.361 | <.0001* |
| Pearson | 32.000 | <.0001* |

**Summary of Result :**

| Probecard State | No Probe Damage | With Probe Damage |
|---|---|---|
| Non-Planar | 0 | 16 |
| Planar | 16 | 0 |

Sample Photos




Conclusion: The result in the summary table is so convincing that even without the Chi-squared test one can confidently state that non-planar probe card is conclusively inducing probe damage. The KPIV therefore is VALID.

# SIX SIGMA

## The DMAIC Model


Define Opportunity
*(What is important?)*

Measure Performance
*(How are we doing?)*

Analyze Opportunity
*(What is wrong?)*

Improve Performance
*(What needs to be done?)*

**Define** the goals of the improvement activity.

Select the appropriate responses (Y's) to be improved.

**Measure** the existing system.

Gather data to measure and verify the response variable --- the problem or improvement opportunity.

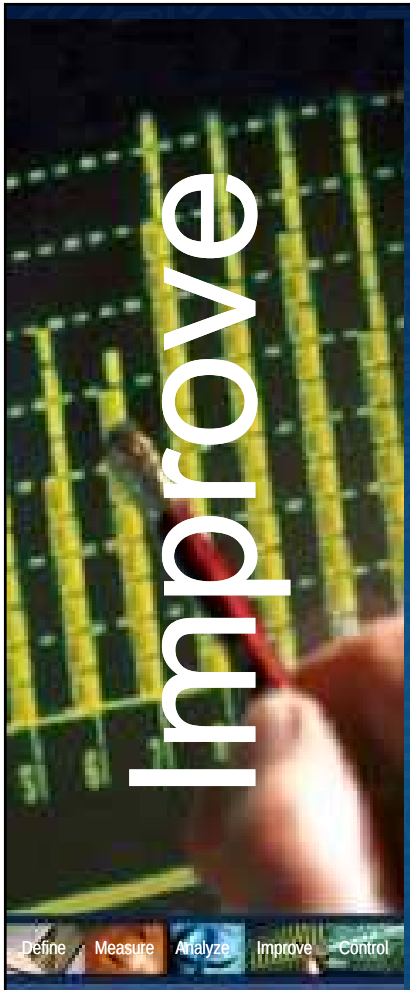
**Analyze** the system to identify the causes or gaps.

Find the relevant X's.

**Improve** the system.

Identify ways to eliminate the gap.

Reduce variability or eliminate the cause.




Corrective / Preventive Actions

- Implementation of a more robust and efficient set-up methodology to determine if there is an equipment or probe card issue prior running the complete lot shows early detection of issues.
- Implementation of XY bracket during prober relocation also shows effective methodology when transporting one prober to another tester.
- Use of POR screws on ELTESO probe card likewise eliminate probe damage caused by probe card expansion when subjected to high temp.

- Implementation Result
  - Significant improvement was observed after completion and partial implementation of a defined corrective actions.

Define

Measure

Analyze

Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# Corrective / Preventive Action (CAPA) Plan

| Item | Validated KPIV/Cause | Quick Win/s (Containment Action/s) | Permanent Action/s | Responsible/ Completion Date |
|---|---|---|---|---|
| 1 | **KPIV 1** Operational condition of prober after equipment relocation. | a. Enhance equipment buy-off prior MFG acceptance (production use). | 1.1. Enhance equipment buy-off prior MFG acceptance (production use).<br><br>1.2. Use bracket during transfer of probers to support XY prober arm during relocation. | Six Sigma Team/ Done<br><br>Deployment (Maan L)/ Done<br><br>Rod Salmorin/ Done |
| 2 | **KPIV 2** Using defective prober footings will cause planarity problem and can induce probe damage. | a. Do one time checking of all prober footings. | 1.1 Do one time checking of all prober footings.<br><br>1.2 Include checking of prober footings on the PM checklist | Bert Bugarin / Done<br><br>Rod Salmorin/Done |
| 3 | **KPIV 3** Incorrect card relative z height and over drive can cause probe damage | a. Enhance procedure during setting of card relative z height. | 1.1 Enhance procedure during setting of card relative z height. | Glenn Placido/Done |
| 4 | **KPIV 4** "Model not found" and "auto focus error" will induce probe damage if not properly corrected. | a. Generate OCAP for this prober error. | 1.1 Generate OCAP for this prober error.<br><br>1.2 Qualify PCB theta jig with tighter specs. | Glenn Placido / done.<br><br>Enan dela Cruz/ Done |

Define

Measure

Analyze

Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# Corrective / Preventive Action (CAPA) Plan

| Item | Validated KPIV/Cause | Quick Win/s (Containment Action/s) | Permanent Action/s | Responsible/ Completion Date |
|---|---|---|---|---|
| 5 | **KPIV 5,6** Incorrect soak time have effect on probe mark size and position. | a. Remove manual soaking by integrating soaking time on the prober to tester interface | 1.1 Remove manual soaking by integrating soaking time on the prober to tester interface. | Sherwin Gan/Done. |
| 6 | **KPIV 7** Procedure is not yet robust/define | a. Generate specs for non existing procedures.<br>b. Enhance existing procedure to improve detection of defects | 1.1 Generate specs for non existing procedures.<br>1.2 Enhance existing procedure to improve detection of defects | Six Sigma Team/Done<br>Sherwin Gan/Done |
| 7 | **KPIV 8** Use of incorrect screws in PC stiffener (ELTESO PC) can induce probe damage. | a. Do one time check of all ELTESO PC if using standard screw. | 1.1 Do one time check of all ELTESO PC if using standard screw.<br>1.2 Perform inspection using filler gauge. | Enan dela Cruz/ Done<br>Enan dela Cruz/ Done |
| 8 | **KPIV 9** Loading an incorrect / not updated BOP disk can smash the probe card and eventually cause probe damage. | a. Eliminate the use of BOP disk. Use prober to tester interface to set up the cleaning unit height per device requirement. | 1.1 Eliminate the use of BOP disk. Use prober to tester interface to set up the cleaning unit height per device requirement. | Rod Salmorin, Sherwin Gan/Done |

Define

Measure

Analyze

Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# Corrective / Preventive Action (CAPA) Plan

| Item | Validated KPIV/Cause | Quick Win/s (Containment Action/s) | Permanent Action/s | Responsible/ Completion Date |
|---|---|---|---|---|
| 9 | **KPIV 10** Use of Sodium Hyroxide and old type epoxy (Duralco) can weaken the probe needle which can lead to premature needle misalignment . | a. Implement gel pad during needle etching.<br>b. Use of Pelnox epoxy | 1.1 Implement gel pad during needle etching.<br>1.2 Use of Pelnox epoxy (on high temp PC<br>1.3 Implement touchcount monitoring on every probecard on high runner devices | Enan dela Cruz/ Done<br>Enan dela Cruz/ As per rebuild./Done<br>Enan dela Cruz/250k TD/Done |
| 10 | **KPIV 11, 13** Use of worn out cleaning material and incorrect replacement of cleaning material can cause probe damage. | a. Used gel pad/lapping paper should be endorsed to line supervisor prior replacement of new one. | 1.1 Used gel pad/lapping paper should be endorsed to line supervisor prior replacement of new one. | Vangie Ocampo / Done |
| 11 | **KPIV 12** Accumulated debris on the probe card needle causes probe damage. | a. Do online cleaning every middle of the lot for devices | 1.1 Do online cleaning every middle of the lot for devices | Done |

Define

Measure

Analyze

Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# Corrective / Preventive Action (CAPA) Plan

| Item | Validated KPIV/Cause | Quick Win/s (Containment Action/s) | Permanent Action/s | Responsible/ Completion Date |
|---|---|---|---|---|
| 12 | **KPIV 14** Leaning on test head and removal of cable on cable setup | a. Put warning sign "Do not lean on test head" for OH setup.<br><br>b. Establish procedure for proper removal and installation of cables/PC on cable setup. | 1.1 Put warning sign "Do not lean on test head" for OH setup.<br><br>1.2 Establish procedure for proper removal and installation of cables/PC on cable setup.<br><br>1.3 Vacuum Docking | Glenn Placido / Done<br><br>Glenn Placido/ Done<br><br>Rod Salmorin – Done. |
| 13 | **KPIV 15** Probe Card Planarity | a. Establish procedure / criteria to detect probecard planarity issue during initial setup. Establish criteria. | 1.1 . Establish procedure / criteria to detect probecard planarity issue during initial setup. Establish criteria. | Glenn Placido / Done. |

Define

Measure

Analyze

Improve

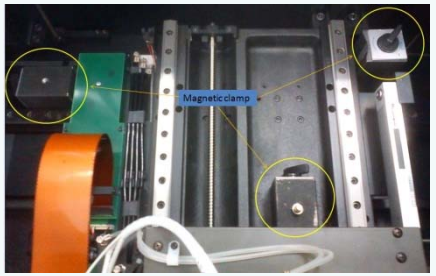
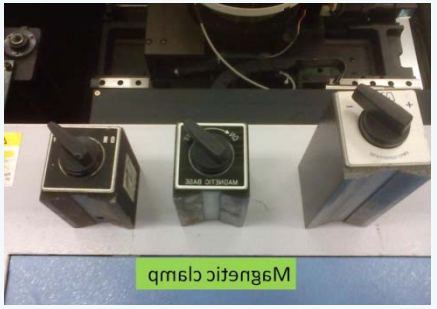
- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# CAPA for Validated KPIV # 1

(Operational condition of the prober after equipment relocation)

Enhance equipment buy-off and use of bracket during transfer of prober.

| Process | Before | After |
|---|---|---|
| Buy-off after prober transfer | Theta check using naked eye. | Theta check but with actual measurement of XY deviation. |
| Transfer of prober from one tester to another. | Does not use brackets during transfer of prober. |   |

Define

Measure

Analyze

Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# CAPA for Validated KPIV # 2

(Operational condition of the prober using defective prober footings)

Enhance equipment buy-off and use of bracket during transfer of prober.

| Process | Before | After |
|---|---|---|
| Transfer of prober from one tester to another. | No checking of prober footings condition. | Checking of prober footings prior equipment endorsement. |
| | | |

Define

Measure

Analyze

Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# CAPA for Validated KPIV # 3,4,7

(Incorrect card relative z height and over drive; "Model not found" and "auto focus error" and Procedure is not yet robust/define)

| Process | Before | After |
|---|---|---|
| Initial setup | Checking of probe mark is done visually. | Checking of probe mark is measured if within spec. |
| | No checking of theta. | Checking of theta. |
| Ongoing probe. | Checking of probe marks after equipment intervention, start of shift is done using cross pattern. | Checking of probe marks after equipment intervention, start of shift is done using the last die that was used. |
| | No procedure define when encountered "Model not found" and "Auto-focus error". | Define OCAP when encountered "Model not found" and "Auto-focus error". |
| | Inspection every 6th wafer is triggered manually. | Inspection every 6th wafer is triggered by the interface. |

Define

Measure

Analyze

Improve

- ❑ Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- ❑ Implementation Result
- ❑ Improve Phase Summary

Control

# CAPA for Validated KPIV # 3,4,7

## (Incorrect card relative z height and over drive; "Model not found" and "auto focus error" and Procedure is not yet robust/define)

**THETA SHIFTING CHECKING PROCEDURE PRIOR PRODUCTION RUN:**

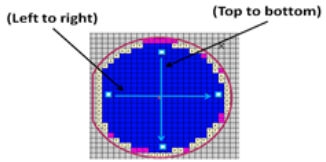
Target Device: ALCA, HSBA, 19791

**Requirement, when to do?**

- Operator to perform theta shifting checking every setup, new lot and next lot.
- For relocated Prober, Operator to indicate in the sort card that the prober to be used was newly relocated

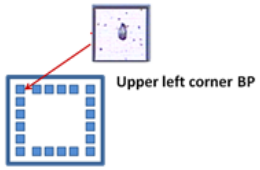
**Step by step Procedure:**

1. Perform Theta shifting check using fresh wafer before probe by inducing probemark on 4 pts (top to bottom,left to right)

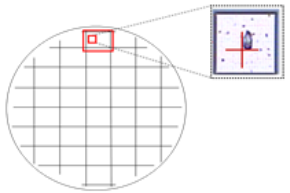



2. Measure the theta XY shift, acceptable measurement should be **(=/< 5um)**
3. Record the value on the Sort setup sheet and coordinates of the dice.
4. Use the upper left corner bonding pad of the die as reference

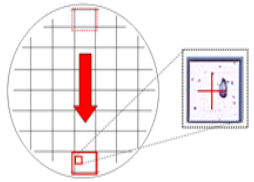
**Note: For 0MAFA and 0ALCA use the smallest bond pad as reference**
**: For Multi sites use the bonding pad of 1 site**



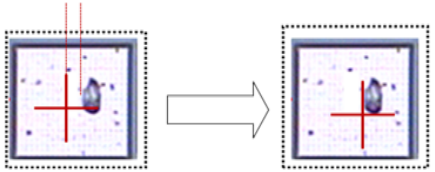

5. At the Top of the wafer, position the Crosshair on Probe mark of upper left corner BP. When Done, Press Position display.



6. Go to INDEX mode and Index down the wafer to the Last Die at the bottom. Press " ZERO Reset"



7. Move the crosshair to its original position relative to the bonding pad.



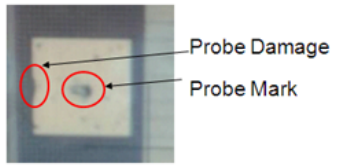
8. X and Y position values on Prober screen should indicate your theta shifting. If any one of these values exceeds **5um**, endorse the setup to Probe tech.
9. If these values are okay, then repeat step (5-8) for Bond pad of Left die to Right direction.

–END–

**NEW INLINE INSPECTION METHODOLOGY:**

**Inspection should be done after wafer probing, except for First wafer.**

1. First wafer is considered setup wafer thus probe mark should be induced.
2. Perform inspection after every 6th wafer, last wafer, start of the shift and any intervention.
   **Note: KLA pause before unloading is enabled**
3. For every 6th wafer and last wafer, inspect 5 dice cross pattern (top, mid bottom, left and right) using Probe mark template.
4. During inspection. Inspect also the bond pad periphery at high mag.




5. For every start of the shift, inspect 1 last die sorted. Take note of the coordinates and wafer number.
6. For any intervention inspect the 1st die sorted using the probe mark template. After equipment endorsement, inspect after 10th die sorted. Take note only of the 1st die sorted coordinate and the wafer number.

**Note: Interventions are:**

- Change of peripherals (Probe card, Loadboard, cables)
- Change of overdrive
- Equipment repair (intervention by support group)
- Clearing of reference model if encountered "Model not found error".

**PC / Loadboard Installation on Cable Setup :**

1. During setup Install probe card, Loadboard and cable prior performing needle alignment.
2. Any reseating done on the cable, needle alignment should be performed.

Define

Measure

Analyze

Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# CAPA for Validated KPIV # 3,4,7

(Incorrect card relative z height and over drive; "Model not found" and "auto focus error" and Procedure is not yet robust/define)

| ERROR MESSAGE | CAUSE OF ERROR | IMPACT TO PRODUCT | ERROR CATEGOR | RECOVERY | RESPONSIBLE |
|---|---|---|---|---|---|
| Prober Error: Load Cassette not set up | o Start was pressed but loader is not in loading postion | Downtime | A | o Press "new cassette" (yellow button) | o Operator |
| Prober Error: Wafer ID not read (No ID characters) | o Uncalibrated OCR<br>o Wafer scribe not readable<br>o Different format of wafer scribe | Misprocessing (Wrong wafer) | C | o Call Maintenance if wafer scribe is readable or in correct format otherwise call process/TA | o Operator |
| | | | | o Calibrate OCR | o Maintenance |
| | | | | o (Fab feedback) if wafer scribe is unreadable/in different wafer scribe format. | o Process /TA |
| Prober Error: Needle alignment error (Needle position not found. Low Mag) | Inconsistent position of PC | o Offset probing due to wrong site assignment for multi-site.<br>o Single site - shifted probemark.<br>o Possible probedamage | C | Perform Manual alignment | o Operator |
| Prober Error: Needle alignment error (Insufficient number of Needles found. High Mag) | o PC with planarity issue<br>o Smash probecard<br>o Wrong site assignment | o Offset probing due to wrong site assignment for multi-site.<br>o Shifted probemark for single site.<br>o Possible probedamage | C | o Check if there is a matched needle vs prober reference. If none, call technician. | o Operator |
| | | | | o Check is there is probecard planarity issue.<br>o Replace probecard | o Maintenance |
| Error: Tester Command: EITst::loadprogram error (1). | o Loadstring not define at KLA. | Possible wrong test program | C | o Endorse to TSA. | o Operator |
| Prober Error: Head stage open | o Unlock head stage | Safety. | C | o Check headstage/Sidepanel if open. Call tech. | o Operator |
| | | | | o Check interlock | o Technician |
| Prober Error: Needle alignment error (Low mag. search position shifted) | Inconsistent position of PC | o Offset probing due to wrong site assignment for multi-site.<br>o Shifted probemark for single site.<br>o Possible probedamage | C | Manual alignment. | o Operator |
| Prober Error: Model not found | Theta of PC is out of spec | o Offset probing<br>o Probe damage | C | o Change reference model<br>o If problem cannot be corrected, Endorse to tech | o Operator |
| | | | | o Replace PC | o Technician |
| Prober Error: Focus point not found within processing area | Blurred image :<br>posssible cause :<br>- unplanarize check<br>- profile sensor not calibrated | Downtime | A | o Endorse to tech | o Operator |
| | | | | o Calibrate profile sensor<br>o Planarize chuck<br>o Hard down | o Technician |
| Prober Error: GPIB receive command format invalid | Corrupted KLA file | Downtime | A | o Re-initialize prober<br>o Reload KLA<br>o Reload BOP<br>o Endorse to TA | o Operator |
| Prober Error: Elevator 1 (Wafer safe sensor) | o Protruding wafer on the cassette.<br>o Equipment Vibration | Broken wafer | B | Endorse to technician. | o Operator |

Define

Measure

Analyze

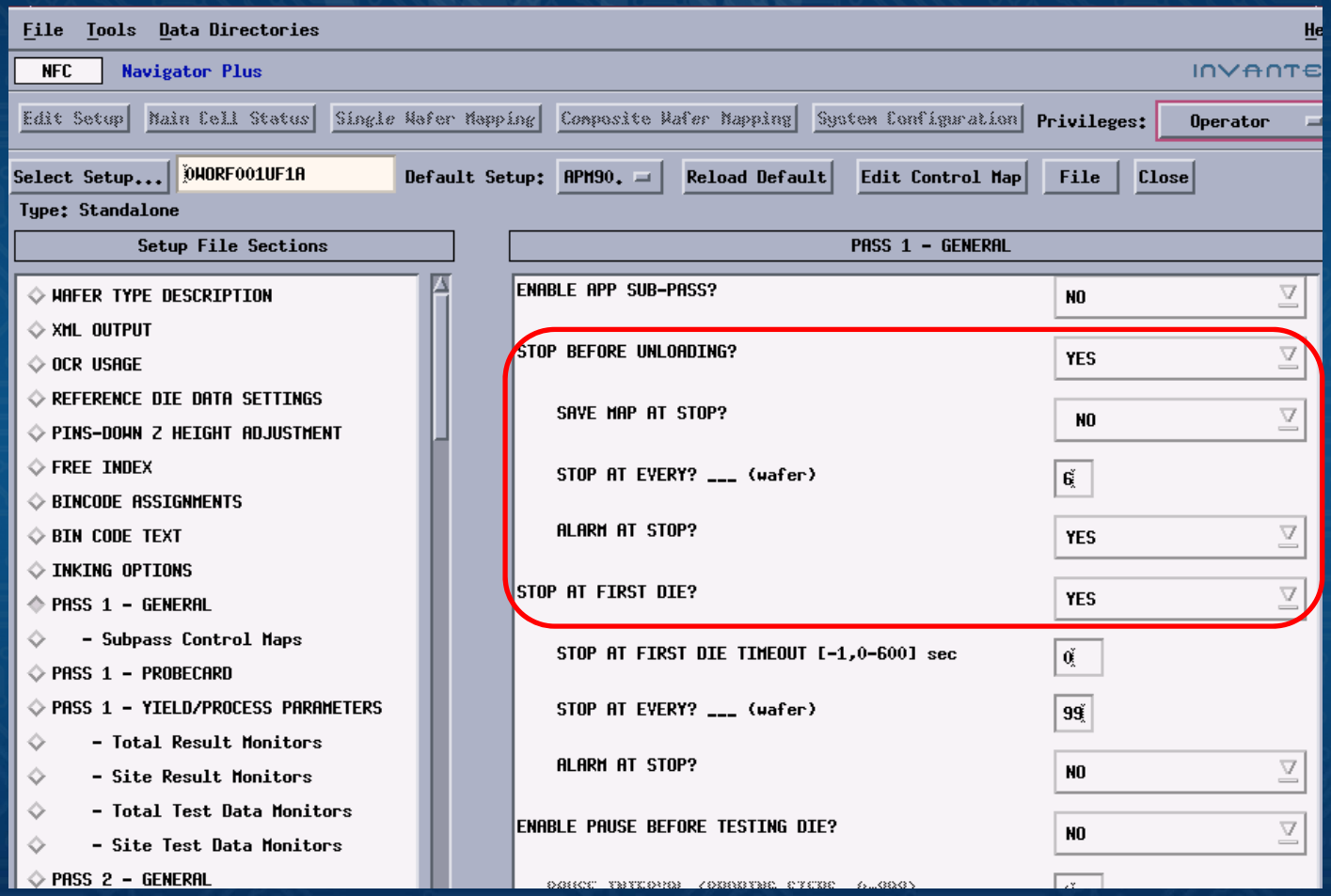
Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# CAPA for Validated KPIV # 3,4,7

(Incorrect card relative z height and over drive; "Model not found" and "auto focus error" and Procedure is not yet robust/define)



Define

Measure

Analyze

Improve

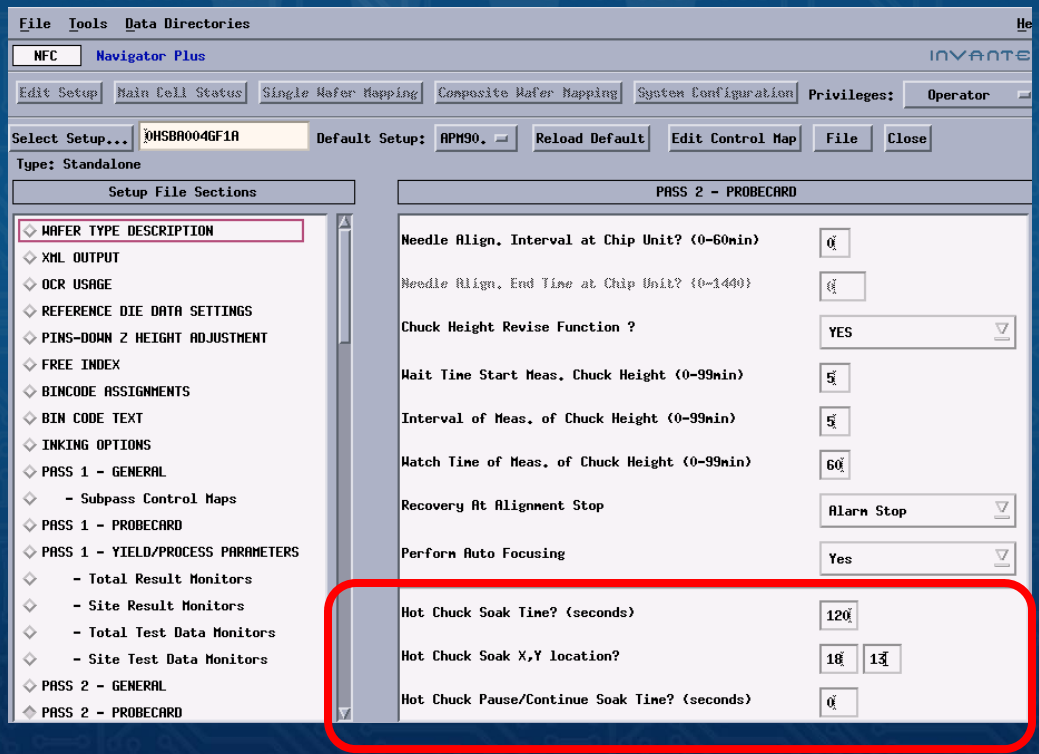
- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# CAPA for Validated KPIV # 5,6

(Incorrect soak time have effect on probe mark size and position.)

| Process | Before | After |
|---|---|---|
| Soaking before :<br>• Probing<br>• Any intervention | Manual soaking | Auto-soaking. Integrated to KLA. |



Define

Measure

Analyze

Improve

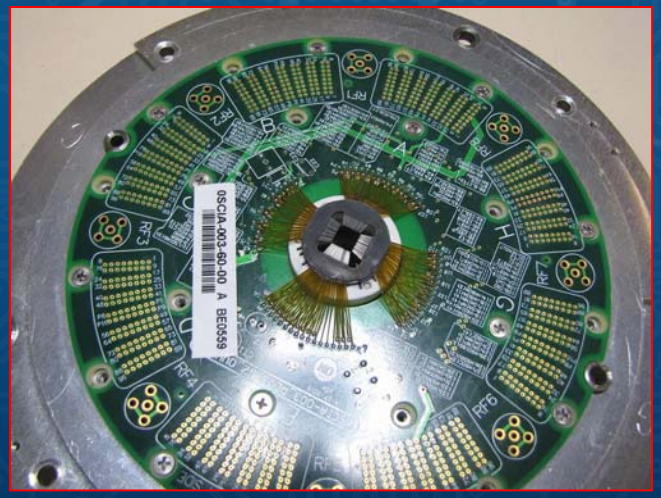
- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

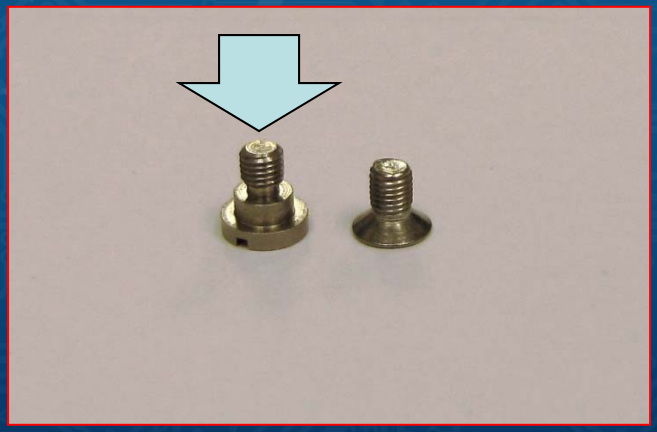
Control

# CAPA for Validated KPIV # 8

(Use of incorrect screws in PC stiffener (ELTESO PC) )

| Process | Before | After |
|---|---|---|
| Probe Card Build | Use of non-standard screws on ELTESO probe card is ok. | Non-standard screws are replaced with the POR screws.<br><br>Perform inspection using filler gauge. |





Define

Measure

Analyze

Improve

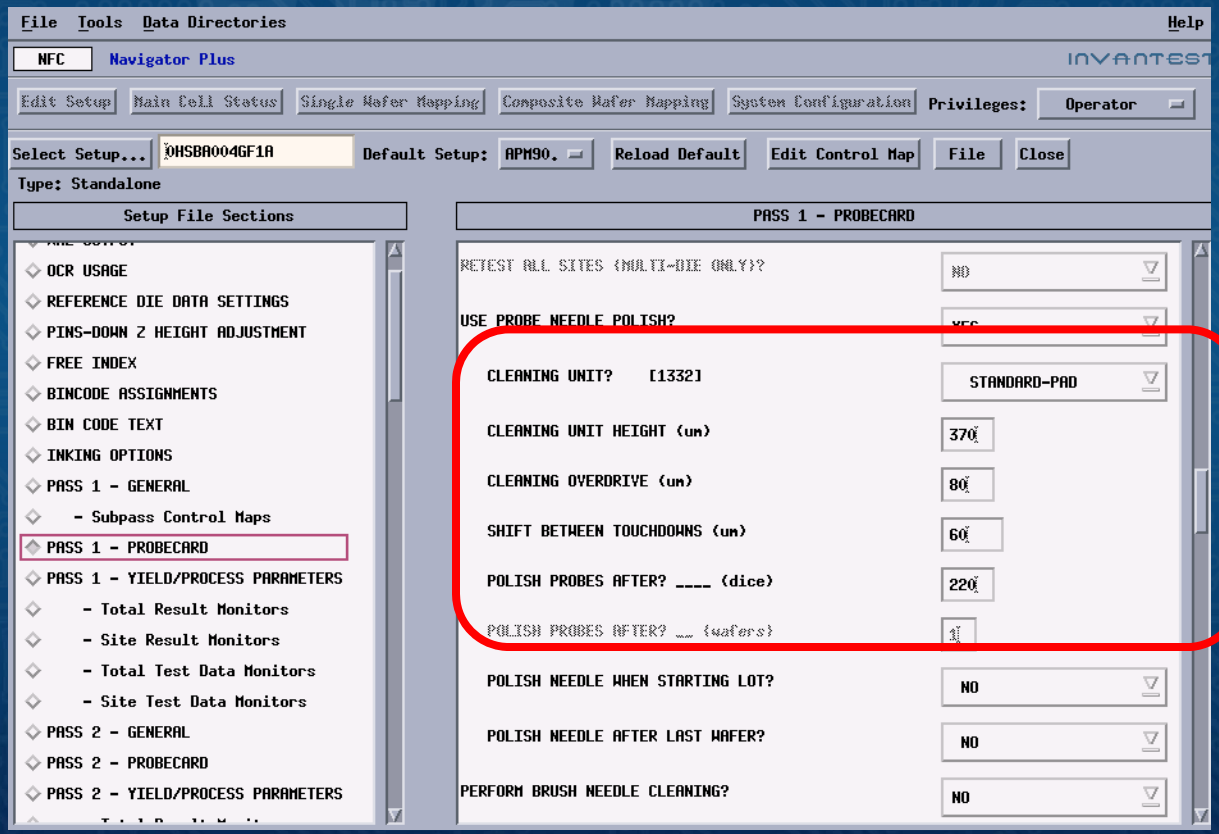
- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# CAPA for Validated KPIV # 9

(Loading an incorrect / not updated BOP disk can smash the probe card )

| Process | Before | After |
|---|---|---|
| Needle Cleaning | Use of BOP disk per cleaning material. | Include needle cleaning info on the device KLA. |



Define

Measure

Analyze

Improve

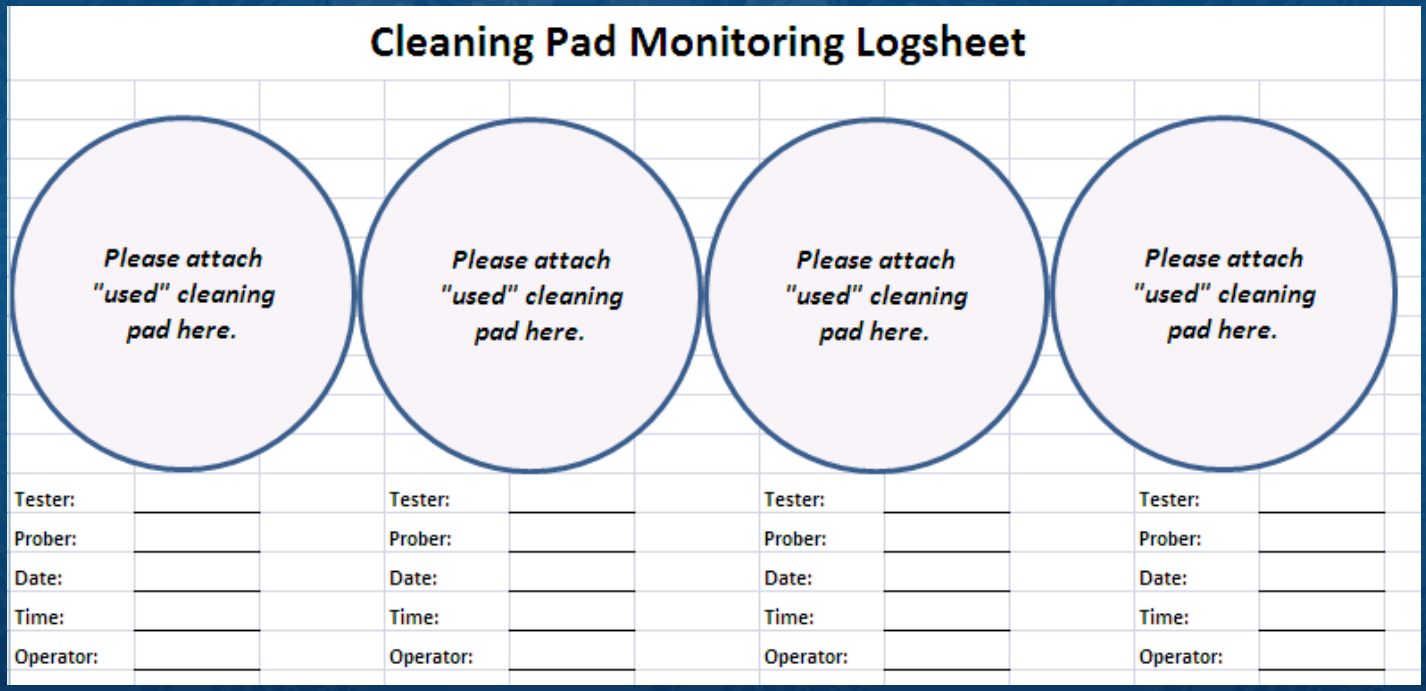
- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# CAPA for Validated KPIV # 11,13

(Use of worn out cleaning material and incorrect replacement of cleaning material.)

| Process | Before | After |
|---|---|---|
| Needle Cleaning | No procedure on replacement of cleaning material. | Established procedure that ensures replacement of cleaning material. |



Define

Measure

Analyze

Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# CAPA for Validated KPIV # 12

(Accumulated debris on the probe card needle.)

| Process | Before | After |
|---|---|---|
| Probing | No procedure on how to prevent accumulation of debris on probe card needle. | Online needle cleaning of probe card needle after 12th wafer. |

## SORT SETUP SHEET

New Device

INKLESS

DEVICE : 19791-001
RC : L
DOD Y/N? : N
PART TITLE : RUBY
PH : MS-SIAS-AUT-MS
PART TYPE : DWR
CUSTOMER : NAGANO KEIKI CO LTD

SPECIAL INSTRUCTIONS

*** Sort Requirements ***

Use Red Amp cables.

LOADBOARD:
WS1 ---> 19791-001-61-0A-0000-01
WS2 ---> 19791-001-61-0A-0000-00

" Do not use production wafers for setup troubleshooting. Only reference wafer should be used."

New probe card should be using the new probe card drawing .

Special Instruction for WS1 and WS2 Setup
Online cleaning of probecard by PC personnel is required every start and mid-wafer of the lot; stop probing and call the attention of PC personnel (*MT to request to PC personnel to note at sort card the wafer ID of current wafer after online cleaning*)

Define

Measure

Analyze

Improve

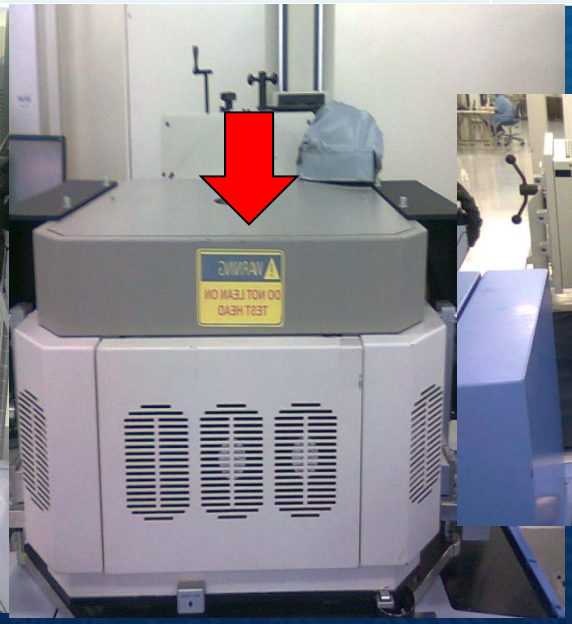
- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# CAPA for Validated KPIV # 14

(Leaning on test head and removal of cable on cable setup.)

| Process | Before | After |
|---|---|---|
| Probing | Procedure is not clear when reseating cable on a cable set-up. | Established procedure to perform needle alignment every reseating of cable.<br><br>Put a warning sign not to lead on test head on OH set-up. |


Define

Measure

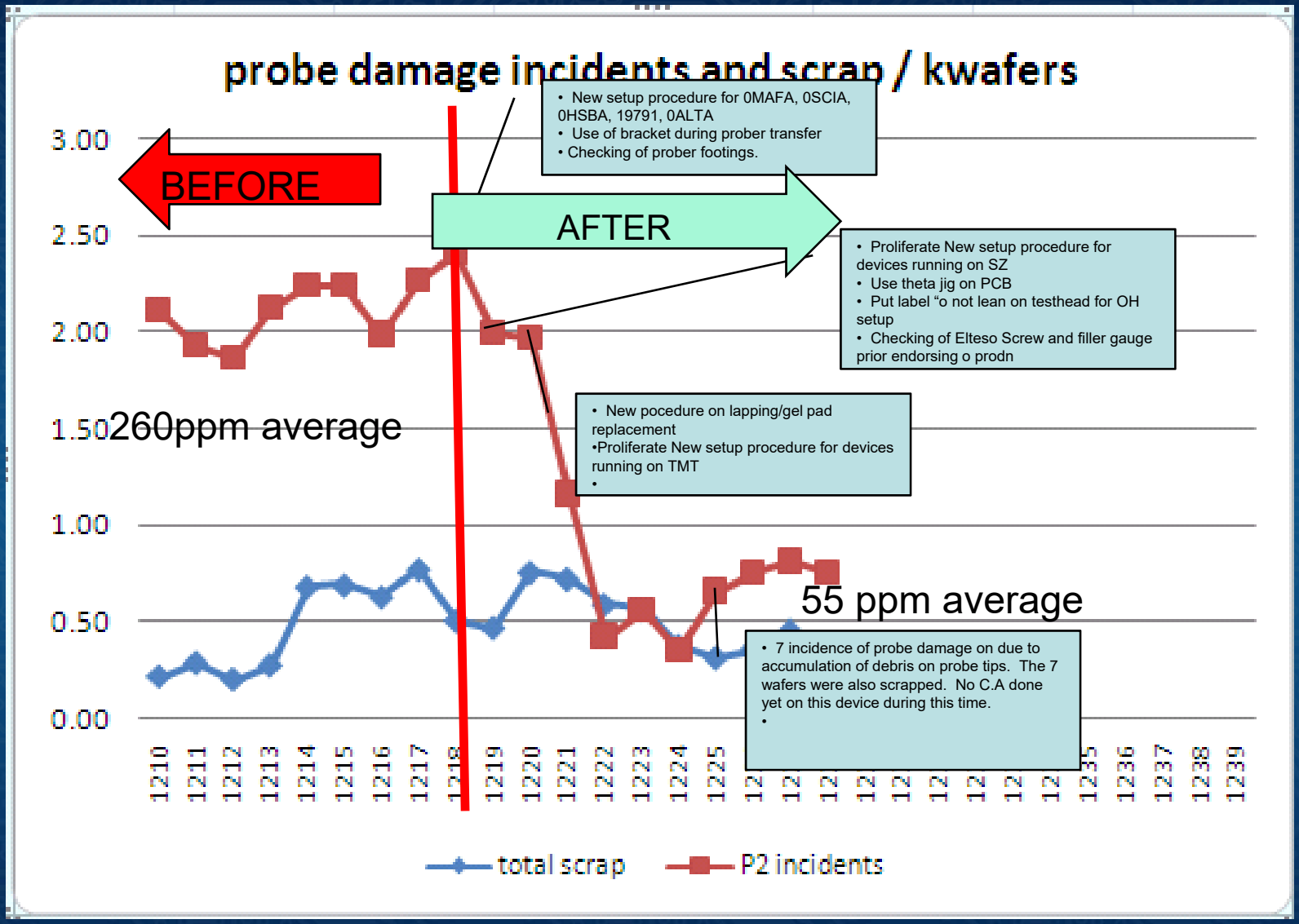
Analyze

Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# Before and After Implementation Comparison



Define

Measure

Analyze

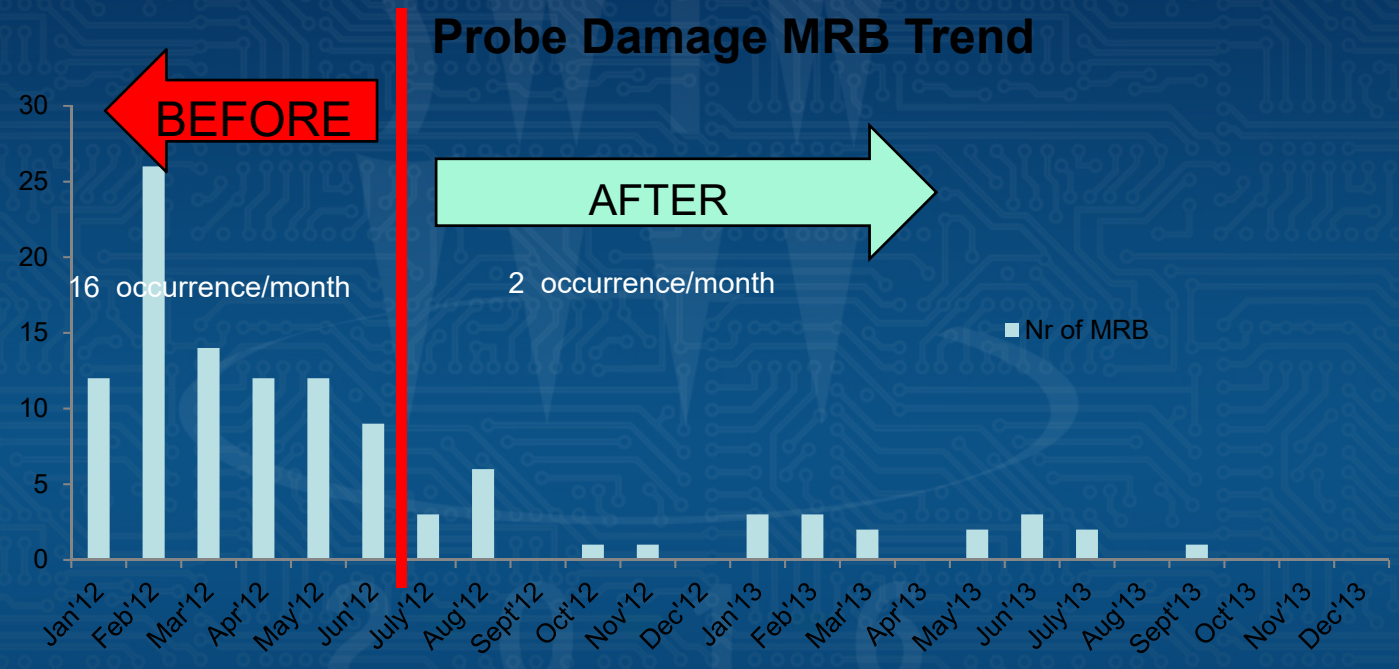
Improve

- Corrective / Preventive Action:
  - DOE, and/or
  - Poka-Yoke
- Implementation Result
- Improve Phase Summary

Control

# Before and After Implementation Comparison

## Secondary Metric




MRB occurrence due to probe damage was reduced from 16 occurrence per month to 2 occurrence per month

# SIX SIGMA

## The DMAIC Model


| Define Opportunity *(What is important?)* | Measure Performance *(How are we doing?)* | Analyze Opportunity *(What is wrong?)* | Improve Performance *(What needs to be done?)* | Control Performance *(How do we guarantee performance?)* |
|---|---|---|---|---|
| **Define** the goals of the improvement activity.<br><br>Select the appropriate responses (Y's) to be improved. | **Measure** the existing system.<br><br>Gather data to measure and verify the response variable --- the problem or improvement opportunity. | **Analyze** the system to identify the causes or gaps.<br><br>Find the relevant X's. | **Improve** the system.<br><br>Identify ways to eliminate the gap.<br><br>Reduce variability or eliminate the cause. | **Control** the new system.<br><br>With the desired improvements in place, monitor the process to sustain the improvements. |


- Standardization
  - 1.0 Operating Procedure Specification – OK
  - 2.0 Work Instruction – OK
  - 3.0 FMEA – OK
  - 4.0 Control Plan – OK

Define

Measure

Analyze

Improve

Control

- Standardization/ Documentation/ Fan-Out
- Project Transition Plan
- Financial Validation
- Control Phase Summary
- Key Learning

# Standardization Plan

| Item | Action Item | Due Date | Resp. | Remarks |
|---|---|---|---|---|
| 1 | Standardization of prober to tester interface enabled pause before unloading as per defined inspection scheme per tester. | Start: Ww20 | Glenn Placido | Done and Implemented |
| 2 | Standardization of actual wafer probe mark location by using probe mark template. | W20 | Jonah Capua | Done and Implemented. |
| 3 | Generation of efficient set-up procedure for an early detection of equipment/probe card problem prior full lot probing. | W18 | Glenn Placido | Done |

Define

Measure

Analyze

Improve

Control

- Standardization/ Documentation/ Fan-Out
- Project Transition Plan
- Financial Validation
- Control Phase Summary
- Key Learning

# Procedure / Work Instruction

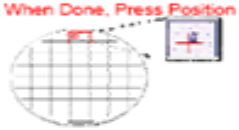
From: None

To:

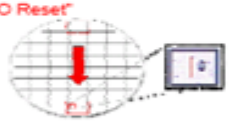
| ON Semiconductor<br>Probe Standard Operating Procedure | Document Number: 201005 | Revision: AG |
|---|---|---|
| | Page 27 of 71 | |

2.9.3.4 Use the upper left corner bonding pad of the die as reference
Note : For 0MAFA and 0ALCA use the smallest bond pad as reference
: For Multi sites use the bonding of 1 site

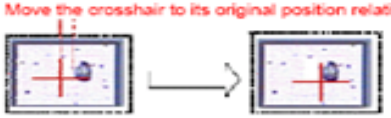
2.9.3.5 At the Top of the wafer, position the Crosshair on Probe mark of upper left corner BP. When Done, Press Position display.



2.9.3.6 Go to INDEX mode and Index down the wafer to the Last Die at the buttom. Press " ZERO Reset"



2.9.3.7 X and Y position values should indicate your Probe mark shifting.
2.9.3.8 If any one of these values exceeds 4um, endorse the setup to Probe tech.
2.9.3.9 Move the crosshair to its original position relative to the bonding pad.



2.9.3.10 If these values are okay, then repeat step (5-8) for Bond pad of Left die to Right direction

2.9.4 Offline Probe mark inspection using microscope with autoloader and image capturing system. Refer to Appendix 1 for Autoloader Operation Procedure.

2.9.5 Offline Probe mark inspection using microscope only without autoloader

2.9.5.1 Press the switch in front of the microscope base to turn on the lamp.

Define

Measure

Analyze

Improve

Control

- Standardization/ Documentation/ Fan-Out
- Project Transition Plan
- Financial Validation
- Control Phase Summary
- Key Learning

# Probe FMEA

**From:** None

**To:**

| Design / Process Function / Requirements | Potential Failure Mode | Potential Effect(s) of Failure | SEV | CLASS | Potential Cause(s)/ Mechanisms | Current Design/Process Prevention Controls | OCC | Current Design/Process Detection Controls | DET | RPN | Recommended Action(s) | Responsibility & Target Completion Date | Actions Taken & Effective Date | SEV | OCC | DET | RPN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | probe damage | Low yield/ wafer scrap. Reliability issue in electrical test (device degrading)/ EFAR | 7 | | Probe mark on the exclusion zone | Set edge exclusion zone on control map.<br>3mm for 5" wafer.<br>4mm for 6" or 8" wafer | 5 | Visual inspection | 7 | 245 | DMAIC | Glenn Placido | Q3'2012 | | | | |
| | | | 7 | | Probe card not soaked at set-up (if > 25'C) | Chuck revise is set on Prober Basic Operating Parameter<br>Needle soaking procedure for ELTESO (> 125C) | 2 | Visual inspection | 7 | 98 | Include soaking as part of KLA parameter | Glenn Placido | Q3'2012 | | | | |
| | | | 7 | | Probe card expansion issue due to unstandardize screws | Use of filler gauge to check distance on elteso P.C | 2 | Visual inspection | 7 | 98 | Use only POR screws on elteso PC | Enan Dela Cruz | Done | | | | |
| | | | 7 | | Incorrect cleaning parameter due to wrong BOP disk use | BOP Disk with proper label | 2 | Visual inspection | 7 | 98 | Include cleaning unit parameter on KLA as per device specific | Glenn Placido | Q4'2 | | | | |
| | | | 7 | | Leaning on test head during probing | None | 3 | Visual inspection | 8 | 168 | Put Warning sign "DO NOT LEAN ON TEST HEAD DURING PROBING". | Glenn Placido | done | | | | |
| | | | 7 | | Prober shifting due to prober transport from other tester | Equipment by-off | 3 | Visual inspection | 7 | 147 | Use of XY bracket | Rod Salmorin | Done | | | | |
| | | | | | | | | | | 147 | Checking of prober footing condition | Rod Salmorin | Done | | | | |

Define

Measure

Analyze

Improve

Control

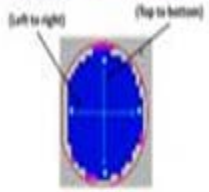
- Standardization/ Documentation/ Fan-Out
- Project Transition Plan
- Financial Validation
- Control Phase Summary
- Key Learning

# Training Plan

## THETA SHIFTING CHECKING PROCEDURE PRIOR PRODUCTION RUN:

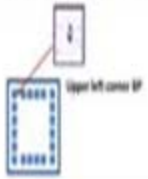
**Operator to perform theta shifting checking every setup, new lot and next lot.**

1. Perform Theta shifting check using fresh wafer before probe by inducing probe mark on 4 pts (top to bottom, left to right)




2. Measure the theta XY shift, acceptable measurement should be (**+/- 5um**).
3. Record the value on the Sort setup sheet and coordinates of the dice.
4. Use the upper left corner bonding pad of the die as reference

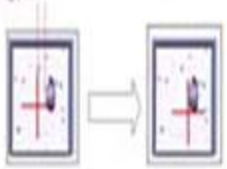
**Note: for DMAFA and DALCA use the smallest bond pad as reference and For Multi sites use the bonding pad of 1 site**




5. At the Top of the wafer, position the Crosshair on Probe mark of upper left corner BP. When Done, Press Position display

6. Go to INDEX mode and index down the wafer to the Last Die at the bottom. Press " ZERO Reset"

7. Move the crosshair to its original position relative to the bonding pad



8. X and Y position values on Prober screen should indicate your theta shifting. If any one of these values exceeds **5um**, endorse the setup to Probe tech.
9. If these values are okay, then repeat step (5-8) for Bond pad of Left die to Right direction

## NEW INLINE INSPECTION METHODOLOGY:

**Inspection should be done after wafer probing, except for First wafer.**

1. First wafer is considered setup wafer thus probe mark should be induced
2. Perform inspection after every 6th wafer, last wafer, start of the shift and any intervention

**Note: KLA pause before unloading is enable**

3. For every 6th wafer and last wafer, inspect 5 dice cross pattern (top, mid bottom, left and right) using Probe mark template
4. During inspection. Inspect also the bond pad periphery at high mag


5. For every start of the shift, inspect 1 last die sorted. Take note of the coordinates and wafer number.
6. For any intervention inspect the 1st die sorted using the probe mark template. After equipment endorsement, inspect after 10th die sorted. Take note only of the 1st die sorted coordinate and the wafer number.

**Note: Interventions are:**

- Change of peripherals (Probe card, Loadboard, cables)
- Change of overdrive
- Equipment repair (intervention by support group)
- Clearing of reference model if encountered "Model not found error"

## SCRIBE FORMAT

**VALID SCRIBE FORMAT:**

**Where:** A = alpha characters
N = numeric characters
CS = string checksum

| | |
|---|---|
| **FAB2:** | **AANNNNN-NN-CS or A'NNNNN-NN-CS** |
| **FAB10:** | **ANNNNN-NN-CS** |
| **Gresham:** | **NNNAANNNAACS** |
| **TSMC:** | **ANANNN-NNCS or AN'NNN-NNCS** |
| **Magnachip:** | **AAANNNN-NNCS** |

**Note on CS:**

- CS represents 2 characters. 1st is an alpha character (from A-H) and the 2nd is a numeric character (from 0-7)
- It is important to enter the last 2 characters as "**CS**", these are the checksum value of the string which is being computed by the OCR software

**Please DO NOT edit CONFIG 0 to 5, these are allotted for the following FABs**

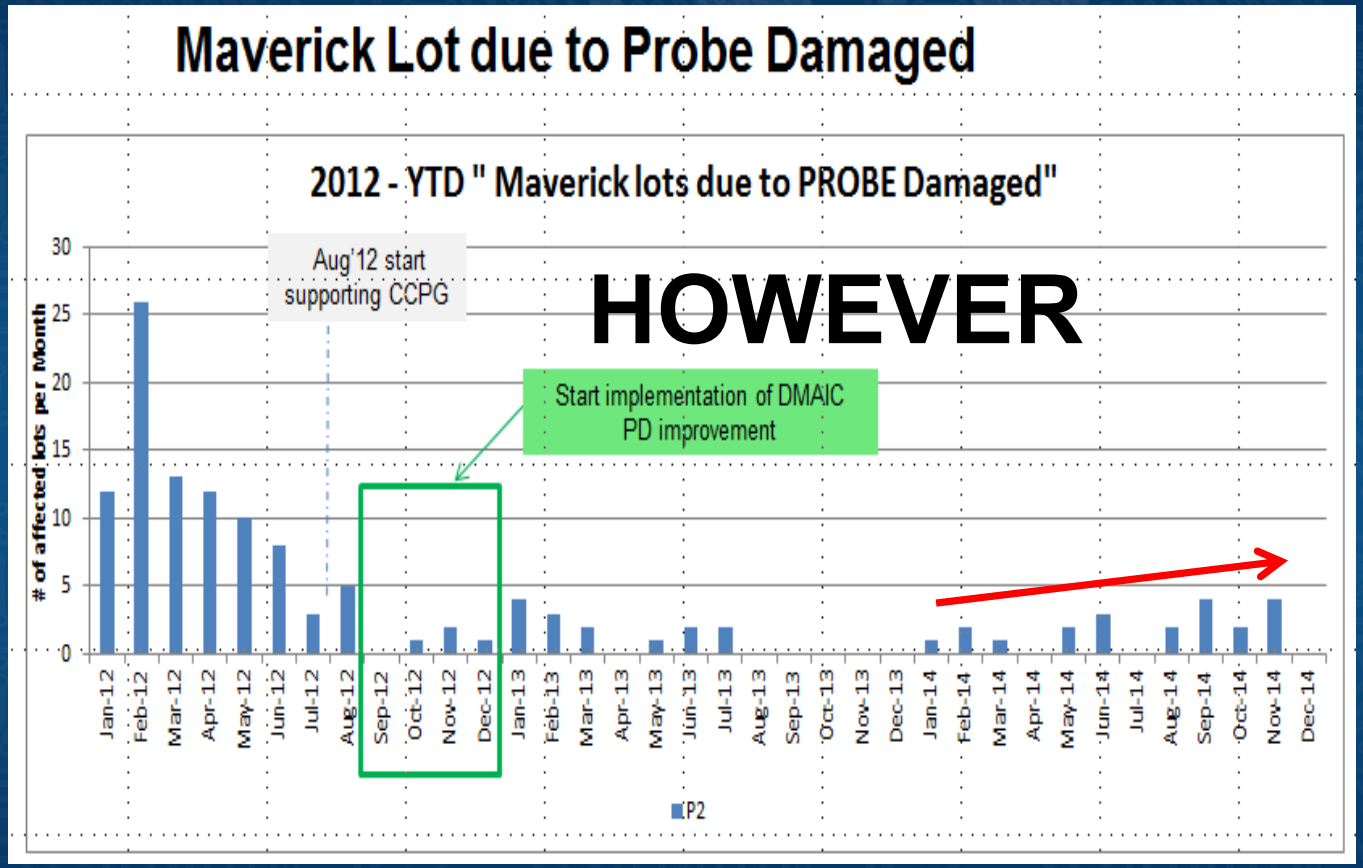
| | | |
|---|---|---|
| **Config 0 and 1 -** | **Fab2** | **6"** |
| **Config 2 and 3 -** | **Fab10** | **8"** |
| **Config 4 and 5 -** | **Grshm** | **8"** |

Use config 6 and above for the ff conditions

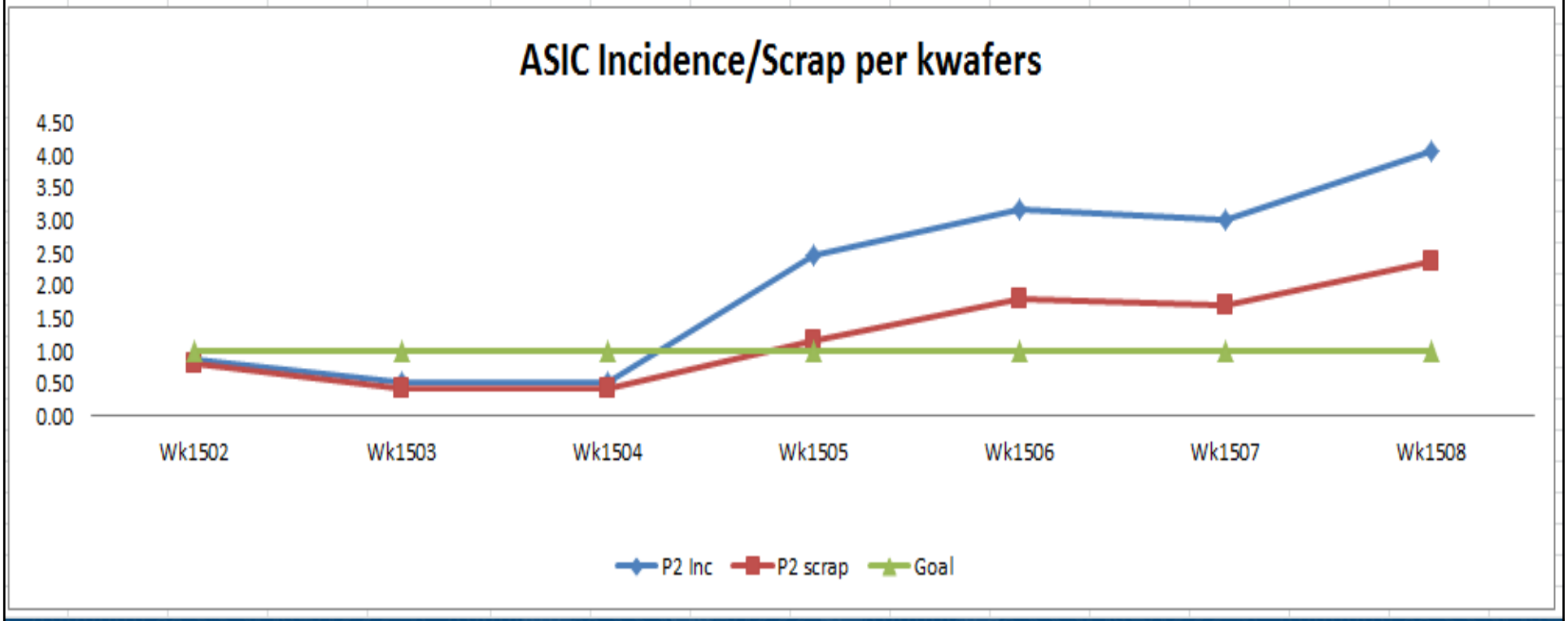
- If there's a need to reconfigure the above settings
- Needed for another external FAB devices

Pls refer to 211021 for OCR updating Procedure

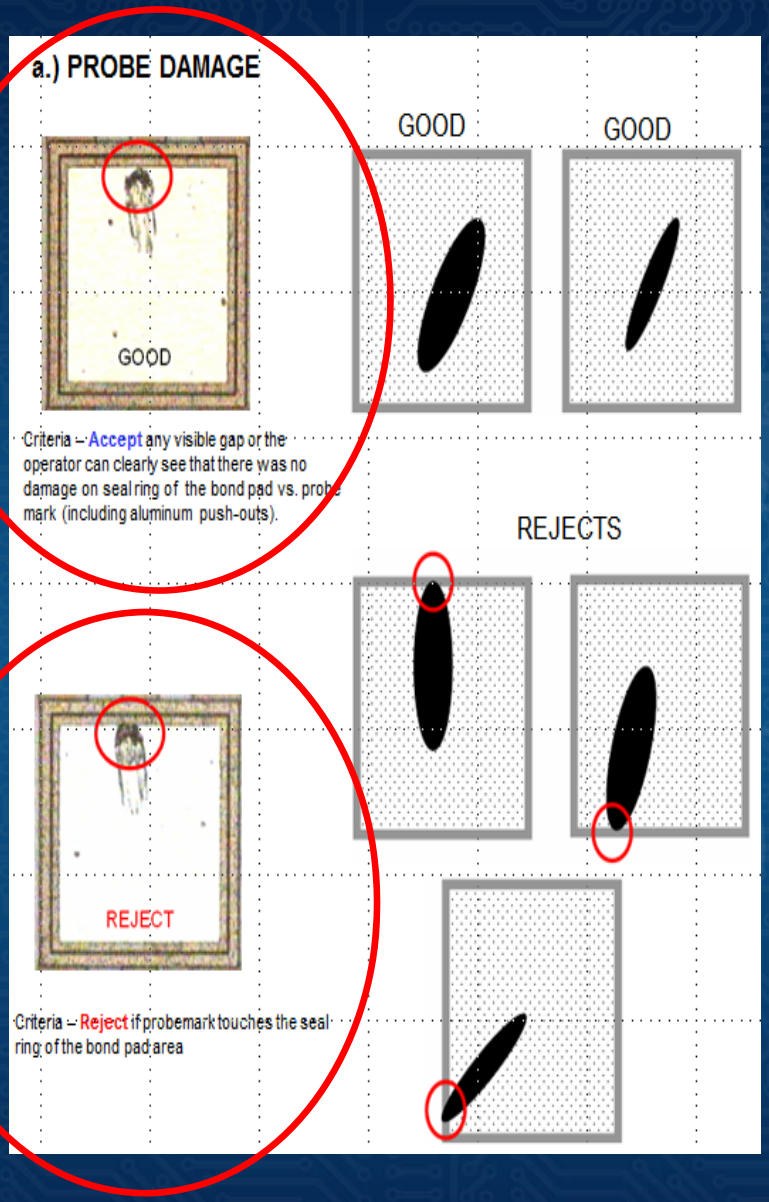
- End of 2014 shows increase in MRB occurrence



- Start of 2015 shows increase in probe damage scraps and incidence



- Probe damage are defects induce during probing.



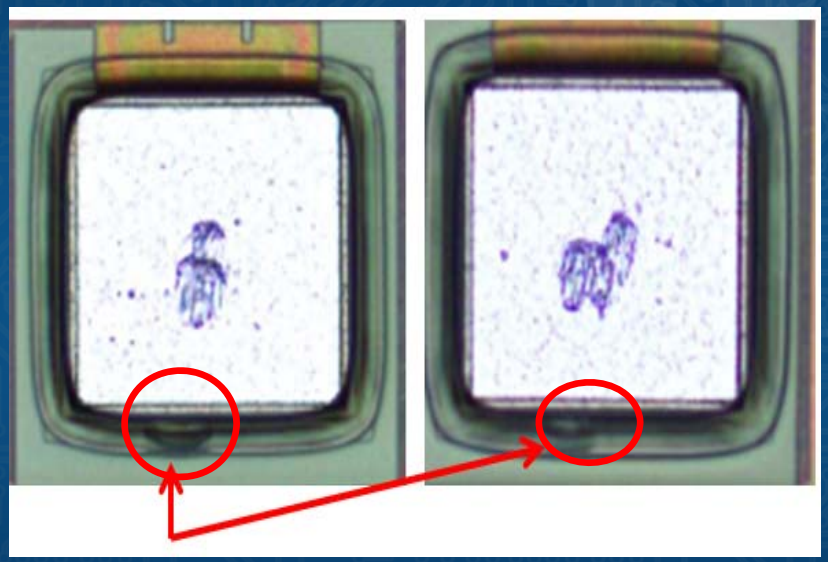

Example of a good probe mark

- Probe mark is center
- Not touching the sealant

Common Probe damage defect during 6 sigma

# What If??

- Probe marks are centered but there are disturbance on the seal ring?



New defect signature not included during PD six sigma project

# EDX Analysis showed probe damage reaching the die specifically the bond ring.

## Analysis: FA report of worst pad with damage

0WICA-002-DWR NE39112.1 SEM and EDX Results

**Summary Narrative:** One die (SN2 13,1) with noted probe damaged on the bond pads was submitted for analysis, to determine if the probe damage reaches the die. Optical inspection after polyimide removal showed probe damage reaching the die specifically the bond pad ring.

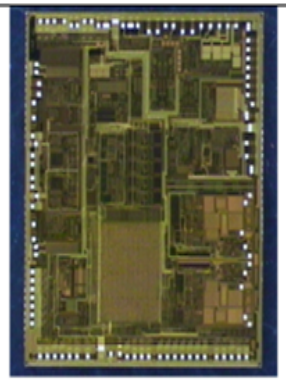


**Figure 1**. Sample 1.

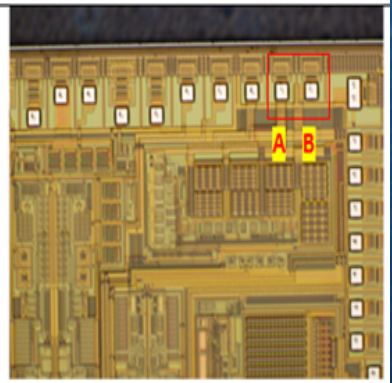



**Figure 2:** Location of the affected pads.

## Analysis: FA report

0WICA-002-DWR NE39112.1 SEM and EDX Results

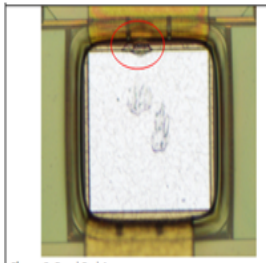


**Figure 3:** Bond Pad A

**Figure 4:** Bond Pad A

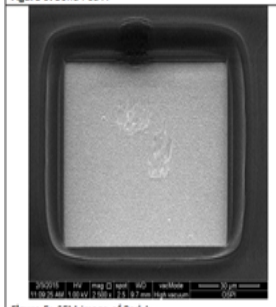


**Figure 5:** SEM image of Pad A

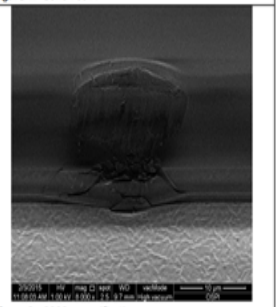
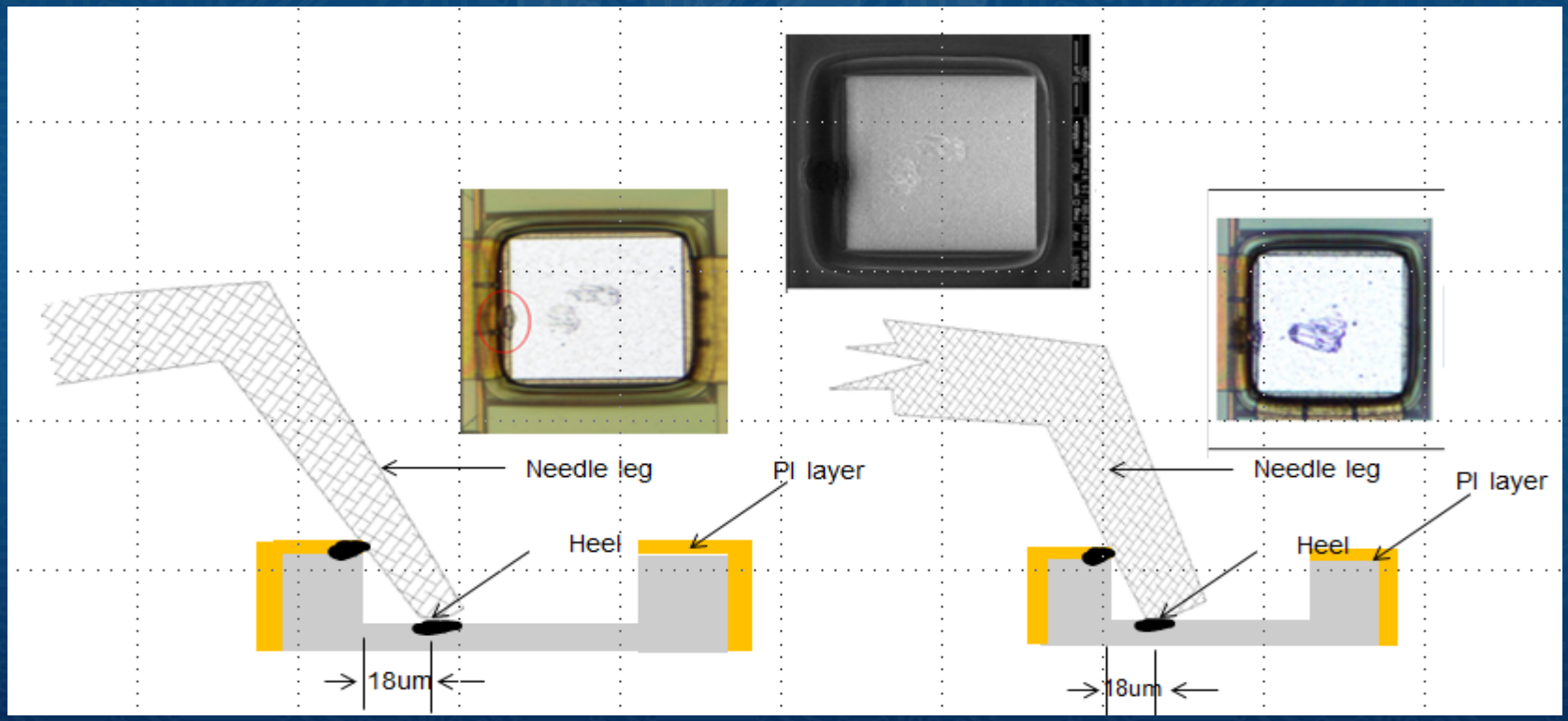


**Figure 6:** 8000x magnification

# Our Findings?

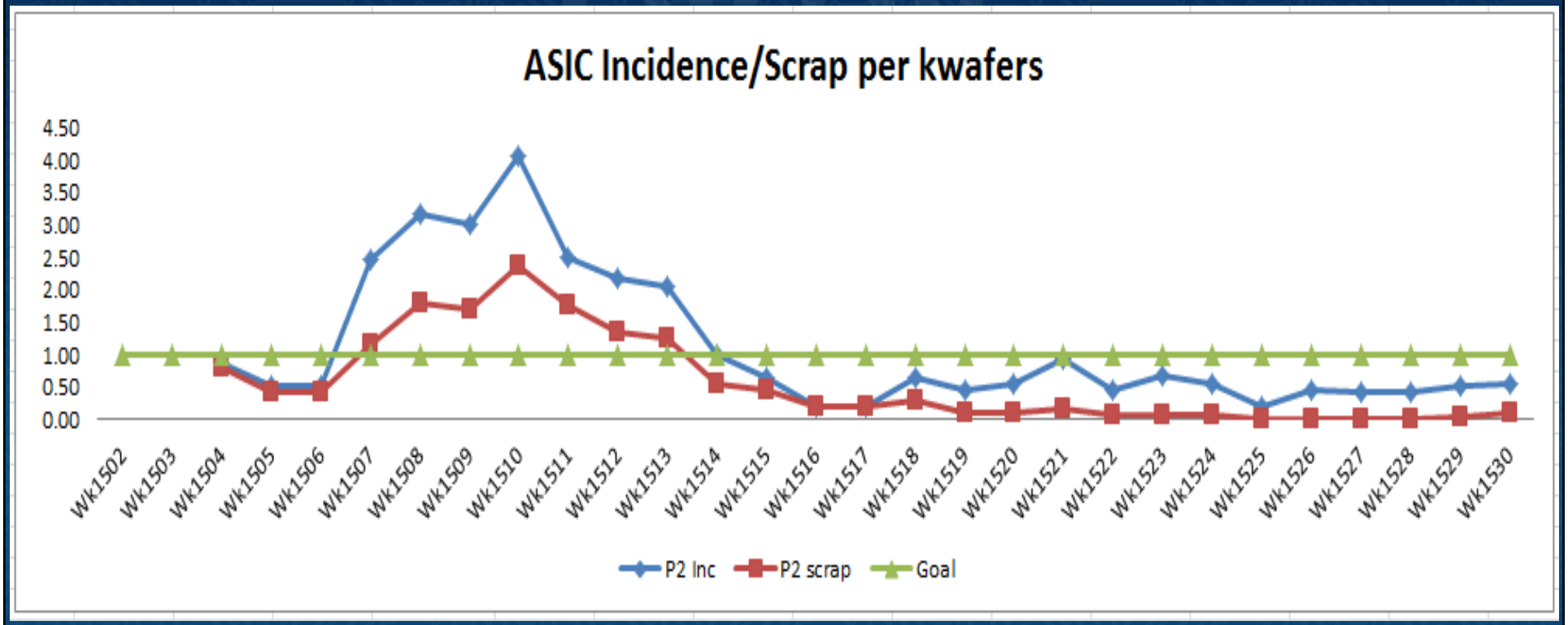
- During probing, the leg of the needle touches and damages the highest part of the bond pad which is the sealant with polyimide layer. The needle impression came from the heel of the needle and not the full diameter of the needle.
- This explains the gap between the probe marks and the damage sealant.
- This is most rampant on the 3x3mils bond pad due to the limitation on the bond pad area.



Quick Wins:

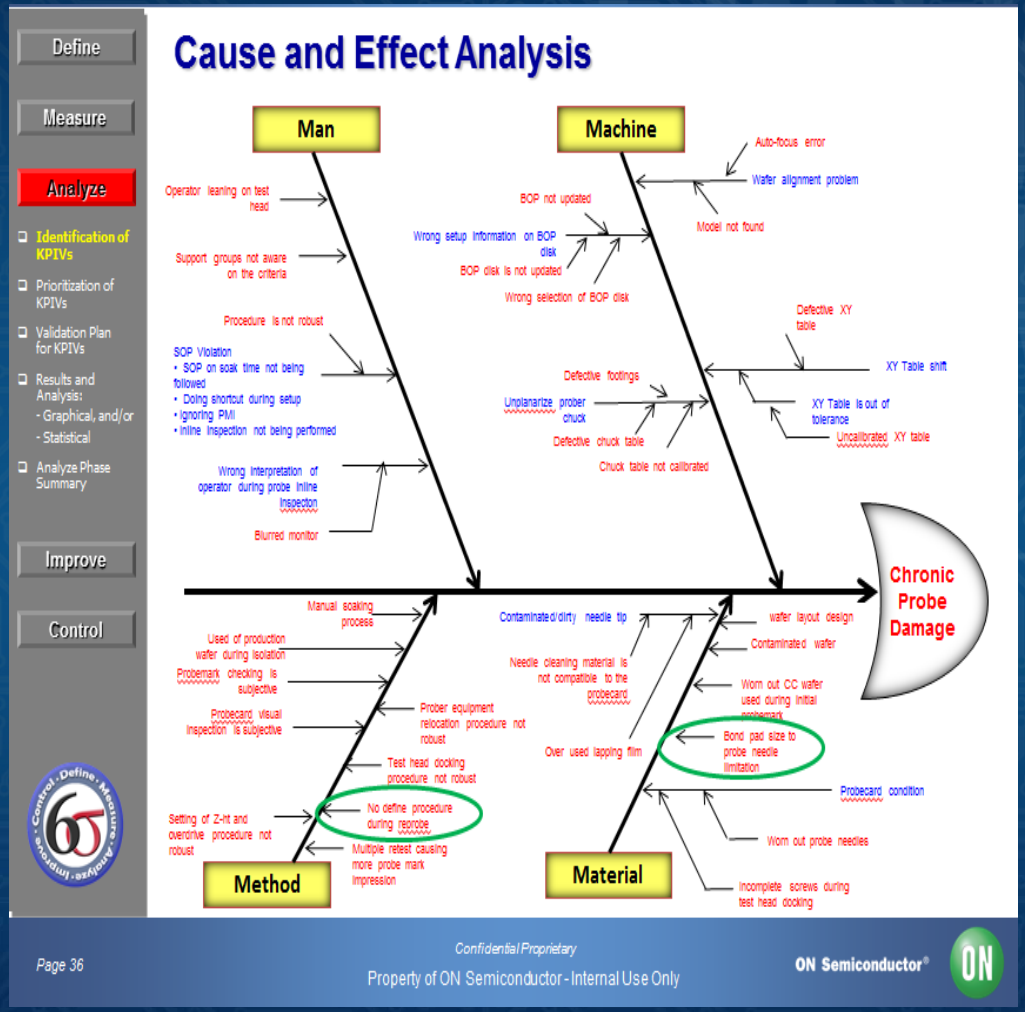
- Perform tighter PCB scrub analysis on PRVx
- Tighten probe needle diameter requirement to 0.8mil to 1mil vs 0.8mil to 1.2mils.
- Convert probe needle type from Cantilever to Vertical.

# Result:


ASIC Incidence/Scrap per kwafers
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Wk1502
Wk1503
Wk1504
Wk1505
Wk1506
Wk1507
Wk1508
Wk1509
Wk1510
Wk1511
Wk1512
Wk1513
Wk1514
Wk1515
Wk1516
Wk1517
Wk1518
Wk1519
Wk1520
Wk1521
Wk1522
Wk1523
Wk1524
Wk1525
Wk1526
Wk1527
Wk1528
Wk1529
Wk1530
P2 Inc
P2 scrap
Goal

# What Went Wrong?

- 2 KPIVs under FMEA was deprioritized and missed out.




1. No define procedure during reprobe.
2. Bond pad size to probe needle limitation

# Key Learning

1. Strong sponsorship by the top management
2. Strong team leadership and teamwork
3. Correct ownership of the problem
4. Use of correct performance metric measurements
5. Thoroughness in process risk analysis
6. Correct use of the appropriate statistical and problem-solving tools
7. Emphasis on poka-yoke solutions
8. Proper documentation
9. Proper fan-out
10. Follow through of improvement actions through process audit
11. Continuous monitoring of a DMAIC project.
    - New learnings and findings along the way
12. Revisit low KPIVs.
    - This might harm you in the future.

# End

# Thank You!