OPTIMIZATION OF PROBE CAPABILITY USING MACHINE/PROCESS CAPABILITY STUDY

AND

HOOKE'S LAW EXISTENCE ON BLADE TYPE NEEDLE AT PROBE PROCESS

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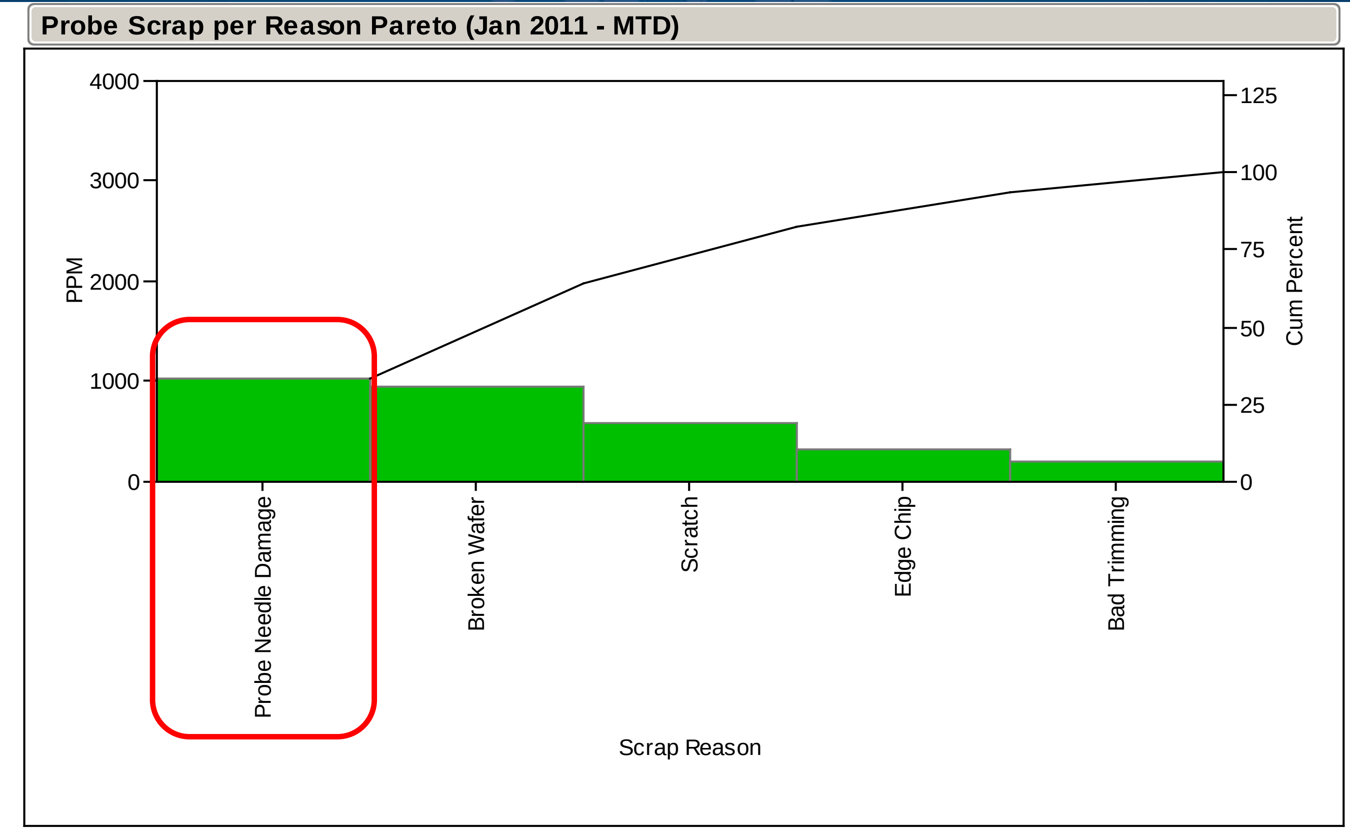
OPTIMIZATION OF PROBE CAPABILITY USING MACHINE/PROCESS CAPABILITY STUDY

- Introduction / Background
- Objectives / Goals
- Methods / Materials / Procedures
- Results / Relevant Findings / Key Data
- Discussion of Results / Strengths / Weaknesses, etc.
- Summary / Conclusion
- Follow-On Work

Introduction

At 1000 ppm, Probe Damage related to Probe Needle is on top of Pareto in terms of wafer scrappage reason.



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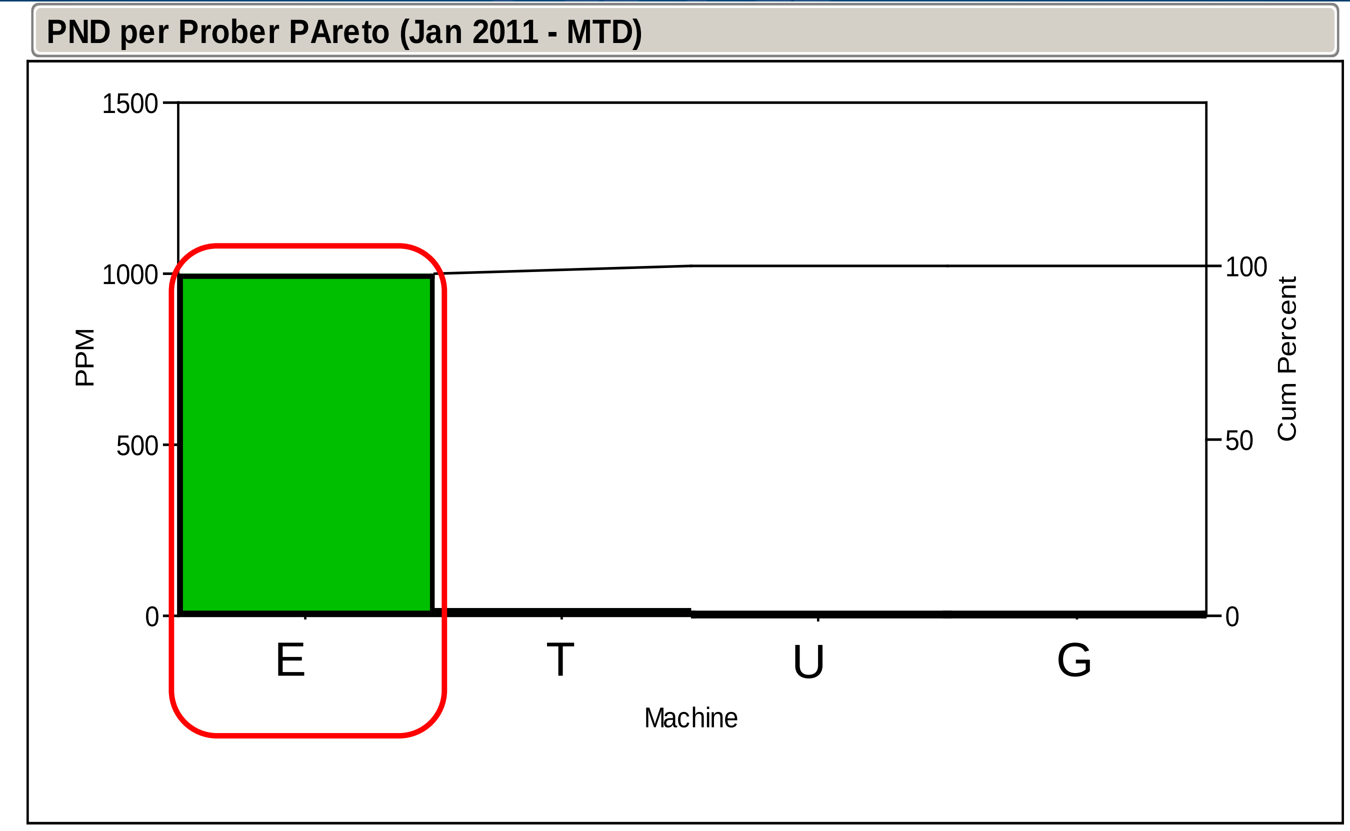

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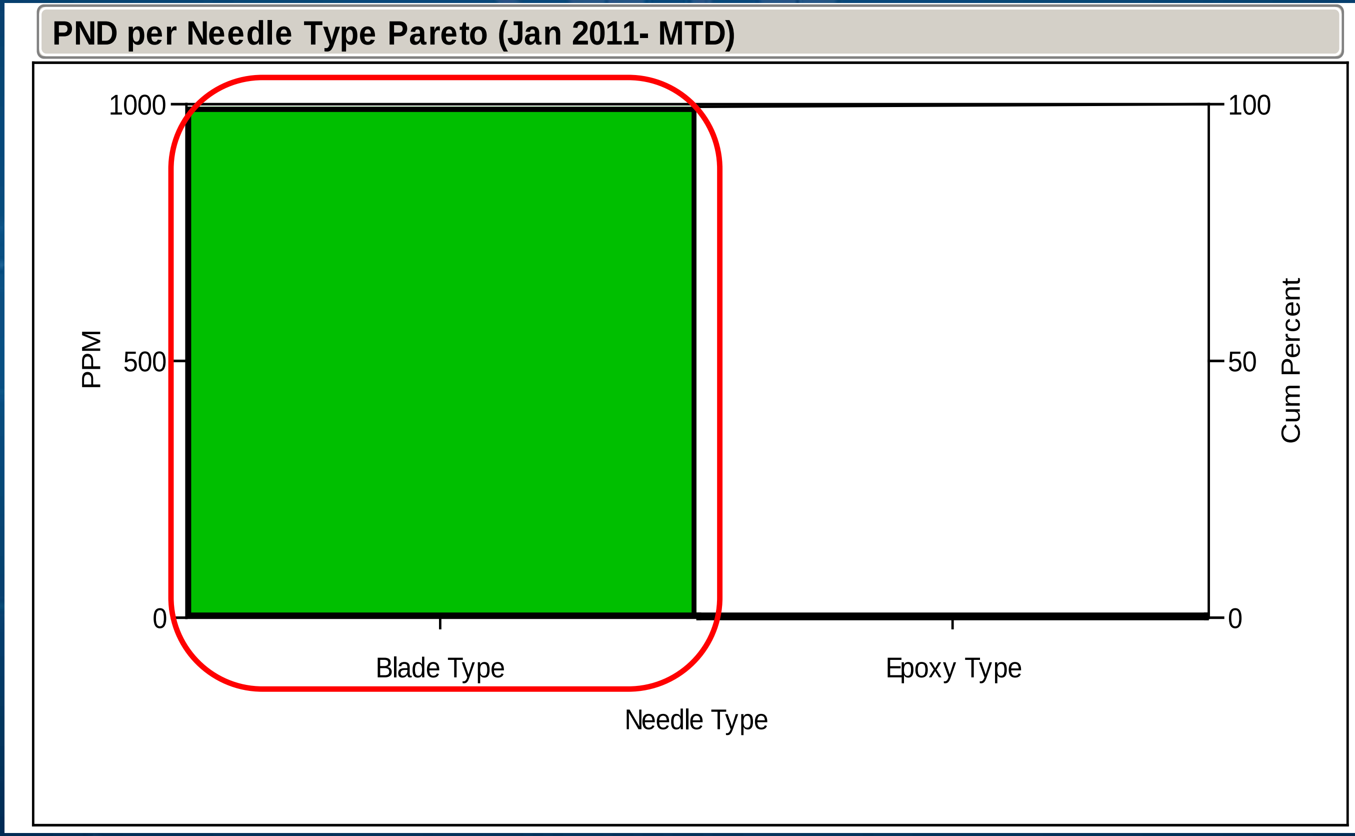
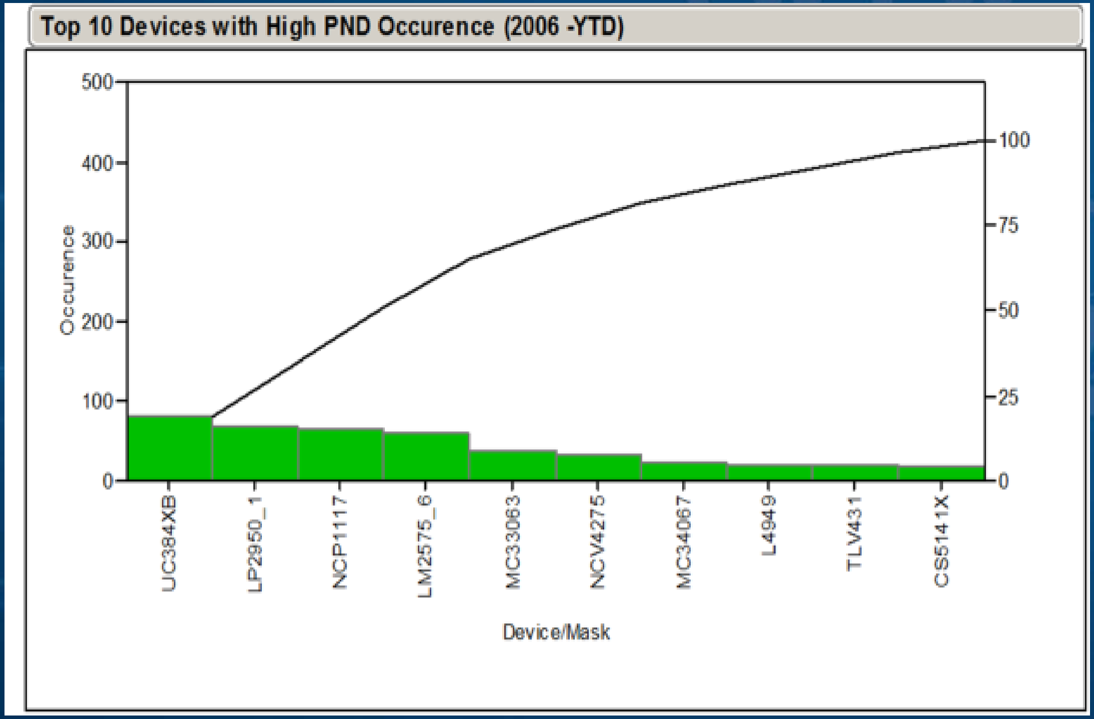


Introduction

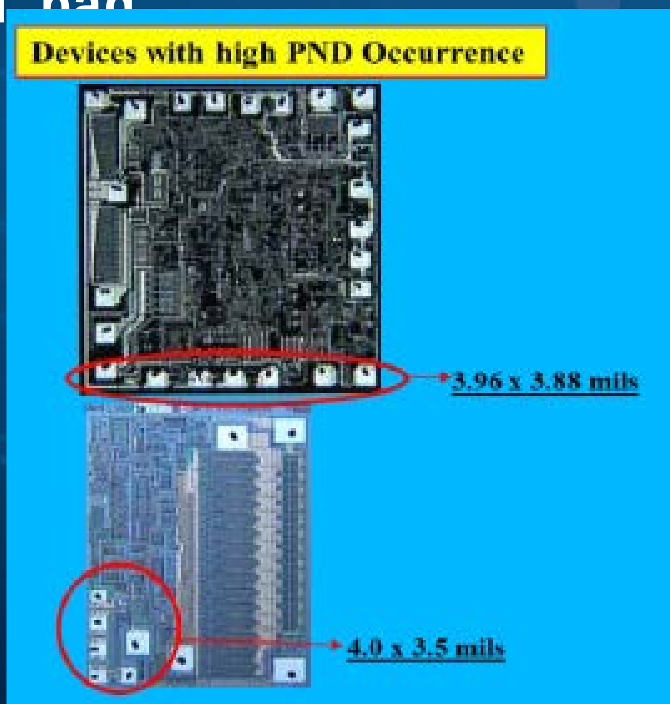
Further data stratification shown Top Devices with high Probe Damage Occurrence

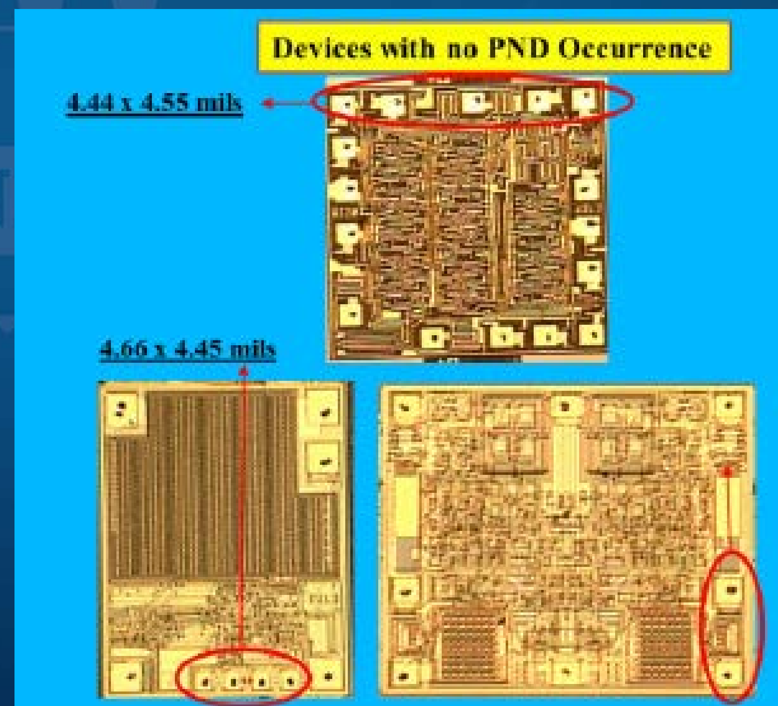


Mask Name	Total Occurrence	Small Pad Size	Big Pad Size
UC384XB	81	3.6 x 4.1 mils	4.2 x 4.2 mils
LP2950_1	69	3.5 x 4.0 mils	4.2 x 4.1 mils
NCP1117	66	4.1 x 3.4 mils	7.7 x 6.3 mils
LM2575_6	61	3.3 x 3.2 mils	7.6 x 7.3 mils
MC33063	39	3.4 x 4.0 mils	4.2 x 4.2 mils
NCP5331	36	3.4 x 3.4 mils	4.0 x 3.8 mils
NCV4275	32	3.7 x 3.6 mils	6.0 x 5.8 mils
NCP5422	24	3.6 x 3.5 mils	4.0 x 4.0 mils
MC34067	23	3.5 x 4.0 mils	4.3 x 4.1 mils
L4949	21	3.3 x 3.2 mils	4.8 x 4.4 mils
TLV431	19	3.1 x 3.1 mils	
CS5141X	17	4.3 x 4.1 mils	

Introduction

Devices with high PND occurrence have an average bond pad size less than 4 x 4 mils compared with devices with no PND occurrence. Initial assumption on high PND occurrence is due to Prober X when using blade type needle is not capable of probing devices with a minimum bond pad

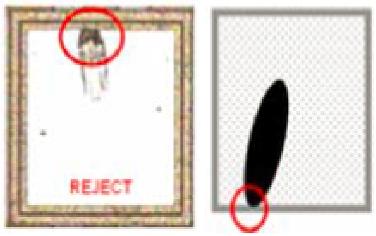
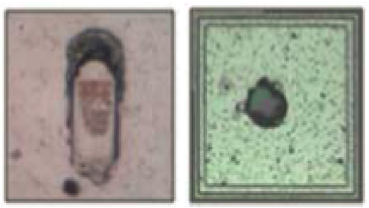




Introduction

What is Probe Damage ?

- Is a phenomena when a part of a die specifically at the Pad Area such as Seal Ring or other metallization has been damage by the Probe Needle during Testing.
- Probe damage is the number one visual defect contributor at wafer sort process having a direct impact on yield and cycle time.

No	Defect visual aid	Remarks
1		Probe marks touching the seal ring of the bond pad
2		Expose oxide on the bonding pad

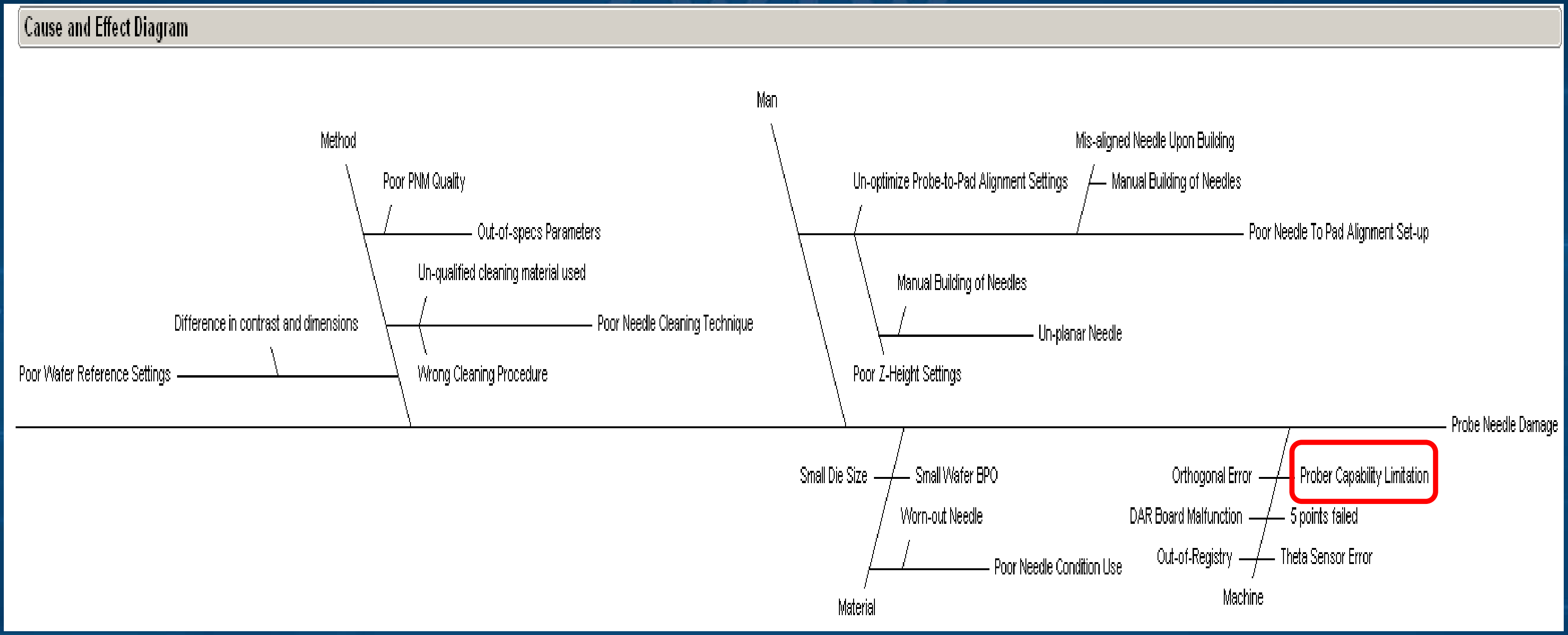
Introduction

What are the causes Probe Damage ?

- **OSPI Engineering Team Brainstorm using Ishikawa Diagram for the Possible Sources of Probe Damage. Specific Factors are came from Man, Machine, Method and Material.**

Introduction

What are the causes Probe Damage ?



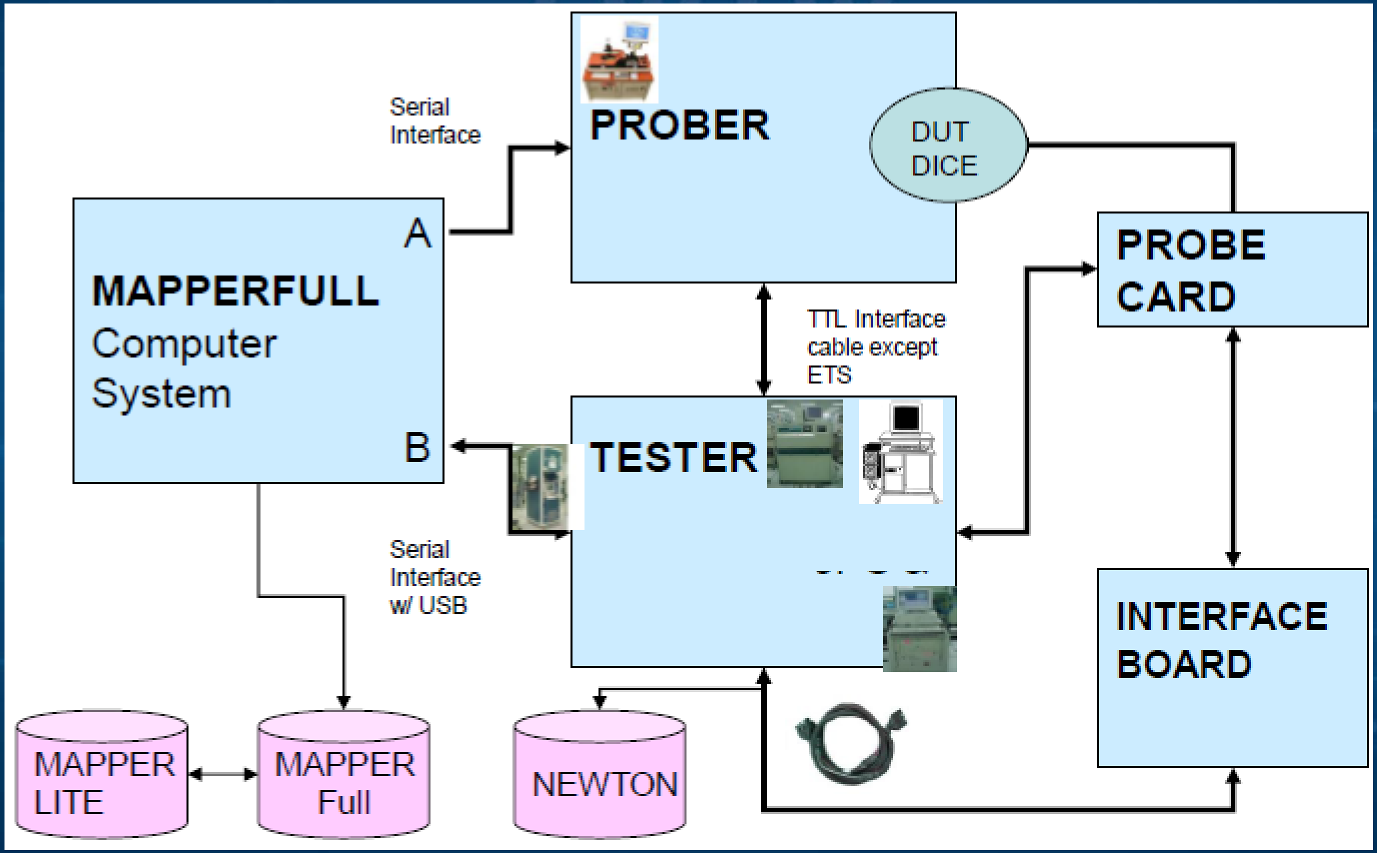
- Probe Capability limitation in terms of minimum bond pad opening has been identified as one of the many causes of Probe Damage on wafers.
- Smaller pad is high risk to Probe Damage.

Objective/Goals

- To determine the current capability of Prober E using Blade Type needle in terms of minimum bond pad capability and how it impact the probe quality.
- To optimize the current capability using the cheapest way.
- The Machine/Process Capability Study only focus on Prober E.

Methods/Materials/Procedure

- Materials involve on the Study

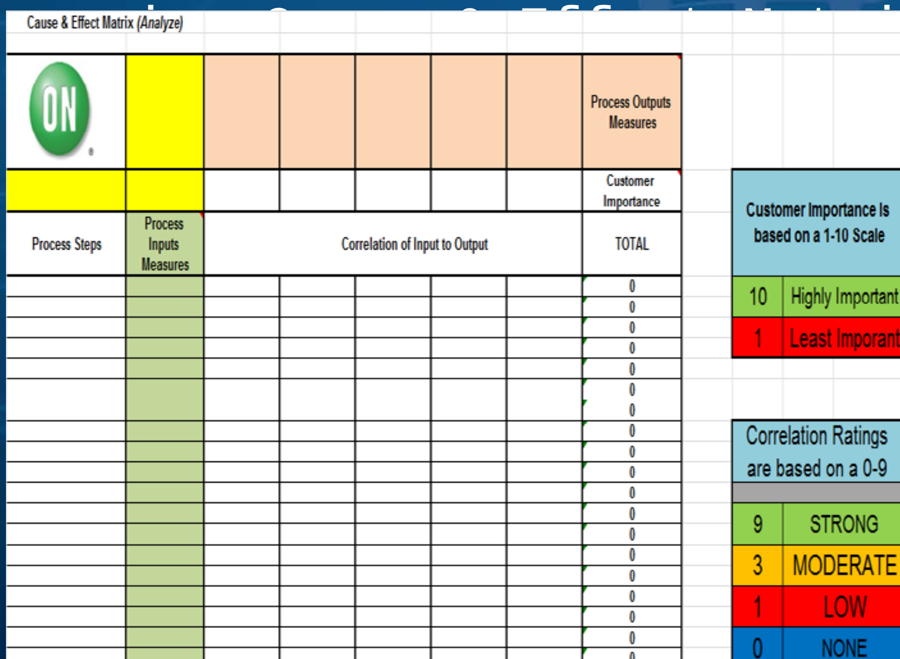


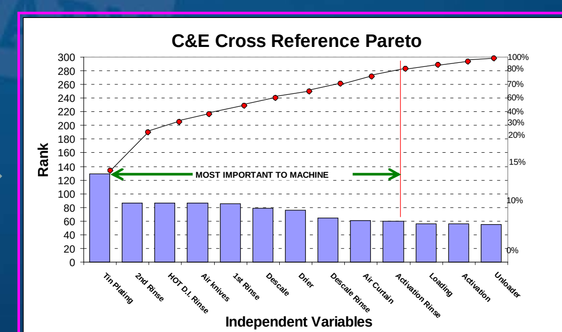
Methods/Materials/Procedure

- **Experiment Condition**
  1. Experiment has been run as normal Probe Process without engineering intervention.
  2. All Probe parameters remains constant throughout the experiment.
  3. Prober that was used during the experiment is A1 condition
  4. Probe-card needles are newly build.
  5. The experiment only cover 3 wafers for the data gathering that involve sampling and randomization.

Methods/Materials/Procedure

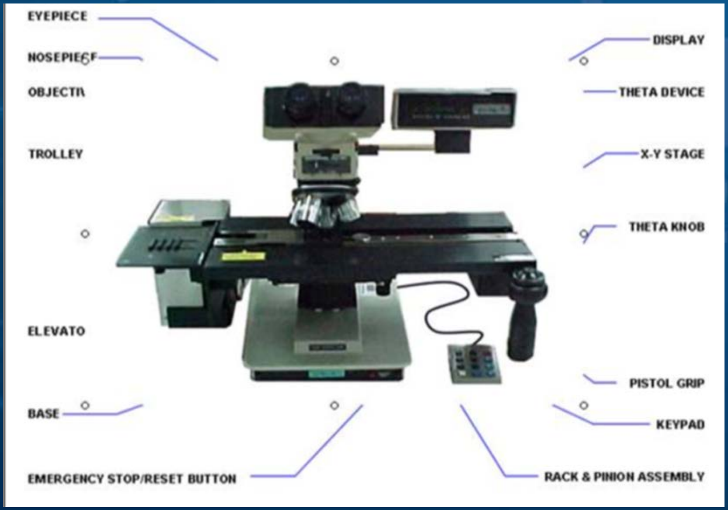
- **Phase 1 Deliverables**
  - MPCPs Phase 1 is Process Characterization wherein all functional characteristics of the machine including sub-process, response and input variables have been determined and summarized x and Pareto Diagram





Methods/Materials/Procedure

- **Phase 2 Deliverables**
  - MPCPs Phase 2 is Metrology Characterization wherein all measurement/gauge use for KPOV of the process has been subjected in MSA Study. This is to verify the soundness of current process measuring equipment



Number of Appraisers = 3 | Gage: Metrology Characterization | Date: 16-Sep-11 | Enter Gage Name, Part Name, Date, and Your Name
Number of Parts = 5 | Part: Nikon HPM | Performed By: Carl Olalia | The numbers fields will fill in automatically
Number of Trials = 3 | Tolerance = | Leave blank for one-sided spec. | Enter Tolerance Width (Upper - Lower)

Enter data and Information in open cells . Leave cell blank if data is missing.
*If Range Check displays "FLAG", check data for errors or rerun trial(s)

Appraisers			1	2	3	4	5	6	7	8	9	10
Krista		1	1.417	0.512	1.358	3.76	3.661					
Almenanza	Trials	2	1.437	0.551	1.358	3.74	3.661					
2.1407333		3	1.398	0.557	1.339	3.76	3.602					
	Range Check*		0.039	0.045	0.019	0.02	0.059					
	$(\Sigma Apart)^2$		18.08	2.6244	16.443	126.79	119.33					
Dec		1	1.398	0.512	1.256	3.74	3.583					
Mendiola	Trials	2	1.398	0.512	1.258	3.74	3.553					
2.0968667		3	1.398	0.512	1.261	3.731	3.601					
	Range Check*		0	0	0.005	0.009	0.048					
	$(\Sigma Bpart)^2$		17.59	2.3593	14.251	125.69	115.28					
Jobert		1	1.398	0.512	1.334	3.74	3.622					
Awa	Trials	2	1.398	0.512	1.358	3.75	3.602					
2.1229333		3	1.398	0.531	1.367	3.72	3.602					
	Range Check*		0	0.019	0.033	0.03	0.02					
	$(\Sigma Cpart)^2$		17.59	2.418	16.475	125.66	117.2					
Part Averages			1.4044	0.5234	1.321	3.7423	3.6097					

You can enter less than 10 parts
Enter data on this line first
Leave rightmost part numbers empty if appropriate
Leave Trial 3 rows empty if only 2 trials are run

ANOVA	DF	SS	MS	F	Prob>F
Appraisers	2	0.01	0.01		
Parts	4	76.95	19.24		
Appraiser*Parts	8	0.01	0.00	5.68	0.000197889
Gage(Error)	30	0.01	0.00	Appraiser*Part Interaction IS Significant	
Total	44	76.99			

If Prob>F is 0.05 or smaller, then Appraisers*Parts interaction is significant; check plots to determine why
A significant Appraisers*Parts interaction means that apprais- tend to obtain different measurements from identical parts

Enter Process Distribution Width in Sigma's (Typically 5.15 or 6.00) = 5.15 | ndc: 64

SOURCE OF VARIATION	SIGMA	VARIATION	TOTAL	TOLERANCE
Repeatability (EV - Equipment Var)	0.02	0.08	1.09%	
Reproducibility (AV - Appraiser Var)	0.02	0.10	1.35%	
Appraiser * Equipment Interaction (IV)	0.02	0.10	1.36%	#DIV/0!
Repeatability & Reproducibility (R&R)	0.03	0.17	2.20%	
Part Variation (PV)	1.46	7.53	99.98%	
Total Process Variation (TV)	1.46	7.53		

The AIAG method uses 5.15, other customers may use 6.00
5.15 standard deviations enclose the central 99% of a normal distribution
If %R&R of Tolerance is blank, enter a Tolerance above

Methods/Materials/Procedure

- **Phase 3 Deliverables**
  - MPCPs Phase 3 is Capability Determination wherein all KPOV has been subjected for Capability Analysis using below data collection plan.

1. Measure the X & Y value as shown in Figure 1. Perform measurements on dice illustrated in Figure 2.

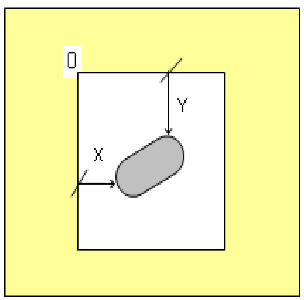


Fig 1

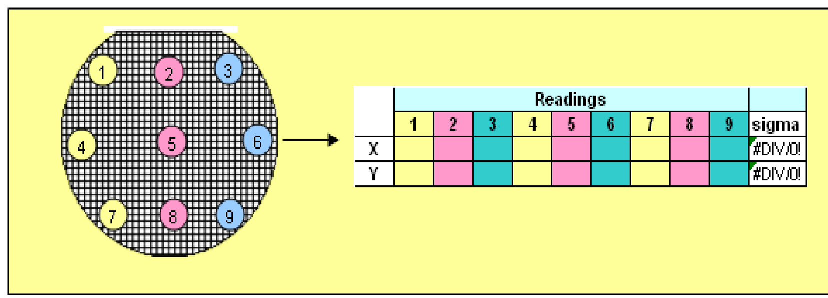


Fig 2

2. Repeat # 1 until 30 data sets is achieved.
3. Compute for the Variation σ Scrub Mark Placement of each data set, then compute for the average of the entire data sets.

Methods/Materials/Procedure

- **Phase 4 Deliverables (If Applicable)**
  - MPCPs Phase 4 is Optimization Stage wherein all applicable KPIV of the process has been subjected in DOE. This is to determine the optimum process parameters.

- **Phase 5 Deliverables**
  - MPCPs Phase 5 is Control Stage where all Standardization, Fan-out, Documentation and CI executed.

Result/Relevant Findings/Key Data

- **Phase 1 Result**
  - Critical Responses (KPOV) and Critical Input (KPIV) has been determined during MPCPs Phase1. Result has been derived from consolidate and summarized C&E Matrix.

Response (Dependent) Variables	Type of Data	Property of Data	Measurement Scale
Wafer Breakage	Attribute	Discrete	Nominal
Probe Needle Damage/Exposed Oxide	Attribute	Discrete	Nominal
Die Surface Damage/Scratches	Attribute	Discrete	Nominal
Wafer Crack	Attribute	Discrete	Nominal
Wafer Chippings	Attribute	Discrete	Nominal
Offset/Shifted Ink Dots	Attribute	Discrete	Nominal

=

Machine Name: Electroglas 2001X	
Category	**Sub-Process Characteristics**
Man	Operator Skills
Method	Cantilever Probing
	Vertical Probing
	Inking
Material	Wafer Size
	Wafer Thickness
	Die Size
	Bond pad size
	Blade Type Needle
	Epoxy Type Needle
	25 mils Xandex Ink
Measurement	2 mils overtravel
	3 mils overtravel
	4 mils overtravel
	5 mils overtravel
	100ms Inker Speed
	60ms Inker Pulse
Environment Facilities	25 deg Room Temp
	60% RH Level
	10K Class Particle Count

y = Function (x)

Result/Relevant Findings/Key Data

- **Phase 2 Result**
  - Total GR&R is 2.2 %.

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Result/Relevant Findings/Key Data

- **Phase 2 Result**
  - GR&R on the affected Measurement tool has been conducted.

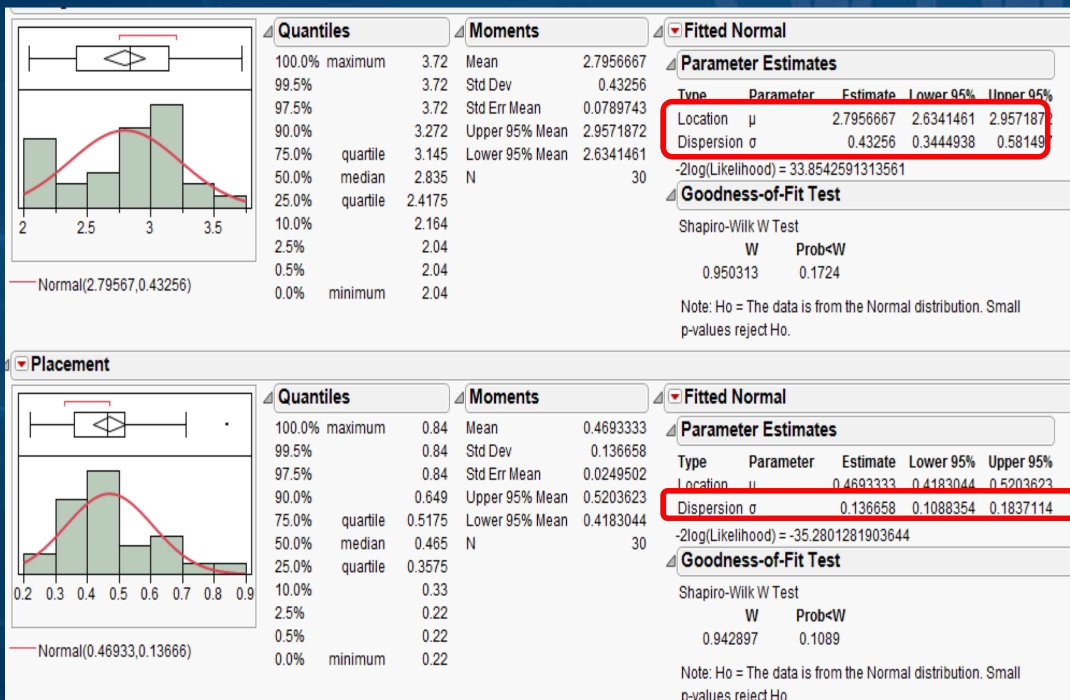
Probe marks sample produce using 3 mils Over travel

Probe marks sample produce using 4 mils Over travel

Probe marks sample produce using 5 mils Over travel

Result/Relevant Findings/Key Data

- **Phase 3 Result (Blade)**



Formula for Capability:

Cp = μ + 3δ ; where δ = √(δ₁² + δ₂²)

Given Values:

μ = 2.80 mils
δ_1 = 0.43 mils
δ_2 = 0.14 mils

Computation for δ:

$\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$
$\delta = \sqrt{0.43 \text{ mils}^2 + 0.14 \text{ mils}^2}$
$\delta = 0.45$ mils

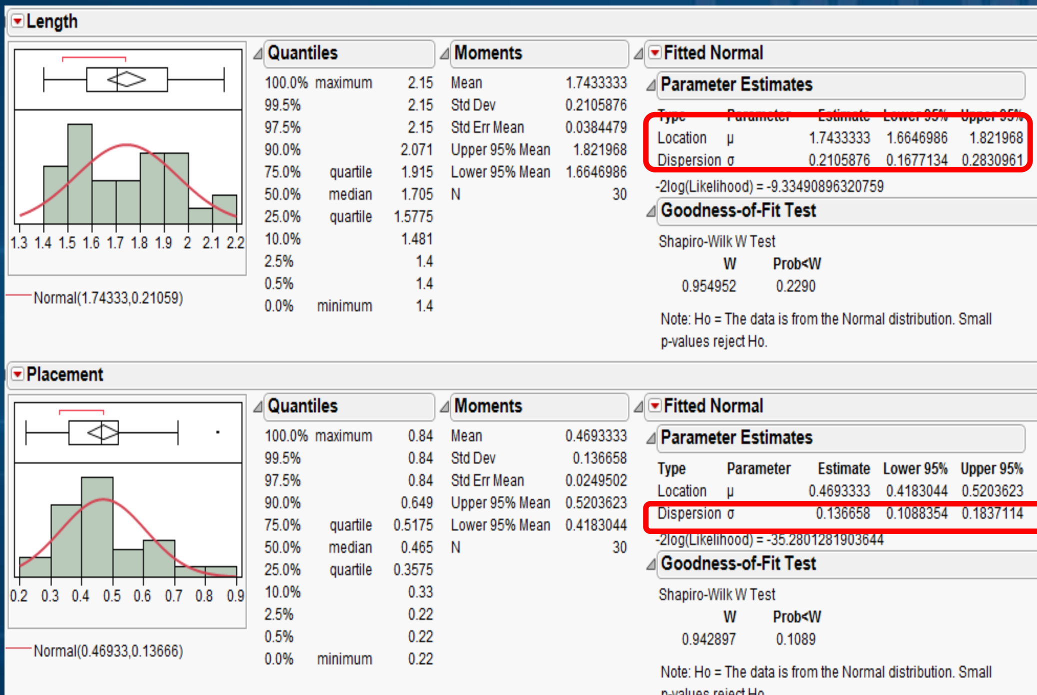
Computation for Cp:

$Cp = \mu + 3\delta$
$Cp = 2.80 \text{ mils} + 3\,(0.45 \text{ mils})$
$Cp = 4.16 \text{ mils} \approx 4.5 \text{ mils}$

➢ Given the mean length and combined standard deviation of probemark size and placement. Minimum pad opening capability of Probe E using Blade Type needle is 4.5 x 4.5 mils.

Result/Relevant Findings/Key Data

- **Phase 3 Result (Epoxy)**



Formula for Capability:

$Cp = \mu + 3\delta$; where $\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$

Given Values:

$\mu = 1.74$ mils
$\delta_1 = 0.21$ mils
$\delta_2 = 0.14$ mils

Computation for δ:

$\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$
$\delta = \sqrt{0.21 \text{ mils}^2 + 0.14 \text{ mils}^2}$
$\delta = 0.25$ mils

Computation for Cp:

$Cp = \mu + 3\delta$
$Cp = 1.74$ mils $+ 3\,(0.25$ mils$)$
$Cp = 2.50$ mils ≈ 3.0 mils

➢ Given the mean length and combined standard deviation of probemark size and placement. Minimum pad opening capability of Probe E using Epoxy Type needle is 3 x 3 mils.

Result/Relevant Findings/Key Data

- **Phase 3 Result (Summary)**

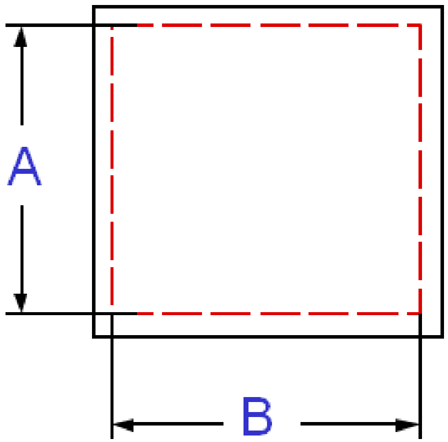
Sub-Process	Wafer Size	Wafer Thickness	Die Size	Bond Pad Opening	Optimization Needed
Blade Type Cantilever Probing	4 to 6 inch	8 mils ≥ X	n/a	4.5 x 4.5 mils ≥ X	Yes
Epoxy Type Cantilver Probing	4 to 6 inch	8 mils ≥ X	n/a	3.0 x 3.0 mils ≥ X	Not

➢ Given Current Minimum BPO Capability of Prober assuming extreme over-travel setting was used (5 mils for Blade, 3 mils for Epoxy) during Probe Process.

Result/Relevant Findings/Key Data

- **Phase 3 Result (Summary)**

	A (mils)	B (mils)
Blade	4.5	4.5
Epoxy	3	3



➢ Since the minimum bond pad being probe is at 3.5 um. Estimated cpk is only at 0.6 which is equivalent to 1.75 sigma level or approximately 400K ppm. Prober X using Blade Type Needle is not capable.

Discussion of Results / Strengths / Weaknesses

- **Phase 4 (Optimization Stage)**

4 M's	Types	Remarks
Man	Probe Operator	No significant effect on the PND issue
Machine	Prober E	Could not be changed.
Method	Overtravel Setting	Could be further explore
Material	Wafer Size	Not a factor
	Die Size	Not a factor
	Bond Pad Size	Out of our control
	Needle Type	Required big change. Needed to re-characterized
	Needle Diameter	Required big change. Needed to re-characterized

➢ To Probe Process using Blade Type Needle Capable, all process inputs has been revisited and checked what can be optimized. Over-travel is one of the KPIV that cab easily be manipulated for Optimization.

Discussion of Results / Strengths / Weaknesses

- **Phase 4 (Optimization Stage)**

Factors (Independent Variable)

	Name	Level
1	Over-travel Setting	4

Responses (Independent Variable)

1 Probemark Length Mean
2 Probemark Length Variation
3 Probemark Placement Variation
4 3 Sigma of Probemark Length and Placement Variation
5 Minimum BPO

Run	Factors	Responses				
	Over-travel Settings	Probemark Length Mean	Probemark Length Variation	Probemark Placement Variation	3 Sigma of Probemark Length and Placement Variation	Minimum BPO
1	2					
2	3					
3	4					
4	5					

- Level 4 Completely Randomized Design experiment has been used for optimization.

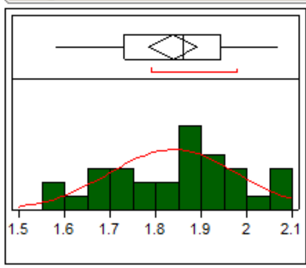
Discussion of Results / Strengths / Weaknesses

- **Phase 4 (Optimization Stage)**

Minimum BPO Capability Computation for 2 mils Over-travel Setting

2 mils

Length



Normal(1.83833,0.14013)

Quantiles

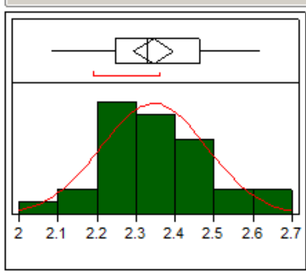
100.0%	maximum	2.0700
99.5%		2.0700
97.5%		2.0700
90.0%		2.0470
75.0%	quartile	1.9425
50.0%	median	1.8600
25.0%	quartile	1.7300
10.0%		1.6150
2.5%		1.5800
0.5%		1.5800
0.0%	minimum	1.5800

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	1.8383333	1.7860097	1.8906569
Dispersion	σ	0.1401251	0.1115966	0.1883724

Placement



Normal(2.34567,0.13569)

Quantiles

100.0%	maximum	2.6200
99.5%		2.6200
97.5%		2.6200
90.0%		2.5380
75.0%	quartile	2.4625
50.0%	median	2.3300
25.0%	quartile	2.2475
10.0%		2.1910
2.5%		2.0800
0.5%		2.0800
0.0%	minimum	2.0800

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2.3456667	2.2949994	2.3963339
Dispersion	σ	0.1356894	0.108064	0.1824093

Formula for Capability:

$Cp = \mu + 3\delta$; where $\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$

Given Values:

μ = 1.84 mils
δ_1 = 0.14 mils
δ_2 = 0.14 mils

Computation for δ:

$\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$
$\delta = \sqrt{0.14\ mils^2 + 0.14\ mils^2}$
δ = 0.19 mils

Computation for Cp:

$Cp = \mu + 3\delta$
Cp = 1.84 mils + 3 (0.19 mils)
Cp = 2.42 mils ≈ 2.5 mils

➢ Given the mean length and combined standard deviation of probe-mark size and placement. Minimum pad opening capability of Probe E using Blade Type needle at 2 mils Over-travel is 2.5 x 2.5 mils.

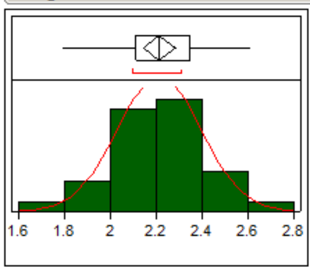
Discussion of Results / Strengths / Weaknesses

- **Phase 4 Result**

Minimum BPO Capability Computation for 3 mils Over-travel Setting

3 mils

Length



Normal(2.214,0.18442)

Quantiles

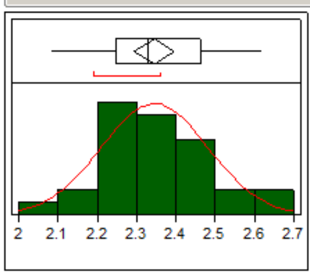
100.0%	maximum	2.6100
99.5%		2.6100
97.5%		2.6100
90.0%		2.4570
75.0%	quartile	2.3425
50.0%	median	2.2100
25.0%	quartile	2.1075
10.0%		1.9330
2.5%		1.7900
0.5%		1.7900
0.0%	minimum	1.7900

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2.214	2.1451361	2.2828639
Dispersion	σ	0.1844208	0.146874	0.2479197

Placement



Normal(2.34567,0.13569)

Quantiles

100.0%	maximum	2.6200
99.5%		2.6200
97.5%		2.6200
90.0%		2.5380
75.0%	quartile	2.4625
50.0%	median	2.3300
25.0%	quartile	2.2475
10.0%		2.1910
2.5%		2.0800
0.5%		2.0800
0.0%	minimum	2.0800

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2.3456667	2.2949994	2.3963339
Dispersion	σ	0.1356894	0.108064	0.1824093

Formula for Capability:

$Cp = \mu + 3\delta$; where $\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$

Given Values:

μ = 2.21 mils
δ_1 = 0.18 mils
δ_2 = 0.14 mils

Computation for δ:

$\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$
$\delta = \sqrt{0.18 \text{ mils}^2 + 0.14 \text{ mils}^2}$
δ = 0.23 mils

Computation for Cp:

$Cp = \mu + 3\delta$
Cp = 2.21 mils + 3 (0.23 mils)
Cp = 2.90 mils ≈ 3.0 mils

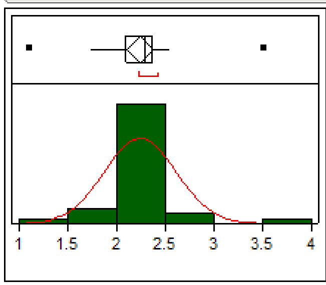
➢ Given the mean length and combined standard deviation of probe-mark size and placement. Minimum pad opening capability of Probe E using Blade Type needle at 3 mils Over-travel is 3.0 x 3.0 mils.

Discussion of Results / Strengths / Weaknesses

- **Phase 4 Result**

4 mils

Length



Quantiles

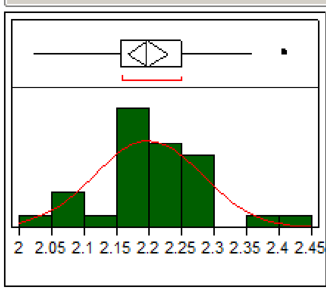
100.0%	maximum	3.5200
99.5%		3.5200
97.5%		3.5200
90.0%		2.5370
75.0%	quartile	2.3575
50.0%	median	2.2900
25.0%	quartile	2.0900
10.0%		1.8870
2.5%		1.1100
0.5%		1.1100
0.0%	minimum	1.1100

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2.2433333	2.1062777	2.3803889
Dispersion	σ	0.3670416	0.2923145	0.4934196

Placement



Quantiles

100.0%	maximum	2.4100
99.5%		2.4100
97.5%		2.4100
90.0%		2.2790
75.0%	quartile	2.2500
50.0%	median	2.1950
25.0%	quartile	2.1575
10.0%		2.0900
2.5%		2.0200
0.5%		2.0200
0.0%	minimum	2.0200

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2.1986667	2.1677543	2.229579
Dispersion	σ	0.0827849	0.0659304	0.1112889

Formula for Capability:

$Cp = \mu + 3\delta$; where $\delta = \sqrt{\delta_1^2 + \delta_2^2}$

Given Values:

$\mu = 2.24$ mils
$\delta_1 = 0.37$ mils
$\delta_2 = 0.08$ mils

Computation for δ:

$\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$
$\delta = \sqrt{0.37\text{ mils}^2 + 0.08\text{ mils}^2}$
$\delta = 0.38$ mils

Computation for Cp:

$Cp = \mu + 3\delta$
$Cp = 2.24\text{ mils} + 3\,(0.38\text{ mils})$
$Cp = 3.37\text{ mils} \approx 3.5\text{ mils}$

➢ Given the mean length and combined standard deviation of probe-mark size and placement. Minimum pad opening capability of Probe E using Blade Type needle at 4 mils Over-travel is 3.5 x 3.5 mils.

Discussion of Results / Strengths / Weaknesses

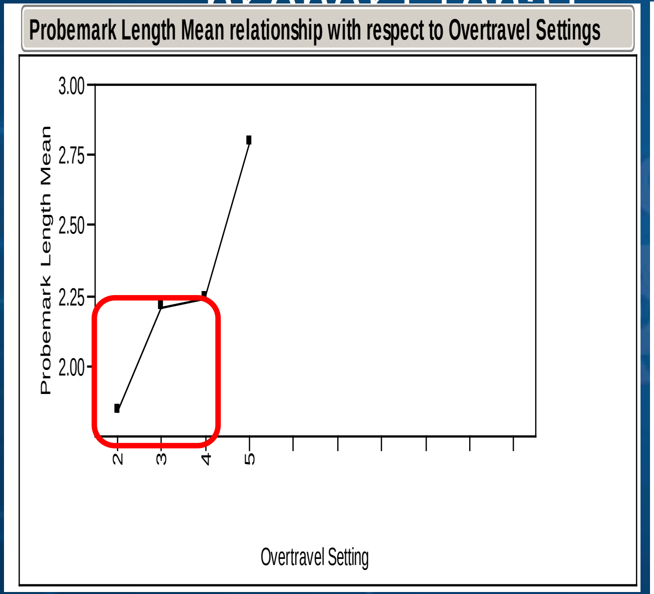
- **Phase 4 Result**

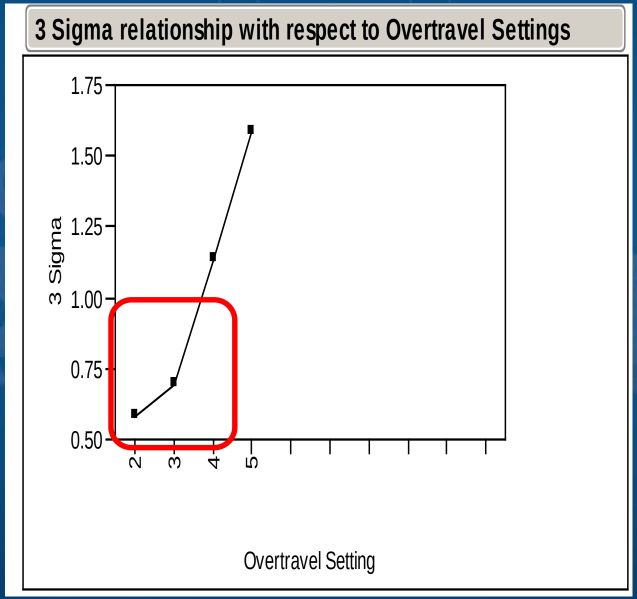
Run	Factors					Responses		
	Prober	Needle Type	Process	Device	Over-travel Settings	Probemark Length	Probemark Placement	Minimum BPO
1	Prober E	Blade Needle	Probing	LM124SH	5	2.79	0.3	4.5 x 4.5
2		Blade Needle	Probing	LM124SH	3	2.21	0.14	3.0 x 3.0
3		Blade Needle	Probing	LM124SH	2	1.84	0.14	2.5 x 2.5
4		Blade Needle	Probing	LM124SH	4	2.24	0.08	3.5 x 3.5

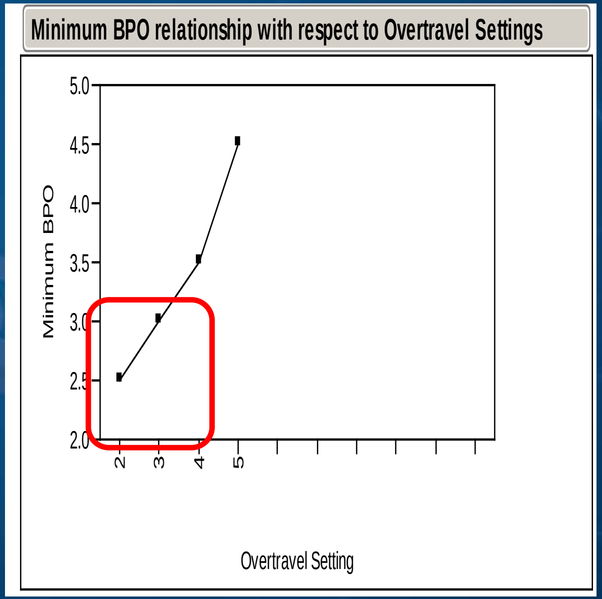
➢ Using Over-travel less than 5 mils, Minimum pad opening capability of Prober E using Blade Type needle are less than 3.5 mils. This capability is meeting the requirement of devices with small pad opening.

Discussion of Results / Strengths / Weaknesses

- **Analysis**
  - Correlation between Over-travel and Probe-mark Length, Variation and Capability are directly proportional







Robustness of the process is present if lower over-travel setting (2 – 4 mils) will be used instead of higher setting (3 -5 mils).

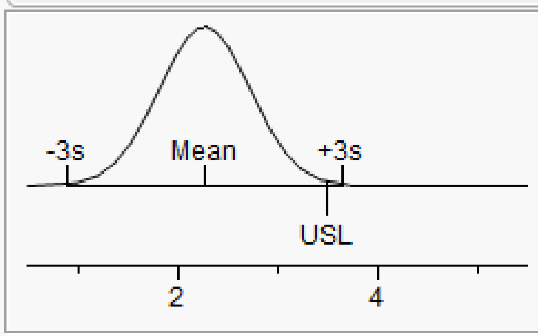
Discussion of Results / Strengths / Weaknesses

- **Risk Assessment**

Capability Analysis

Specification	Value	Portion	% Actual
Lower Spec Limit	.	Below LSL	.
Spec Target	.	Above USL	1.6667
Upper Spec Limit	3.5	Total Outside	1.6667

Long Term Sigma



Sigma = 0.45728

Capability	Index	Lower CI	Upper CI
CP	.	.	.
CPK	0.895	0.766	1.022
CPM	.	.	.
CPL	.	.	.
CPU	0.895	0.766	1.022

Portion	Percent	PPM	Sigma Quality
Below LSL	.	.	.
Above USL	0.3641	3641.2009	4.184
Total Outside	0.3641	3641.2009	4.184

➢ There will be an estimated 3641 ppm of probe damage if the current parameter will not be changed to 2 – 4 mils from 3 to 5 mils

Discussion of Results / Strengths / Weaknesses

- **Phase 5 (Control Phase)**
  - Prior implementation, Change underwent to management approval. All potential risk related to change in parameter has been discussed and conside[illegible]rations.

Needle Type	**Current** Overtravel Settings	**Proposed** Overtravel Settings
Epoxy	2 - 4 mils	2 - 4 mils
Blade	3 - 5 mils	

Pros

1. **Standardization**
   -Less chance of errors on the part of operators
2. **BPO Capability Improvement**
   -Better capability BPO capability at 4mils compared to 5mils Over Travel
3. **Quality**
   -Less chance for PND defect occurrence

Cons

-None

Discussion of Results / Strengths / Weaknesses

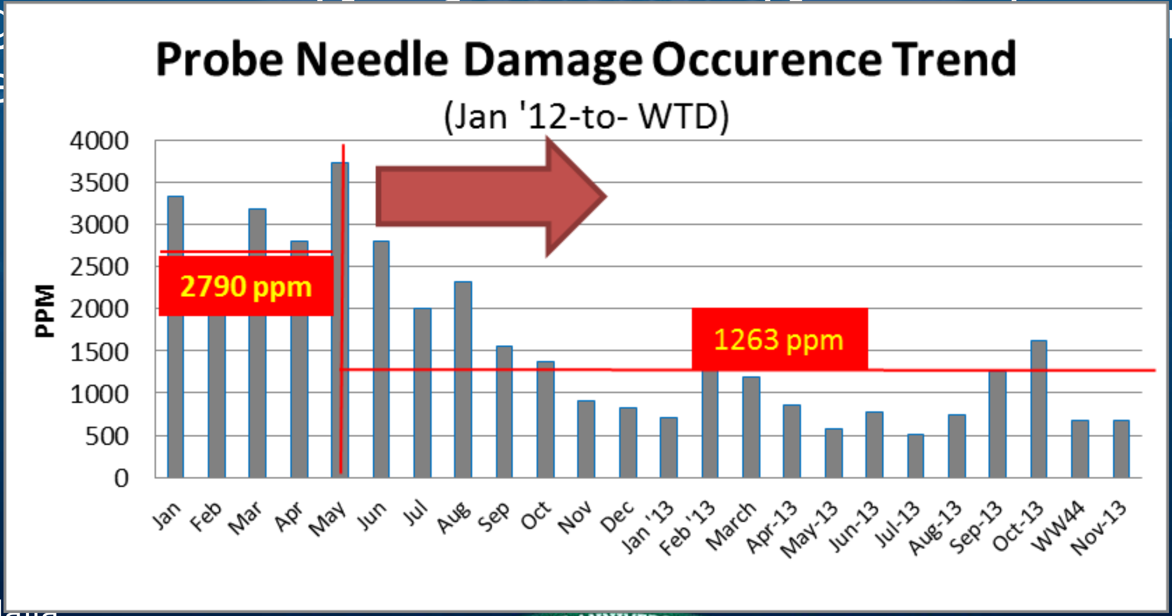
- **Phase 5 (Control Phase)**

#	Probedate	Lot	Device	Average Yield (Sample Mean)	Historical Yield (Population Mean)	α	t-Test (p-value)	Statistically the same	With PND
1	12/28/2011 14:39	P0RH1152760	WT6L2950-3300B.02	98.75	98.96	0.05	0.54	Yes	None
2	1/19/2012 7:37	P0RH1203860	WT6NCV4949A00S.02	99.54	99.58	0.05	0.49	Yes	None
3	1/19/2012 22:43	P0RH1203960	WT6NCV4949A00S.02	99.38	99.58	0.05	0.74	Yes	None
4	1/20/2012 12:03	P0RH1203760	WT6NCV4949A00S.02	99.31	99.58	0.05	0.76	Yes	None
5	1/21/2012 1:47	P0RH1204060	WT6NCV4949A00S.02	99.64	99.58	0.05	0.43	Yes	None
6	1/21/2012 12:48	P0RH1204360	WT6NCV4949A00S.02	99.39	99.58	0.05	0.12	Yes	None
7	1/22/2012 0:52	P0RH1204260	WT6NCV4949A00S.02	99.72	99.58	0.05	0.06	Yes	None
8	1/22/2012 9:59	P0RH1257260	WT6NCV4949A00S.02	99.76	99.58	0.05	0.06	Yes	None
9	1/22/2012 19:30	P0RH1234260	WT6NCV4949A00S.02	99.70	99.58	0.05	0.07	Yes	None
10	1/24/2012 8:34	P0RH1234160	WT6NCV4949A00S.02	99.73	99.58	0.05	0.30	Yes	None
11	2/11/2012 0:40	P0RH1350060	WT6NCP306301H.01	99.13	99.13	0.05	0.12	Yes	None
12	2/11/2012 13:35	P0RH1350260	WT6NCP306301H.01	99.26	99.13	0.05	0.06	Yes	None
13	2/16/2012 2:35	P0RH1350160	WT6NCP306301H.01	99.14	99.13	0.05	0.06	Yes	None
14	2/17/2012 18:10	P0RH1388660	WT6NCP306301H.01	99.33	99.13	0.05	0.24	Yes	None
15	2/18/2012 0:41	P9RH1403760	WT6LM293A00N.02	99.98	99.89	0.05	0.55	Yes	None
16	2/18/2012 7:14	P9RH1403860	WT6LM293A00N.02	99.98	99.89	0.05	0.20	Yes	None
17	3/10/2012 9:58	P9RH1471460	WT6MC33274A00N.02	99.84	99.8	0.05	0.66	Yes	None
18	3/10/2012 20:58	P9RH1482760	WT6MC3307800N.01	99.84	99.91	0.05	0.93	Yes	None
19	3/11/2012 3:38	P9RH1482860	WT6MC3307800N.01	99.82	99.91	0.05	0.40	Yes	None
20	3/11/2012 10:54	P9RH1483460	WT6MC3307800N.01	99.95	99.91	0.05	0.48	Yes	None
21	3/11/2012 19:04	P9RH1483060	WT6MC3307800N.01	99.93	99.91	0.05	0.47	Yes	None
22	3/12/2012 0:36	P9RH1482660	WT6MC3307800N.01	99.95	99.91	0.05	0.58	Yes	None
23	3/12/2012 10:00	P9RH1499560	WT6MC3307800N.01	99.96	99.91	0.05	0.52	Yes	None
24	3/12/2012 16:49	P9RH1483160	WT6MC3307800N.01	99.88	99.91	0.05	0.31	Yes	None
25	3/13/2012 9:50	P9RH1482960	WT6MC3307800N.01	99.86	99.91	0.05	0.27	Yes	None
26	3/13/2012 16:45	P9RH1482560	WT6MC3307800N.01	99.91	99.91	0.05	0.20	Yes	None
27	3/18/2012 2:21	P9RH1513360	WT6MC3303300N.02	98.98	99.04	0.05	0.71	Yes	None
28	3/18/2012 20:08	P9RH1513460	WT6MC3303300N.02	98.63	98.76	0.05	0.17	Yes	None
29	3/23/2012 12:37	P9RH1528260	WT6LM124SH25Z.02	99.89	99.92	0.05	0.55	Yes	None
30	3/23/2012 18:59	P9RH1533860	WT6VLM124A00N.01	99.88	99.67	0.05	0.16	Yes	None

Summary/Conclusion

The principal findings of the study were:

- We can therefore conclude that the Capability Limitation of Prober E using blade type needle cause Probe Damage. Most of the trim pad has less than 4 mils pad opening and process only have the 4.5 capability.
- After the Implementation of the change in over-travel setting ... mage ppm has bee...



Follow-On Work

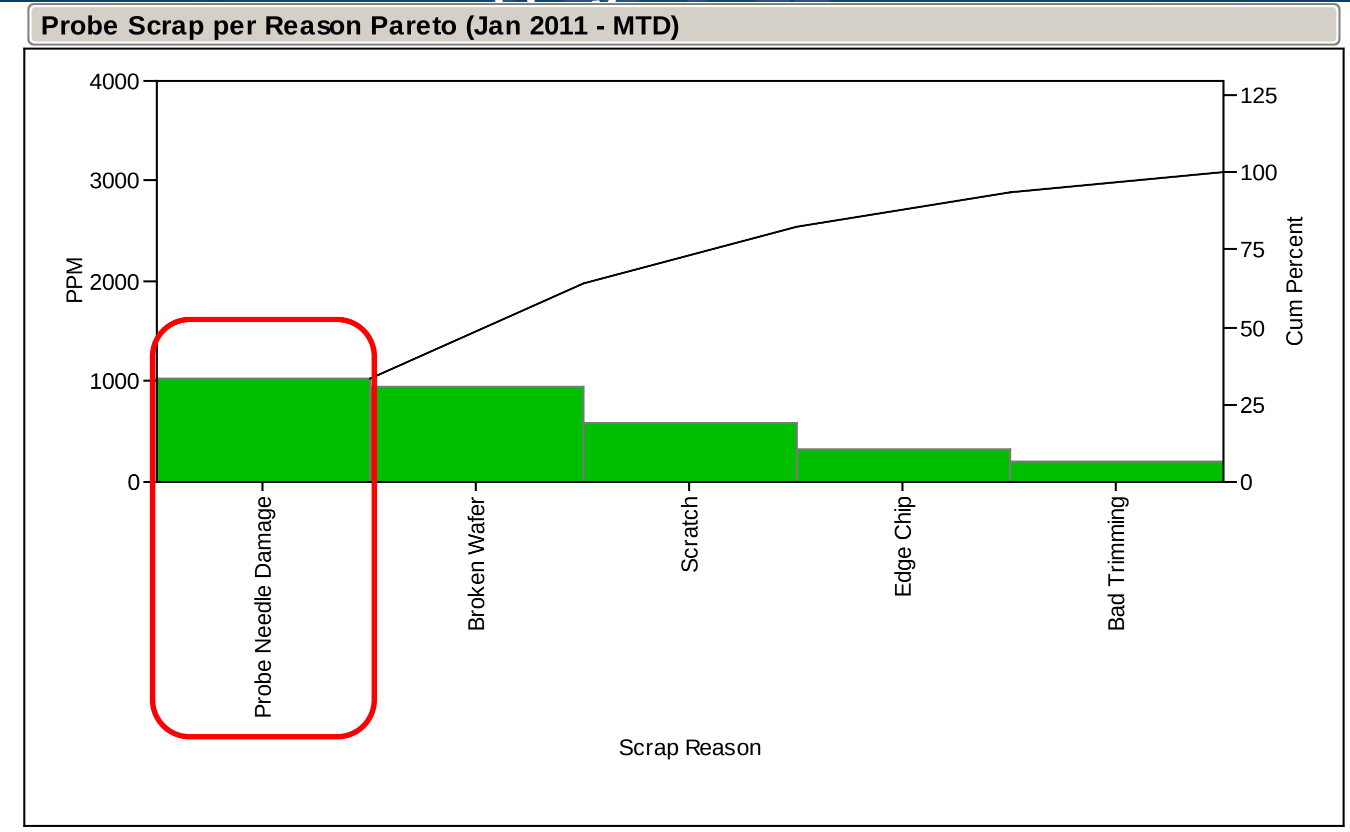
- For new product development, Wafer Probe Equipment capability in terms of placement and stepping accuracy should be consider primarily. Current trend of technology causes the Die Size shrunk. BPO becomes smaller and smaller.
- Probe Technology should also be considered. A wide spread variety of Probe Technology such as Cantilever, Buckling Type, Cobra and Pogo can be chosen depending on the current process requirement and what the customer needs.
- MPCPS should be done on every New Product/Process. This is an anticipation of risk that prevents the issue during the Production Run that cost a lot. Solving the problem at the source is much cheaper.

HOOKE'S LAW EXISTENCE ON BLADE TYPE NEEDLE AT PROBE PROCESS

- Introduction / Background
- Objectives / Goals
- Methods / Materials / Procedures
- Results / Relevant Findings / Key Data
- Discussion of Results / Strengths / Weaknesses, etc.
- Summary / Conclusion
- Follow-On Work

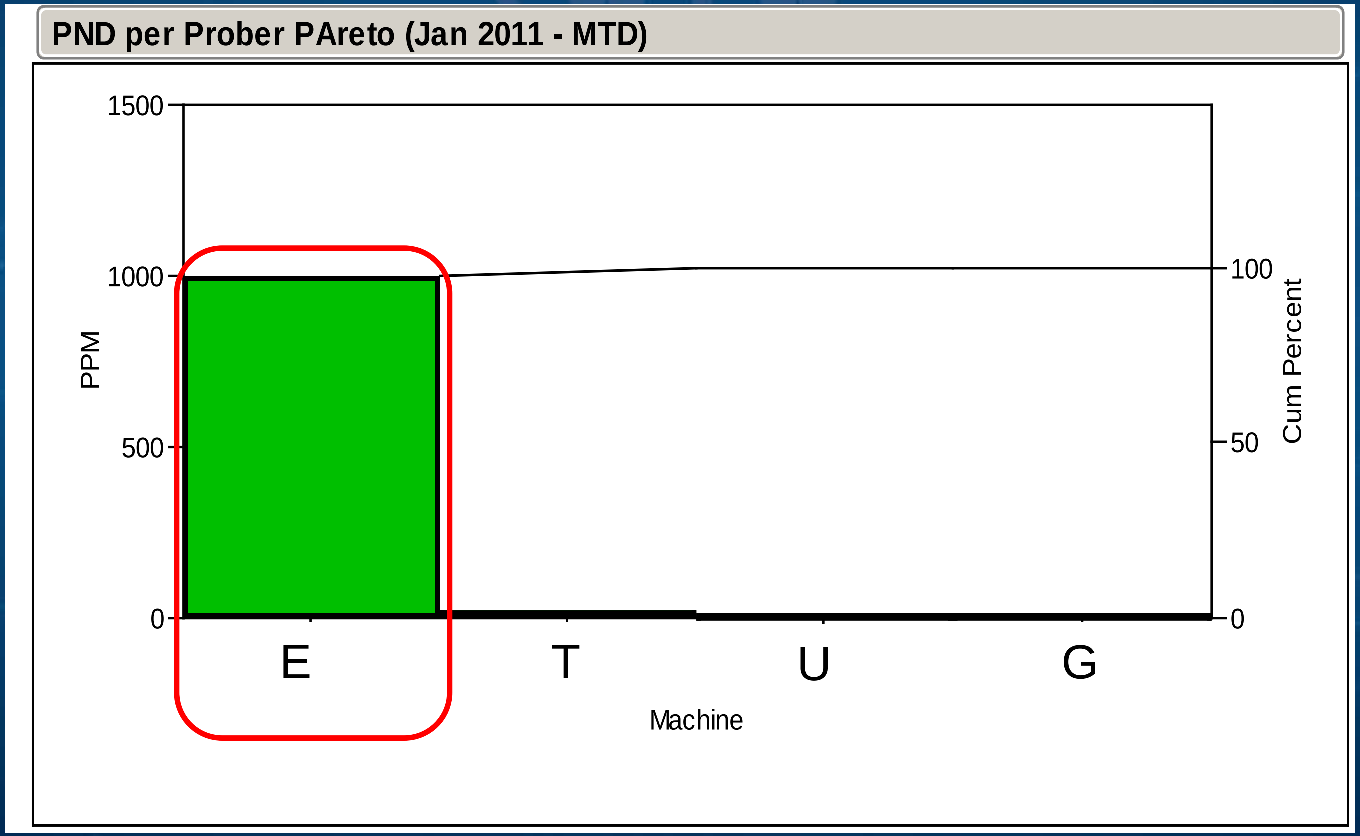
Introduction

At 1000 ppm, Probe Damage related to Probe Needle is on top of Pareto in terms of On Semiconductor Philippines wafer scrappage reason.



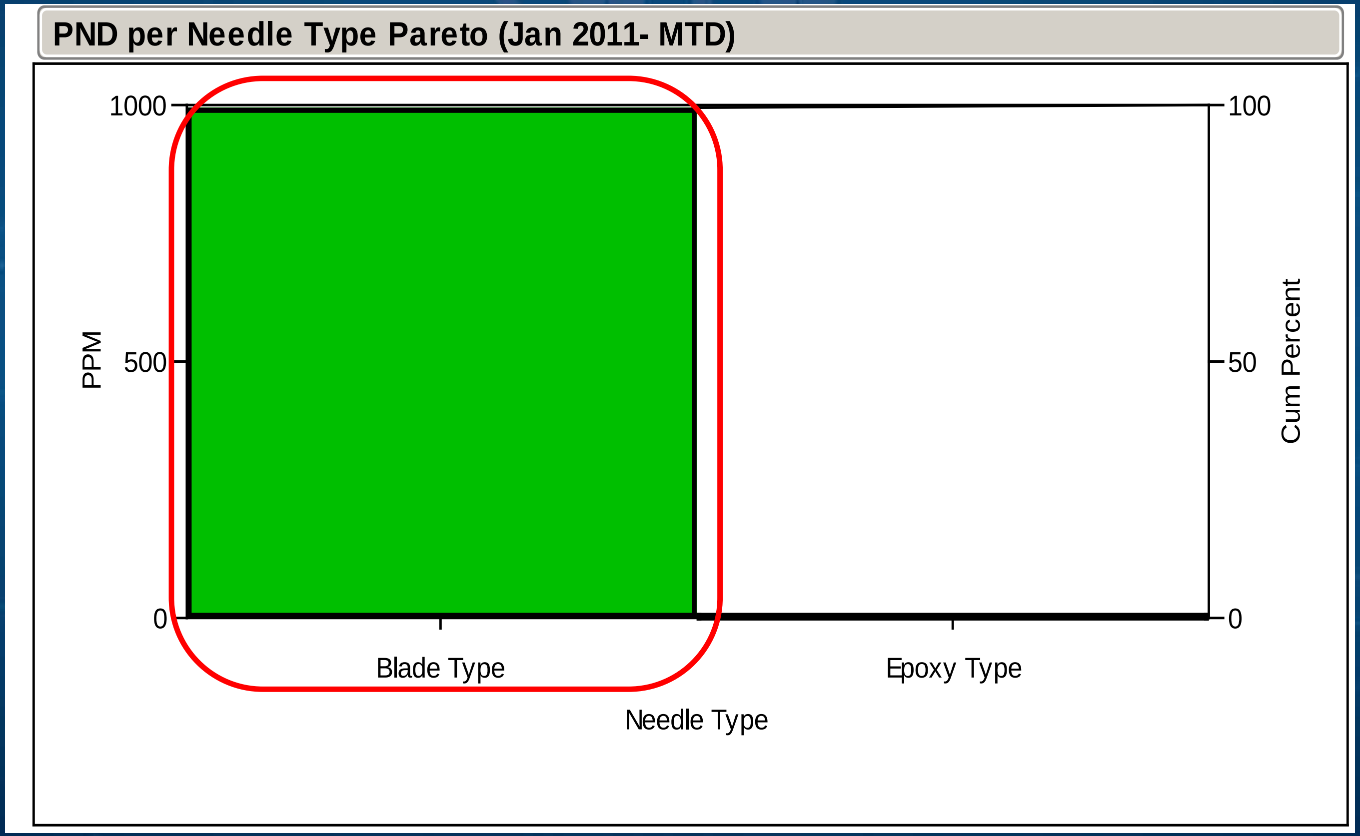
Introduction

100% of those 1000 ppm have been contributed by the Prober E which uses a Blade Type Needle for Probing.



Introduction

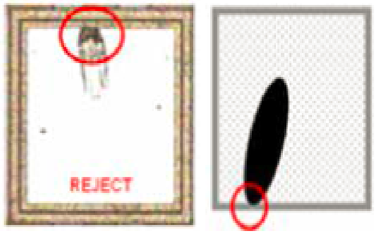
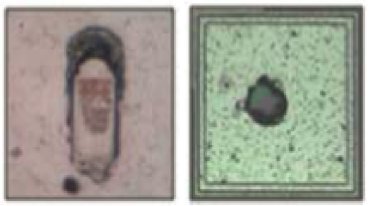
100% of those 1000 ppm have been contributed by the Prober E which uses a Blade Type Needle for Probing.



Introduction

What is Probe Damage ?

- Is a phenomena when a part of a die specifically at the Pad Area such as Seal Ring or other metallization has been damage by the Probe Needle during Testing.
- Probe damage is the number one visual defect contributor at wafer sort process having a direct impact on yield and cycle time.

No	Defect visual aid	Remarks
1		Probe marks touching the seal ring of the bond pad
2		Expose oxide on the bonding pad

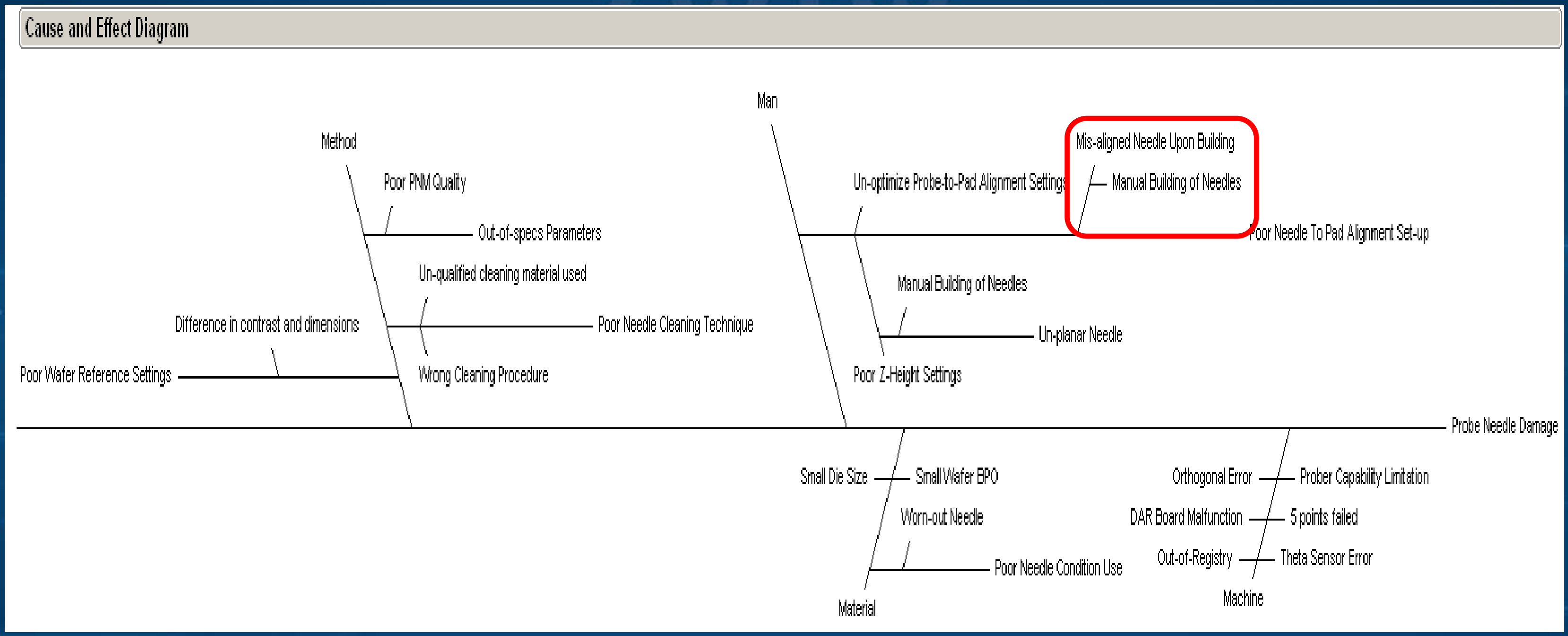
Introduction

What are the causes Probe Damage ?

- **OSPI Engineering Team Brainstorm using Ishikawa Diagram for the Possible Sources of Probe Damage. Specific Factors are came from Man, Machine, Method and Material.**

Introduction

What are the causes Probe Damage ?



- Mis-aligned needle upon building has been identified as one of the many causes of Probe Damage on wafers.
- The phenomena has been explained by the users that initially build mis-aligned needle that was tweak to passed the alignment returned to its original position also know as **“Spring-Effect”**

Introduction

What is Spring Effect or Hooke's Law?

- **In mechanics, and physics, Hooke's law of elasticity is an approximation that states that the extension of a spring is in direct proportion with the load applied to it unless the load does not exceed the material's elastic limit.**
- **Materials for which Hooke's law is a useful approximation are known as linear-elastic or "Hookean" mat… hat str…**

Mathematically, Hooke's law states that

$$F = -kx$$

where

x is the displacement of the spring's end from its equilibrium position (a distance, in SI units: meters);

F is the restoring force exerted by the spring on that end (in SI units: N or $kg \cdot m \cdot s^{-2}$); and *k* is a constant called the *rate* or *spring constant* (in SI units: $N \cdot m^{-1}$ or $kg \cdot s^{-2}$).

Introduction

Hooke's Law Application on Materials:

- **Objects that quickly regain their original shape after being deformed by a force, with the molecules or atoms of their material returning to the initial state of stable equilibrium**
- **We may view a rod of any elastic material as a linear spring. The rod has length L and cross-sectional area A. Its extension (strain) is linearly proportional to its tensile stress … stant factor, the inverse of its modu… icity, E, hence,**

$$\sigma = E\varepsilon$$

or

$$\Delta L = \frac{F}{EA}L = \frac{\sigma}{E}L.$$

- **Steel exhibits linear-elastic behavior in most engineering applications; Hooke's law is valid for it throughout its elastic range (i.e., for stresses below the yield strength).**

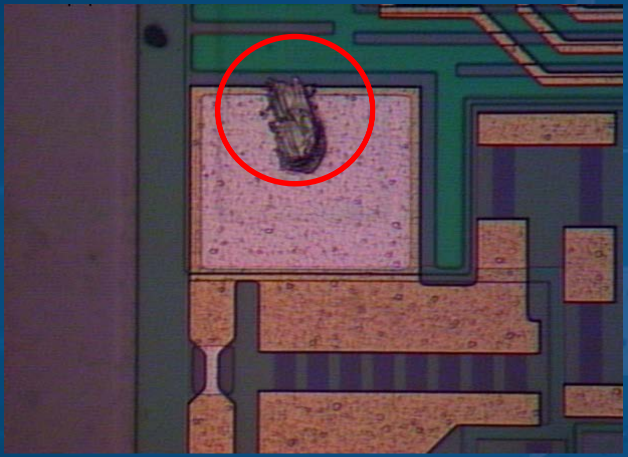
Introduction

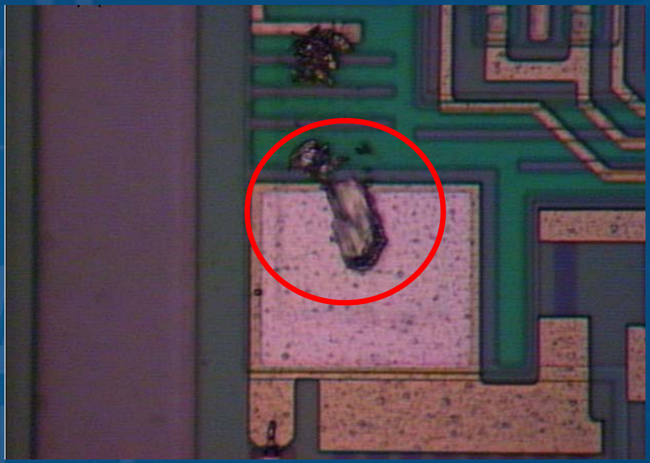
Hooke's Law Application on Probe Needle:

- **Probe Needle made-up of Tungsten due to conductivity for electrical testing of wafers.**
- **Existence of Hooke's Law on Blade Needle happened when a mis-aligned needle was tweak prior or during Probing.**
- **Blade Type needle used is Tungsten which tend to return to it's original position after several time (touchdown count) during Probing.**
- **Needle tweaking is the centering of the needle with respect to pad. This is performed when a probemarks generated by Needle is already on marginal position on Bond pad. This marginal position will eventually become mis-align on bond pad causing Probe Needle Damage on dice**

Introduction

Hooke's Law Application on Probe Needle:

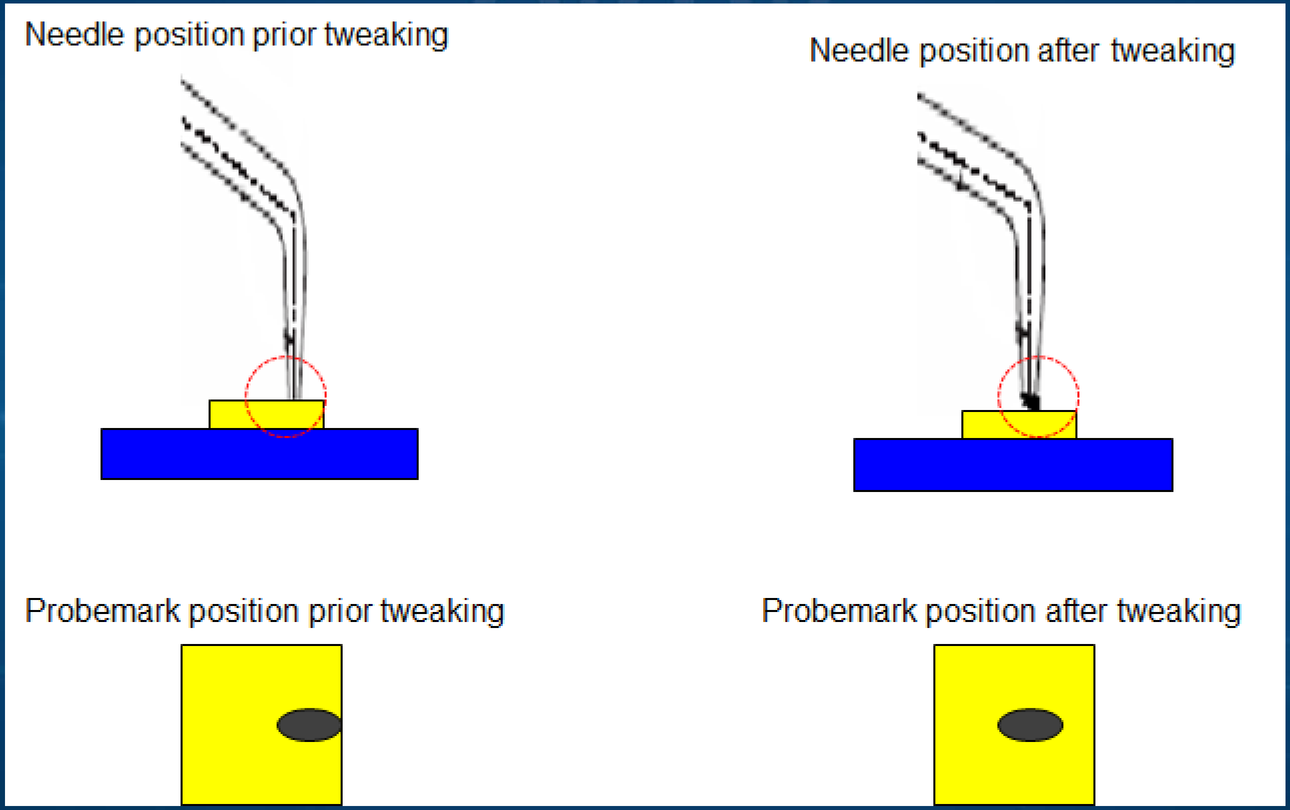




Offset probe marks on bond pad due to mis-aligned Probe needle.

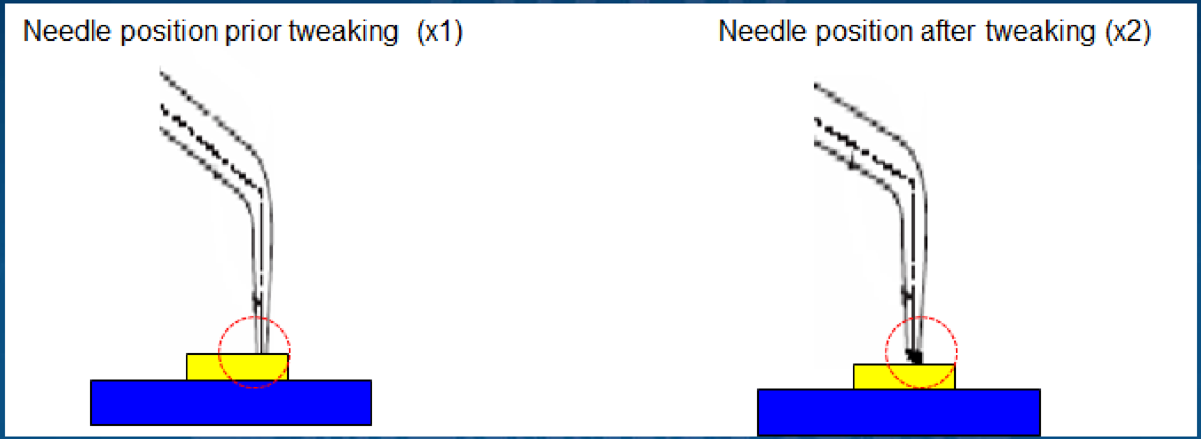
Introduction

Hooke's Law Application on Probe Needle:



Introduction

Hooke's Law Application on Probe Needle:



Mathematically, Hooke's law states that

$$F = -kx$$

where

x is the displacement difference of the blade needle from its original position prior and after tweaking.

F is the restoring force exerted by the spring on new blade needle position toward to its original position (prior tweaking)

k is a constant called the *rate* or *spring constant* (in SI units: $N \cdot m^{-1}$ or $kg \cdot s^{-2}$).

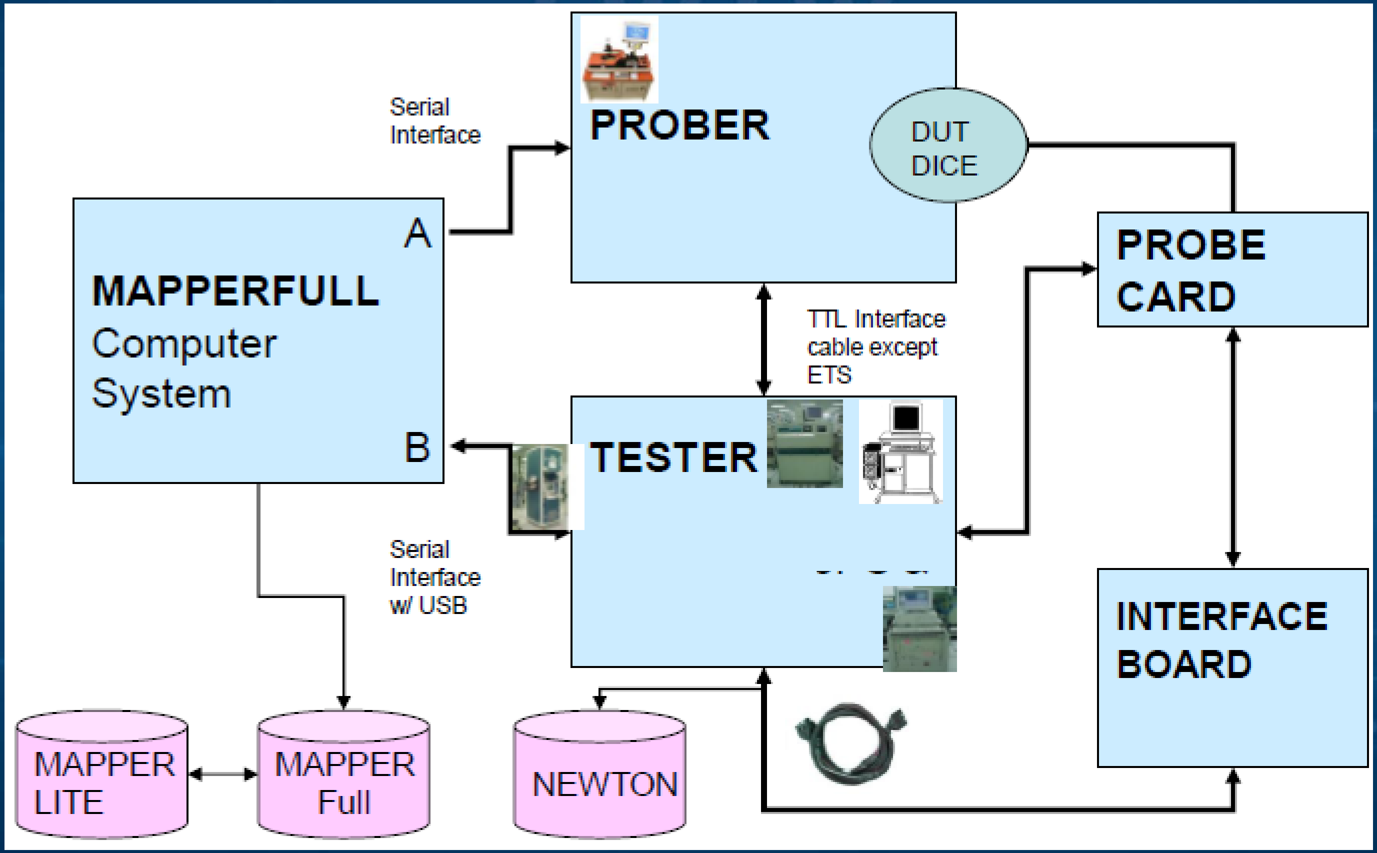
To summarize, Hooke's Law or spring-effect on Blade Needle only exist if there is a tweaking involved because displacement (x) is zero when no tweaking involved..

Objective/Goals

- To validate the existence of Spring-Effect on Blade Type Needle only
- To determine the risk and formulate a corrective action in a form of recomendation.
- The study only focus on Spring-Effect as one of the causes of Probe Damage on Wafer. This only apply to Probe that uses Blade Type Needle.

Methods/Materials/Procedure

- Materials involve on the Study



Methods/Materials/Procedure

- **Experiment Condition**
  1. Experiment has been run as normal Probe Process without engineering intervention.
  2. All Probe parameters remains constant throughout the experiment.
  3. Prober that was used during the experiment is A1 condition
  4. Probe-card needle tweak is newly build while the non-tweak is not.
  5. The experiment only cover 5 wafers for the data gathering. That involved sampling and randomization.

Methods/Materials/Procedure

- **Experiment Design**

Design of Experiment (DOE) PLAN

Validation

Problem Statement

At 1000 ppm, Probe Damage related to Probe Needle is on top of Pareto in terms of On Semiconductor Philippines wafer scrappage reason. Spring-Effect of Needle has been considered as one of he many causes.

Objective

To Validate the Existence of Spring Effect on Blade Type Needle

Variables Under Study

Dependent Variable(s) (Response)	Data Modelling Type	Number of Replicates	Specification	Unit of Measurement
Probemark placement	Continuos	34 Readings	n/a	mils

Independent Variable(s) (Factor)	Data Modelling Type	Number of Levels	Levels	Unit of Measurement
Needle Condition	Categorical	2	Tweak/Non-Tweak	N/A

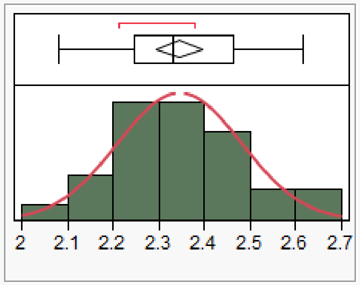
Experimental Design/Model

CRD (Completely Randomized Design)

Result/Relevant Findings/Key Data

- **DOE Result (Normality Test)**
  - Displacement of Non-Tweak Needle is characterized by a Normal Distribution
  - Displacement of Tweak Needle is characterized by a Binomial

Not Tweak



Normal(2.34528,0.13567)

Quantiles

100.0%	maximum	2.61642
99.5%		2.61642
97.5%		2.61642
90.0%		2.5352
75.0%	quartile	2.46185
50.0%	median	2.33
25.0%	quartile	2.24744
10.0%		2.18972
2.5%		2.07952
0.5%		2.07952
0.0%	minimum	2.07952

Moments

Mean	2.3452807
Std Dev	0.1356711
Std Err Mean	0.02477
Upper 95% Mean	2.3959411
Lower 95% Mean	2.2946203
N	30

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2.3452807	2.2946203	2.3959411
Dispersion	σ	0.1356711	0.1080494	0.1823847

-2log(Likelihood) = -35.7149895421947

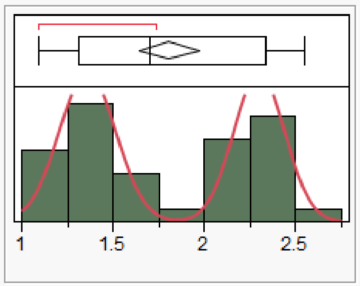
Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.983223	0.9032

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Tweak



Normal 2 Mixture

Quantiles

100.0%	maximum	2.54848
99.5%		2.54848
97.5%		2.54848
90.0%		2.41968
75.0%	quartile	2.33325
50.0%	median	1.70146
25.0%	quartile	1.31441
10.0%		1.18685
2.5%		1.09135
0.5%		1.09135
0.0%	minimum	1.09135

Moments

Mean	1.8037074
Std Dev	0.5030462
Std Err Mean	0.0816049
Upper 95% Mean	1.9690546
Lower 95% Mean	1.6383602
N	38

Fitted Normal 2 Mixture

Parameter Estimates

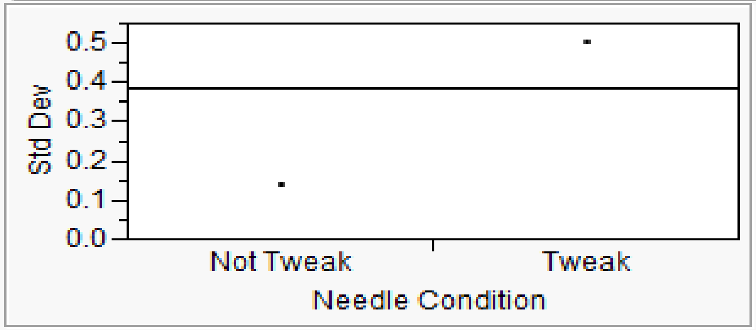
Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ1	1.3584311	1.2900658	1.4267965
Location	μ2	2.298542	2.233462	2.363622
Dispersion	σ1	0.1560005	0.1054795	0.2307193
Dispersion	σ2	0.1408673	0.0928913	0.2136216
Probability	π1	0.5263716	0.3058286	0.7370831
Probability	π2	0.4736284	0.272241	0.6839779

-2log(Likelihood) = 21.5220200784518

Result/Relevant Findings/Key Data

- **DOE Result (Equality of Variance Test)**
  - Using Bartlett Test showing a p-value of less than α = 0.05, Variances (placement consistency) are significantly different. Displacement consistency of Not-Tweak is better.

Tests that the Variances are Equal



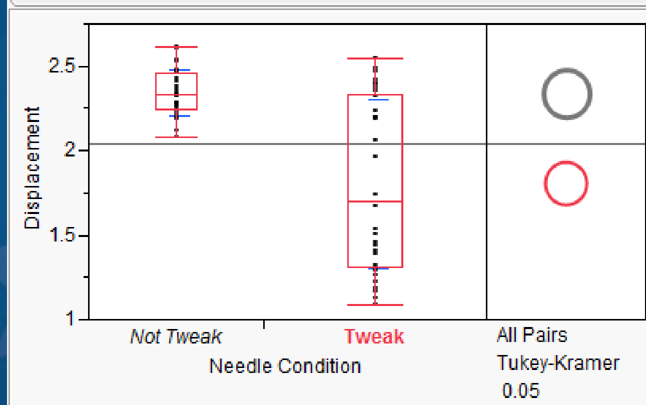
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
Not Tweak	30	0.1356711	0.1089760	0.1081989
Tweak	38	0.5030462	0.4690925	0.4654403

Test	F Ratio	DFNum	DFDen	p-Value
O'Brien[.5]	70.9237	1	66	<.0001*
Brown-Forsythe	82.2027	1	66	<.0001*
Levene	121.7311	1	66	<.0001*
Bartlett	40.8377	1	.	<.0001*
F Test 2-sided	13.7480	37	29	<.0001*

Result/Relevant Findings/Key Data

- **DOE Result (Non-Parametric Test)**
  - Using Wilcoxon Test showing a p-value of less than $\alpha = 0.05$, overall means and variance of displacement are significantly different, Non-Tweak displacement readings and consistency are better.

Oneway Analysis of Displacement By Needle Condition



Missing Rows 8

Tests that the Variances are Equal

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

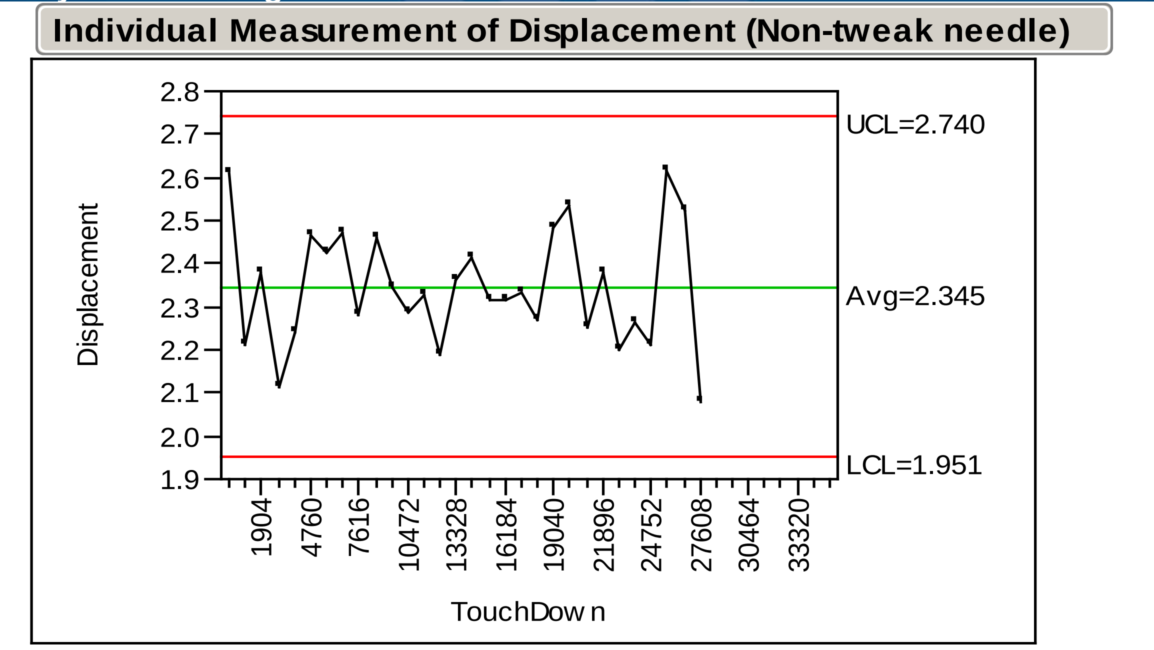
Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
Not Tweak	30	1376.00	1035.00	45.8667	4.206
Tweak	38	970.000	1311.00	25.5263	-4.206

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
1376	4.20563	<.0001*

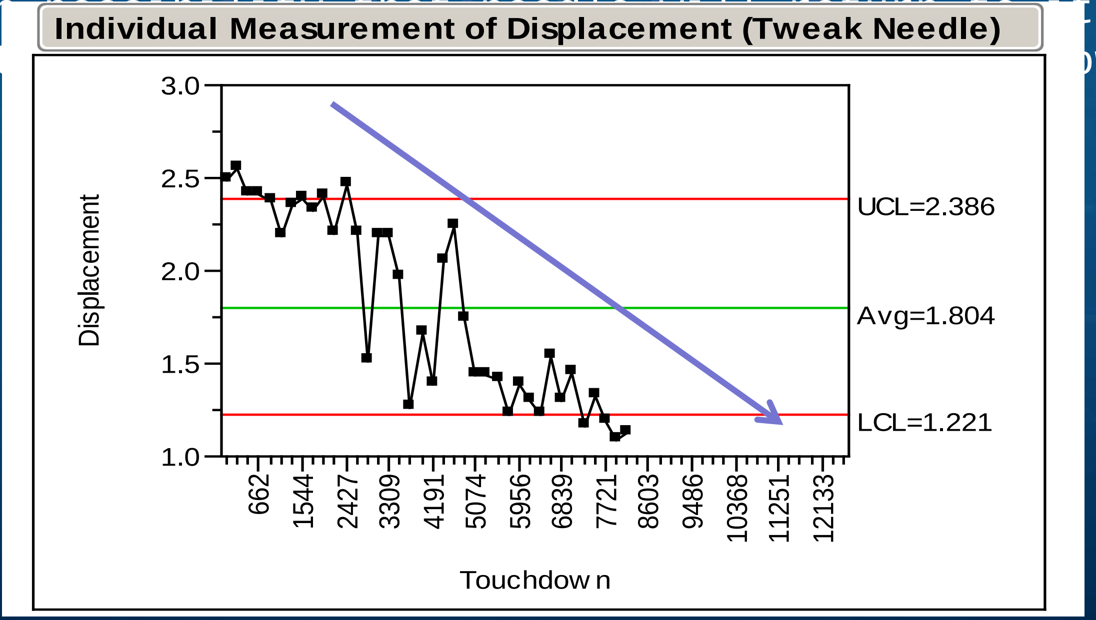
Result/Relevant Findings/Key Data

- **Probe-mark Displacement Stability of Non-Tweak**
  - Result of Non-Tweak Needle using Control Chart to monitor the Probe mark placement (displacement) of non-tweak needle with respect to touchdown count (time), practically there is stability on alignment since no out of control condition found.



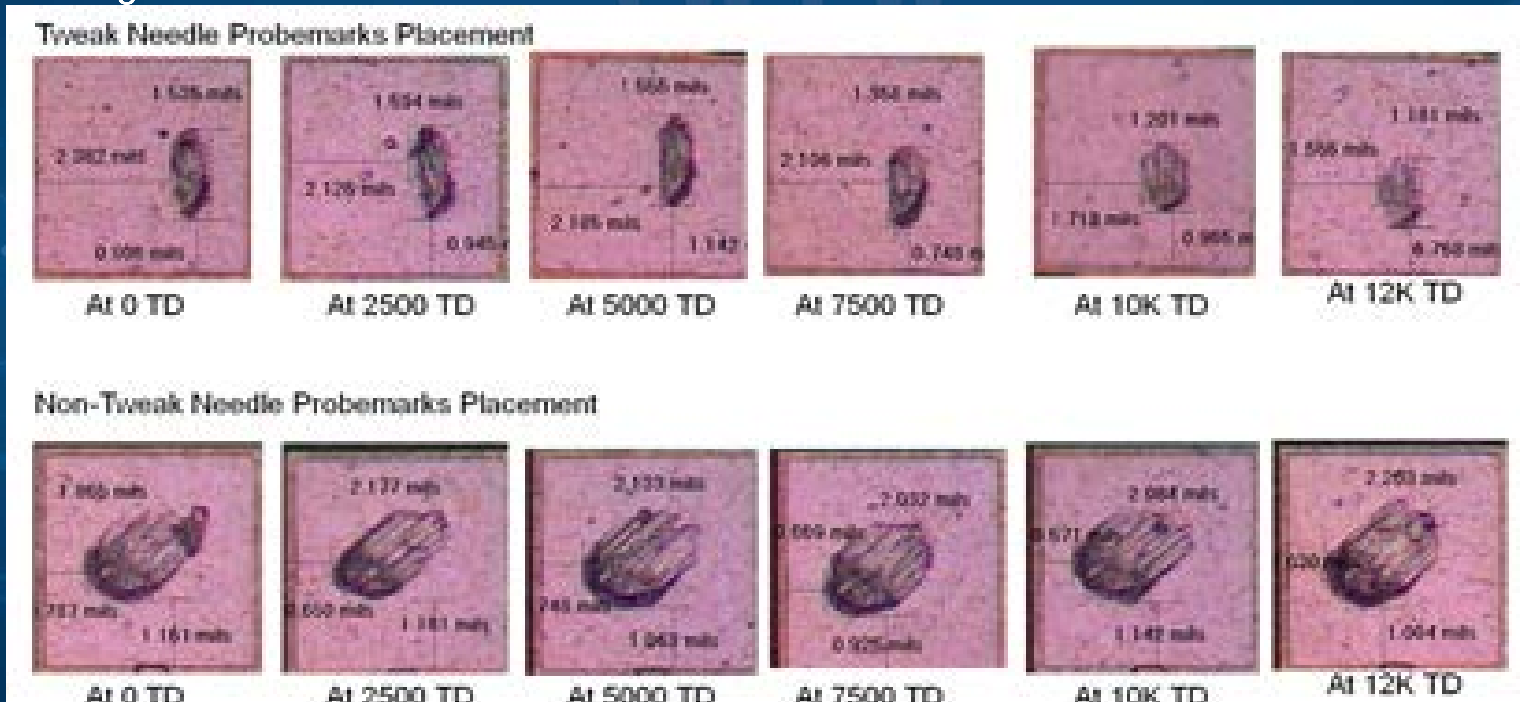
Result/Relevant Findings/Key Data

- **Probe-mark Displacement Stability of Tweak**
  - Result of Tweak needle using Control Chart to monitor the Probe mark placement (displacement) of tweak needle with respect to touchdown count (time), practically needle alignment is un-stable on tweak needle since there are out of control conditions found. There is a data above the UCL, data below LCL, and 7 consecutive data above and below avg. data. There is a high … ts original alignment … own.



Result/Relevant Findings/Key Data

- **Probe-mark Displacement Images**
  - Illustration how tweak needle move back to its original alignment.



Discussion of Results / Strengths / Weaknesses

- **Risk Assessment**
  - If the Spring-Effect has not been eliminated, there is an estimated Probe Damage occurrence of 246ppm at 4 sigma level.

Parameter Estimates

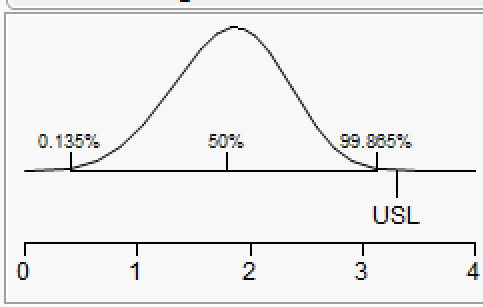
Type	Parameter	Estimate	Lower 95%	Upper 95%
Scale	α	1.9933096	1.8304632	2.1608989
Shape	β	4.1676422	3.1731721	5.3338218

-2log(Likelihood) = 53.509610219902

Capability Analysis

Specification	Value	Portion	% Actual
Lower Spec Limit	.	Below LSL	.
Spec Target	.	Above USL	0.0000
Upper Spec Limit	3.312846	Total Outside	0.0000

Quantile Sigma



Capability	Index
CP	.
CPK	1.135
CPM	.
CPL	.
CPU	1.135

Portion	Percent	PPM	Sigma Quality
Below LSL	.	.	.
Above USL	0.0247	246.5564	4.984
Total Outside	0.0247	246.5564	4.984

Discussion of Results / Strengths / Weaknesses

- **Discussion of Result**
  - Spring Effect only exist at Blade Type needle when there is a needle tweaking happened.
  - Needle tweaking perform to adjust misaligned needle during initial build when if was set-up for the 1st time at Prober.
  - Blade Type needle is manually build and soldered by the PC personnel. Dummy wafers and old Wentworth jig is the only assurance use by PC personnel for good alignment. Chances of misaligned needle at initial build is high

Summary/Conclusion

The principal findings of the study were:

- There is stability on needle alignment of non-tweak needle. There will be no misalignment of needle that will cause a Probe Needle Damage during the process.
- On the other hand, There is un-stability on needle alignment of tweak needle. The process condition has a high risk of needle mis-alignment that will cause Probe Needle Damage on Dice. There is a high possibility that needle will return to its original alignment when reach that certain number of Touchdown. Significant difference on variation of the 2 needle condition will also support the findings above.
- We can therefore conclude that indeed Hooke's Law on blade type needle exists. Existence of Hooke's Law (spring-effect) on needle is the major factor why Probe Damage occurrence/scrapping are came from wafers processed using blade type needle.

Follow-On Work

- Probe Shop need to improve the accuracy and precision of Needle Building for Blade Type.
- There will be no needle tweaking if the Probe-mark generated by the newly build needle are preferable landed at the center of the pad.
- Probe planarity and angular rotation of ring insert need to be precise to eliminate the variation of needle alignment between Prober and Probe Needle.