A 44µm Probe Process Characterization and Factory Deployment Using Probe-Over-Passivation

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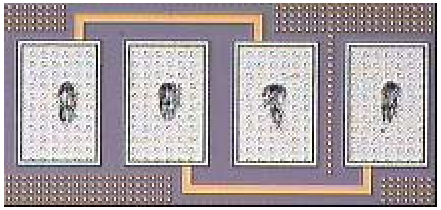
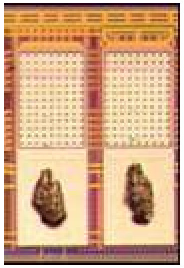
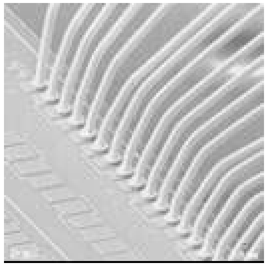
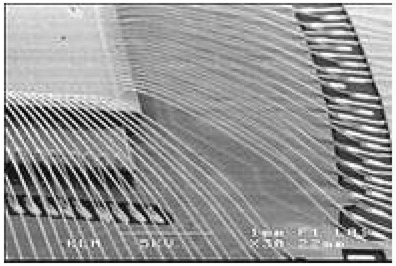
Co-Authors: Tony Angelo, S.S. Yan, Tu-Anh Tran, Stephen Lee, Matt Ruston









Today's Objectives:

1.) Motorola's FMTC Probe Technology Development Methods

2.) 44µm Probe Characterization Process Used by FMTC

3.) Introduce POP (Probe-Over-Passivation): What is it? & Why needed?

4.) 44µm Technology Transfer to Factory Flow & Results Highlights

5.) "3 Key Lessons Learned": a.) Cleaning, b.) Prober set-up, and c.) Needle Alignment OD

6. Acknowledgements of Key 44µm Probe Project Participants

Are Your Seat Belts Fastened? This will be FAST
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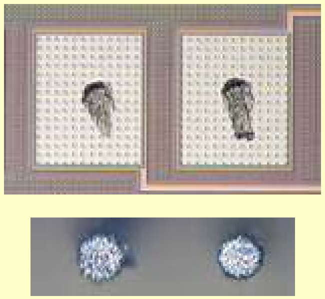
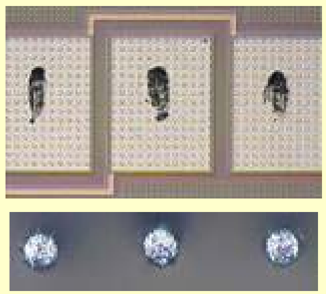
<u>Primary FMTC Team Goal:</u> Drive advancements in probe technology to enable silicon shrinks in support of SPS Product group roadmaps

Jan'99



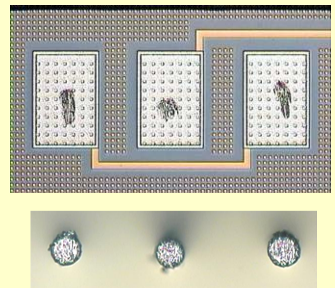
91+ µm pitch

Jan'00



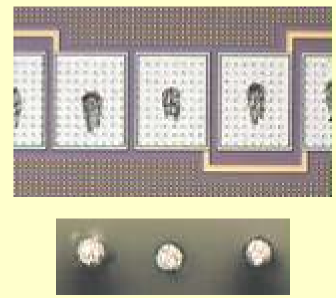
76 µm pitch

Jan'01



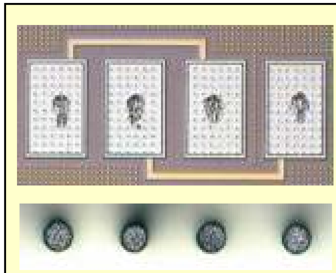
63 µm pitch

June'01



52 µm pitch

Jan'02



44 µm pitch

<u>Secondary Team Goal:</u>

Accelerate improvements in Motorola's wafer probe position to move from "tied for dead-last" in late'98 to a position of one of the Industry Leaders by '2002 for Fine Pitch Probe!

Original slide is courtesy of Lois Yong

44µm Probe Transfer Flow

also used for 63µm & 52µm

Process Definition

FMTC Probe

Establish Engineering Probe Capability

- Identify probe card requirements (tip diameter, probe force etc)
  - Solicit Production site probe card design standards
- Procure probe cards from one vendor
- Characterize card performance using test wafer (e.g. L21C or J56S)
  - Tip conditions
  - Scrub Marks vs. Overdrives
  - Resistance vs. Overdrives and Touches
  - Probe mark impact: size and depth, visual inspection, acid dip
  - If needed, re-procure probe cards and re-characterize
- Identify "normal" probe condition for each tip diameter and force
- Probe wafers at normal setting for assembly process definitions

Process Optimization

FMTC Probe

Create Probe Recipe

- Optimize card performance on test wafers (e.g. L21C or J56S)
  - Multiple overdrive testing
  - Multiple touch testing
  - Probe mark impact: size and depth, visual inspection, acid dip
- Identify production-worthy tip diameter and card characteristics
- Probe wafers at low, normal and worst case settings for assembly process optimization
- Evaluate other probe card vendors

Validate Process at NPI Test Site

FMTC Probe

NPI Probe

- Characterize probe recipe on test chip wafers (e.g. L21C or J56S)
  - Sample size: 3 wafer lots of 3 wafers minimum
  - Evaluate sources of variance
- Probe L21C test chip wafers for assembly verification
- Hand-off to NPI Test manufacturing

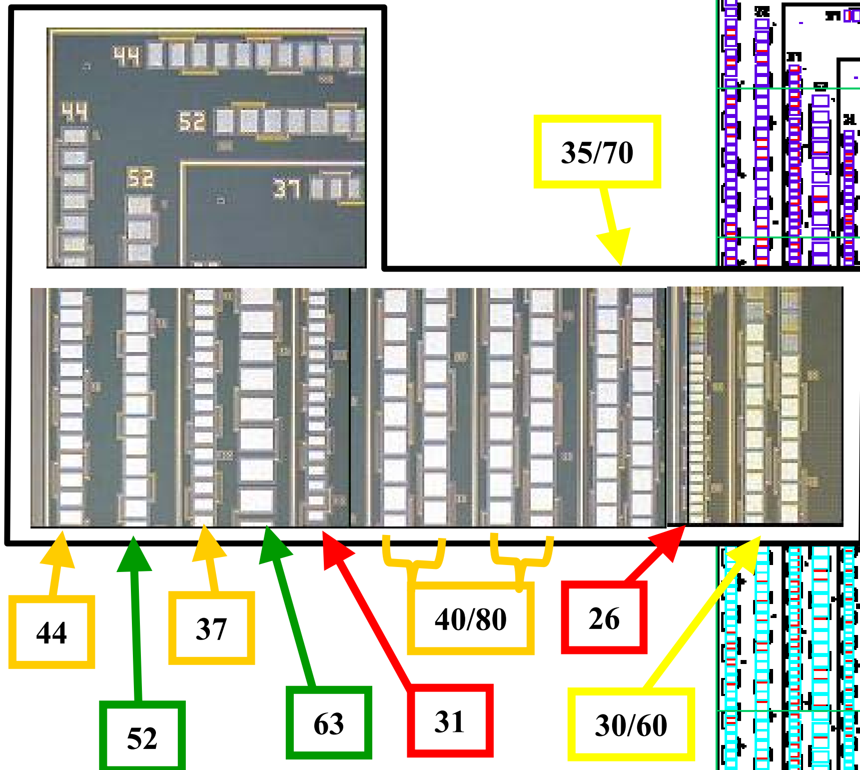
Probe 44µm Product at NPI Test Site

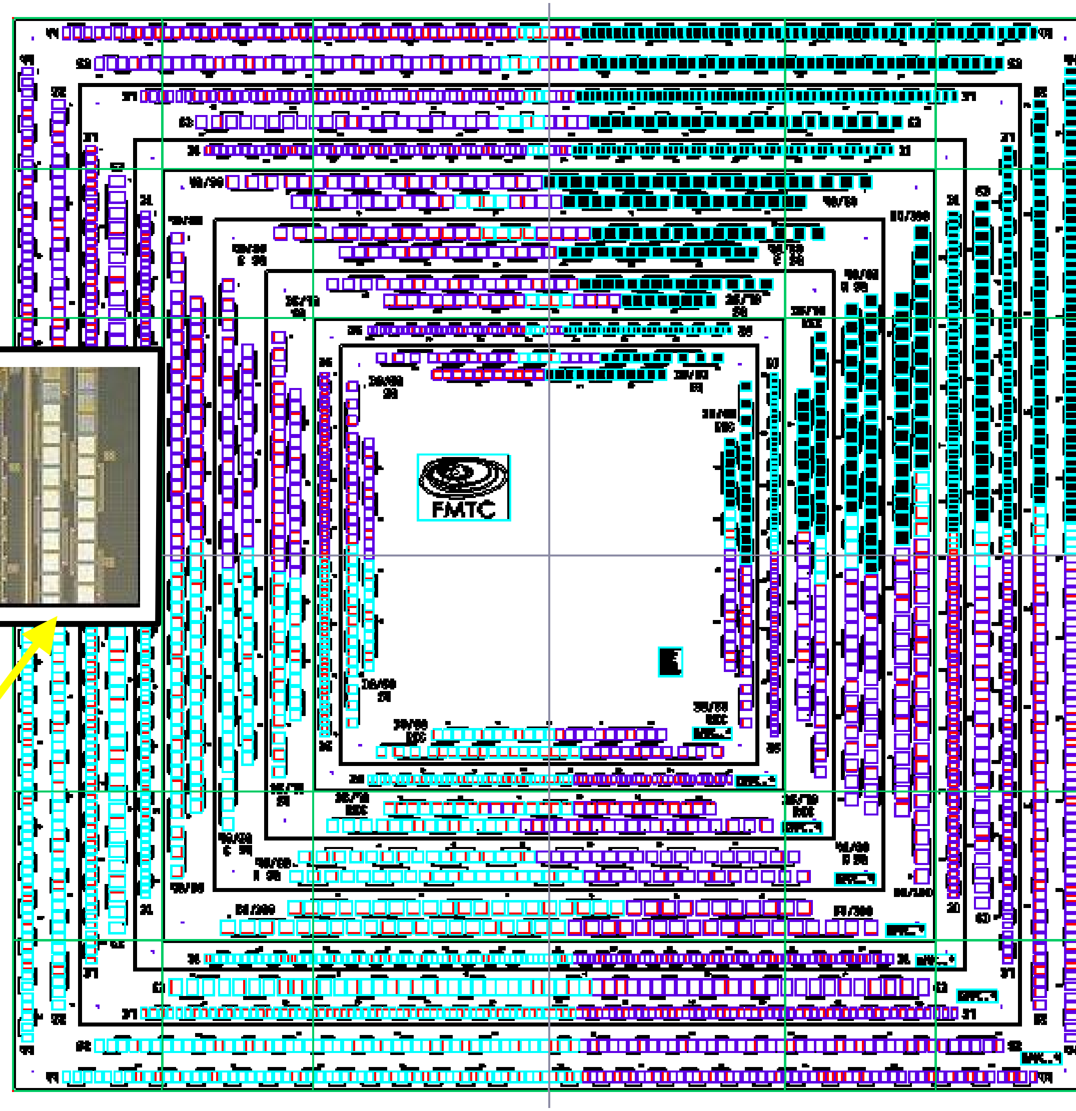
NPI Probe

FMTC Probe

Qualify New Product

- Verify probe recipe on new real product wafers (and daisy chains)
  - Probe yield, Bin switching, Gage R&R etc.
  - Probe damage assessments, acid dip tests
  - Probe wafers for assembly verification





L21C Test Chip

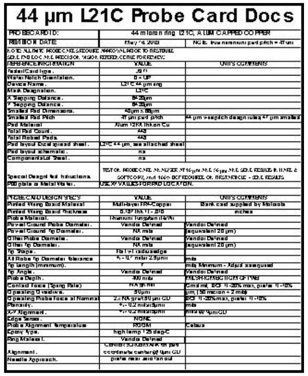
63, 52, 44, 37, 31, 26 inline

50/100, 40/80, 35/70, 30/60 staggered

44 µm = 448 pads @ 40µm x 66µm

Fine Pitch Probe Process Development:

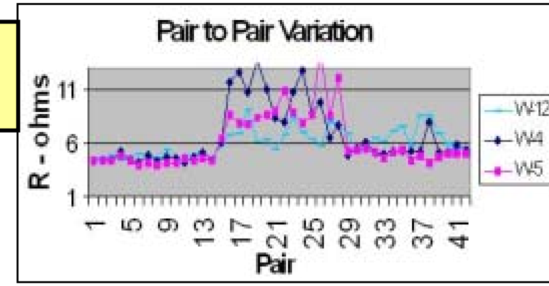
Fine Pitch, Alum Capped Copper and Direct Probe on Copper



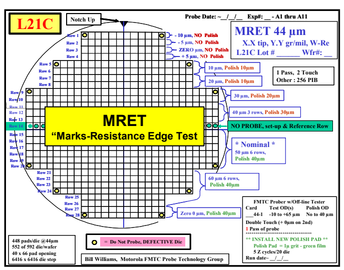
Step 1.) Define & Obtain Probe Hardware

~125K resistance data points / L21C wafer

Step 4.) Electrical Test & Contact Resistance

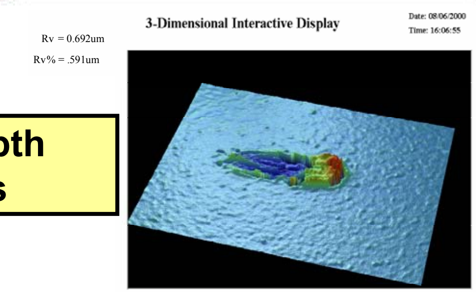


2.) Prep DOE and Probe Wafers



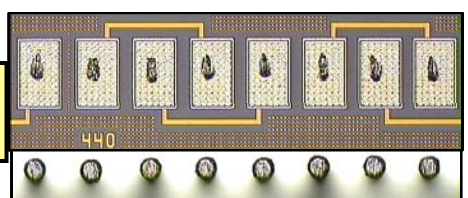
5.) Scrub Size & X-Y Cpks

Scrub Length Process Capability	Cp	CpK	Min Pad L	Delta Pad
25 Deg-C -S	1.33	1.17	120	+24
25 Deg-C +S	1.84	1.58	92	-4
135 Deg-C -S	1.06	0.67	171	+75
135 Deg-C + S	1.80	1.55	94	-2



6.) 3-D Depth Analysis

3.) Photo doc Scrubs & Probes



44 µm

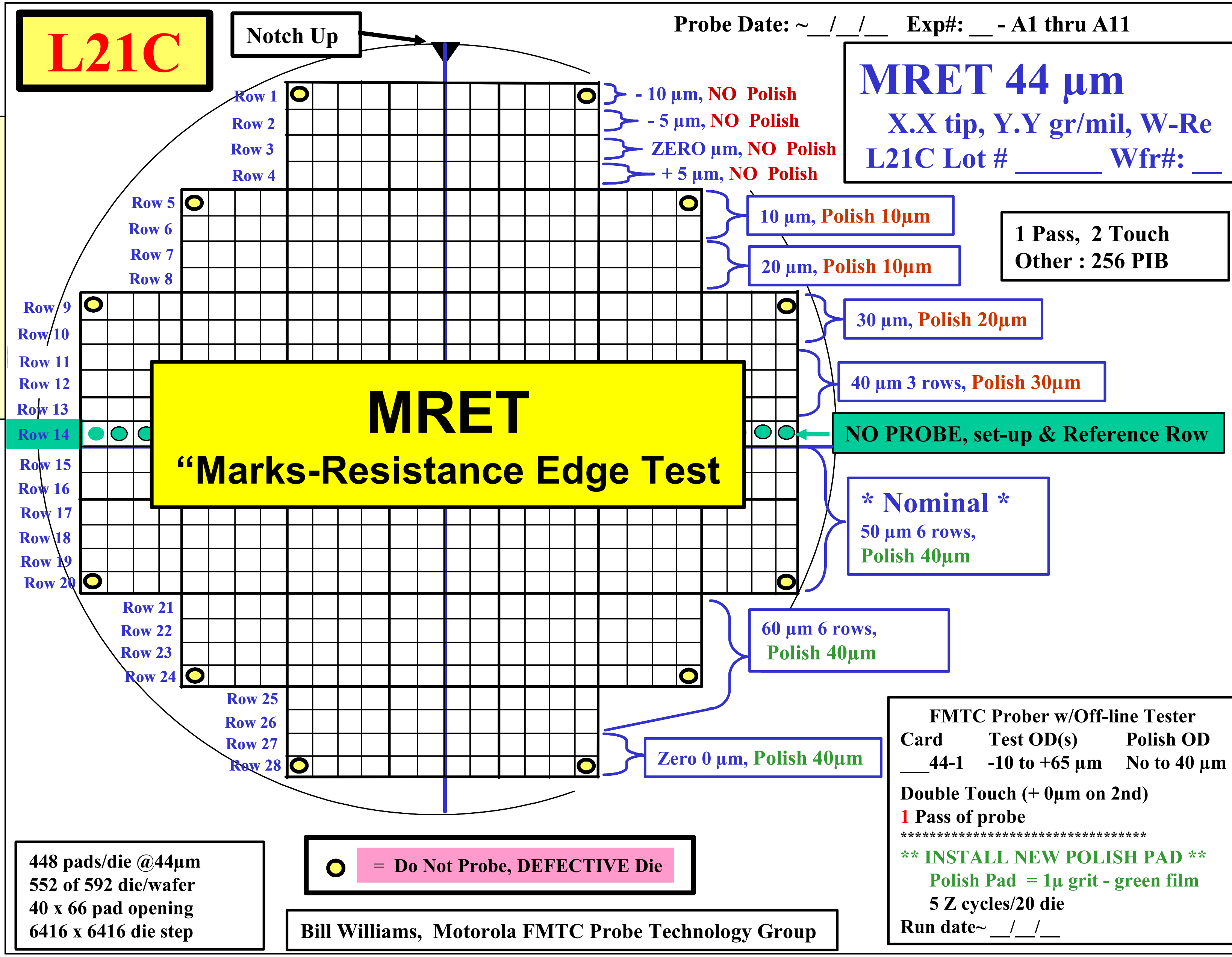
~ 1600 Photos/5Wfr-DOE

Acid Dip Testing

7.) Transfer Recipe, Process & Methods to Production Site

Sample Probe Map MRET

"Marks Resistance Edge Test"



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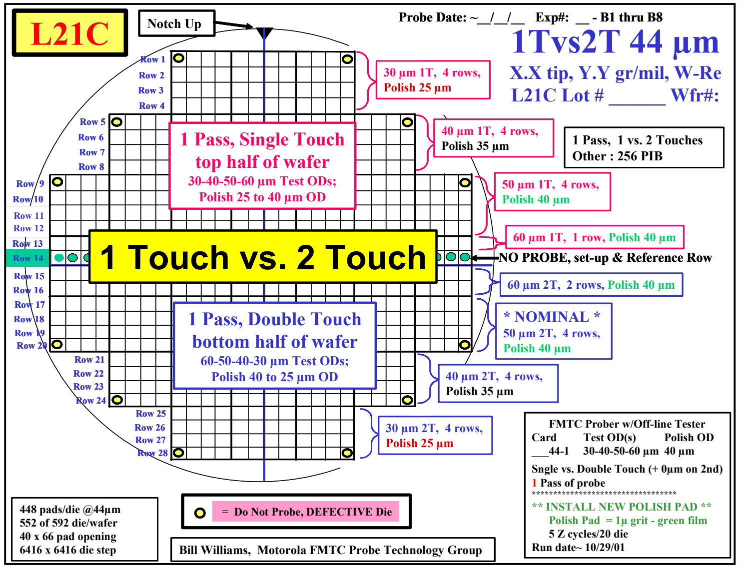
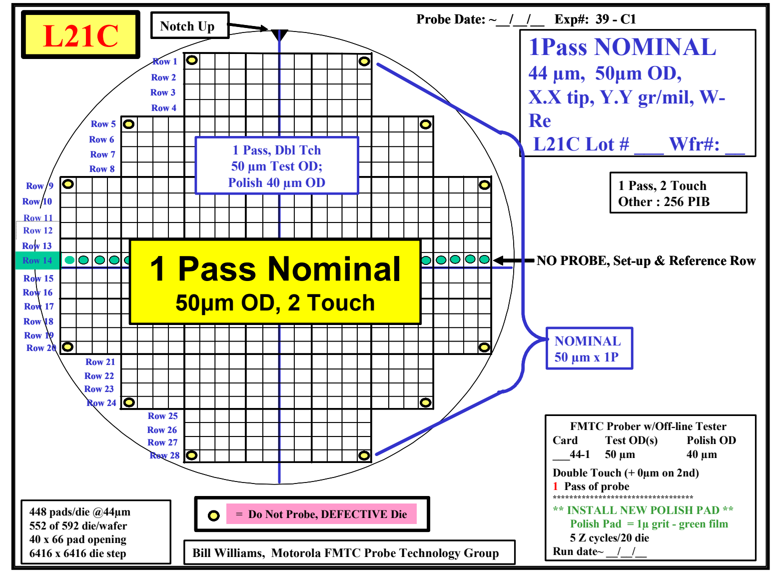
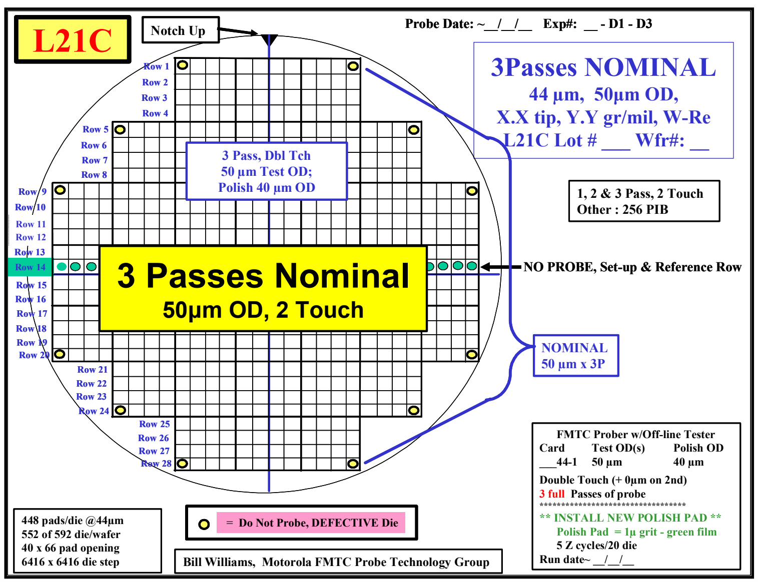




4 Other Maps: 1T vs. 2T, 1Pass Nominal, 3 Pass Nominal, 1-6Pass Heavy60, + MANY Assembly Wafers 1&3P



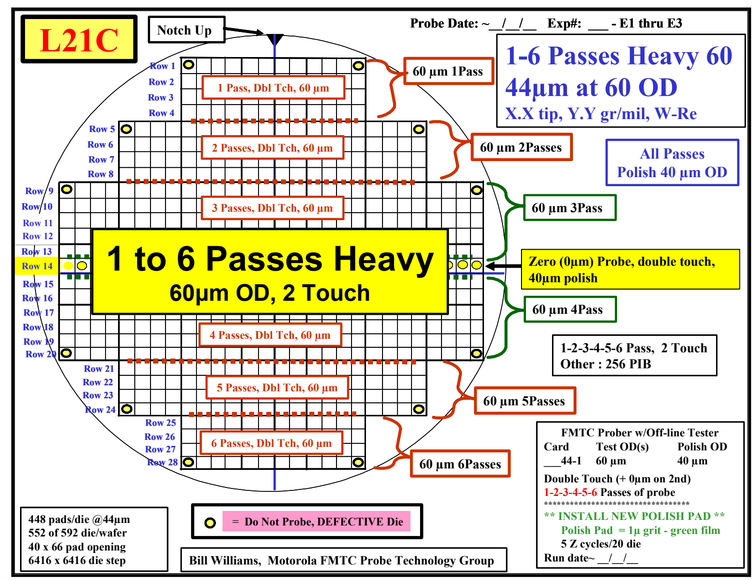


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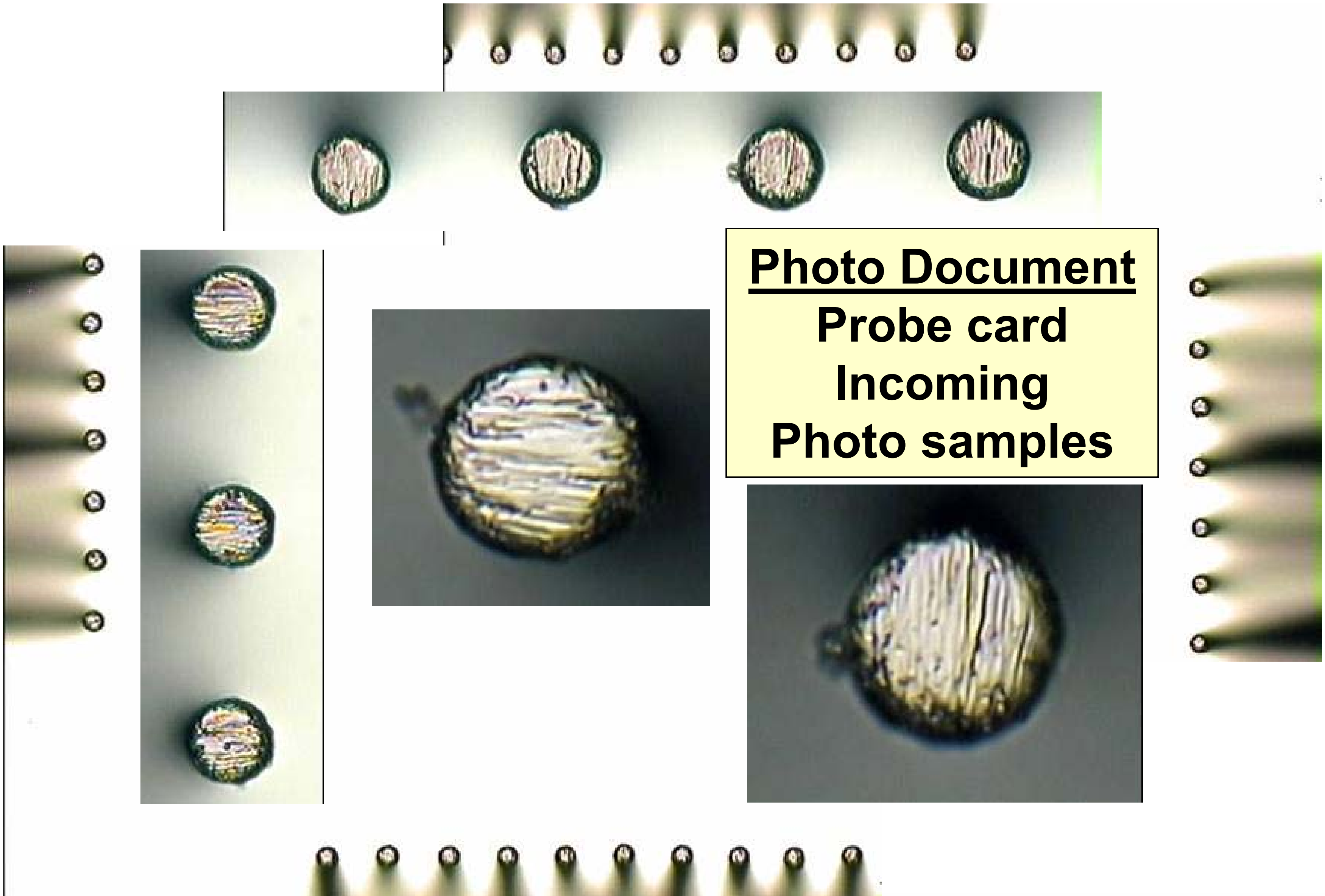
Photo Document
Probe card
Incoming
Photo samples



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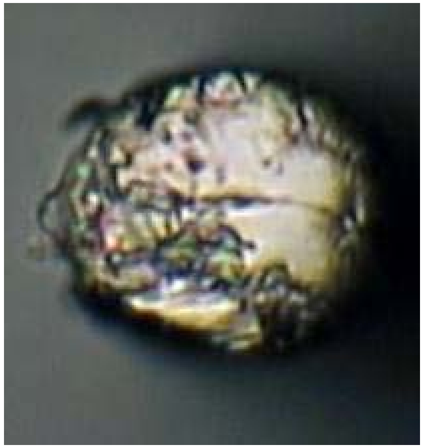
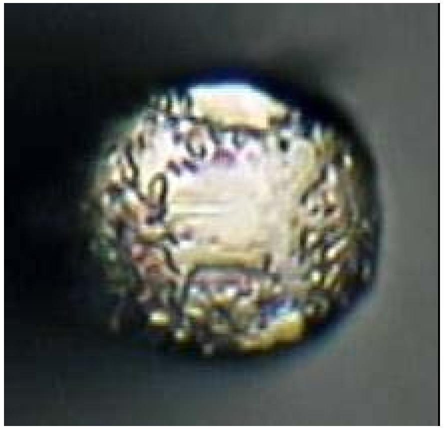
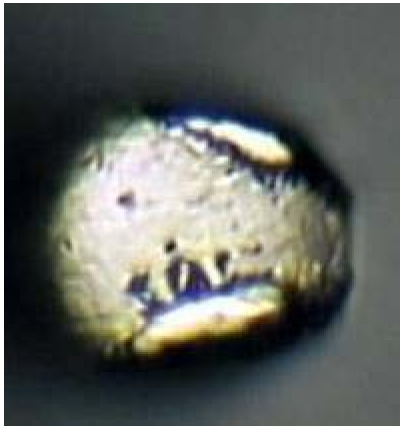
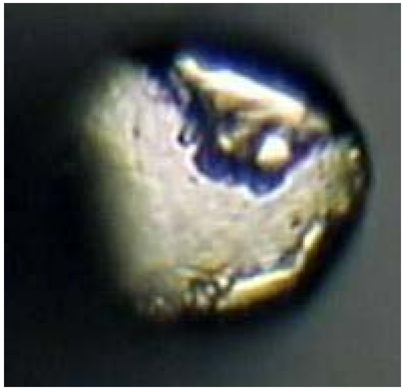
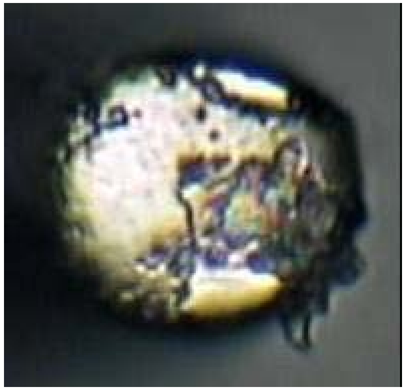
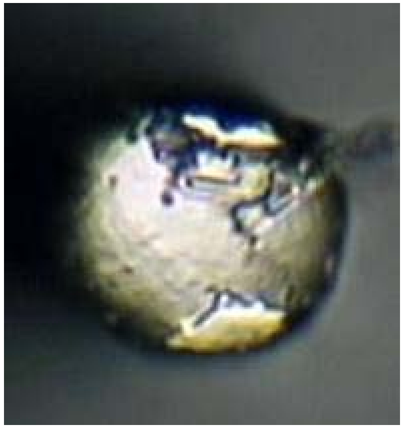
Probe card Incoming Photo samples

Pre probe card photo(50X) - Tip Quality Issues

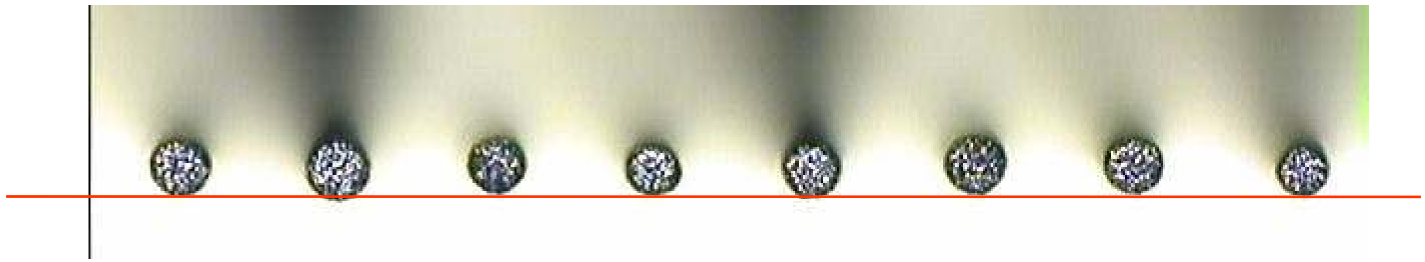







44um Pre-Probe Alignment Comparison - Free State

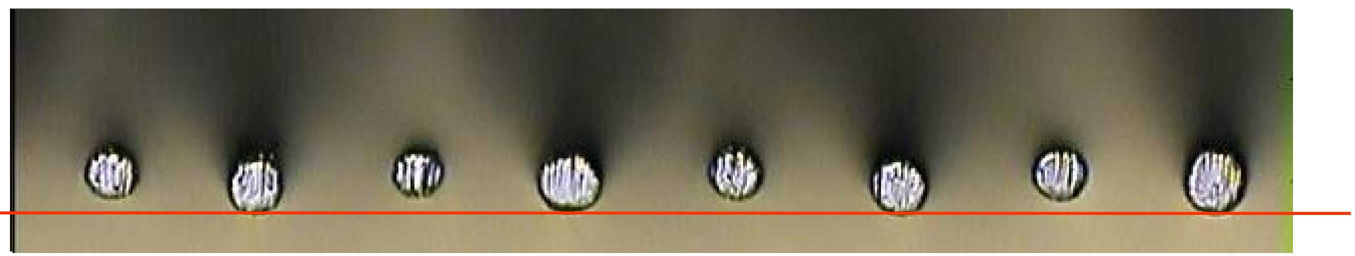
Photo Document
Probe photos
w/ Comparisons

Key Responses:
- Probe X, Y and Z Placement
- Tip Diameter & Shape Variations

Company A



Company B



Company C

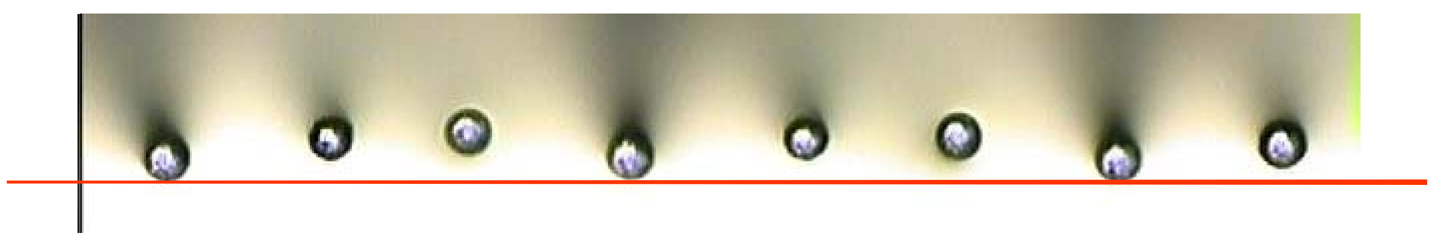


Photo Document Scrub Photos w/ Comparisons

Key Responses:
- Scrub Placement Pad to Pad
- Scrub Uniformity Tier to Tier

Scrub Alignment Comparison

44um Pitch

3 Pass, 2 Touch, 50um OD

= 1/4 of pad Scrub Limit

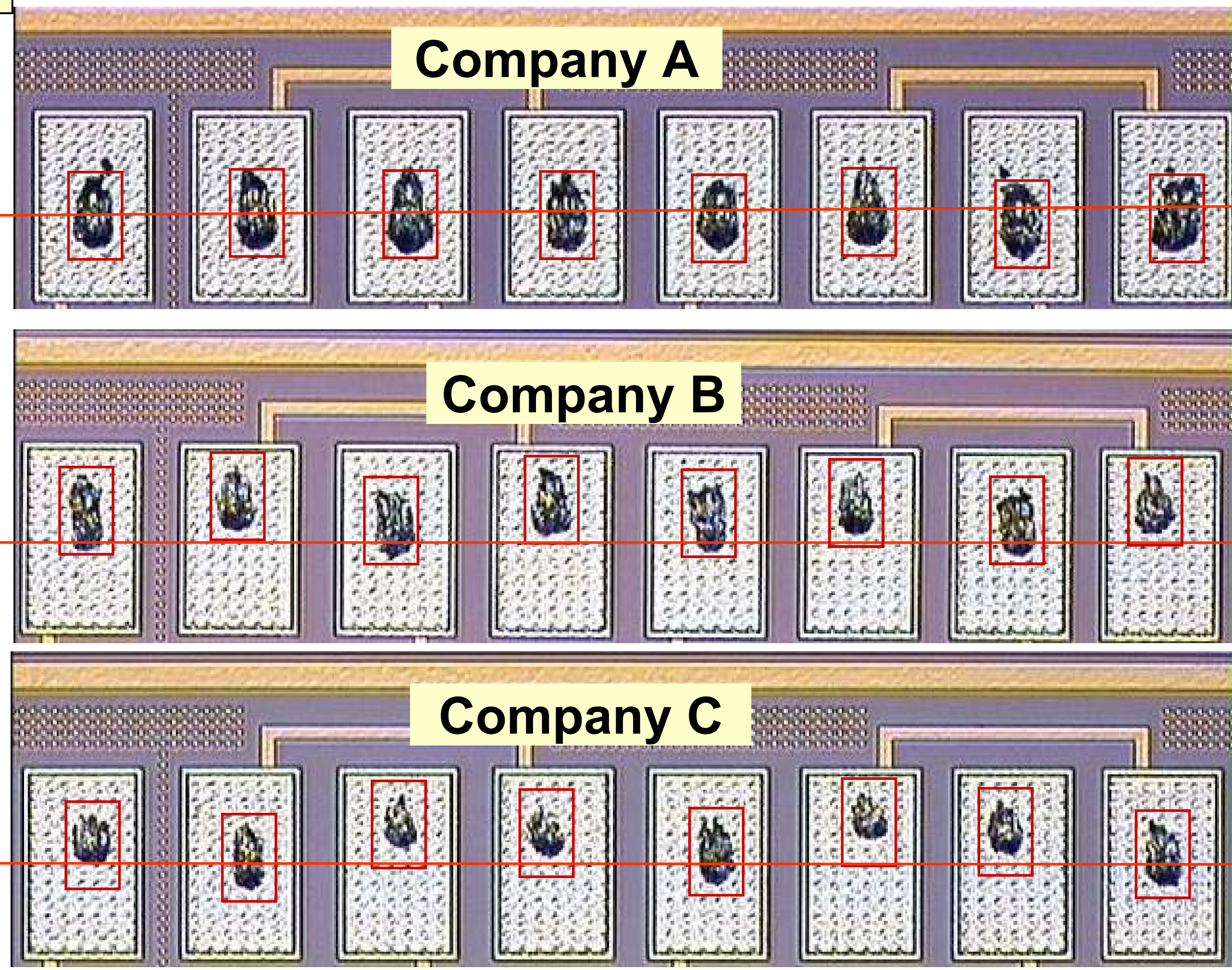
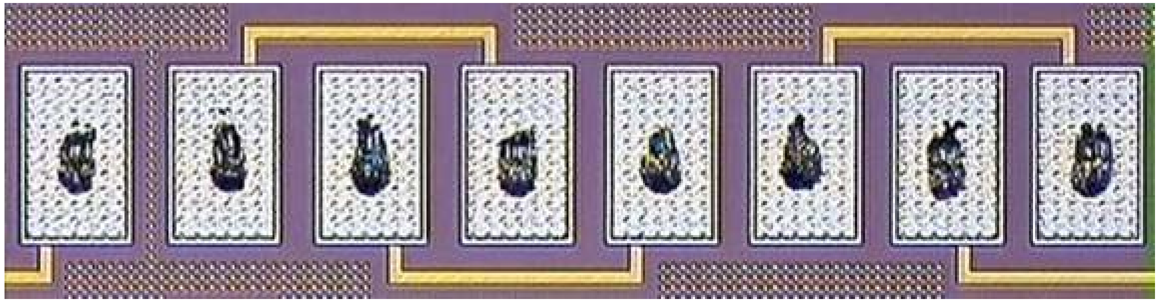
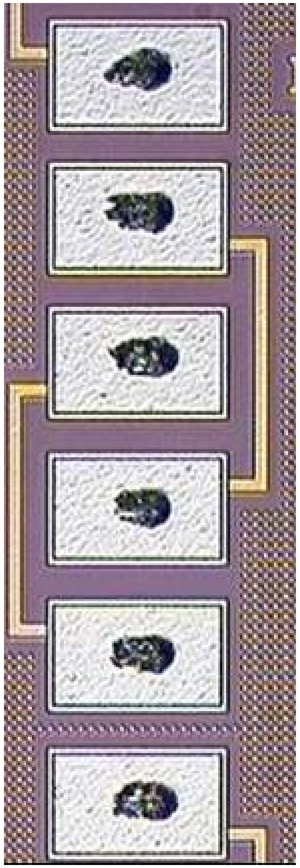


Photo Document
Scrub Photos



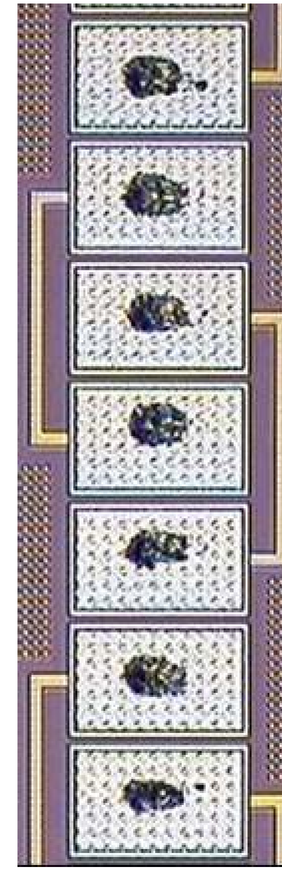


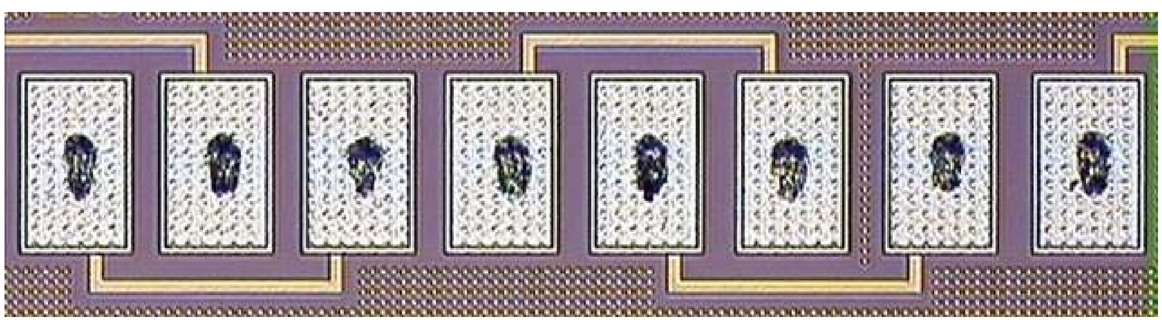
"44 micron Best in Class"

44µm wire pitch w/ 448 pads @40µm x 66µm

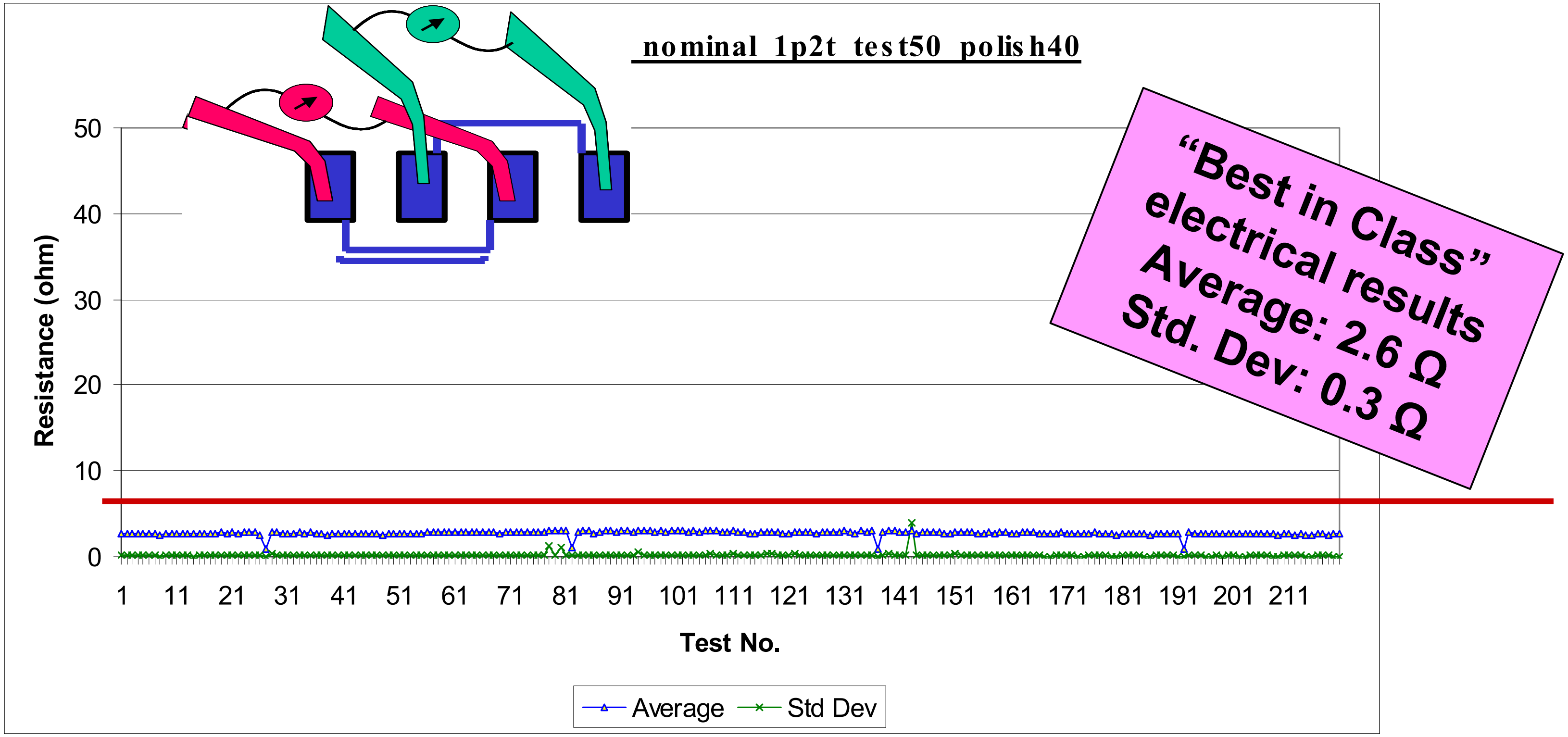
3 full passes of double touch probe

Y Cpk > 1.57!





44 µm x 448 pads “Best-In-Class” Electrical Data
1 Pass – 2 Touch – Nominal 50µm



Average: 2.6 Ω
Std. Dev: 0.3 Ω

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Electrical Data Comparisons - Full Path Resistance

44um Pitch 1 Pass, 2 Touch, 50um OD

Key Electrical Responses:

- Pad-Pair Path Resistance
- Standard Deviation

Company A

	A	B	C	D	E
113					
114	Average:=	2.607807			
115	Stdev.:=	0.270834			

DataSheet

Company B

	A	B	C	D	E
90	Average:=	2.683533			
91	Stdev.:=	0.447946			
92					

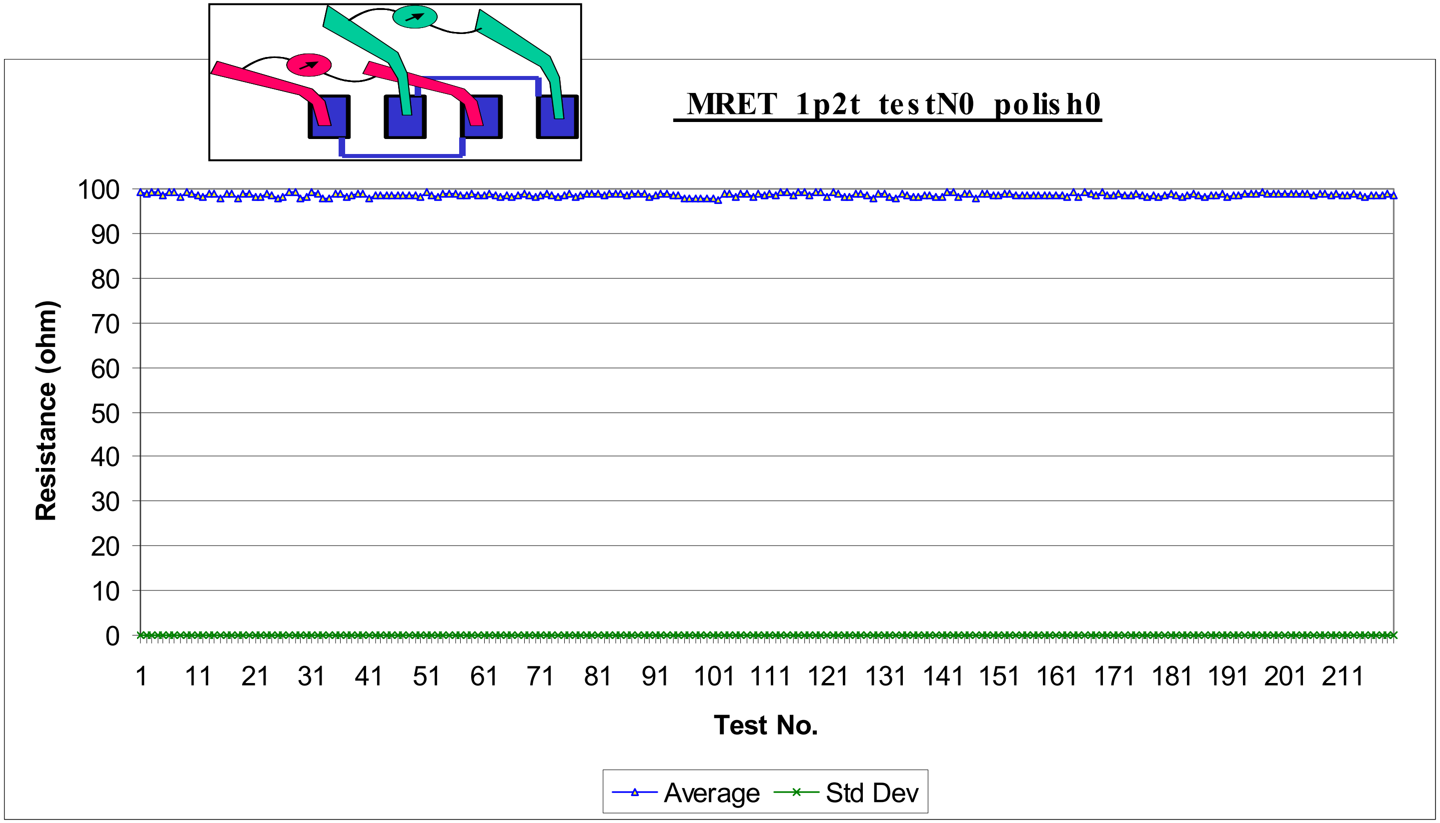
DataSheet

Company C

	A	B	C	D	E
38	Average:=	3.660059			
39	Stdev.:=	0.507779			
40					

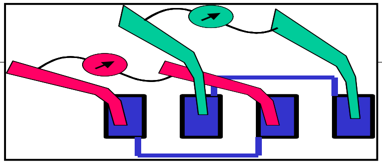
DataSheet

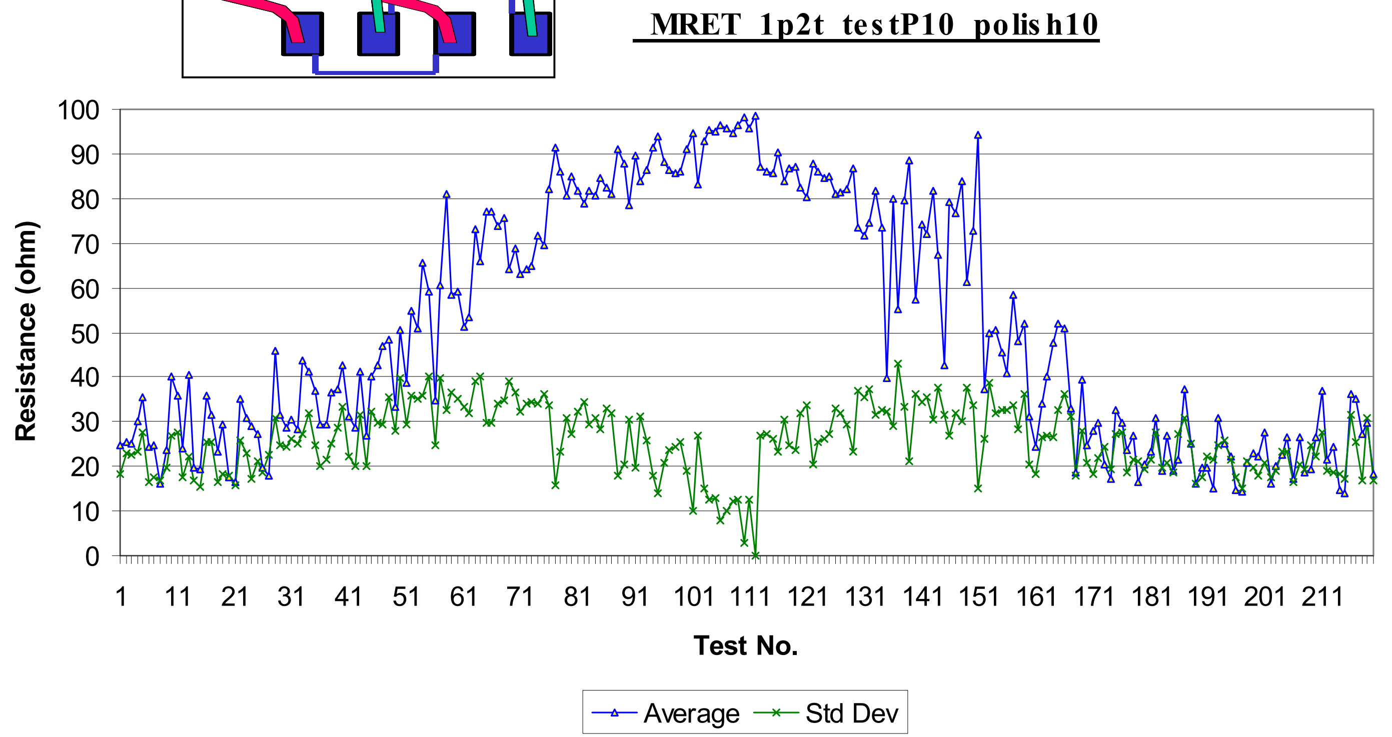
MRET Electrical Data 0 1st Zero Overdrive
Marks-Resistance Edge Test
1 pass - 2 touch - 0 µm Over Drive



Average: 98.6 Ω
Std. Dev: 0.4 Ω

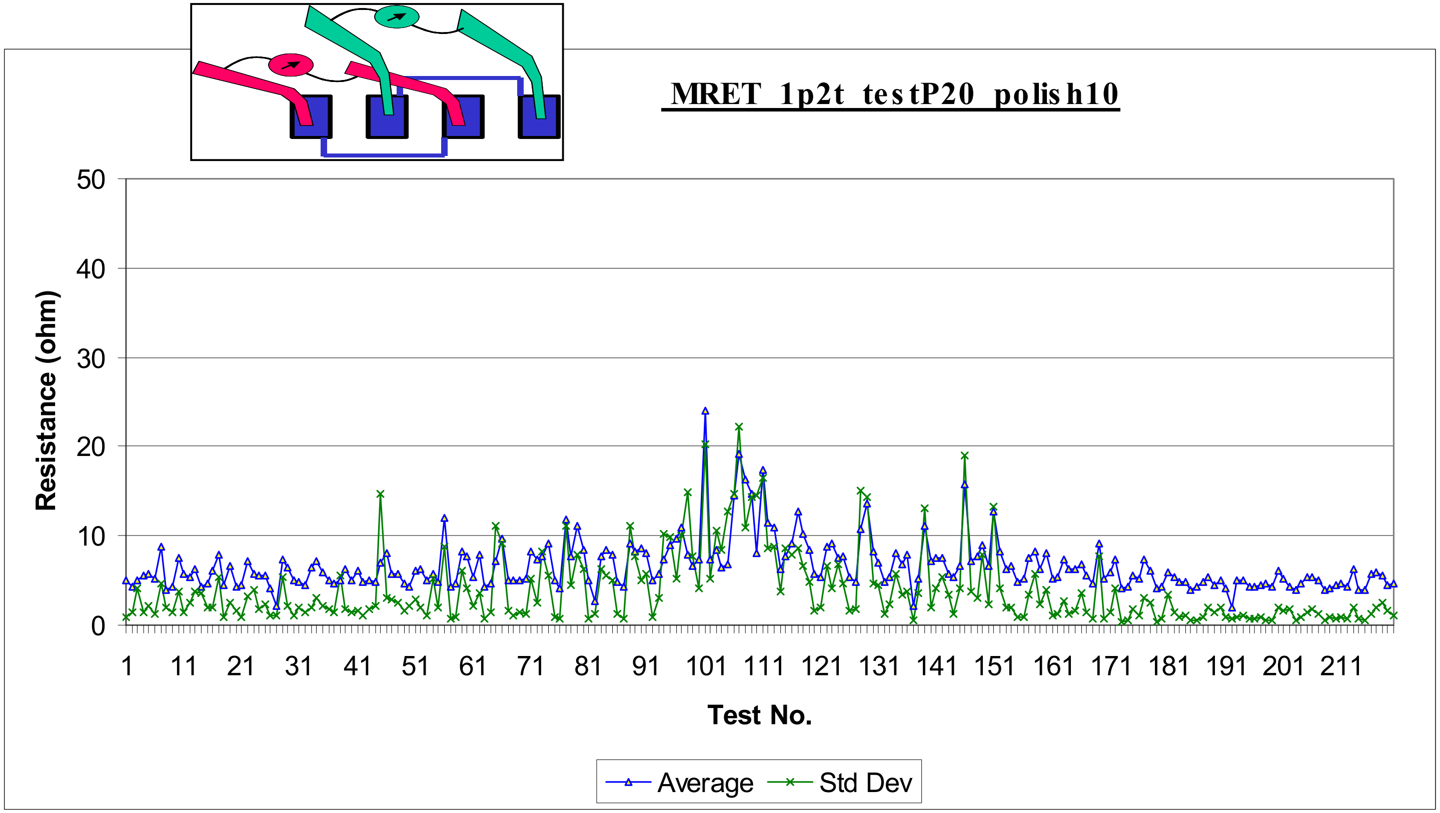
MRET Electrical Data 10µm Overdrive
"Marks-Resistance Edge Test"
1 pass - 2 touch - 10 µm Over Drive





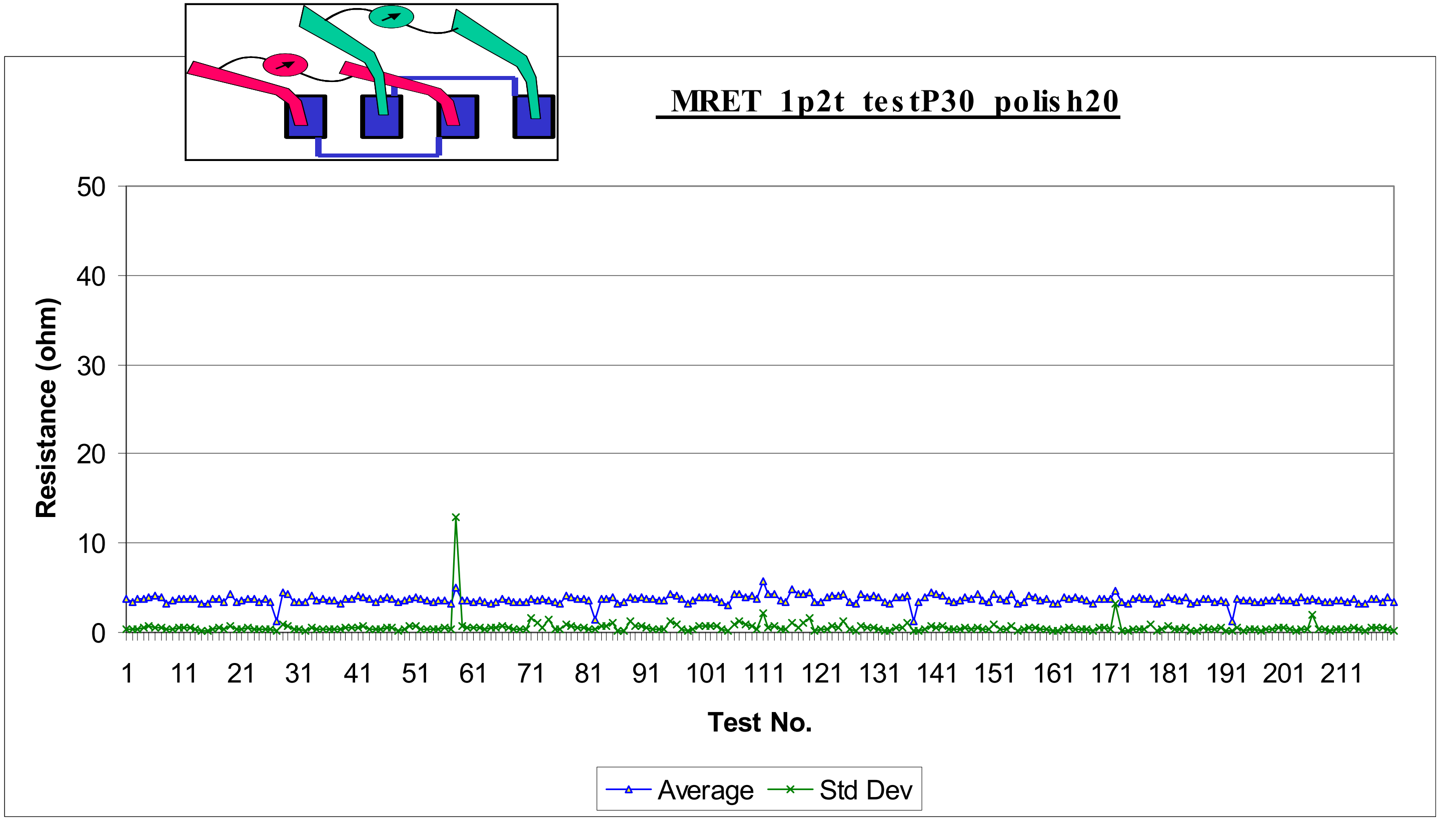
Average: 51.8 Ω
Std. Dev: 37.7 Ω

MRET Electrical Data 20µm Overdrive
Marks-Resistance Edge Test
1 pass - 2 touch - 20 µm Over Drive



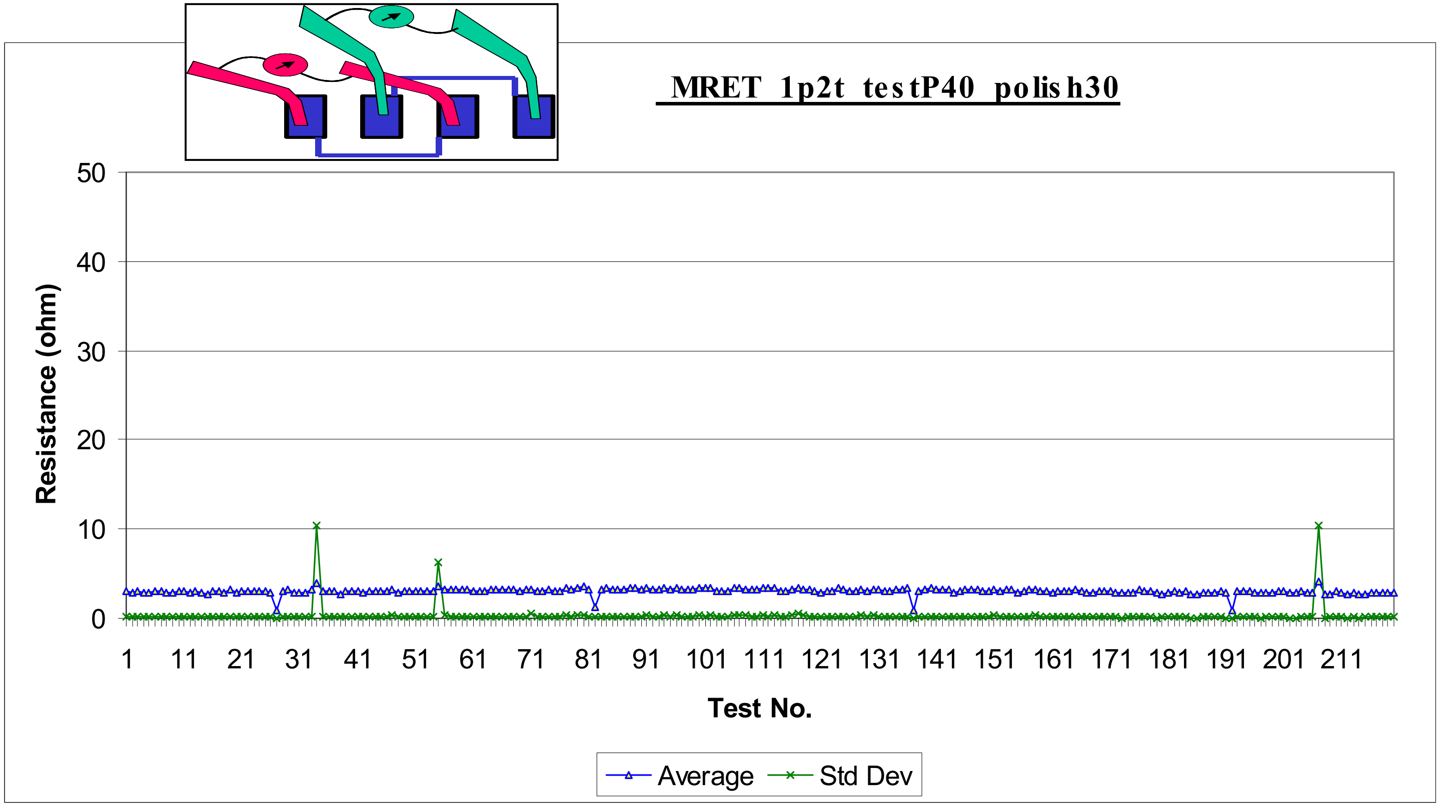
Average: 6.6 Ω
Std. Dev: 6.2 Ω

MRET Electrical Data 30µm Overdrive
Marks-Resistance Edge Test
1 pass - 2 touch - 30 µm Over Drive



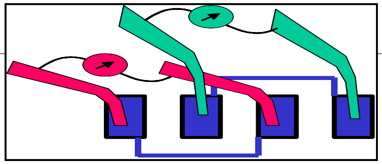
Average: 3.7 Ω
Std. Dev: 1.2 Ω

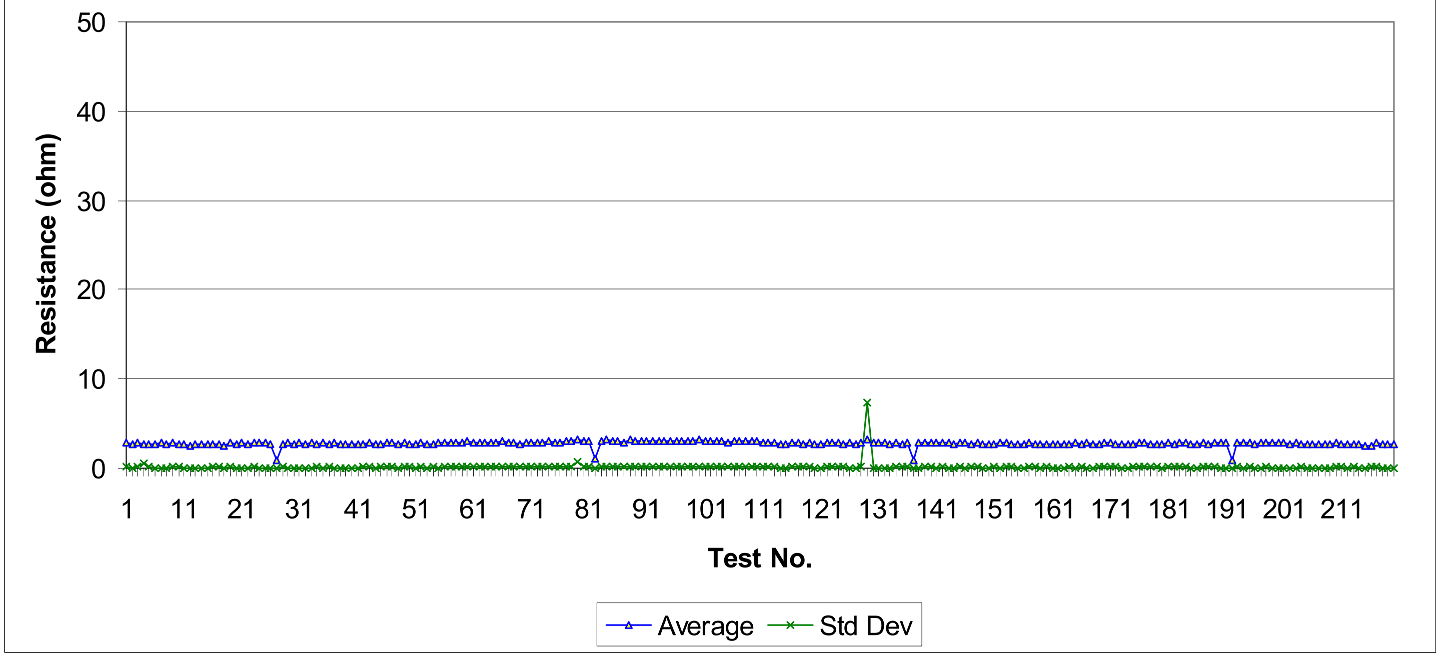
MRET Electrical Data 40µm Overdrive
Marks-Resistance Edge Test
1 pass - 2 touch - 40 µm Over Drive



Average: 3.0 Ω
Std. Dev: 1.1 Ω

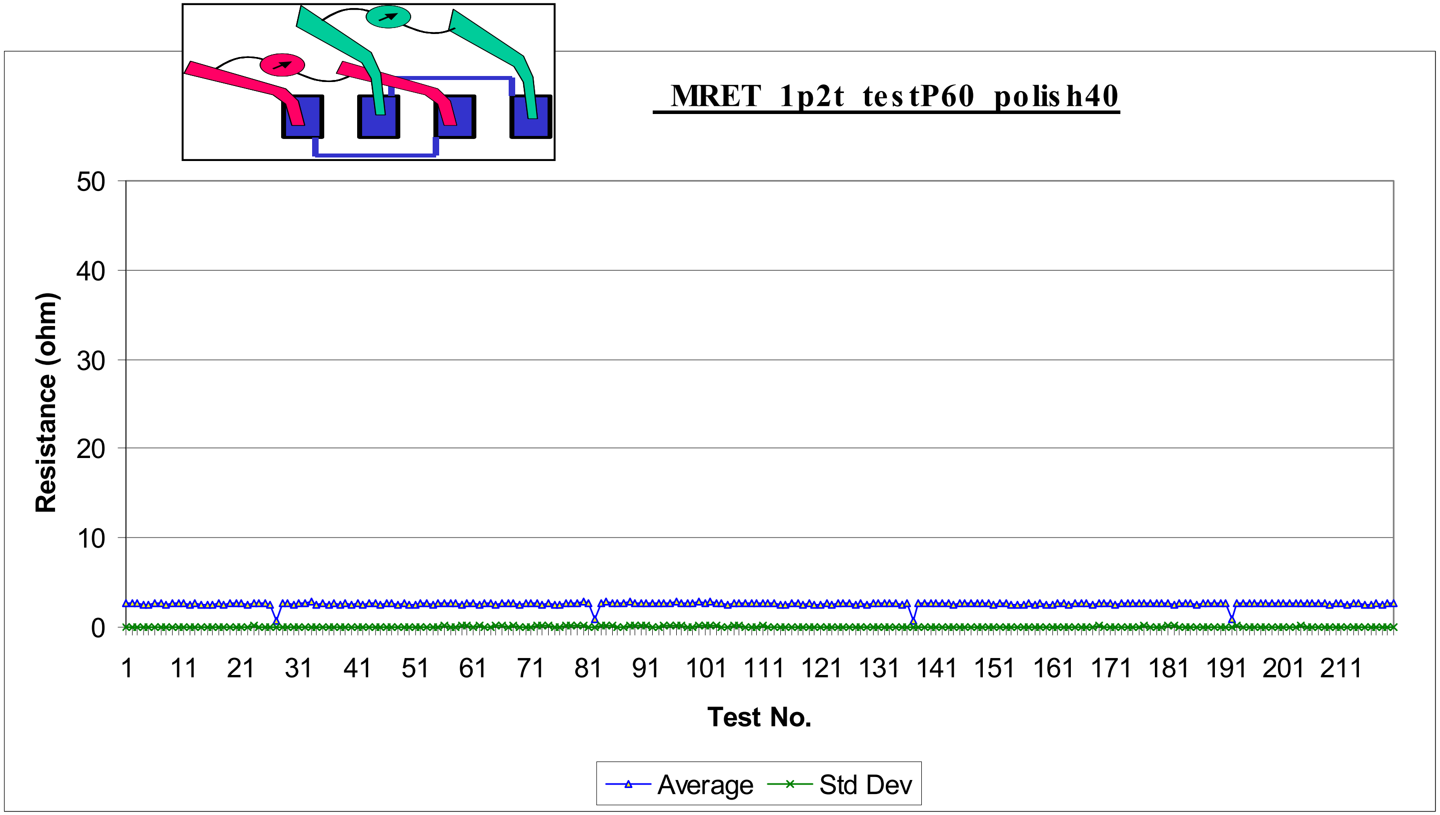
MRET Electrical Data 50µm Overdrive
Marks-Resistance Edge Test
1 pass - 2 touch - 50 µm Over Drive * NOMINAL *





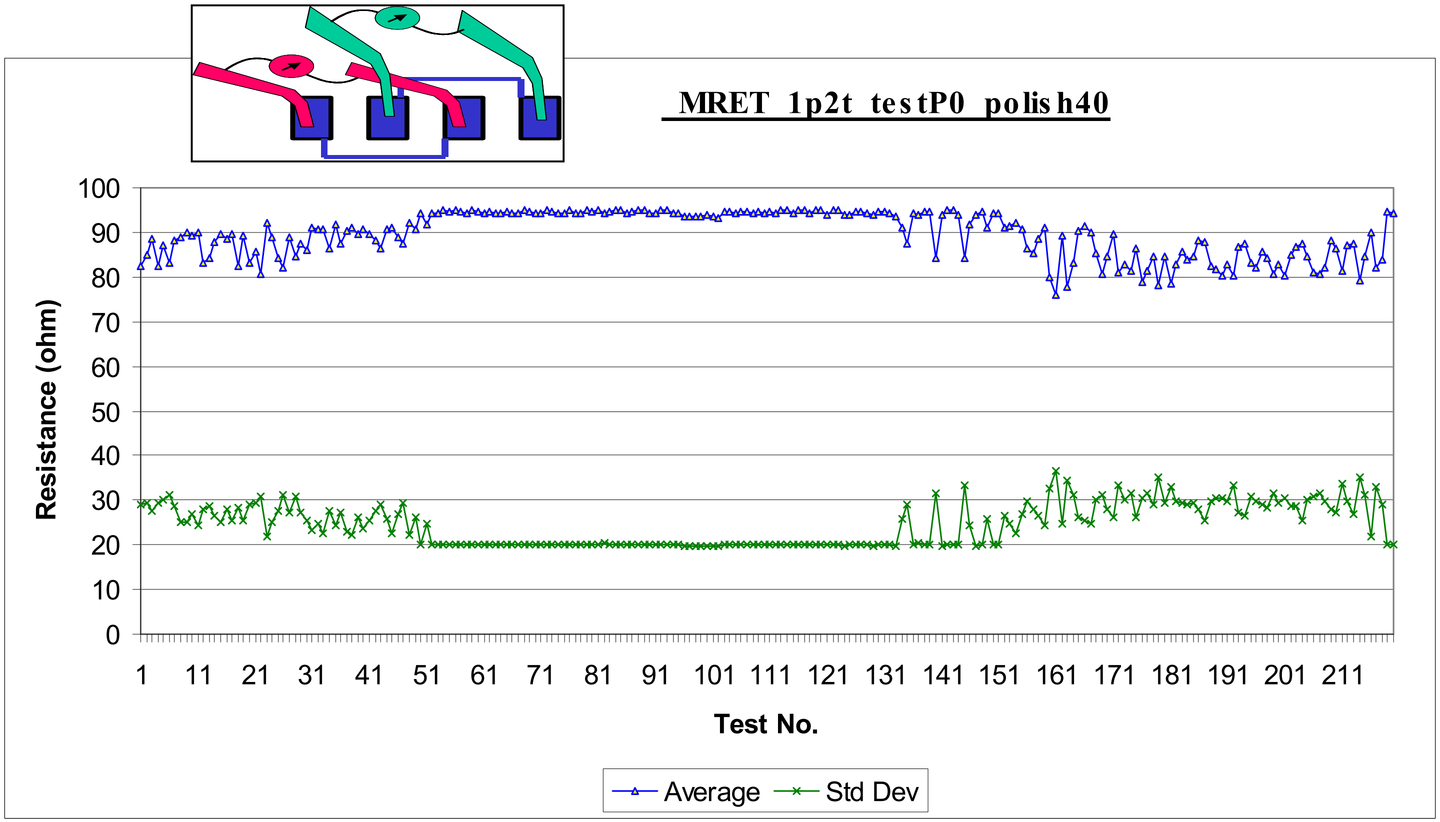
Average: 2.8 Ω
Std. Dev: 0.6 Ω

MRET Electrical Data 60µm Overdrive
Marks-Resistance Edge Test
1 pass - 2 touch - 60 µm Over Drive * Heavy 60 *



Average: 2.6 Ω
Std. Dev: 0.3 Ω

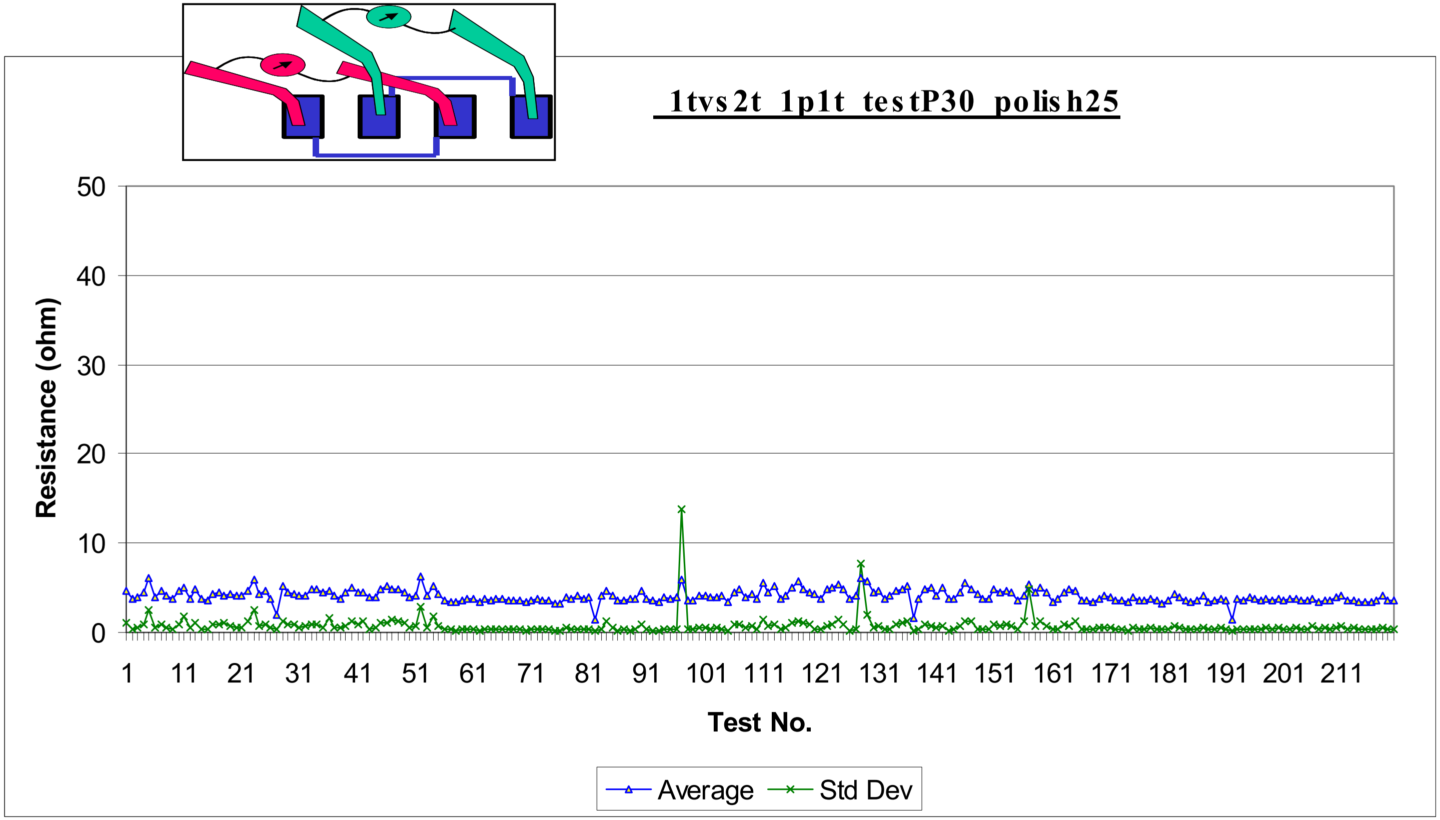
MRET Electrical Data 0 2nd Zero Overdrive
Marks-Resistance Edge Test
1 pass - 2 touch - 0 µm Over Drive



Average: 89.7 Ω

Std. Dev: 25.0 Ω

1T vs. 2T Electrical Data **30 Overdrive**
1 Touch Test
1 pass - 1 touch - 30 µm Over Drive



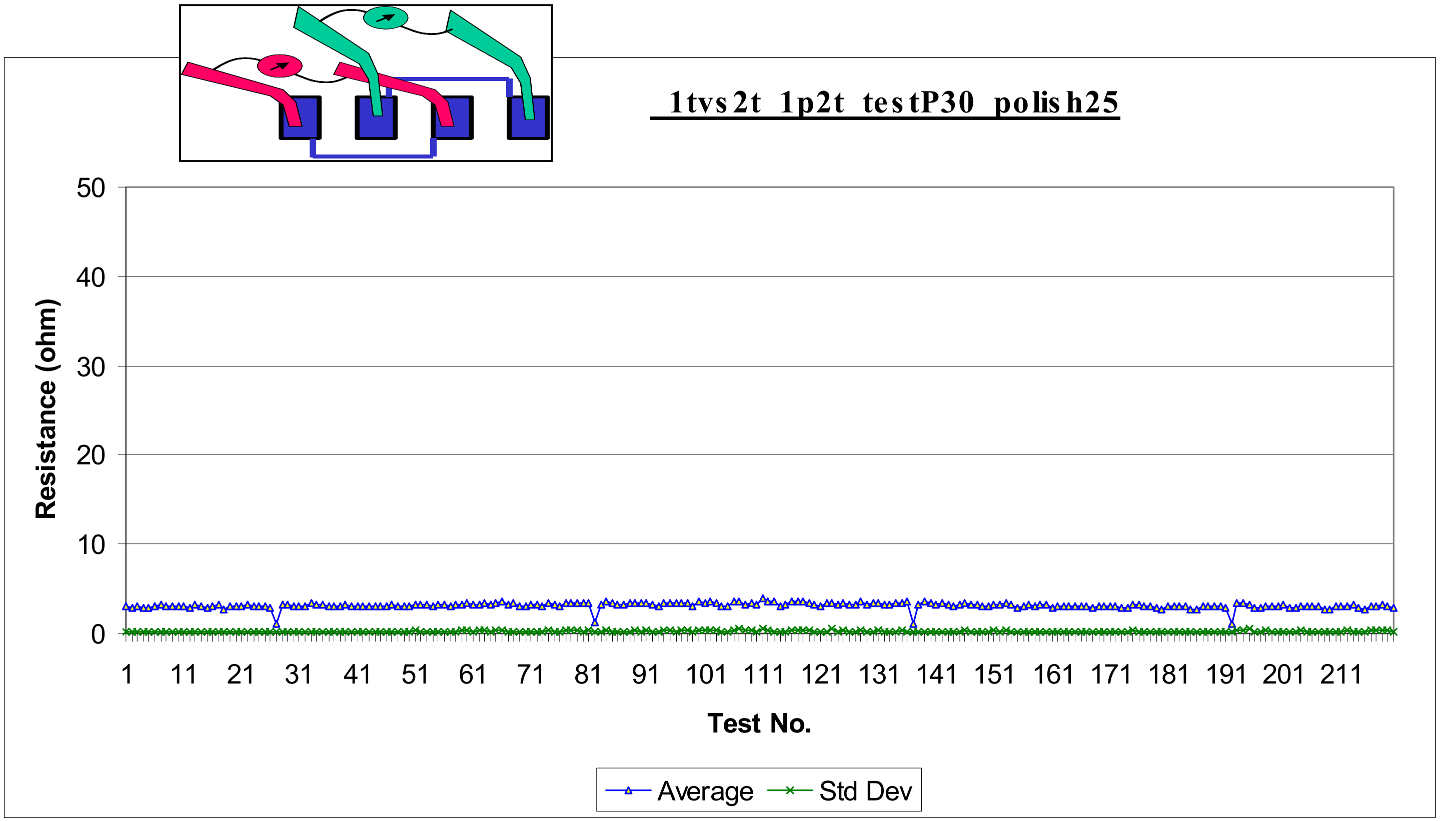
Average: 4.1 Ω
Std. Dev: 1.5 Ω

Note

1T vs. 2T Electrical Data 30 Overdrive

2 Touch Test

1 pass - 2 touch - 30 µm Over Drive



Average: 3.1 Ω

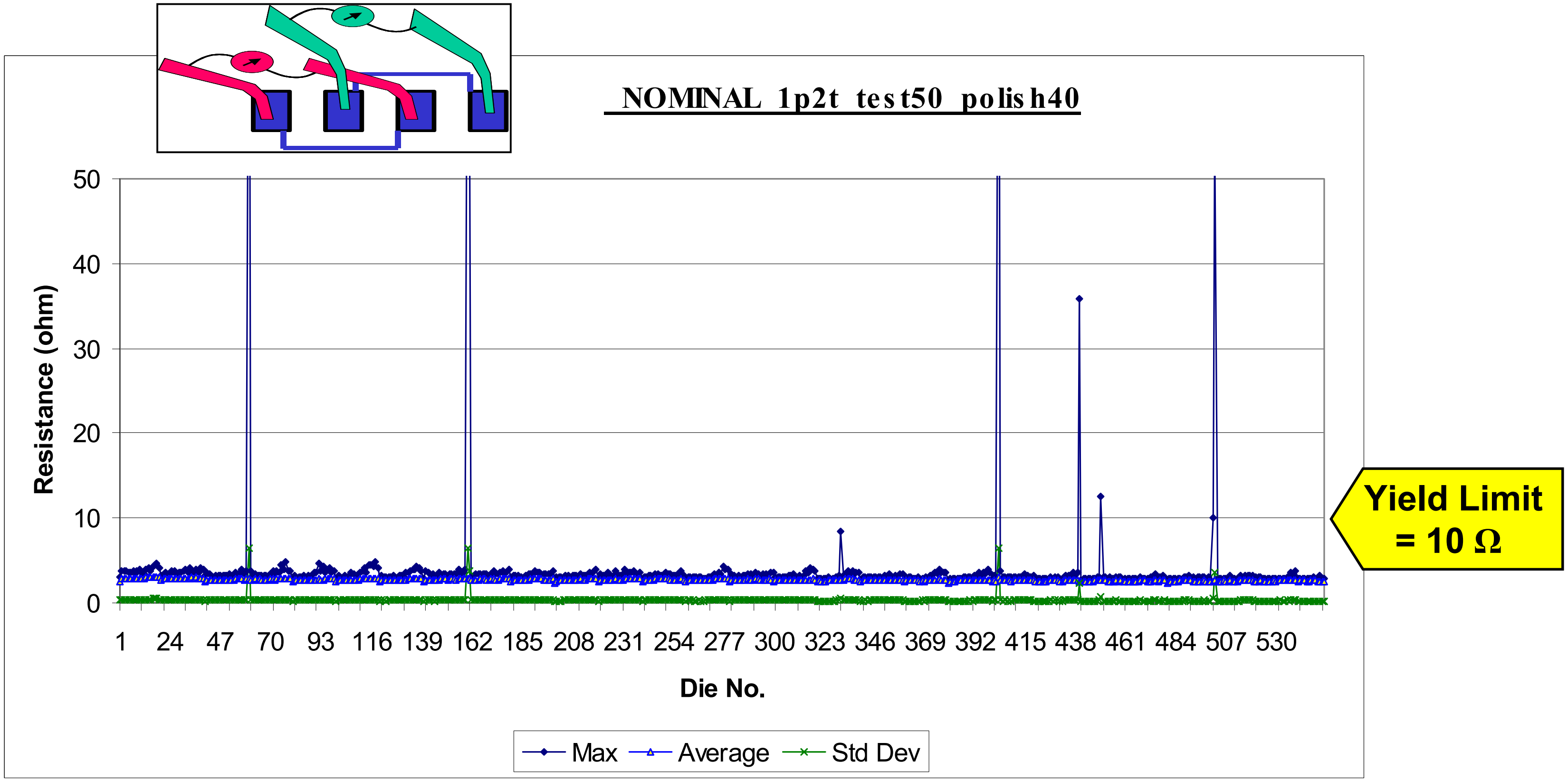
Std. Dev: 0.4 Ω

Note: Δ = 1.0 Ω Ave & Δ = 1.1 Ω SDV

1 Pass Nominal Electrical Data 50 Overdrive

** By Die Results ** 1 Pass Nominal **

1 pass - 2 touch - 50 µm Over Drive



Average: 2.7 Ω

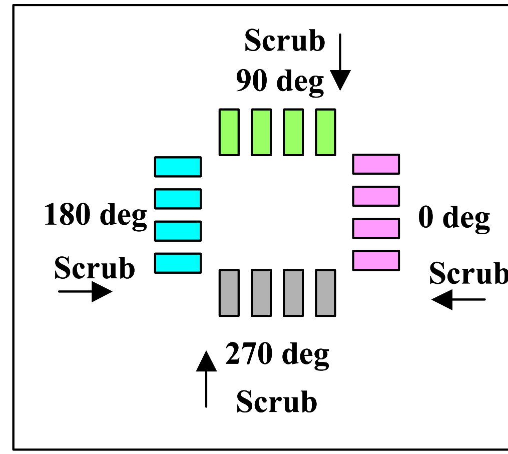
Std. Dev: 0.6 Ω

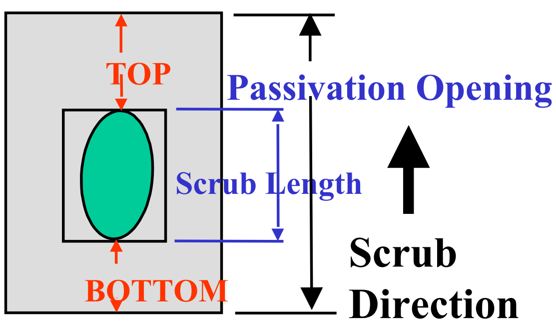
"Probe Process Capability" Monitor

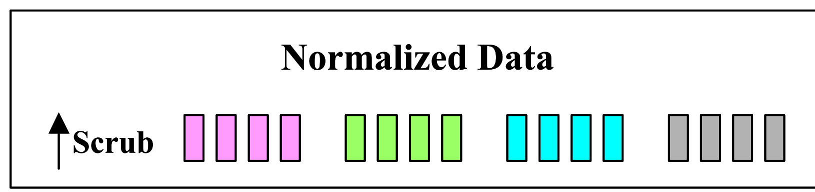
- Scrub data is collected from all four sides of the die. It is rotated so that all pad and scrub mark data are relative.

Cp and Cpk Formula Descriptions

Y C_P = (Spec Width) / (6 Sigma)
Y C_P = $(PO-SL) / (6*(SQRT(SD_{SL}^2+SD_{TE}^2)))$
Y C_{PK} = (Mean - Closer Spec Limit) / (3 Sigma)
Y C_{PK} = $(PO/2-SL/2-TE) / (3*(SQRT(SD_{SL}^2+SD_{TE}^2)))$
PO = Passivation Opening (Length)
SL = Average Scrub Length (PR Scrub Size)
TE = Average Scrub Center Target Error |Top-Bot| / 2
SD_{SL} = Standard Deviation of Scrub Length - SL
SD_{TE} = Standard Deviation of Scrub Target Error - TE







Scrub Mark Size & Placement Capability Comparisons

(1.5 Y-Cpk Target)

Company A

PO = Passivation Opening	66
SL = Average Scrub Length (PR Scrub Size)	28.76
TE = Average Scrub Center Target Error |Top-Bot| / 2	2.10
SD_{SL} = Standard Deviation of Scrub Length - SL	2.91
SD_{TE} = Standard Deviation of Scrub Target Error - TE	1.53
$Y\ C_{PK} = (PO-SL-TE)/(6*(SQRT(SD_{SL}^2+SD_{TE}^2)))$	**1.78**

Company B

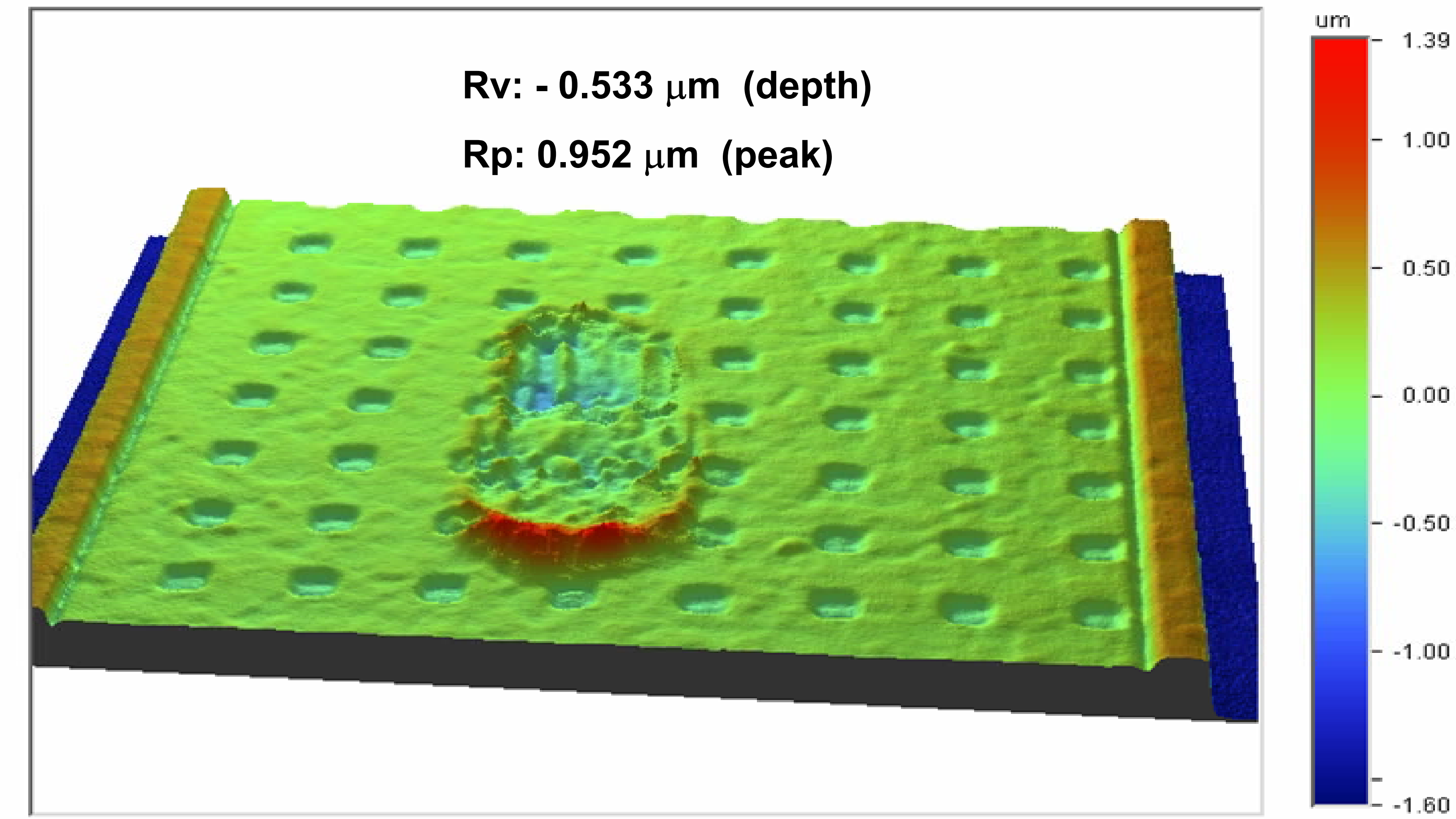
PO = Passivation Opening	66
SL = Average Scrub Length (PR Scrub Size)	26.32
TE = Average Scrub Center Target Error |Top-Bot| / 2	4.28
SD_{SL} = Standard Deviation of Scrub Length - SL	3.77
SD_{TE} = Standard Deviation of Scrub Target Error - TE	3.28
$Y\ C_{PK} = (PO-SL-TE)/(6*(SQRT(SD_{SL}^2+SD_{TE}^2)))$	**1.18**

Company C

PO = Passivation Opening	66
SL = Average Scrub Length (PR Scrub Size)	37.29
TE = Average Scrub Center Target Error |Top-Bot| / 2	3.01
SD_{SL} = Standard Deviation of Scrub Length - SL	4.20
SD_{TE} = Standard Deviation of Scrub Target Error - TE	2.29
$Y\ C_{PK} = (PO-SL-TE)/(6*(SQRT(SD_{SL}^2+SD_{TE}^2)))$	**0.90**

Scrub Mark Depth Analysis
3D Profilometer

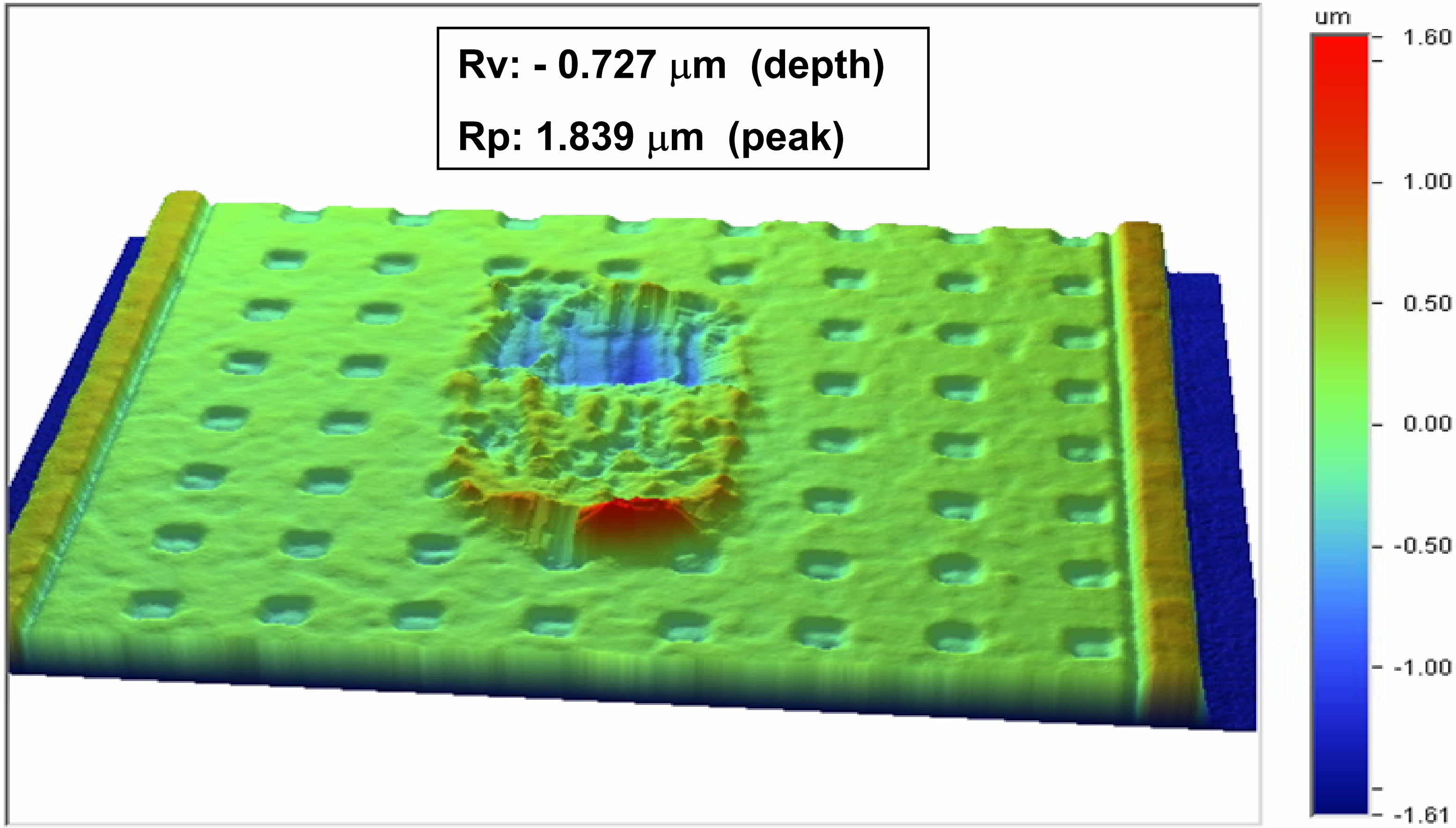
1 Pass 2 Touches 50µm OverDrive



Scrub Mark Depth Analysis

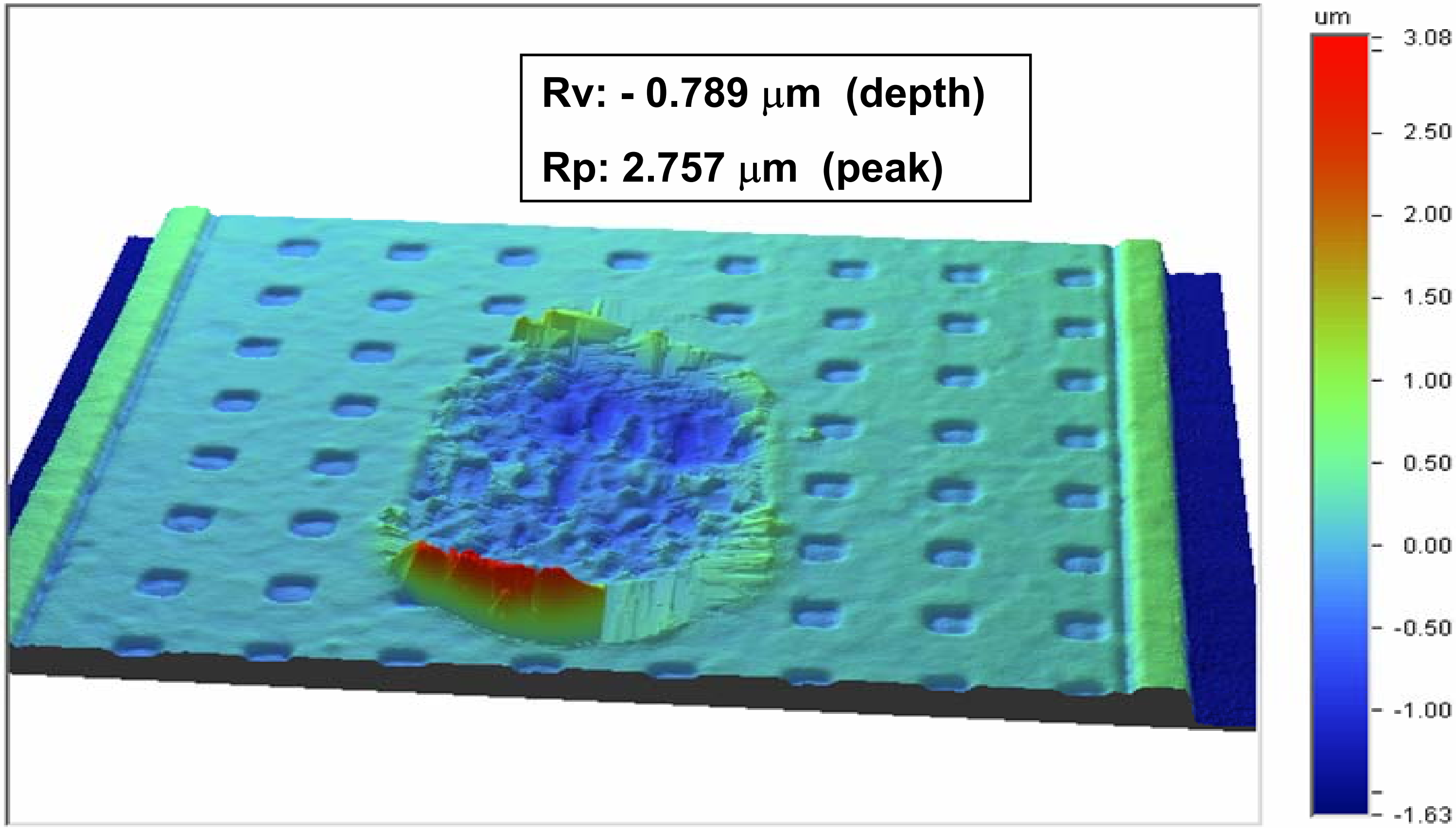
3D Profilometer

3 Passes 2 Touches 50µm OverDrive

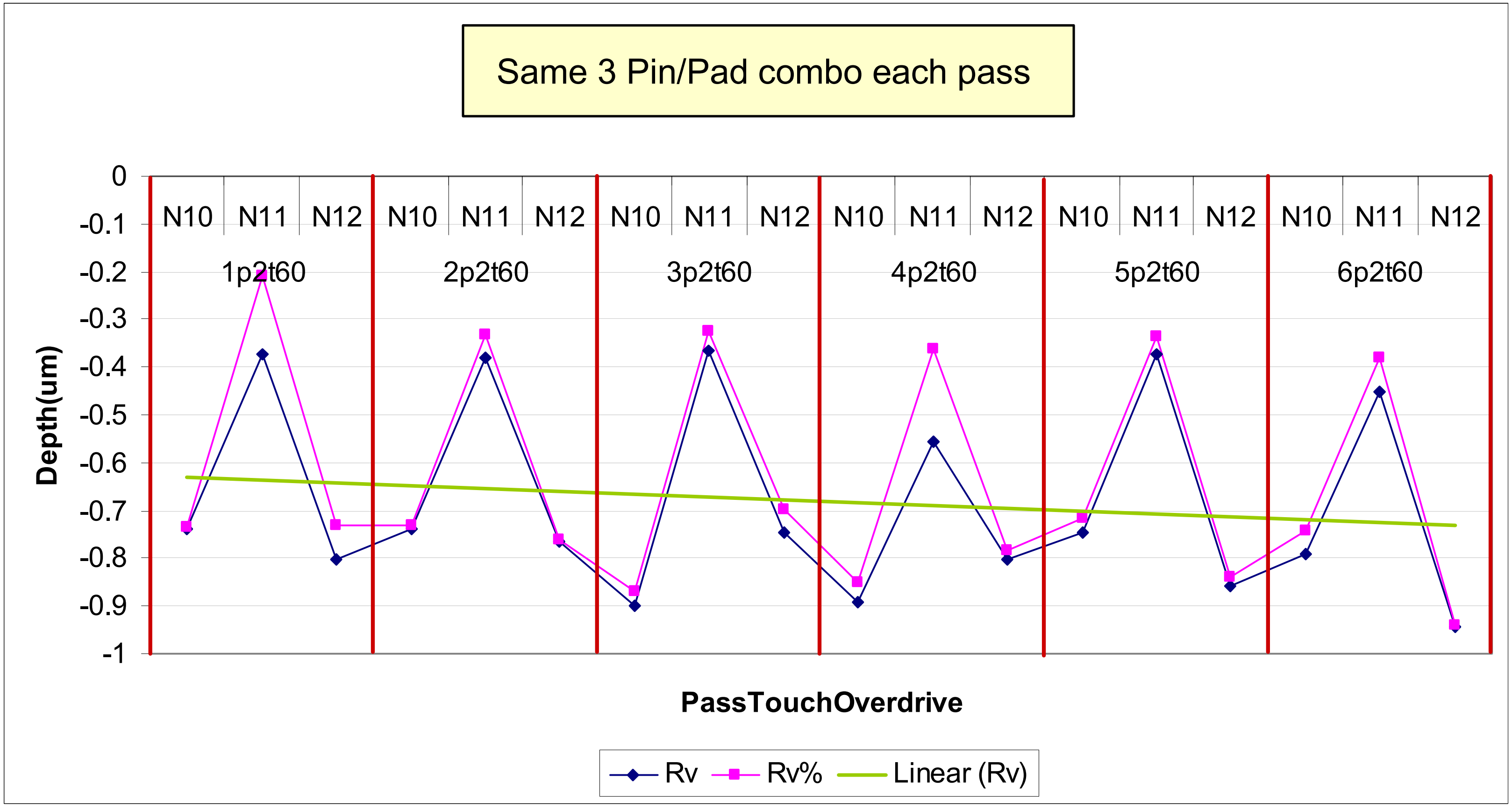


Scrub Mark Depth Analysis
3D Profilometer

6 Passes 2 Touches 60µm OverDrive



Summary of Scrub Mark Depth Analysis Data
6 Passes 2 Touches 60µm OverDrive



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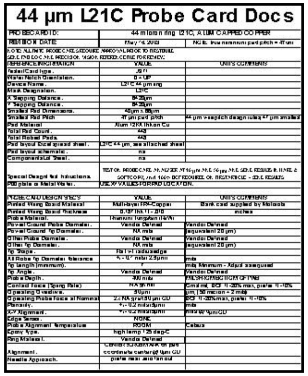
Fine Pitch Probe Process Development:

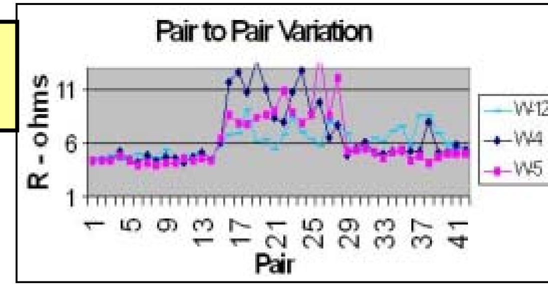
Fine Pitch, Alum Capped Copper and Direct Probe on Copper



Step 1.) Define Probe Hardware

~125K resistance data points / L21C wafer

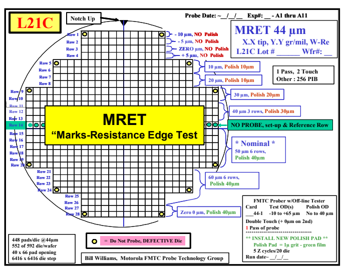
Step 4.) Electrical Test & Contact Resistance

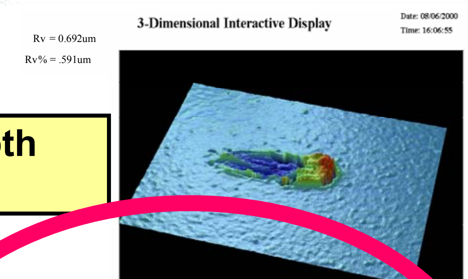


2.) Prep DOE and Probe Wafers

5.) Scrub Size & X-Y Cpks

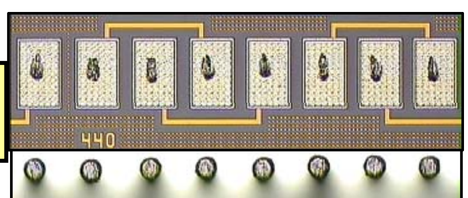
Scrub Length Process Capability	Cp	CpK	Min Pad L	Delta Pad
25 Deg-C -S	1.33	1.17	120	+24
25 Deg-C +S	1.84	1.58	92	-4
135 Deg-C -S	1.06	0.67	171	+75
135 Deg-C + S	1.80	1.55	94	-2





6.) 3-D Depth Analysis

3.) Photo doc Scrubs & Probes



44 µm

~ 1600 Photos/5Wfr-DOE

Acid Dip Testing

7.) Transfer Recipe, Process & Methods to Production Site

A 44µm Probe Process Cx and Factory Deployment using Probe-Over-Passivation
SWTW-2003 Long Beach, Bill Williams Motorola FMTC

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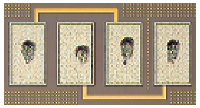
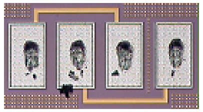
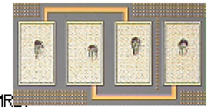
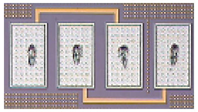
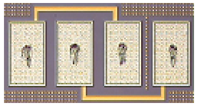
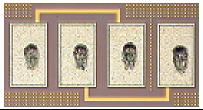
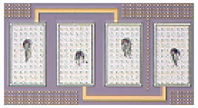
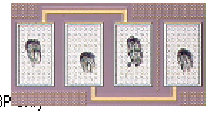
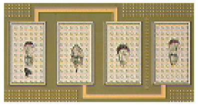
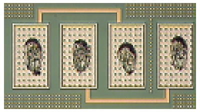
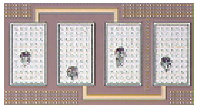
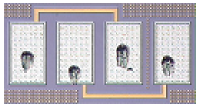
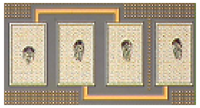
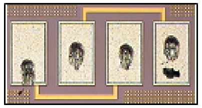
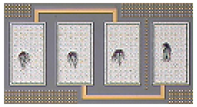
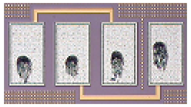
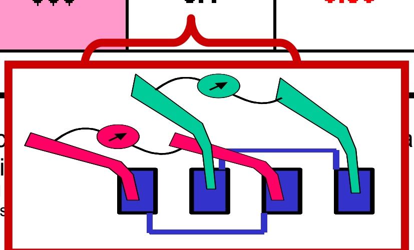
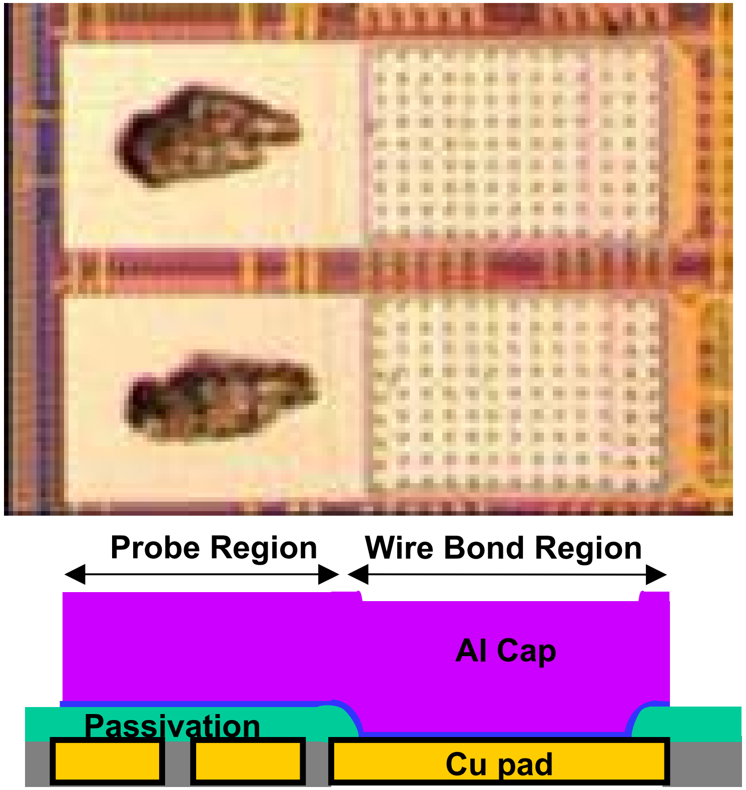
Reduced data set: 44um Probe Key Responses Results Summary

Est. Rank	Suppliers	Relative Cost $ - $$$$	Res. Pad Pair Ohms	Elec Cpk Pair vs 10 ohm	Die Yield %	Y Cpk 1P / 3P	% Pad Damage 1P / 3P	1 Pass 2T Nom 50um OD	6 Pass 2T Heavy 60um OD
1	A A44-1	$	2.75	5.56	99.3	1.81 / 1.57	14 / 18		
2	B B44-2	$$	3.24	3.86	98.9	1.87 / 1.64	6 / 10		
3	C C44-1	$$$$	3.03	3.00	97.8	1.84 / 1.77	8 / 12		
4	D D44-1	$	2.62	4.01	98.9	1.19 / 1.11	8 / 11		
5	A A44-2	$	2.5	6.15	99.5	1.10 / 0.89	19 / 25		
7	B B44-1	$$	3.09	0.76	77.5	FAILED	FAILED		
8	E E44-2	$$$	2.69	3.36	98.9	1.39 / 1.21 FAILED	11 / 16 FAILED		
9	E E44-1	$$$	3.1	0.36	0.0	FAILED	FAILED		



What is POP? & Why Is It Used?



Probe Over Passivation Bond Pad

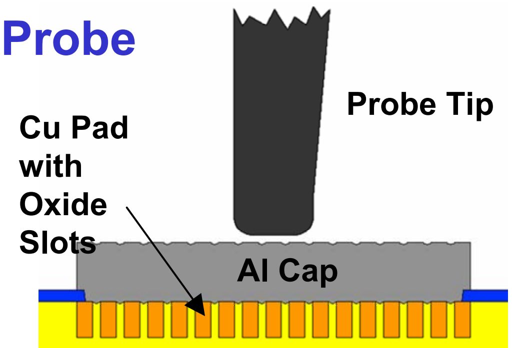
- **POP is "Probe-Over-Passivation"**
- **We define it as a "Novel Method of Separating Probe and Wire Bond Regions Without Increasing Die Size".**
- **POP is easily implemented on Alum Capped Copper pad wafer designs and may be adapted to others.**
- **POP saves die size!**

For a more detailed paper on POP (Probe-Over-Passivation) please see an ECTC-2003 paper titled "Novel Method of Separating Probe and Wire Bond Regions Without Increasing Die Size" by Tu Anh Tran (presenter), Lois Yong, Stephen Lee, Bill Williams and Jody Ross

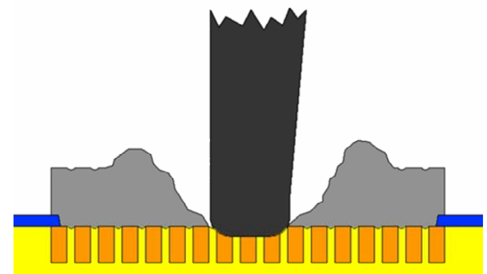
Why is POP needed??: A Problem Description

- From an Assembly person's point of view!

Fine Pitch Probe

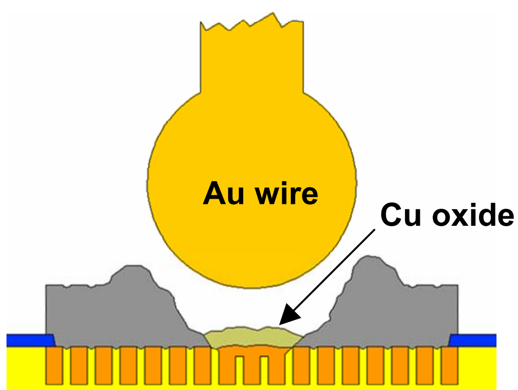


Standard Al Cap Cu Bond Pad

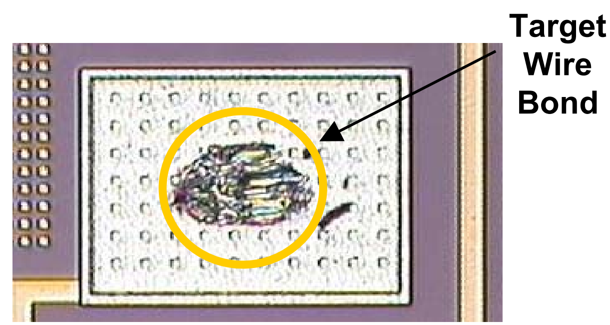


Probe Tip Displacing Al and Leaving Cu Exposed

Fine Pitch Wire Bond

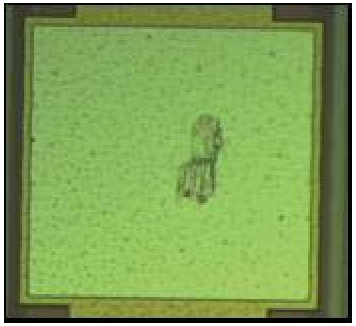


Cu Oxide Causing NSOP (Non Stick on Pad)



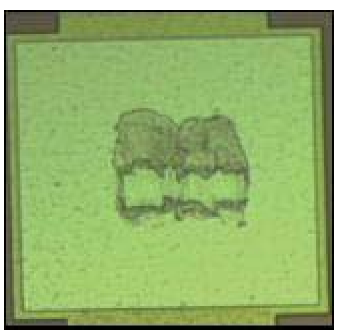
Pad damage causing NSOP

Ratio of Probe Area to Wire Bond Area

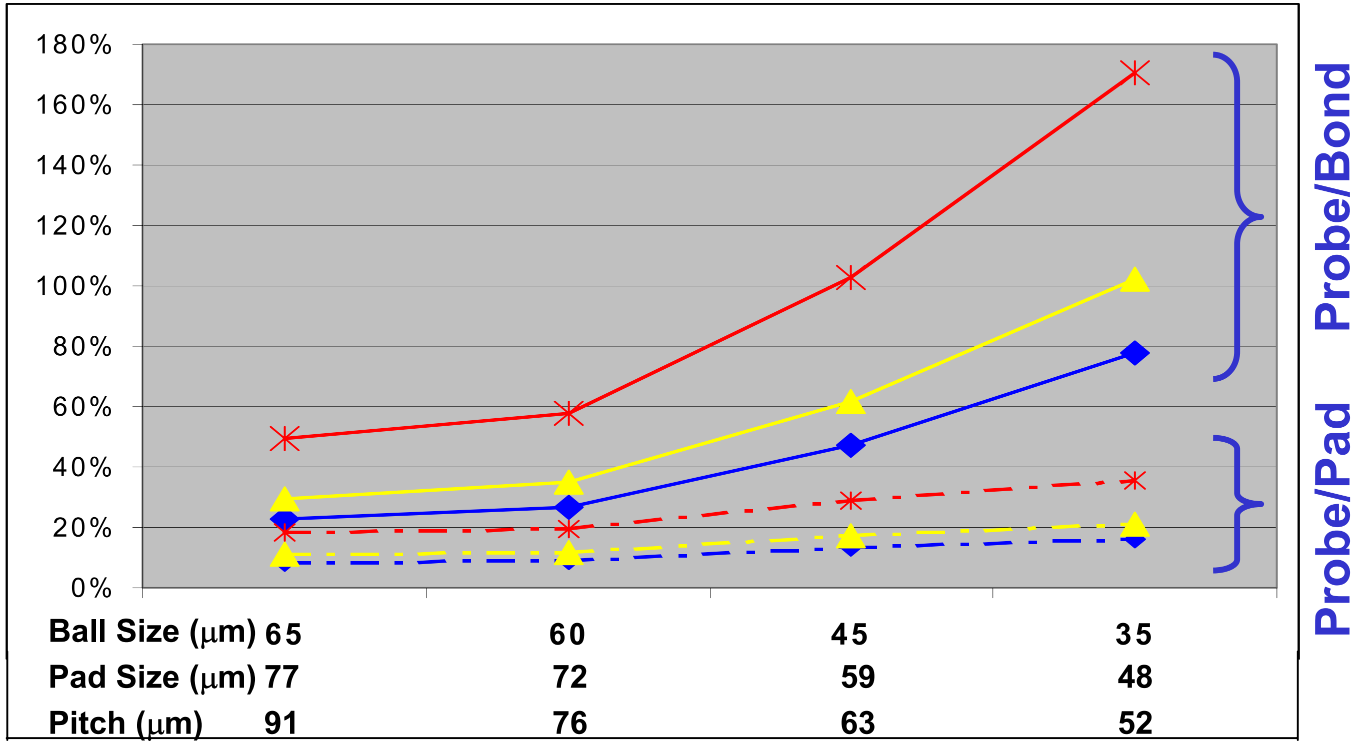


1X Light - 22x28μm

1X Heavy - 20x40μm



2X Heavy - 27x49μm



- Probe / Bond Area is more meaningful than Probe / Pad Area.
- Fine pitch technology <u>magnifies</u> the interaction between probe mark and small bond area.

Data Courtesy of Fuaida Harun

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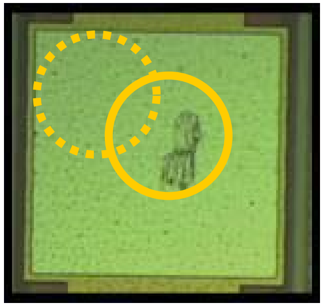
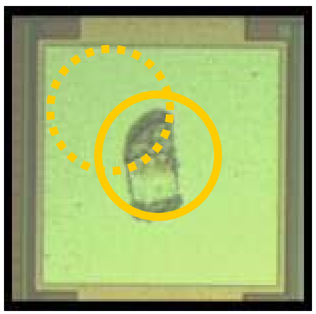
Wire Bond Yield Loss

43µm Ball Bond

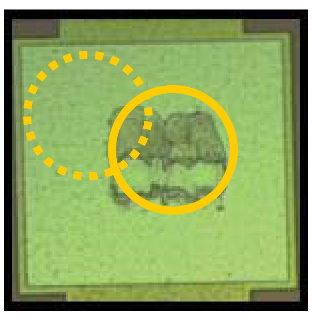
1XL



1XH



2XH



	NSOP		*Lifted Metal*	
	Center Probe	Offset Probe	Center Probe	Offset Probe
1 X Light	0%	0%	0%	0%
1 X Heavy	0%	0%	1.17%	0%
2 X Heavy	12%	0.13%	1.95%	0.19%

Non-stick on Pad(NSOP):

- Very significant NSOP rate for Center Probe compared Offset Probe in 2XH

Lifted Metal after wire bonding:

- Both Heavy probe marks experience Lifted Metal for Center of Probe with higher rate for 2XH
- Lifted metal also experienced for the Offset Probe (no space)

Large probe marks decrease Au-Al intermetallics coverage and increase bond non-sticks and pad lifts.

Data Courtesy of Fuaida Harun

Alternative Solutions to Probe & Wire Bond Conflicts

PROBE:

- Reduce probe tip diameter
- Reduce spring force or overdrive
- Control number of probe passes

Benefits:

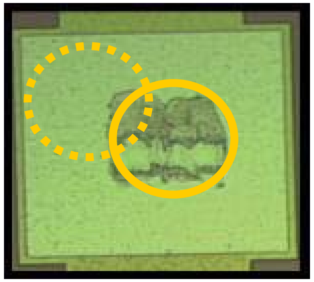
- Create smaller probe mark
- Minimize probe size / depth

Concerns:

- Difficult probe card fabrication
- Difficult process control
- Unstable contact resistance
- Reduced card life

WIRE BOND:

- Plasma clean before wire bonding
- Optimize parameters
- Offset wire bond location away from probe



Benefits:

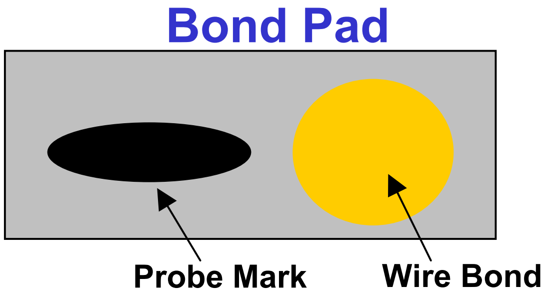
- Minimize NSOP

Concerns:

- Difficult in small geometry

PAD DESIGN:

- Elongate bond pad



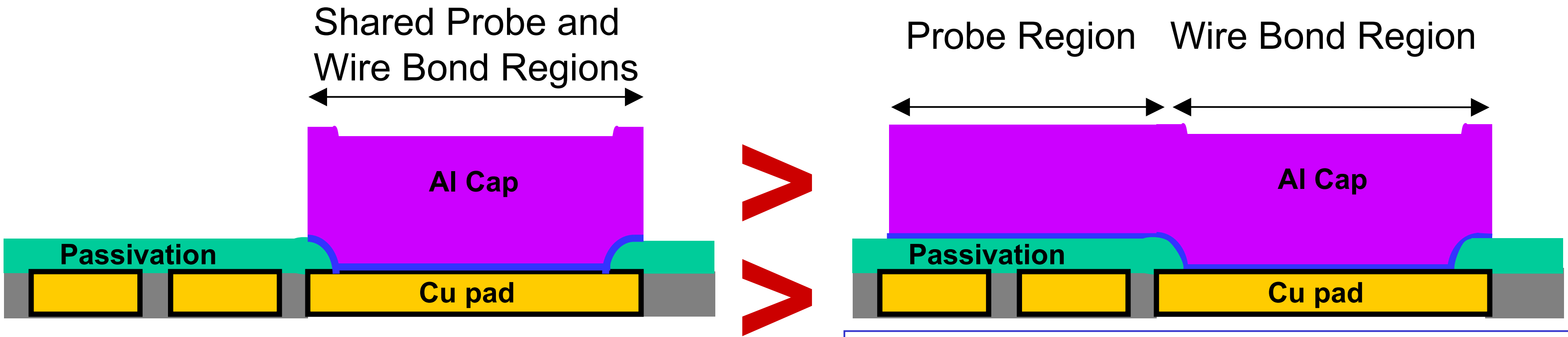
Benefits:

- Separate probe and wire bond regions

Concerns:

- Increase die size

Our POP (Probe-Over-Passivation) Solution



Standard Al Cap Cu Bond Pad

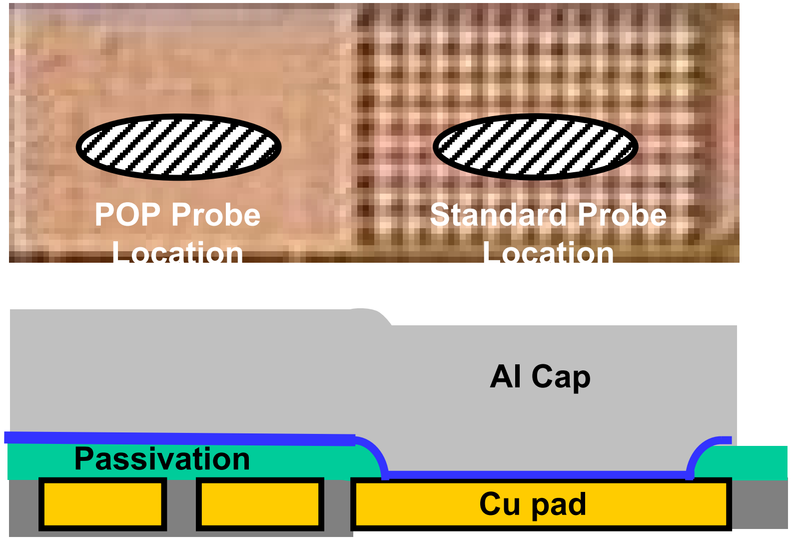
Probe Over Passivation Bond Pad

Benefits:

- Eliminate Cu exposure due to heavy probe marks
- Eliminate probe and wire bond interference
- Create longer bond pad but DO NOT increase die size
- Requires 1 mask change: Al Cap
- Low cost solution
- Ease of implementation on existing and new Cu technology products

Challenges:

- Develop Probe Over Passivation (POP)



POP Probe Experiment

Purposes:

- Establish probe yield equivalency between probing on standard and POP locations
- Ensure no passivation damage
- Establish POP probe card specifications

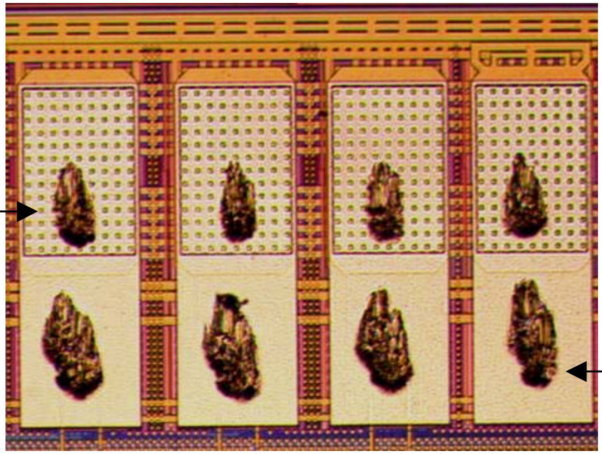
		Probe Card Type			Cell
		Baseline Standard	POP Standard	POP Heavy	
		Standard Location Baseline Force	POP Location Baseline Force	POP Location Heavier Force	
Probe Overdrive Setting	Nominal	X	X		1
	Heavy	X	X		2
	Nominal	X		X	3
	Heavy	X		X	4

Number of Double-touch Passes per Cell: 1,2 3, 4

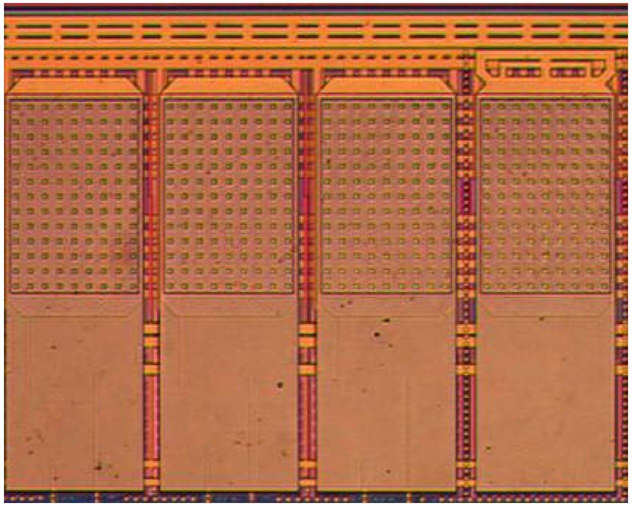
Results: Comparable probe yields between standard location and POP location! Slightly better w/POP

Passivation Integrity (Cell 4)

Baseline Location:
Baseline Force / Heavy OD /
4 Passes

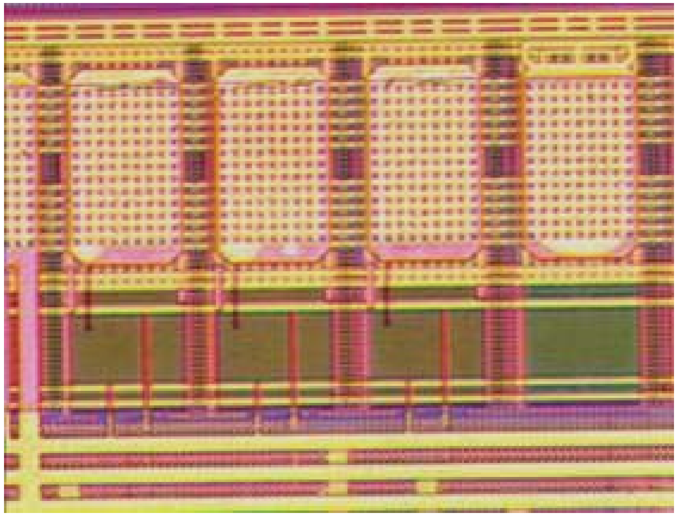


POP Location:
Heavy Force / Heavy OD /
4 Passes



Stripping off Al Cap and Exposing Barrier Layer -

No Damage



Stripping off Barrier Layer and Exposing Passivation -

No Damage

Wire Bond Yield Improvement (from 52µm studies)

Device	Ball Bond Diameter (µm)	NSOP Rejects / Wire Bond Rejects
Device 1	60	41%
Device 2	50	64%
Device 3	35	84%
Device 4 with POP	40	0%

NSOP Improvement due to POP design cannot be achieved by wire bond parameter optimization.

POP Conclusions and Recommendations

POP bond pad design:

- Extends Al Cap above passivation
- Creates separate probe and wire bond regions without die size increase
- Totally eliminates problem of punching through to Cu and interacting with wire bond

Probe evaluations demonstrated:

- Comparable electrical yield probing at standard and POP locations
- No damage of passivation or Cu after 6 double-touch passes at heavy force and heavy overdrive
- New POP probe card specification includes higher spring force

Assembly and package reliability testing:

- Achieved significant improvement in NSOP reduction
- Passed MC-level qualification

Numerous Motorola devices fab'ed in Cu technology at 50μm and finer pad pitches have switched to POP bond pad design.

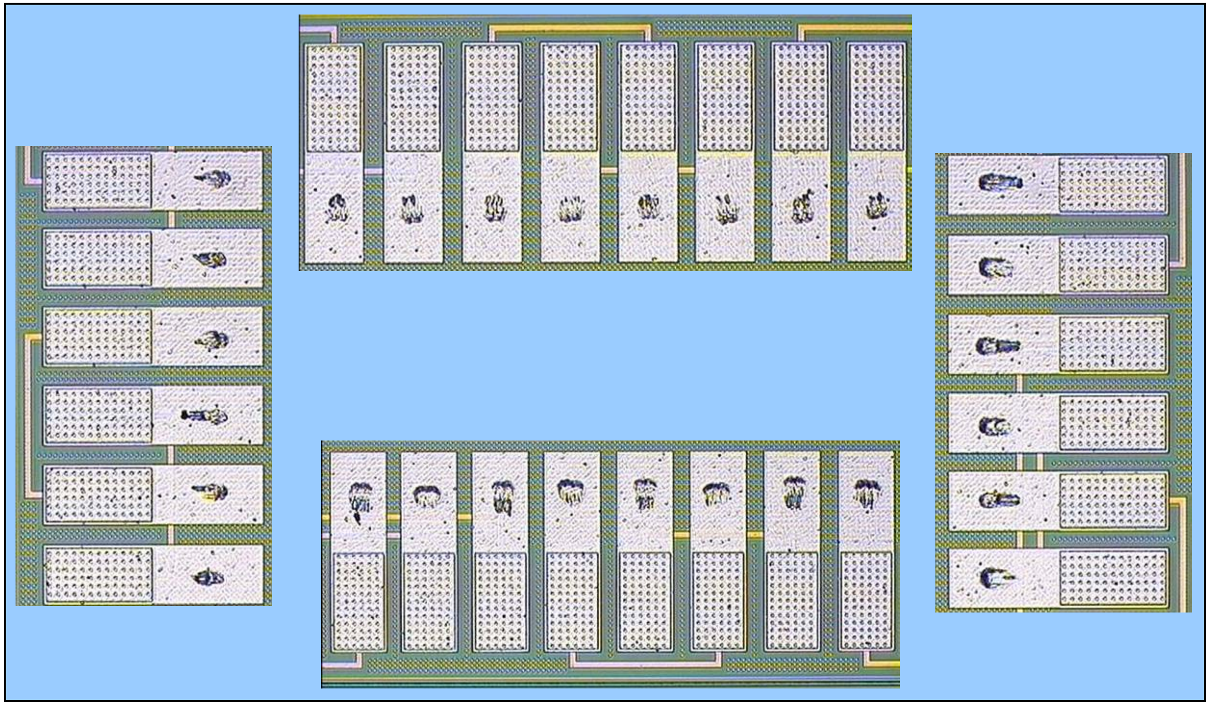
For a more detailed paper on POP (Probe-Over-Passivation) please see an ECTC-2003 paper tiltled "Novel Method of Separating Probe and Wire Bond Regions Without Increasing Die Size"
by Tu Anh Tran (presenter), Lois Yong, Stephen Lee, Bill Williams and Jody Ross

The following 2 slides are from 44µm POP (Probe-Over-Passivation) in the factory.

This first device has 500 peripheral pads at 44µm design rules with POP pads. Additional products are in que.

2 new probe suppliers were qualified for this technology transfer into the Factory.

POP (Probe Over Passivation) Probed in Manufacturing Daisy Chain Device



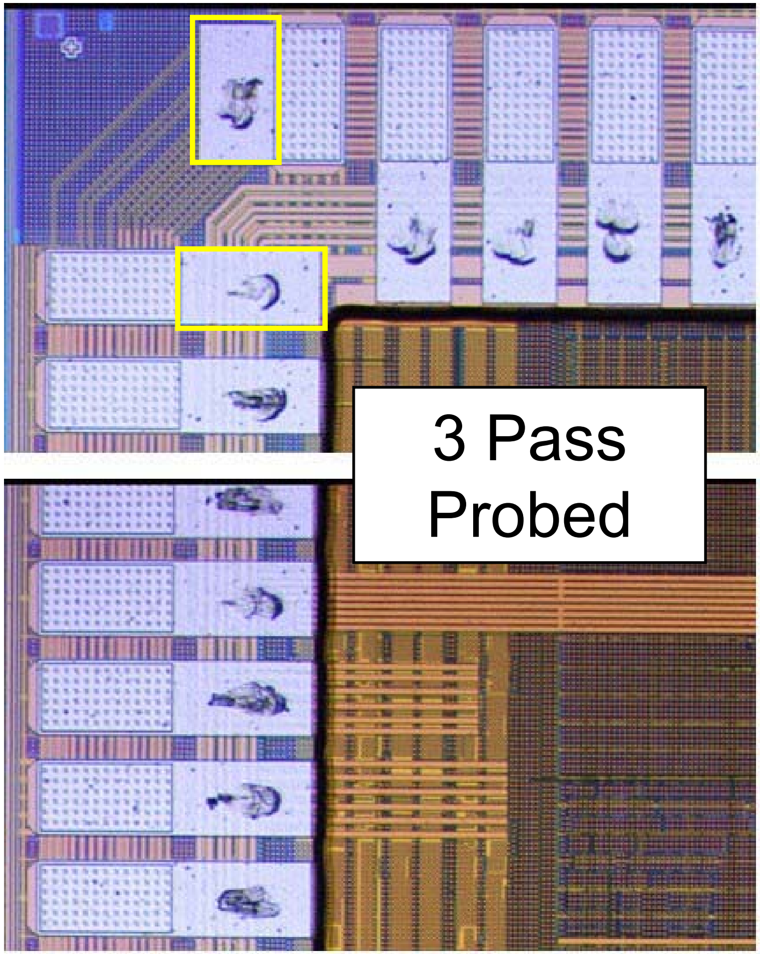
Key Responses:

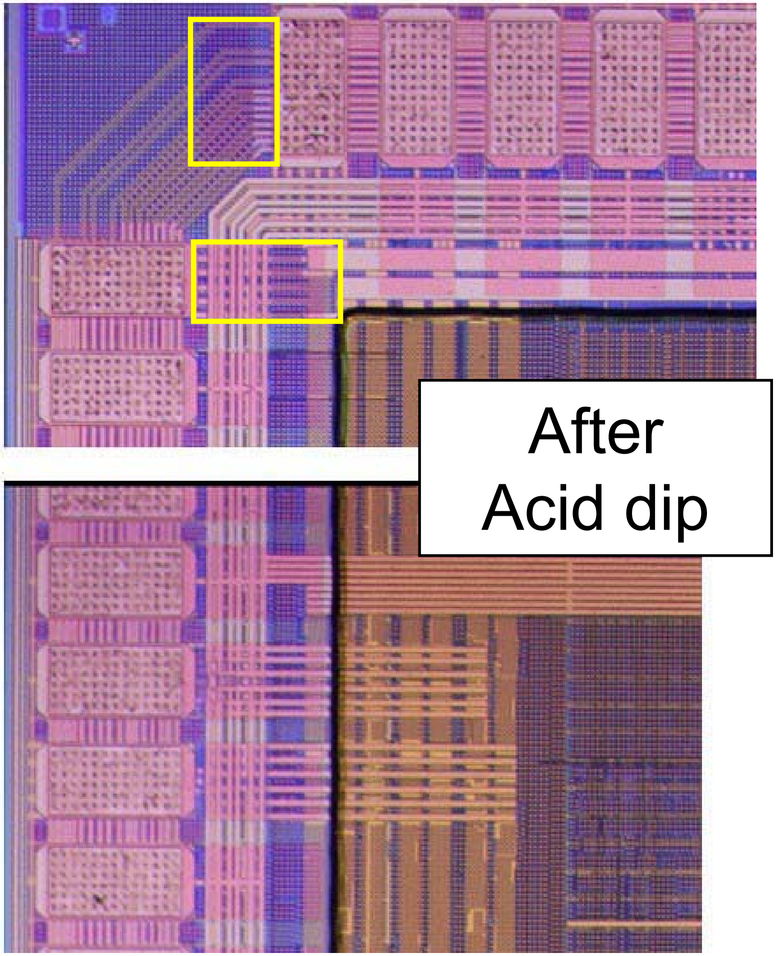
- Prober index accuracy is excellent.
- Relative scrub alignment is excellent.
- Probe layer scrub variation is minimal.

PL= Passivation Length	82.00
SL= Average Scrub Length (PR Scrub Y Size)	26.75
TE= Average Scrub Target Error |Top-Bot| / 2	4.92
SD_{SL}= Std Dev of Scrub Length	4.90
SD_{TE}= Std Dev of Target Error	3.00
Y C_{PK}= $(PL/2-SL/2-TE)/(3*(SQRT(SD_{SL}{}^2+SD_{TE}{}^2)))$	1.32
Y C_P= $(PL-SL)/(6*(SQRT(SD_{SL}{}^2+SD_{TE}{}^2)))$	1.60

Durability Testing POP (Probe-Over-Passivation)

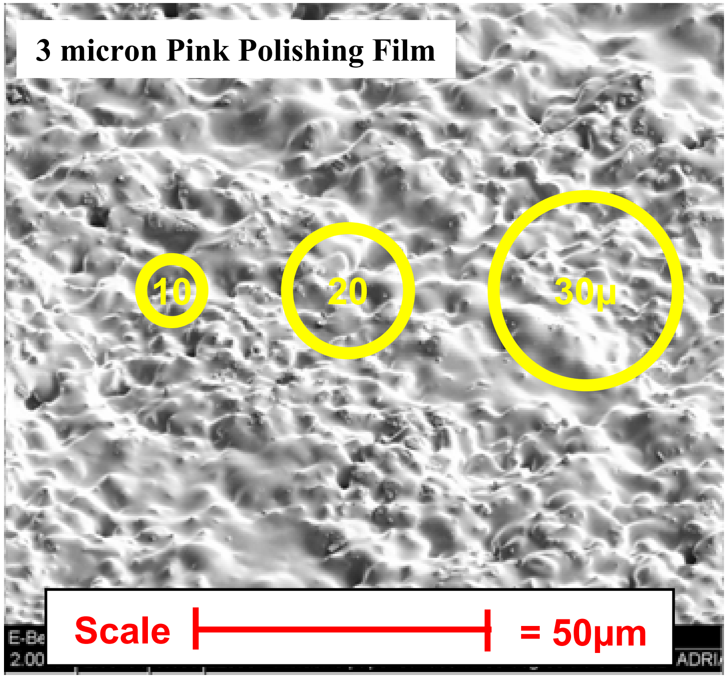
Probe = 3 Passes of Double Touch

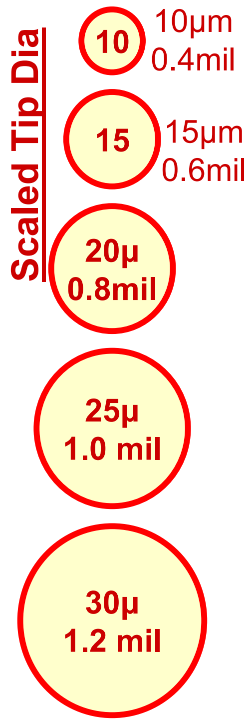


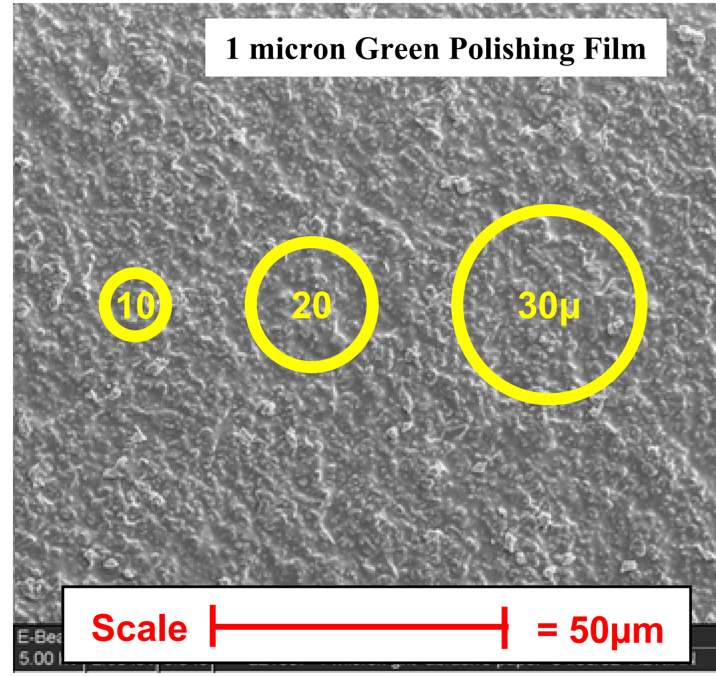


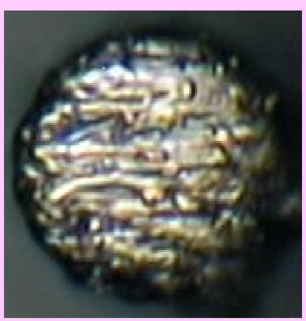
The following "Lessons Learned" are but a few of the many things we had to "experience" before successful 44um probe.

Lesson Learned #1: Changed 3um to 1um Grit Polishing Film









3μm Texture

Cause and Effect of debris on Pad Damage

1μm Texture

Lesson Learned #2: Polish Pad Level Effect on Polish Z-Accuracy

Problem Statement:

- **If the polish pad is out of level the probe system does not compensate.**
- **The prober finds the Z position in 1 spot near center of pad**

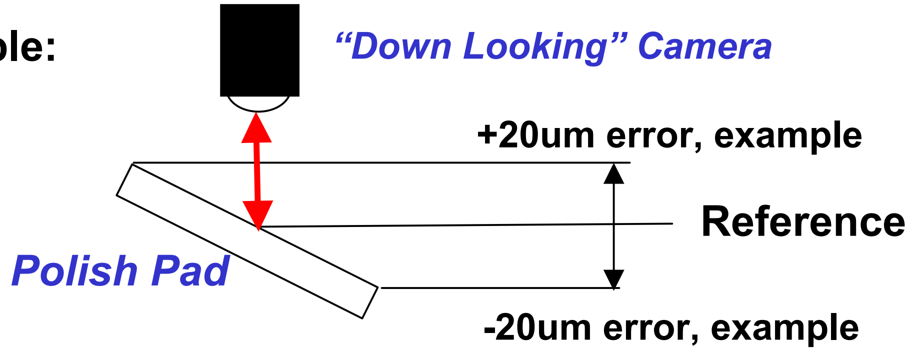
Concerns:

- **The polish overdrive will vary ± by ~ half the amount a pad is out of level.**
- **Either too much polish (damage) or too little polish (dirty)**

→ Check your polish pads! You can see the patterns.

Our Prober Planarity spec is ±10µm

Example:

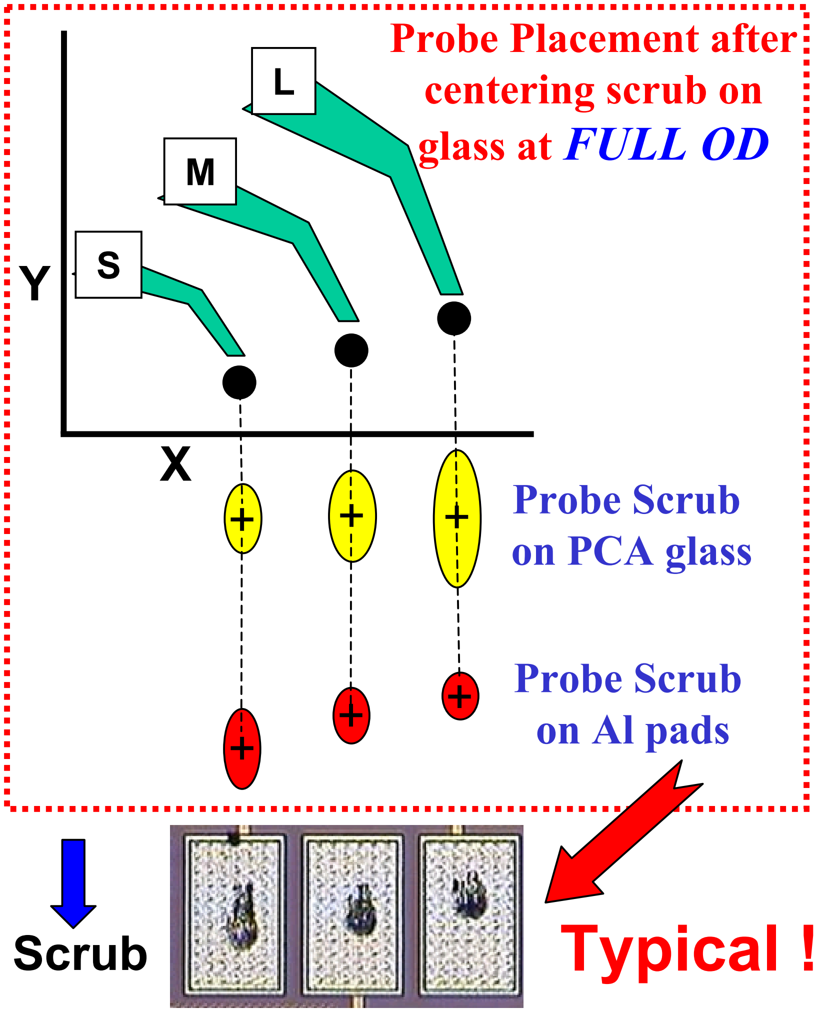


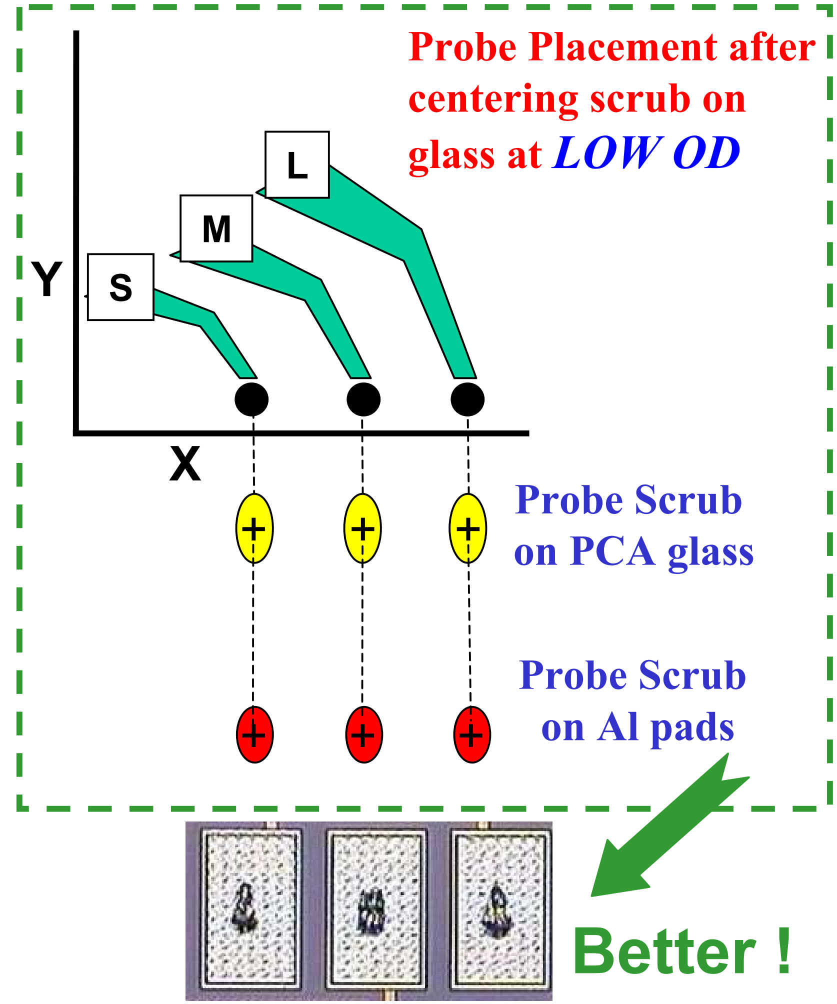
Our Fine Pitch Polish Overdrive is 40um.
In this example the actual polish overdrive would range from 60 to 20um.

Solutions:

- **Use special care in maintaining polish pad planarity to ± 10µm spec during PMs**
- **Must Check pad planarity on prober before any change-over to fine pitch products**
- **(Pending) Adaptive Z for the pad Z plane is being developed by our prober supplier.**

Lesson Learned #3: Use LOW Overdrive Probe Alignment





Key Observation: **Probe alignments performed at low overdrive, <10µm, on a glass PCA tool will typically result in good scrub alignment on Al pads.**

Acknowledgements 44μm Teams

44μm Success

There are <u>many</u> people supporting the 44um effort, my sincere apologies to any of those I have neglected to highlight !

NPI Austin Test OHT
- Devin Sheridan – Mgr
- Steve Dabose - Mgr
- Sonny Soto - Mgr
- Anil Kinikar
- Jody Ross
- Keith Bird

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- Tony Angelo
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- Bill Williams - Mgr

FMTC Asia Assy
- L.C. Tan - Mgr
- Fuaida Harun
- Soosan Yong

FMTC 44um Fine Pitch Wire bond Team
- TuAnh Tran - Mgr
- Matt Ruston
- Stephen ChuChung Lee

TSPG POP Team
- Marcus Fechter - Mgr
- Jeff Blackwell
- Fonzell Martin – PPE

NCSG 44μm POP Team
- Joe Sigmund - Mgr
- Jeff Metz
- Sean Hand
- Nolan Wetterling
- Dieu Van Dinh
- Jeannie Miller – FMTC PPE

<u>Key 44μm Support Team Participants:</u>

- **Probe Card Suppliers**
- **Prober Suppliers**
- **Polish & Tooling Suppliers**

Legal issues prevent me from recognizing you individually in public,

You know who you are! And I say... Thanks! Great Work!

You are the keys to this success and future development!

Thanks for your attention!

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Future Work Planned & In Progress

- **44um x2 @ 150 deg-C**
- **37um 448 pads**
- **31um 448 pads**
- **52um Dual Row High Pin Count (parallel rows w/ pads inline)**
- **Probe Polish Material Optimization Continues**

Questions?