Improved Cantilever Probing - Minimizing Scrub Marks

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Agenda

- **What is driving the need for this capability?**
- **Assessment Overview**
- **Probe Windowing Study**
- **Probe & Scrub Examples**
- **WaferWoRx Analysis**
  - Mechanical Results
  - Pad Damage Inspections
- **Electrical Assessments**
  - Kappa (Bin & Yield Studies)
  - Production Results
- **Freescale Summary**
- **TechnoProbe Technology Overview**

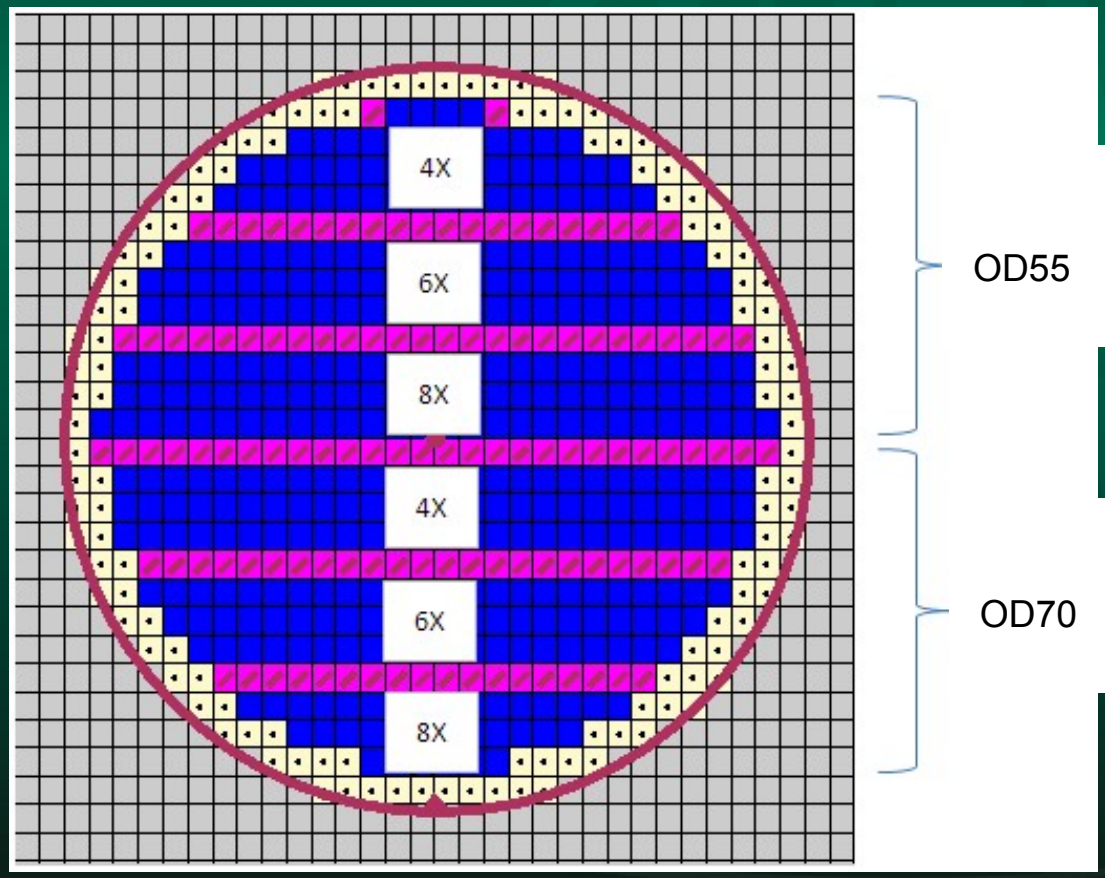
What is driving this need?

- **There are two main issues driving the need for this improved capability**
- **Copper wire bond**
  - Copper bonding migration of legacy devices
  - Devices where Probe and Bond share the same pad real-estate
  - Copper wire bonding is more sensitive to pad damage than gold wire bond
  - Reducing the risk of probe induced ILD damage, when coupled with harsher Copper wire bonding parameters
- **New Product Introductions (NPI's) Cost Savings**
  - New NPI designs are placed on wafers with multiple designs
  - NPI's may go through multiple revisions before finalizing their designs
  - Having a minimal scrub probe card that can be used for all designs revisions, but the final saves cost
  - Enables us to start our device qualifications without having to use high cost Fine Pitch Vertical probe cards

Overview

- *Design of Experiment:*
  - ***Evaluation of the Technoprobe No-Scrub cantilever probe card, to determine feasibility of this probe technology on C90 SOI pad design.***
- *Windowing Study DOE:*
  - ***The wafer was divided into six sections and probed with various overdrives and touchdowns using the Technoprobe No-Scrub™ probe card. The objective was to observe which section exhibits excessive pad damage to under layers (ILD) and to what level of damage. In addition, to assess the probe cards overall mechanical performance.***

Probe Windowing Study



Wafer:
- Technology: 90 nm

Prober: TEL - P12XL

Probe Card:
- TP No-Scrub x1 cantilever
  - BCF / Tip diameter = 1.4 / 0.6

Probe Conditions:
- Overdrive
  - 55
  - 70
- Touchdowns
  - 4
  - 6
  - 8
- Z-position set from first touch
  - Measured planarity = 25µm
- Room temp probe (25C)

Outputs:
- Probe analyzer measurement
  - Alignment
  - Planarity
  - Tip diameter
- Scrub size/position analysis
- Scrub depth measurement
- Pad damage assessment

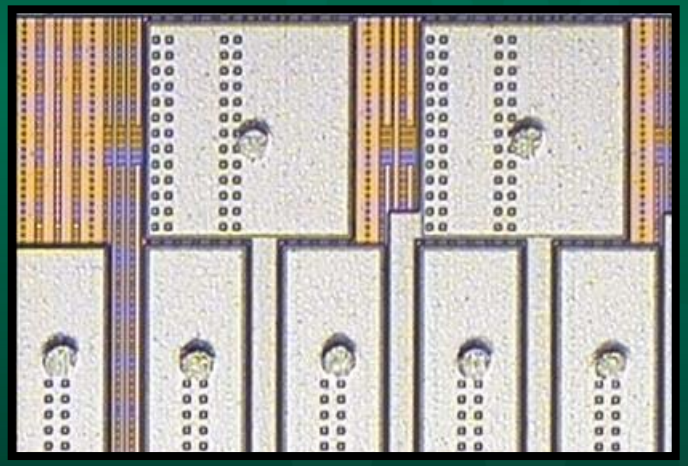
Probe/Scrub Mark Examples

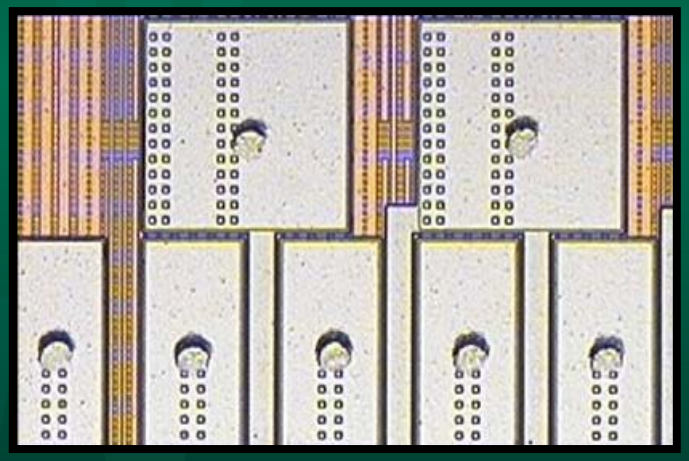
55µm – Overdrive

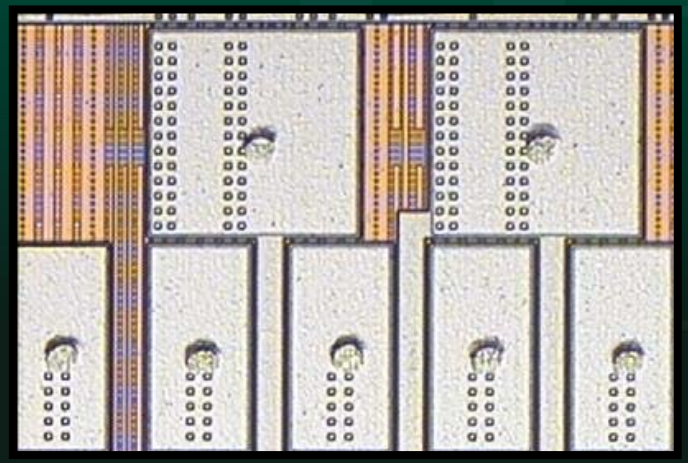
70µm – Overdrive

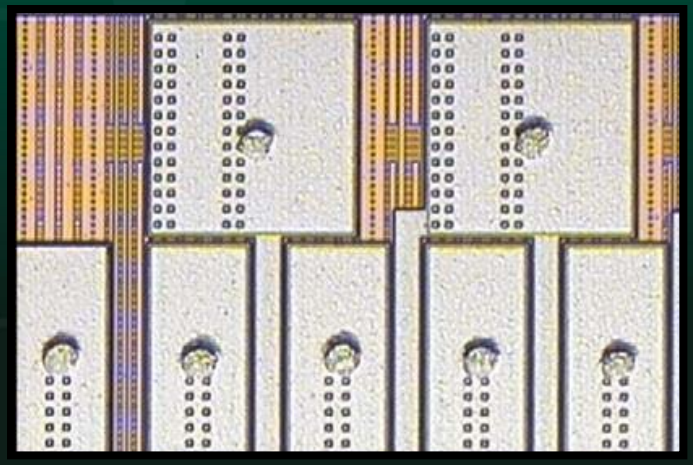
4 - Touchdowns

8 - Touchdowns





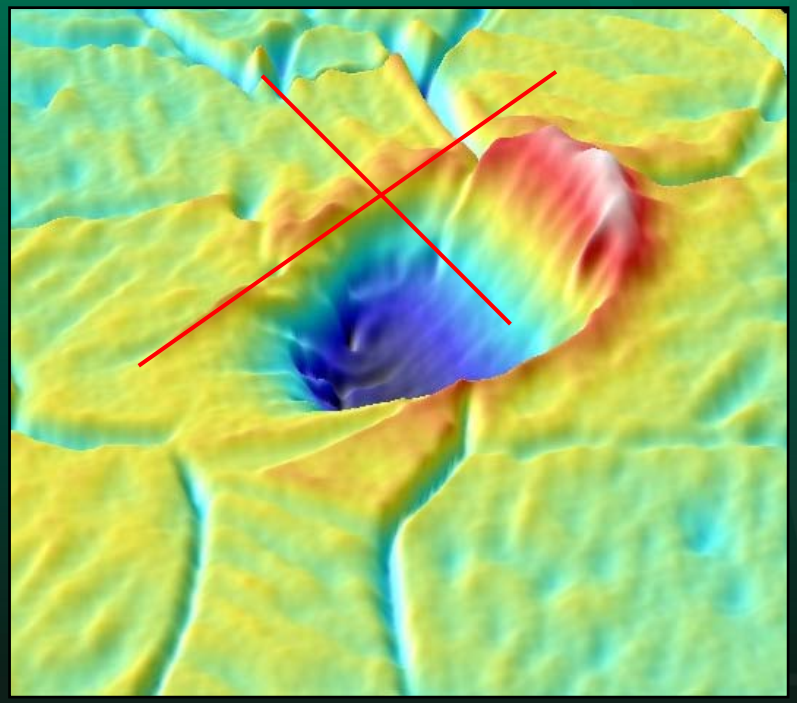


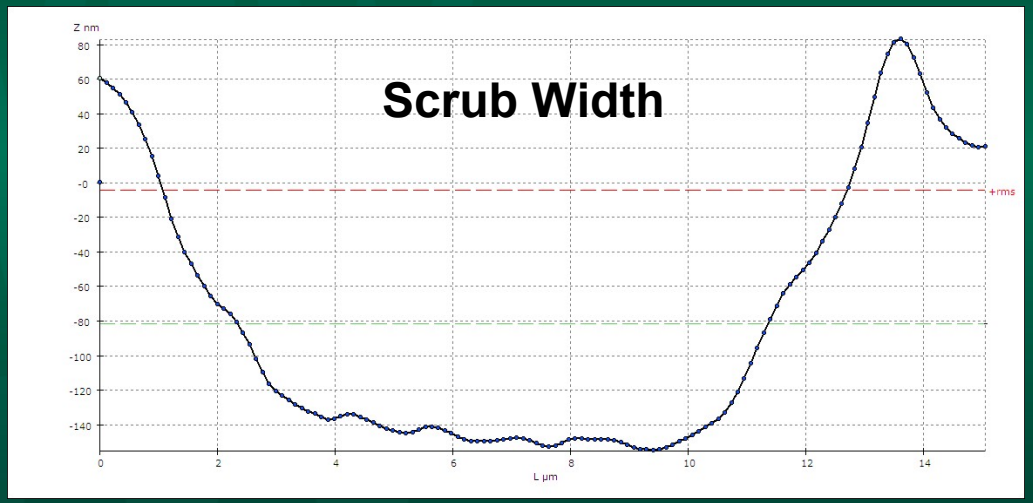


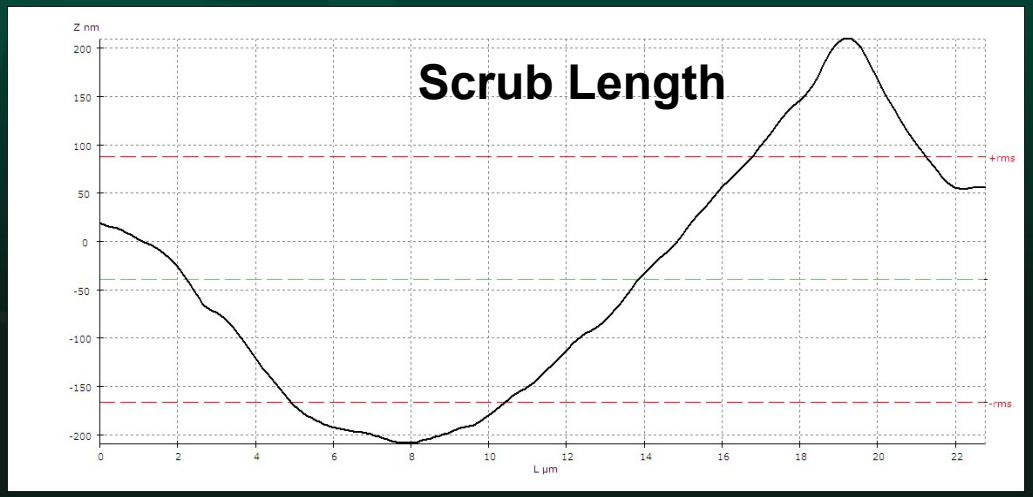
Probe Card Design

Scrub Analysis

- Typical Scrub at OT = 50 µm 1TD







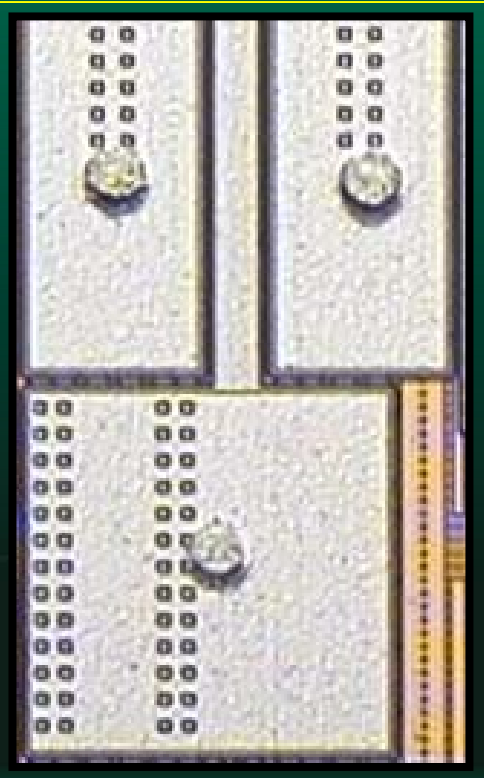
Probe Tip Needle Examples

- *Online/Offline Visual Inspection of Probecard:*
  - ***Complete visual of Probecard including image capture of same pin location pre and post windowing study***
    - ***No visible debris or contamination build-up found on probes or tips***
- *No abnormal wear observed including no oxide buildup*

Pre-Probe

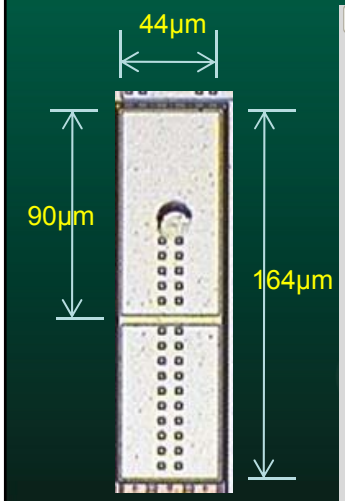
Post-Probe

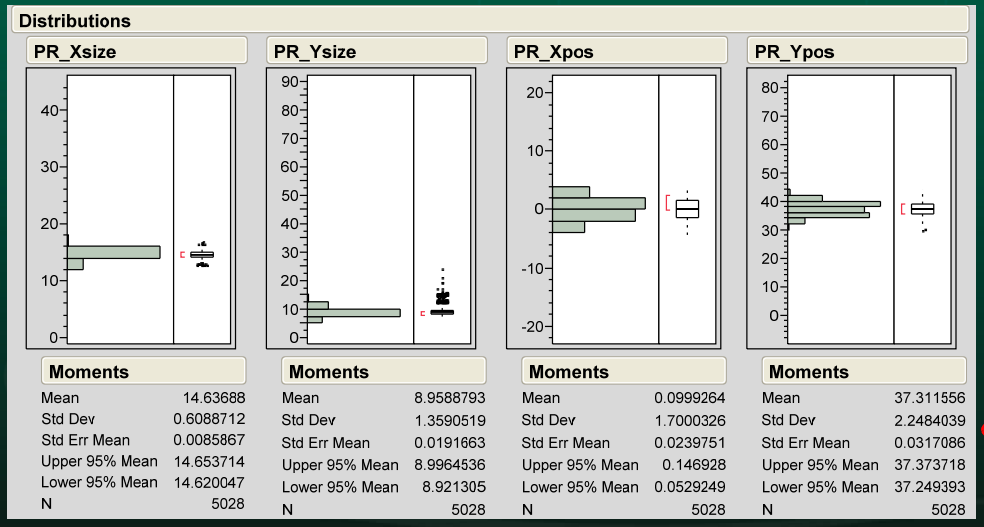
Example: Scrub Marks



WaferWoRx Analysis

- Measured 15 die from the OD55/TD06 cell (nominal process) on WaferWoRx.
- Measurements include X and Y scrub size and placement within the probe area of the pad.
- These calculations include a combination of scrub size and position to determine overall capability.
- Cp values are the preferred metric, as this excludes probe-to-pad alignment variation.
- Recommended Cp value is >1.67. {Y-axes on Distributions chart below are set to pad dimensions}



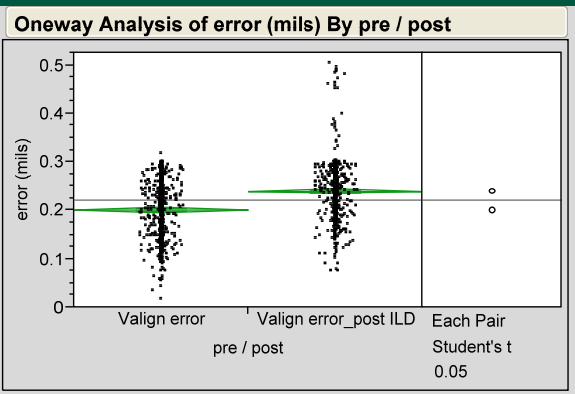


	M68P TechnoProbe No-scrub	
	X	Y
USL	22	82
LSL	-22	-8
Pos_mean	0.100	37.310
δ_pos (PR_Scrub __ Pos)	1.700	2.250
δ_size (PR_Scrub __ Size)	0.610	1.360
δ_scrub	1.806	2.629
Cp	**4.06**	**5.71**
k	0.00	0.01
Cpk	**4.04**	**5.67**

Probe Card Measurement

- *The Technoprobe No Scrub™ card was measured on the PRVX analyzer before and after the ILD wafer was probed*
- *A minor increase in Alignment Error was observed*
- *Significant improvement in Planarity*
- *Minor increase in Tip Diameter*

Alignment



Means Comparisons

Comparisons for each pair using Student's t

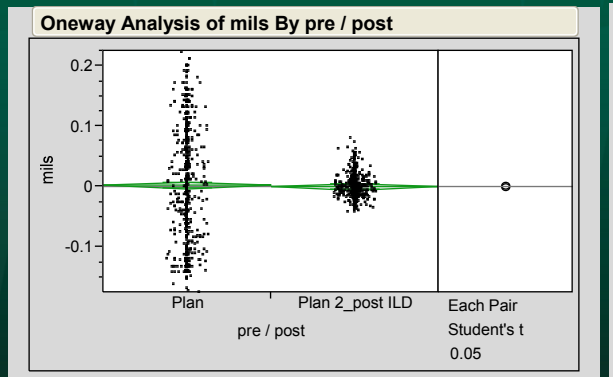
t	Alpha
1.96203	0.05

Abs(Dif)-LSD

	Valign error_post ILD	Valign error
Valign error_post ILD	-0.00701	0.03133
Valign error	0.03133	-0.00701

Positive values show pairs of means that are significantly different.

Planarity



Missing Rows 11

Means Comparisons

Comparisons for each pair using Student's t

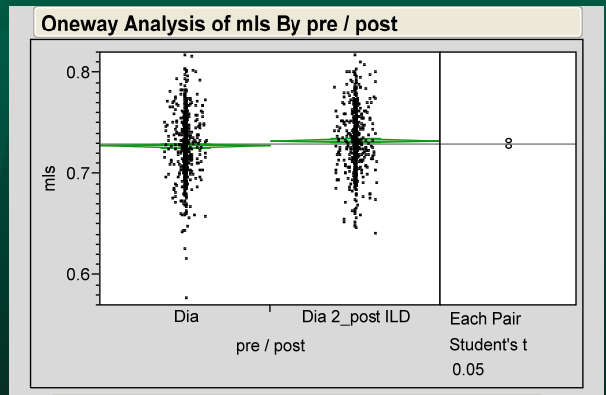
t	Alpha
1.96205	0.05

Abs(Dif)-LSD

	Plan	Plan 2_post ILD
Plan	-0.00816	-0.00582
Plan 2_post ILD	-0.00582	-0.00816

Positive values show pairs of means that are significantly different.

Tip diameter



Means Comparisons

Comparisons for each pair using Student's t

t	Alpha
1.96203	0.05

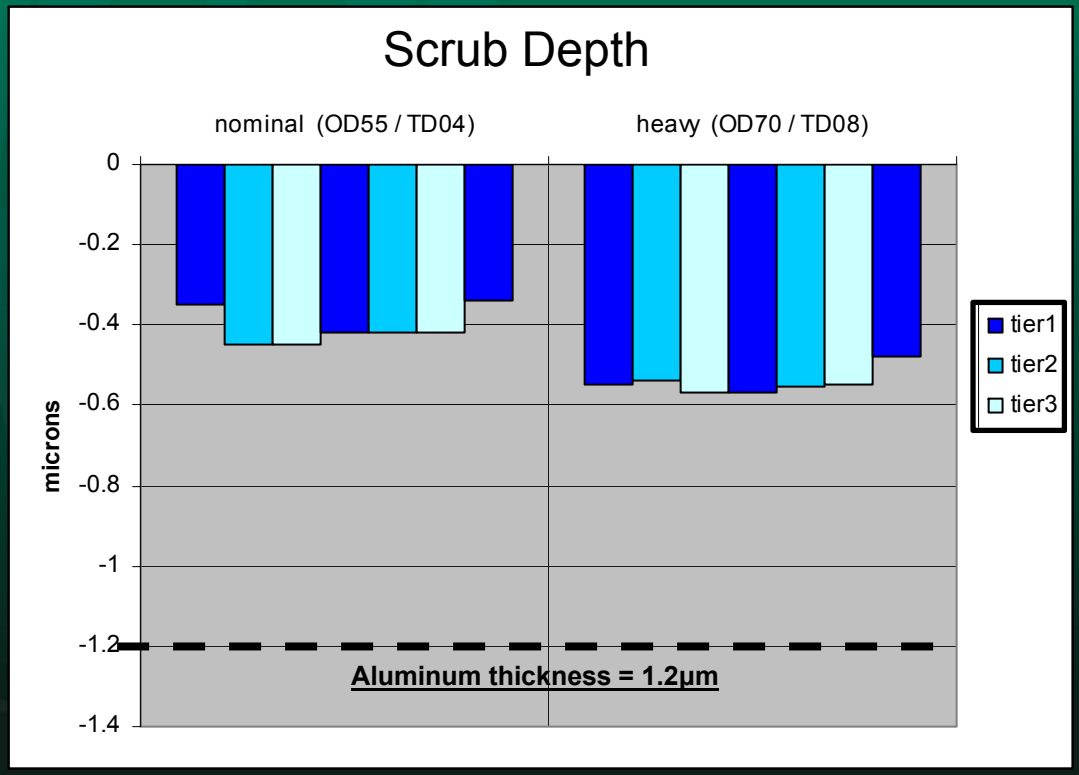
Abs(Dif)-LSD

	Dia 2_post ILD	Dia
Dia 2_post ILD	-0.00365	0.001876
Dia	0.001876	-0.00365

Positive values show pairs of means that are significantly different.

Probe Mark Depth

- Same 7 outer-row of pads measured from nominal and heavy probe cells.
- Depth measured using a Veeco Profilometer
- Nominal probe recipe:
  - Scrub depth average = -0.41µm
  - Standard deviation = 0.045
- Heavy probe recipe:
  - Scrub depth average = -0.54µm
  - Standard deviation = 0.031

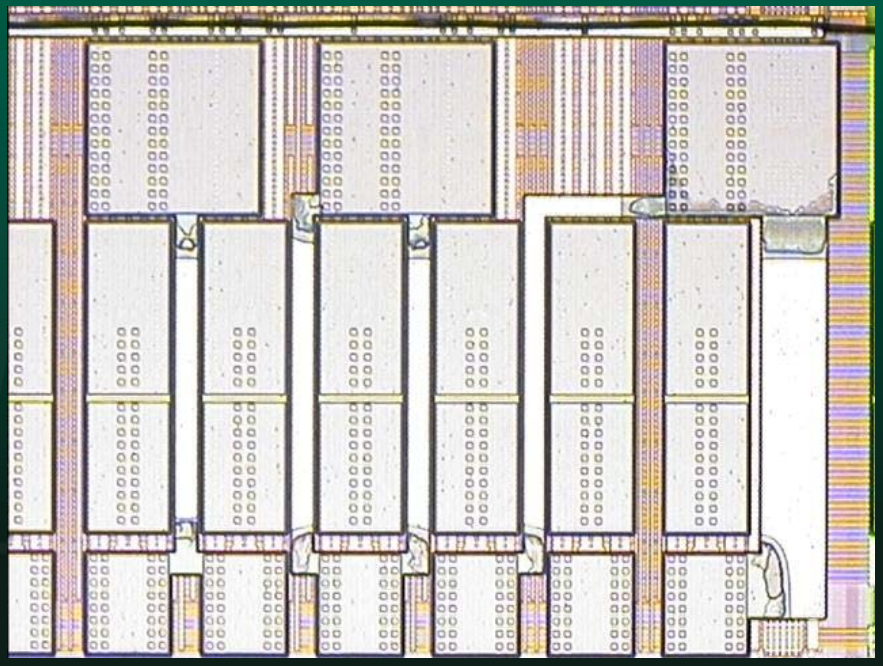


Pad Damage Inspection Results

Platform	Probe Technology	Probe Stresses		Pad Damage Inspection	
		Overdrive	Touchdowns	Die Inspected	Failed
J973	Technoprobe (No Scrub™) Cantilever	55	4	2	0
			6	10	0
			8	10	0
		70	4	2	0
			6	10	0
			8	10	0
100% pads inspected per die (575 probed pads per die) No barrier layer breach or under-etch observed in any cell					

Pad Damage Inspection Example

- Sample shown is from the heaviest-stress cell (OD70 / TD08).
- Aluminum removed from pads to enable barrier layer damage assessment.
- Extremely minor barrier layer deformation is observed in the heavy-stress cells, but no evidence of barrier layer breach or ILD damage is observed in any cell.



Electrical Assessment

- **Bin & Yield Kappa Studies**
  - This was a two wafer kappa study
  - This is a comparison between the probe card technology of record Vs. the new technology
  - Both Probe Technologies are probed using the same prober/tester configuration, test program, test temperature and the same two wafers
  - To be considered passing the new technology must pass the Bin & Yield limits of 6% and 3% respectfully.
  - It's a plus, if it beats the standard technology

Summary

- Over 25,000 pads were inspected
- Scrub placement accuracy is above the recommended minimum.
- Scrub size consistency is above recommended minimum.
- Scrub depth is significantly less than the aluminum thickness in all cells.
- There is no evidence of barrier layer breach or under-pad circuitry damage in any cell.
- Kappa Study results
  - Bin Flipping (<6% is Passing) – 2.1%
  - Yield (<3% is Passing) – 1.8%

Future Work:

- Continue gathering data on production wafers, to obtain long term electrical stability results and card wear rate data.

Probe Card Design

No Scrub™ Technology Overview

- **Technoprobe has developed *No Scrub™* Technology, a new needle structure suitable for small Aluminum pads**
- ***No Scrub™* has been in production since October 2009, following a 1-year development & test period**
- **Benefits:**
  - Short scrub length
  - Low stable C_{RES}
  - Longer Life than Standard technology

Probe Card Design

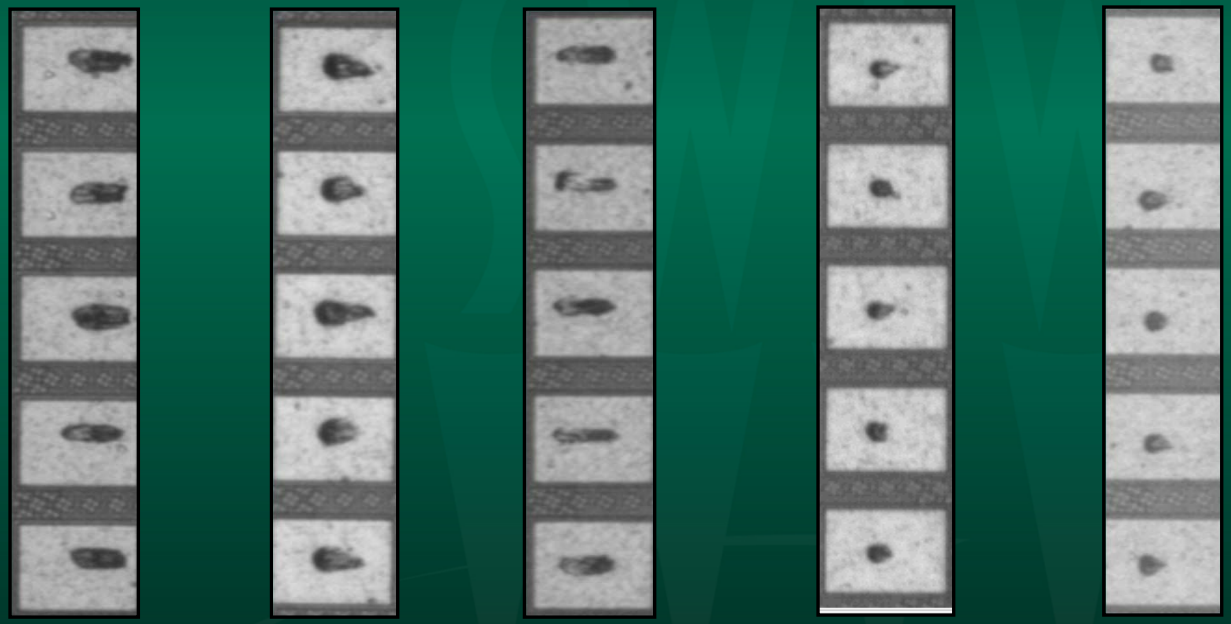
No Scrub™ Technology

PARAMETER	Technology No Scrub
Material	W(Re)
Vertical Force	TO BE PROVIDED ON REQUEST
Tip Length	TO BE PROVIDED ON REQUEST
Lapped Diameter	TO BE PROVIDED ON REQUEST
Certification Overdrive	25 µm
Alignment Specification	6.5 µm
Clearance	> 20 µm
Planarity Specification	± 5 µm
Max CCC	**From 0,35 A to 0,95 A ***

*Max CCC is function of needle size and contact diameter used.

Probe Card Design

Competitive Scrub Mark Comparisons



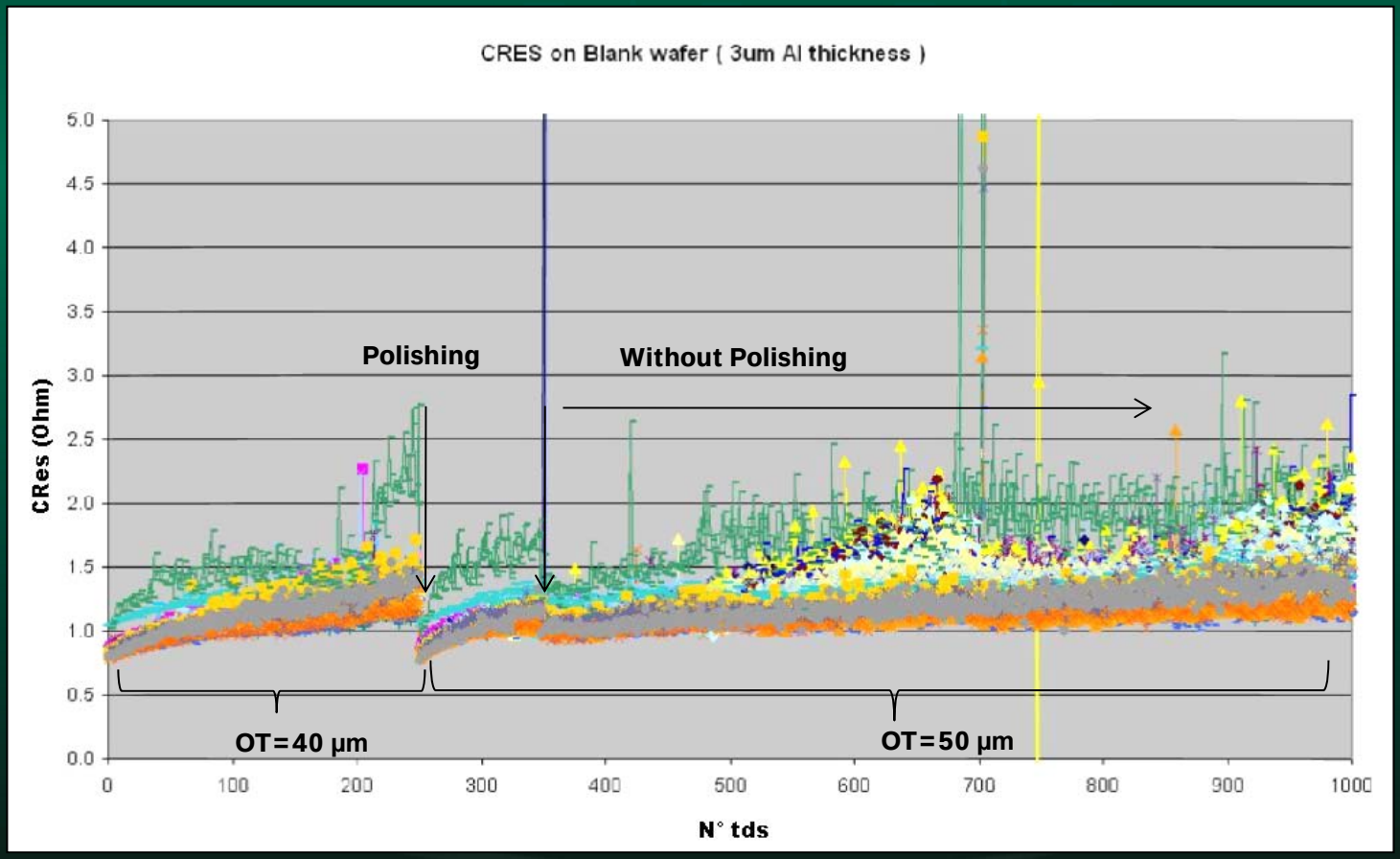
Competitor A TD=342K | Competitor B TD=75K | Competitor C TD=38K | TECHNOPROBE TD=200K | TECHNOPROBE TD=0

Pad Size 65 X 55 µm

- **Scrub marks caused by different probe cards on the same type of pads measured at different touch down values**
- **Technoprobe probe cards have caused a very small scrub mark, uniform over time**

Probe Card Design

No Scrub™ Cres analysis at room temperature



- Cres measurement on Blank Al wafer with UF3000 Prober
- Technoprobe suggest a polishing cycle every 75 TD

Acknowledgements

- **TechnoProbe**
  - Riccardo Vettori – TP Italy
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