Innovative Cleaning Wafer Strategies to Enhance Memory Probing Efficiency

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Overview

- Gel-Pak and JEM Corporate Snapshots
- Probe Tip Cleaning – Requirements and Challenges
- New Cleaning Wafer Requirements
- Experimental Design
- Testing and Results
- Summary / Conclusion
- Next Steps

Gel-Pak®
A DELPHON COMPANY

Proprietary Gel Technology

Gel-Pak's unique gel technology ensures secure and residue-free handling of sensitive devices.

Extensive Industry Experience

Over 40 years of expertise have built Gel-Pak's reputation for reliability and trust.

Customization and Collaboration

Rapid product customization and collaborative development meet evolving industry needs.

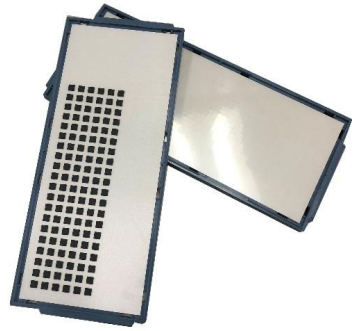
Broad Product Portfolio

ELASTOMER PROBE CARD CLEANING FILMS

Gel-Probe Elastomer Cleaning

- Custom coating of highly engineered elastomer films for semiconductor applications.
- **Customizable probe card cleaning wafer and cleaning sheet applications.**

TEXTURED CARRIER PRODUCTS



Textured Device Carrier Products

- **Universal Fixture for device handling in-process, singulated die testing, and shipping.**

SMALL DIE SHIPPING & HANDLING

Vacuum Release (VR) Carriers

- Automated pick & place applications for bare die and devices ranging from <250 micron to 75mm in size.
- **Suitable for transport and handling MEMs Probes**

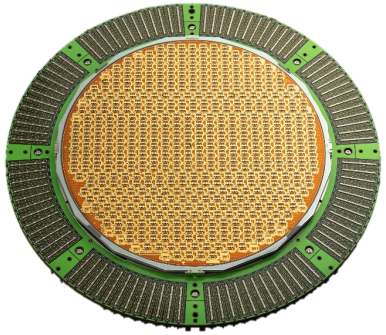
40-Years of Materials Expertise

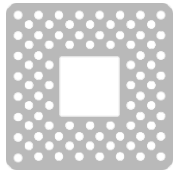
Japan Electronic Materials (JEM)

- **Since 1970, JEM has contributed to the growth and development of the global semiconductor industry.**
  - 4 sites in Japan, 6-sites throughout Asia, 1-site in US, and 1-site in EU
- **Key supplier of Advanced MEMs Type Probe cards for Memory and Logic Device Testing**

MC Series - MEMS Micro Cantilever Type for Memory Test

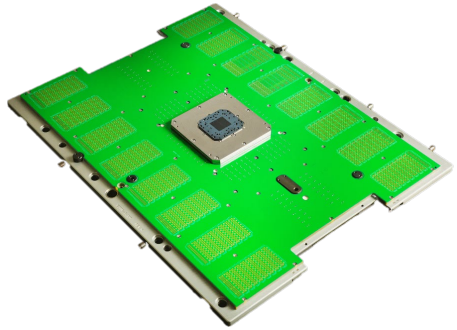
- *High-parallelism testing and fine-pitch pads*
- *High density memory, DRAM, NAND, and Flash*



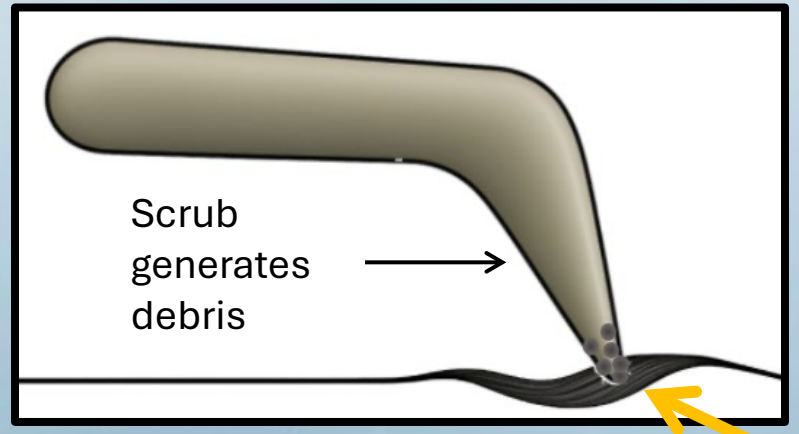


MT Series - Vertical MEMS Type for Fine-Pitch Area Array

- *High-parallelism testing and fine-pitch pads and Cu pillars.*
- *Area array, Logic Devices, and MPU / AP*



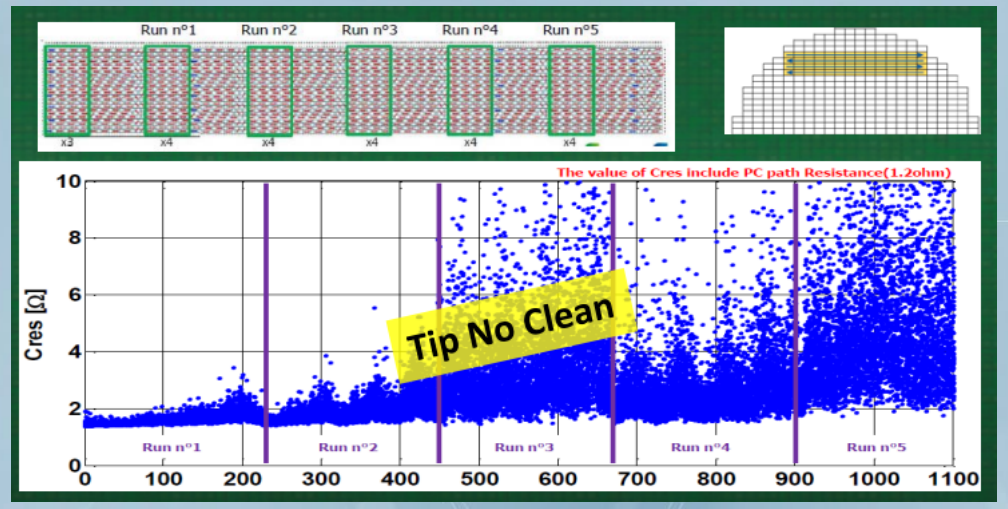
Cleaning Requirement: CRES Recovery

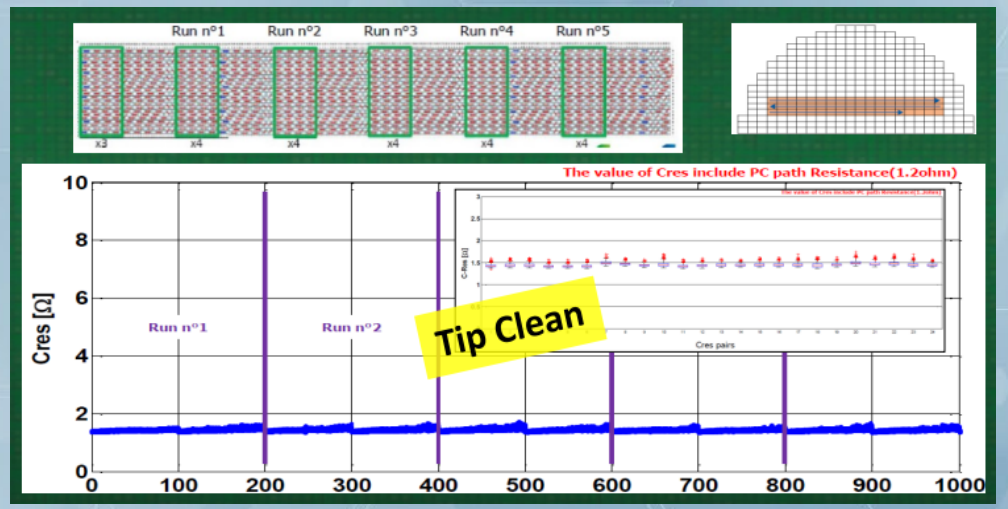


Film Resistance

METALLIC CONTACT

$$C_{RES} = \left(\frac{\left(\rho_{probe} + \rho_{pad}\right)}{4} \sqrt{\frac{\pi H}{P}} \right) + \frac{\sigma_{film} H}{P}$$

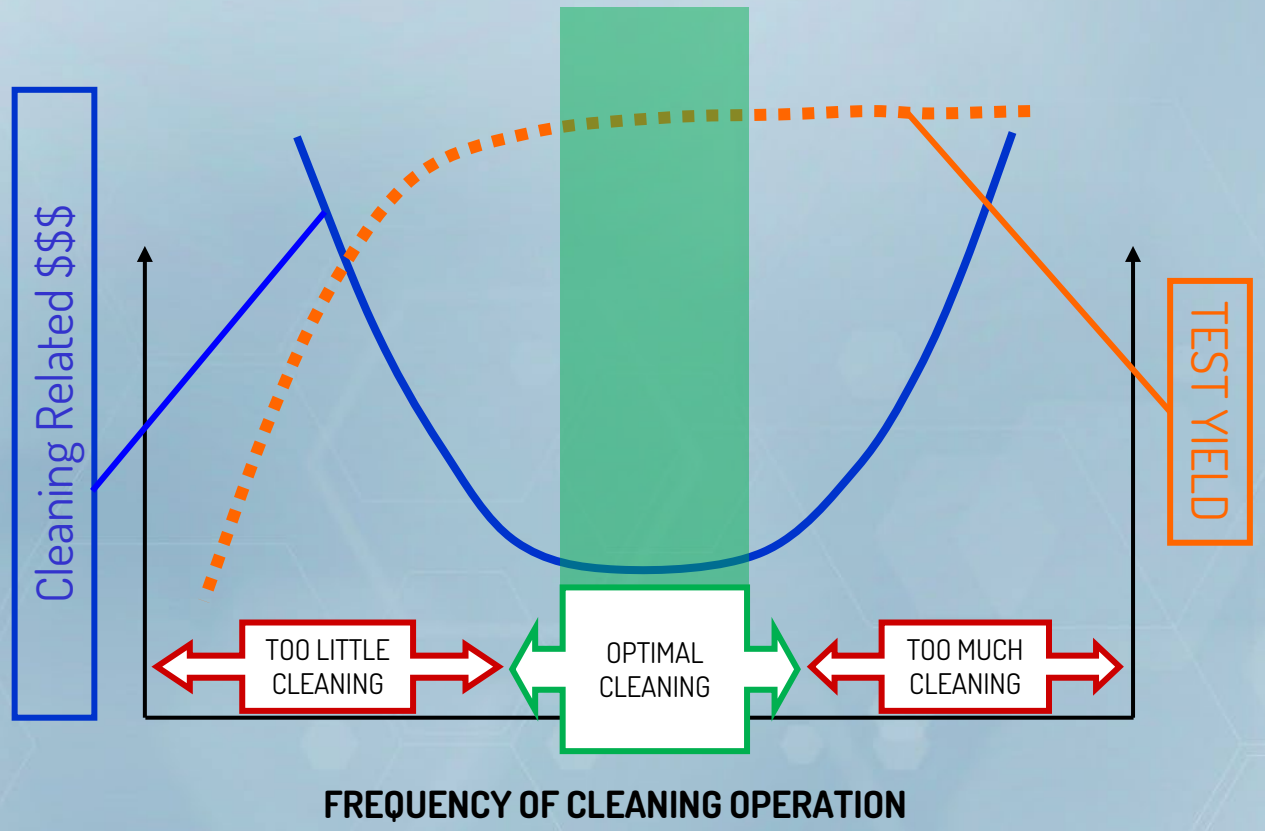




Implement efficient cleaning
to ensure continuously reliable electrical contact.

Source: R. Vallauri, D. Perego, M. Prea, J. Kim, and J. Yun, SWTest 2017

Cleaning Challenge | CRES & Lifetime



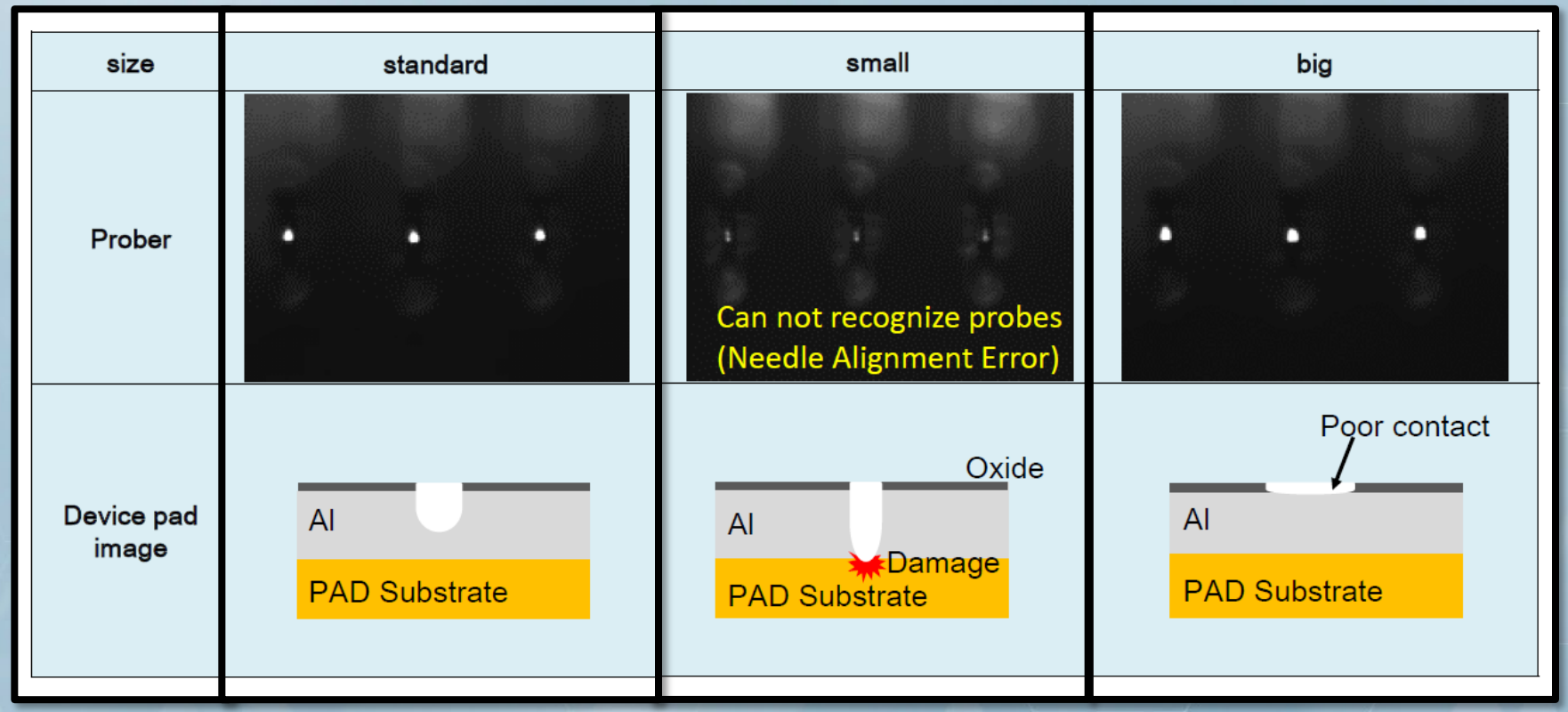
- Cleaning can consume more than **95%** of a probe card lifetime.
- With aggressive cleaning test costs increase.

Source: J Broz, SWTest 2007

Probe Tip Shape Requirements

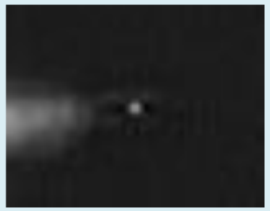
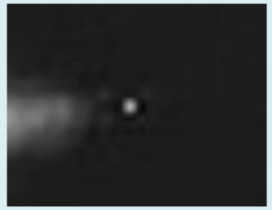
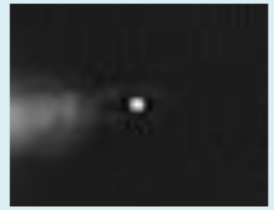
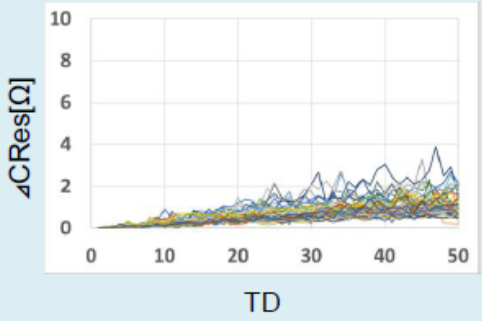
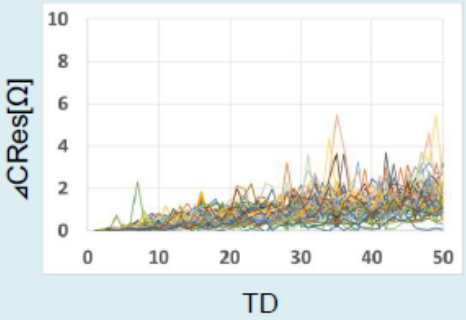
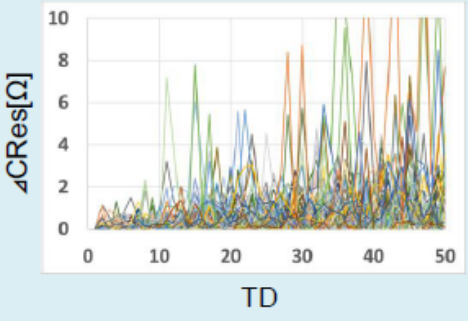
Improper Tip Shape

- Poor probe to pad alignment
- Damage to the pad substrate
- Poor pad contact



Effective probe cleaning must properly shape pins

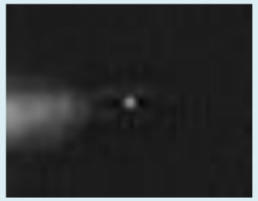
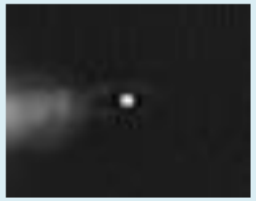
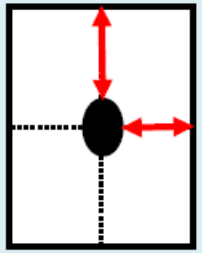
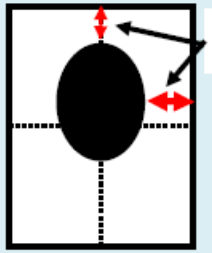
Probe Tip Size Requirements

size	standard	big	huge
2D Scrub Side			
Prober			
OD80um			

Probe pin size and shape directly impacts whether proper electrical contact is made.

Improper tip shape will lead to false test results and poor yield

Probe Tip Size Requirements

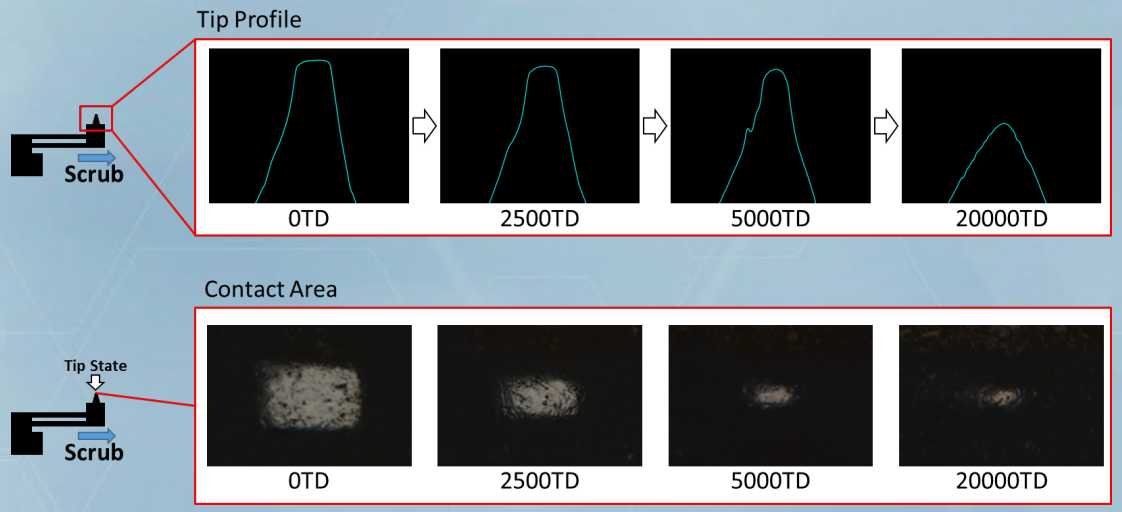
size	standard	huge
2D Scrub Side		
Prober		
Pad Margin		 Pad Margin Insufficient

Probe pin size and shape must be carefully designed and maintained to accommodate pad sizes

Current Cleaning Strategies

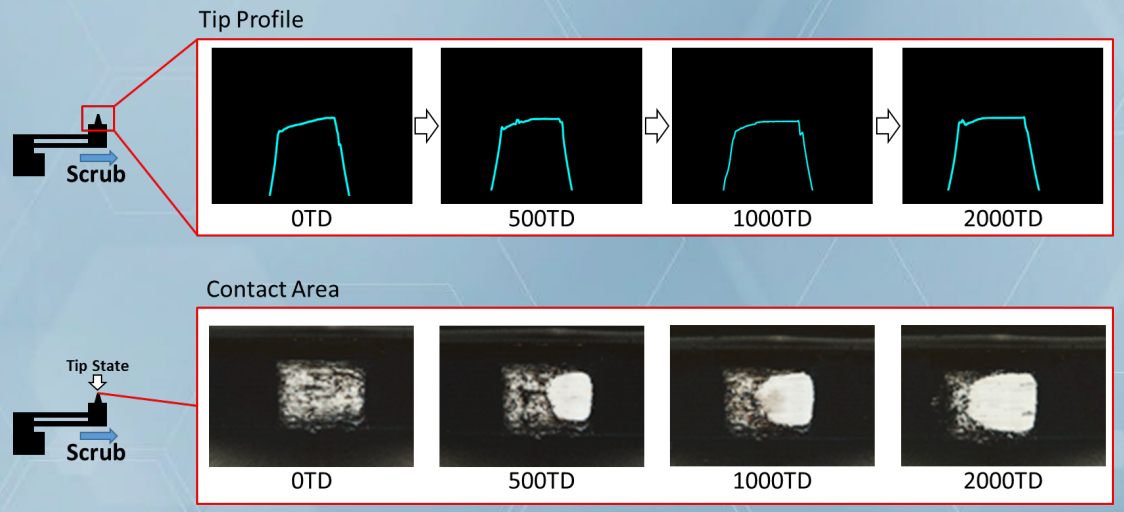
Gel-Probe Refine H3 Polymer Abrasive

- Loaded elastomer for online cleaning.
- Effective for debris removal and tip cleaning
- Overall, low wear rate for long lifetime
- Tip becomes sharper overtime



Abrasive Hard Clean

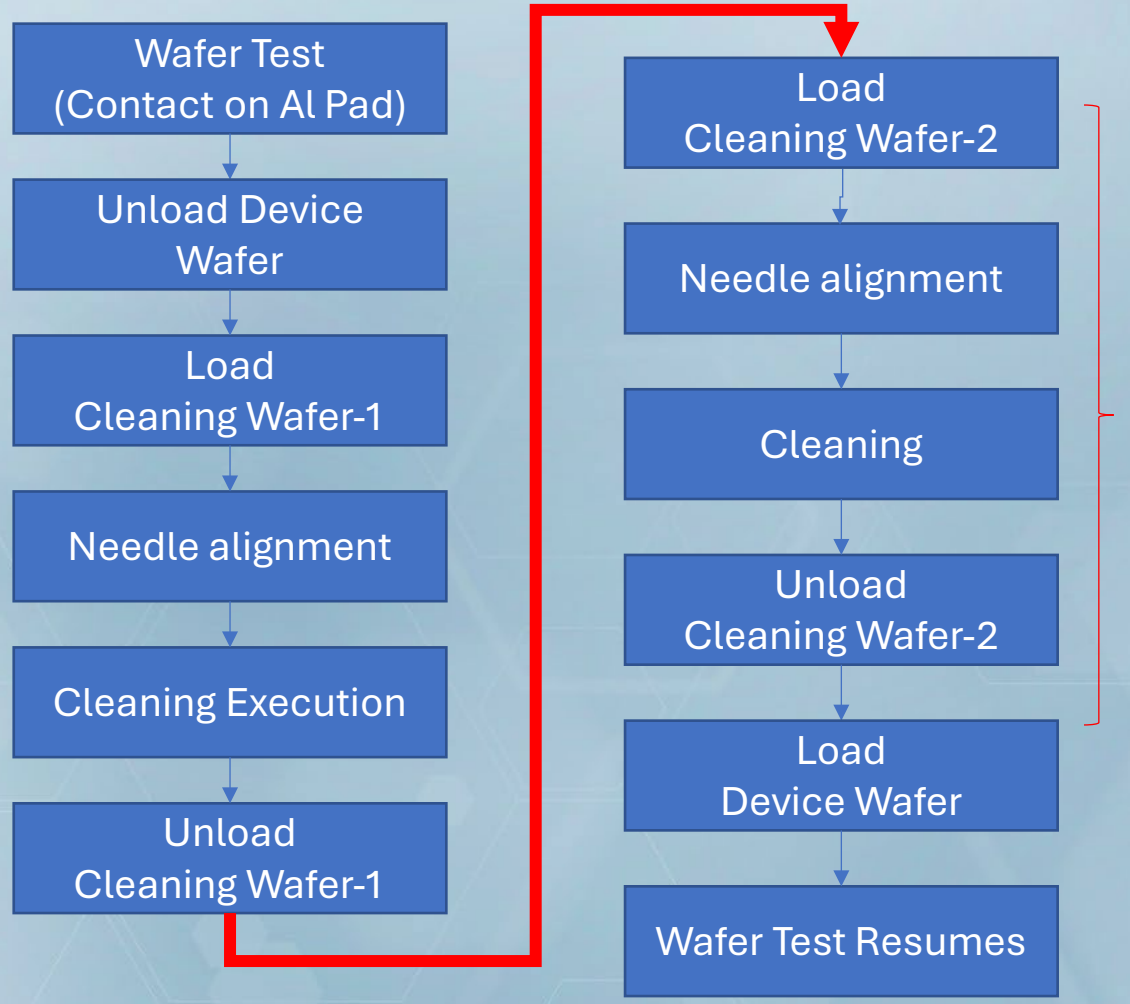
- Hard cleaning wafer
- Effective for probe tip texture and maintaining a flat tip
- Overall, high wear rate for short lifetime
- Tip size becomes top large.

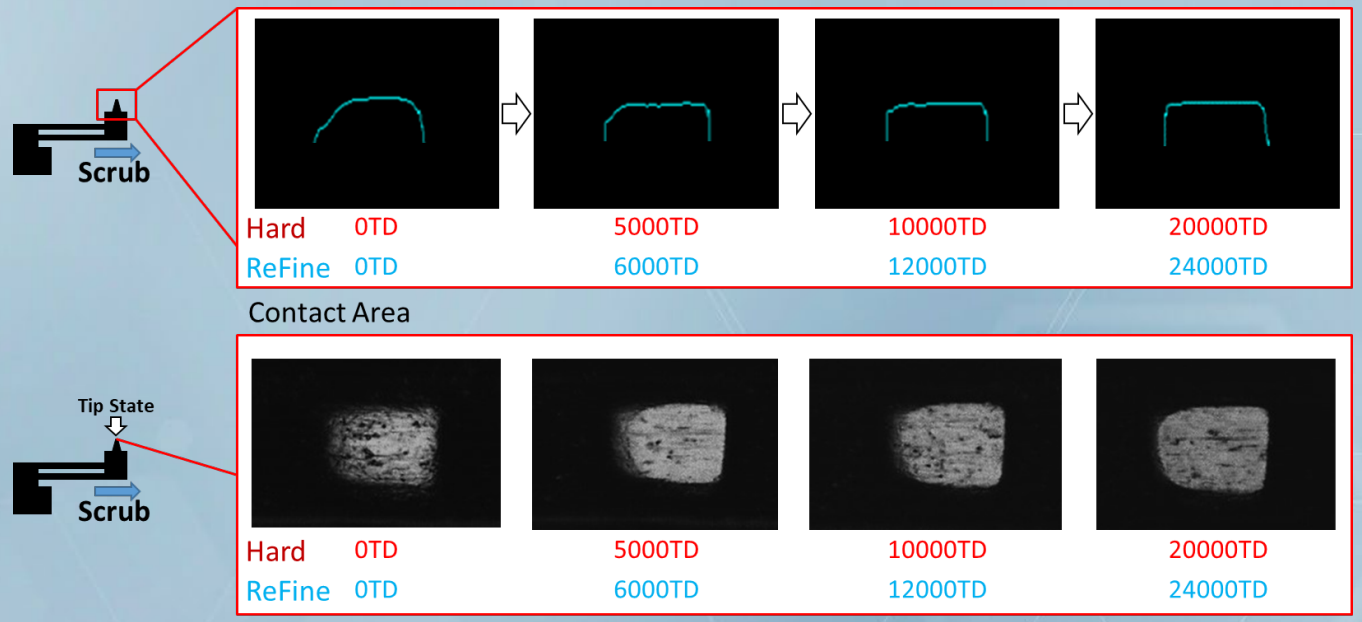


There does not exist an appropriate singular cleaning material

Combination Cleaning Process

Multiple cleaning wafers required



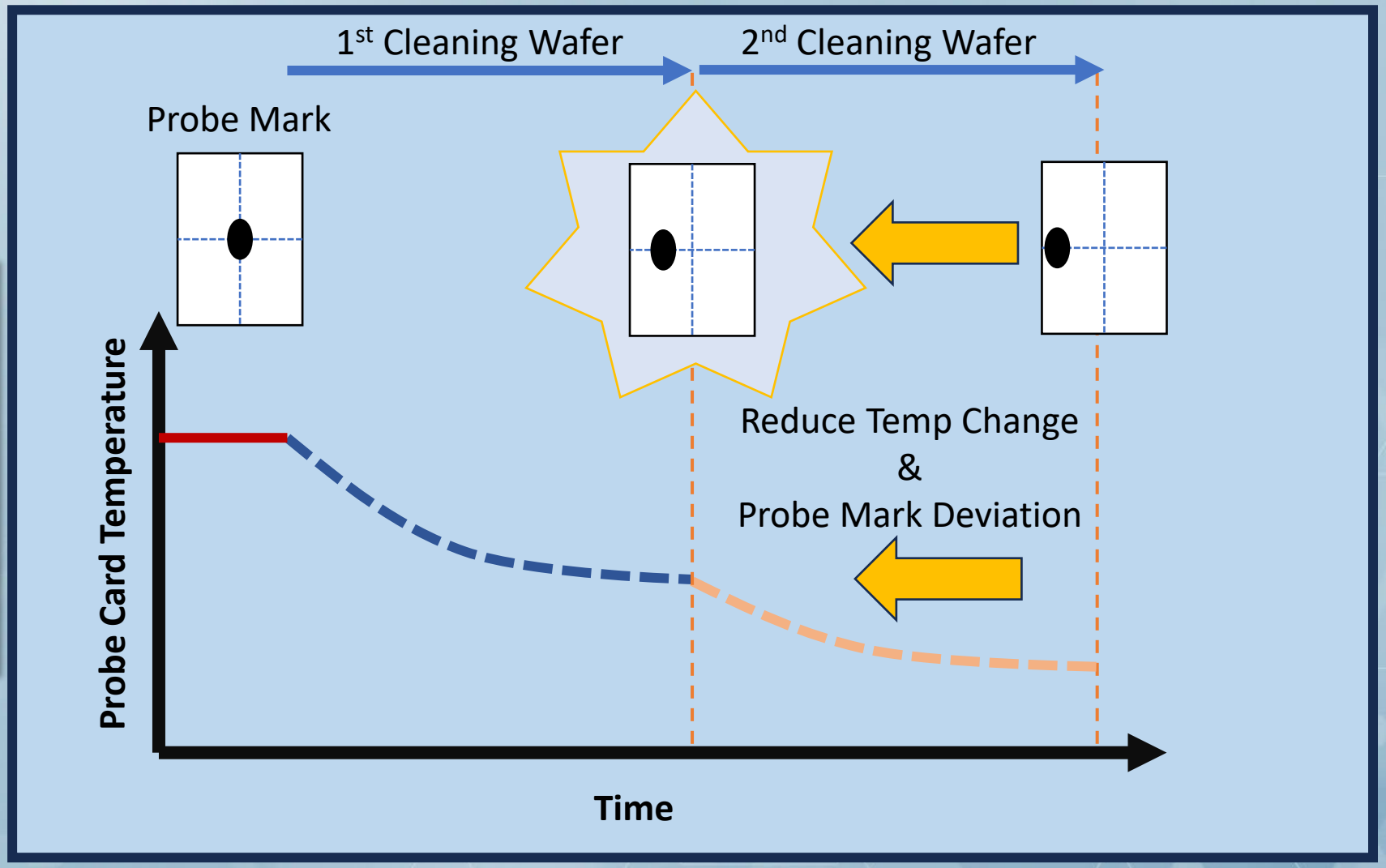


- **Combination Cleaning**
  - Tip shape and size are well-maintained
  - Effective for debris removal and tip cleaning
  - Effective for probe tip texture and maintaining a flat tip

Overhead Increase with Combination Clean

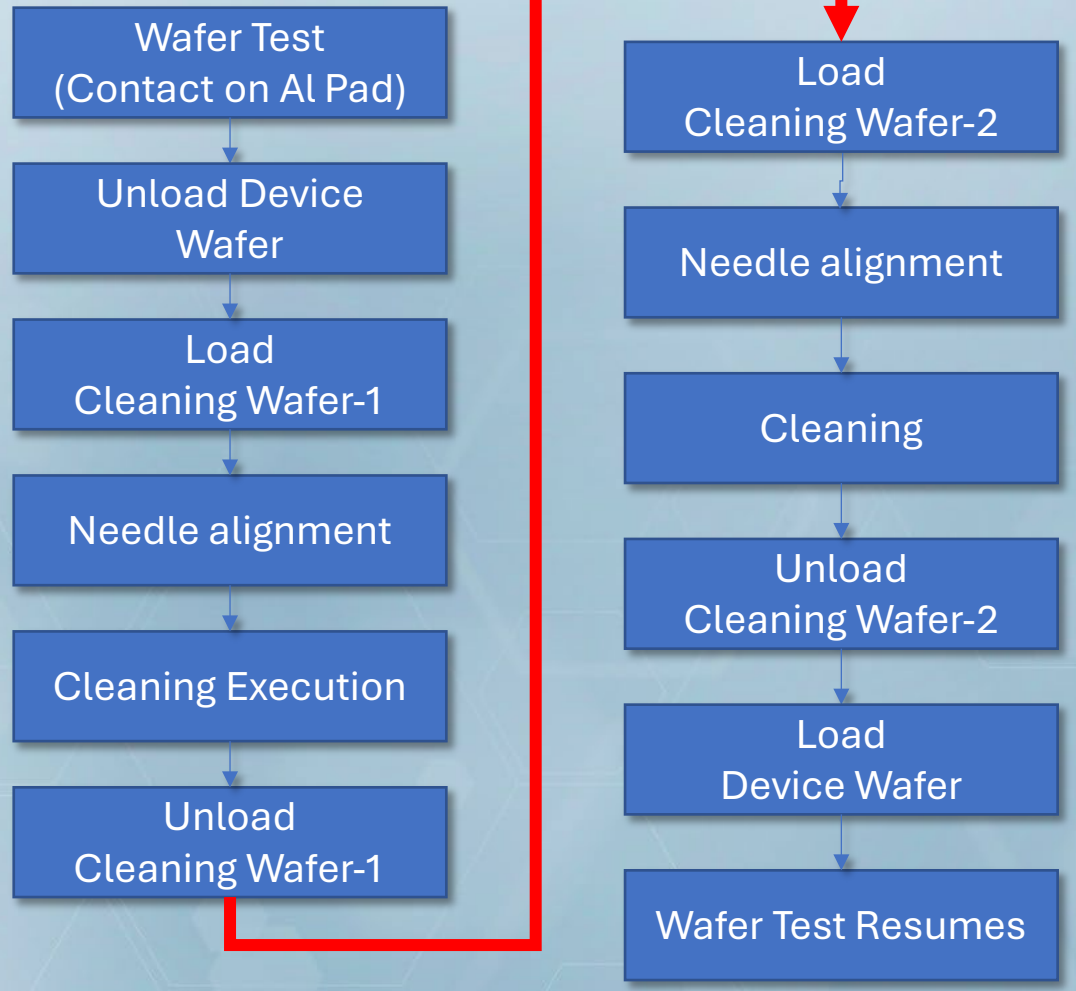
Combination Cleaning

- Increases cleaning time
- Causes more temperature change on probe card
- Increases deviation in probe positioning



Ideal Cleaning Process

Multiple cleaning wafers required



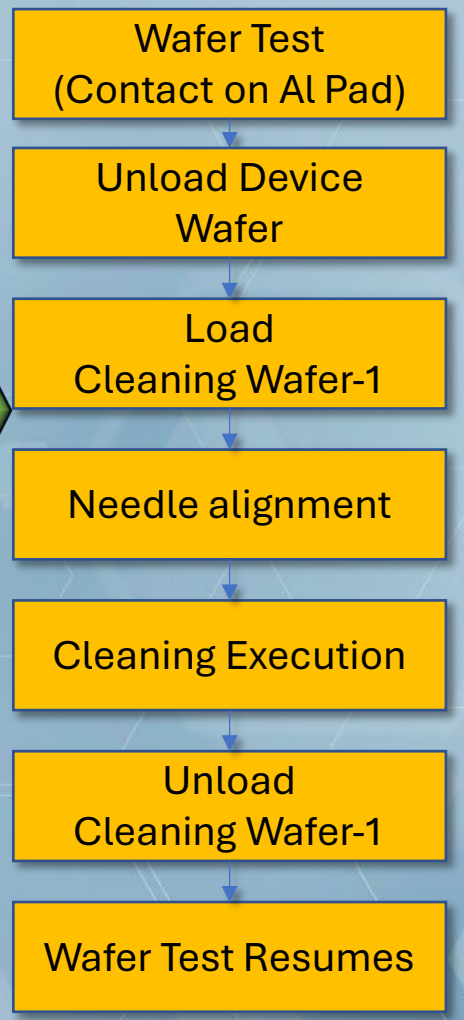
Combination Clean Wafer Cycle will Impact OEE and Cost of Test

- 2 x load/unload cleaning wafer
- 2 x needle alignment
- Approx. 15 minutes

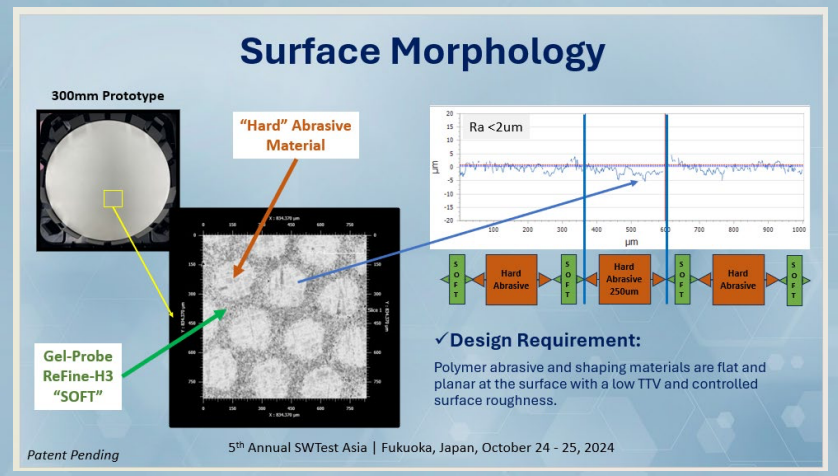
Single Clean Wafer Cycle

- 1 x load/unload cleaning wafer
- 1 x needle alignment
- Less than 5 minutes

Single Wafer

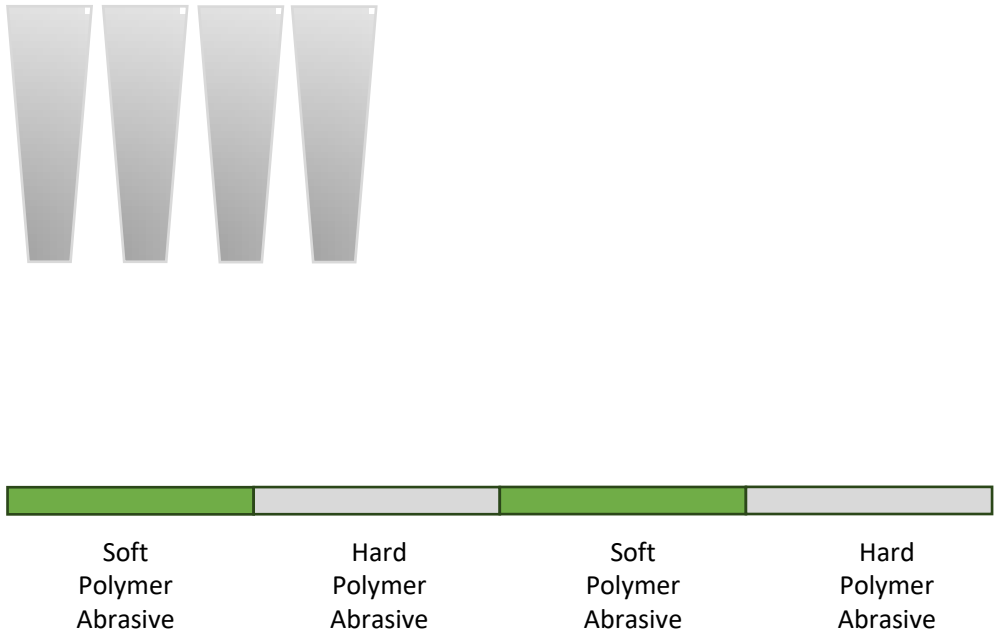


Challenge | Hybrid Cleaning Material



Patent Pending

Animation demonstrates probe tips cleaning sequence



Hybrid Cleaning Development Timeline

Q2-2024 — Technical Feasibility

- Prototype
- Single DUT Testing

Q3-2025 — Design Optimization

- Design Optimization
- Full Wafer Probe Card Testing
- Stacked Prober Testing

Q4-2025 — Qualifications

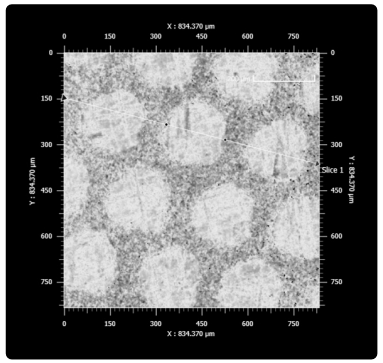
- Stacked Prober Testing
- Memory Probe Card Companies
- Vertical Probe Card Applications
- End Customers

Q1-2026 — Pilot Production

Collaborative Project

Cleaning Materials

Gel-Pak Redesign of
Hybrid Cleaning Material



Patent Pending

Test Vehicle

JEM FULL Wafer
MC Probe card for HVM Prober

Setting Parameters	
Index	20um
OD	100um
TD count	100TD
Same Position TD	1TD
Keep out zone *From the outside	2mm

Card Spec	
Probe Total	92,115pin
Probe Area	φ288mm

Measurement Timing

INT	3,600TD*	7,200TD	10,800TD*	14,400TD
(0°)	(180°)	(360°)	(540°)	(720°)

- Needle tip measurement
- Cres (*Except 3,600TD and 10,800TD)

T= -40C
&
+125C

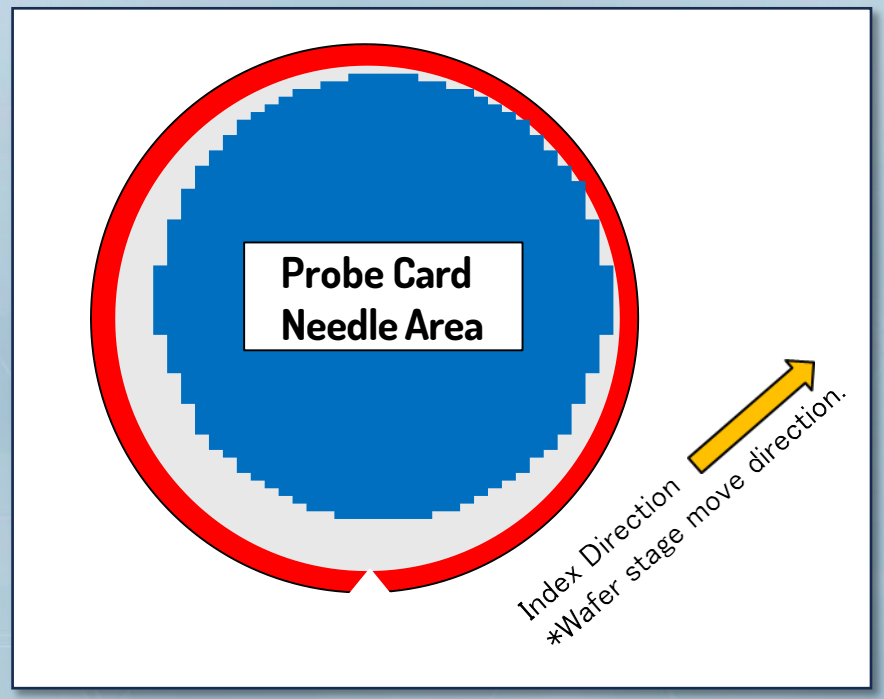
8000A
Blanket Al
Wafer

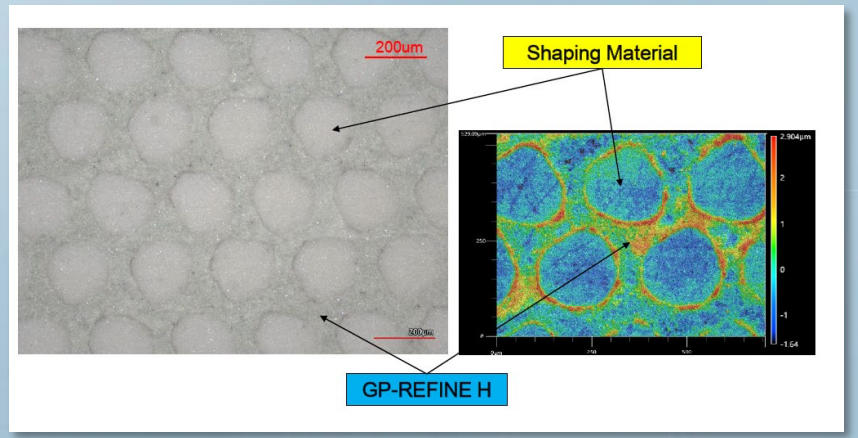
OEE Evaluation

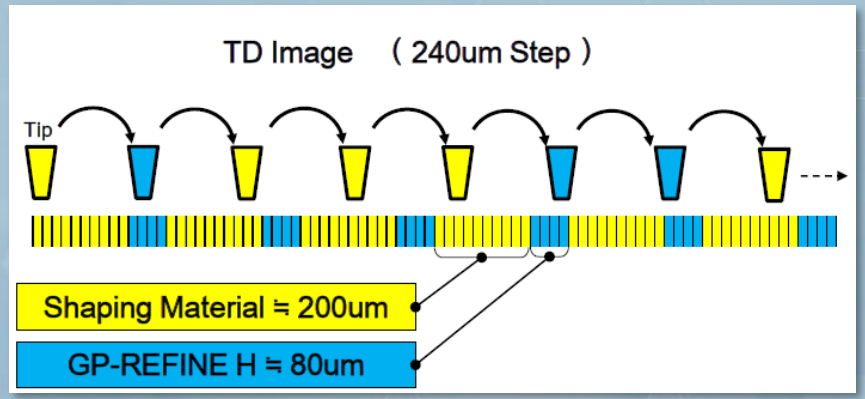
- Debris Removal Efficiency
- CRES Recovery
- Tip Wear Rate
- Cleaning Wafer Longevity

Cleaning Wafer Design Optimization

Indexing on a full wafer probe card is restricted





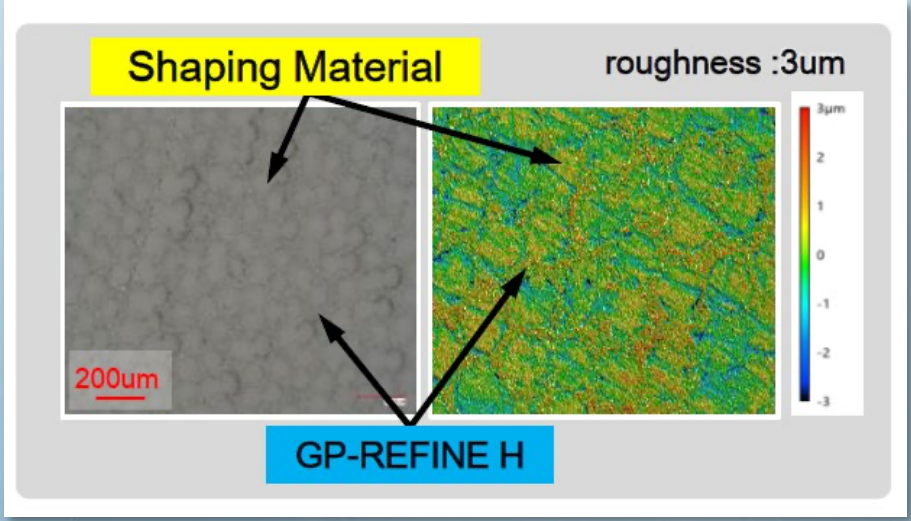


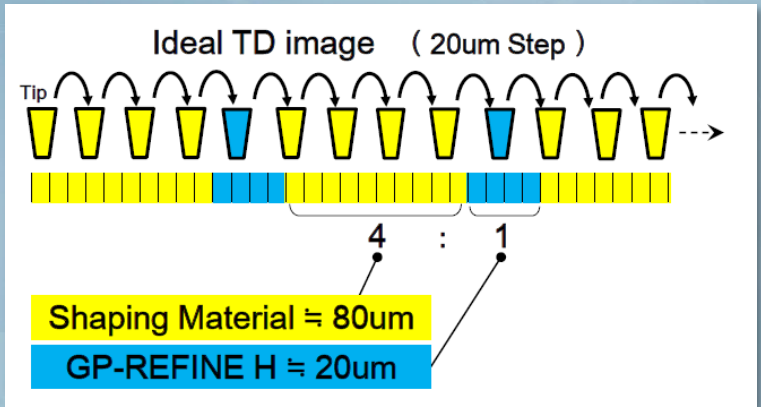
Cleaning Parameter	
Cleaning Index	240um
# of Touchdowns	**20**
Travel Distance	**4800 um**

Cleaning pattern length is too large for full wafer probe card

Cleaning Wafer Design Optimization

Cleaning Material and Indexing Pattern Redesigned





Cleaning Parameters		
	Old	New
Hard Domain Size	200um	80um
Cleaning Index	240	20-40um
# of Touch Downs	20	20
Travel Distance	4800um	400-800um

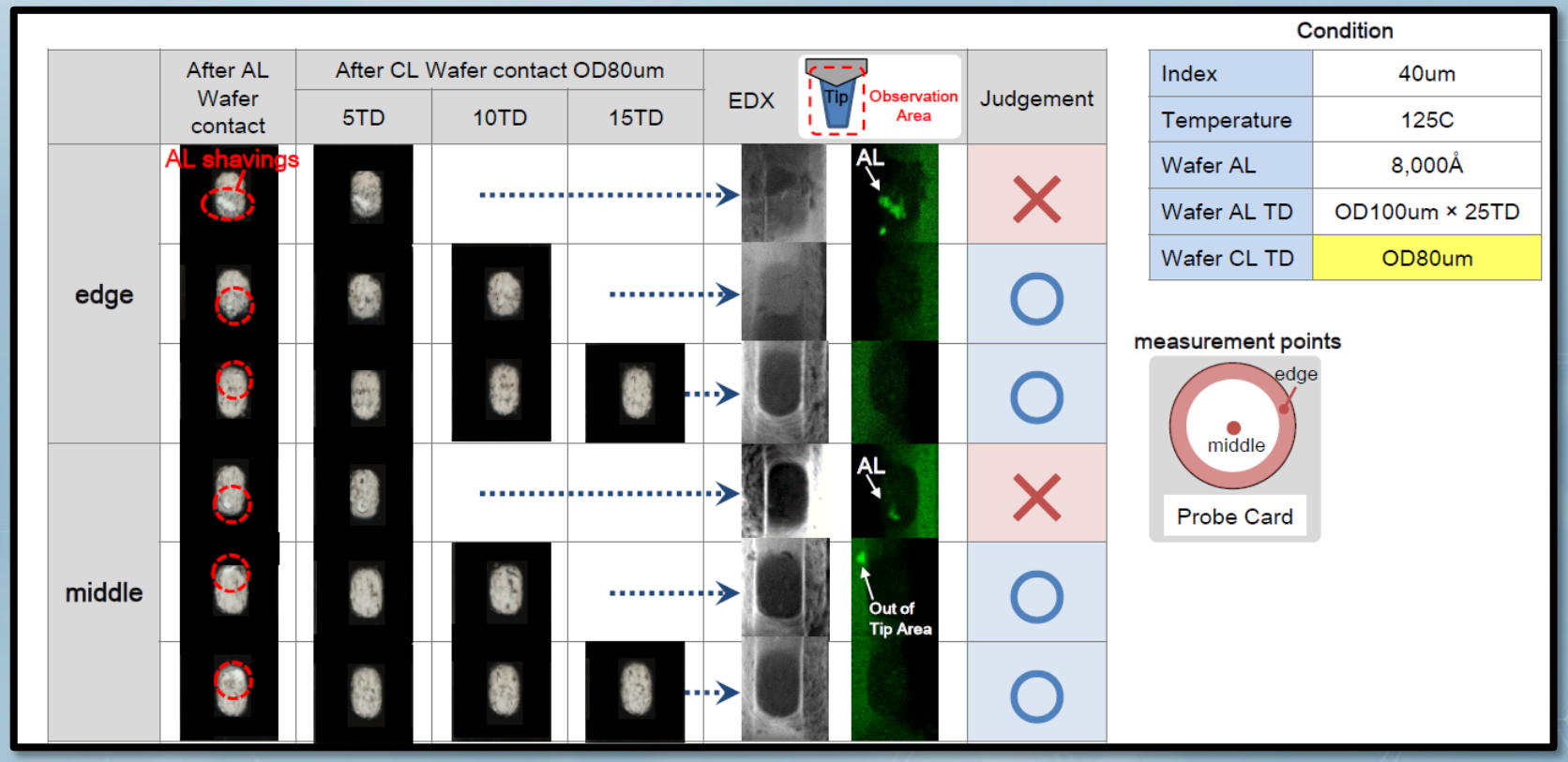
One Touch Wafer Cleaning Requirements

- Debris Removal
- CRES Recovery
- Tip Shape Maintenance
- Low Wear Rate
- Cleaning Wafer Longevity

- **Output → Optimized Cleaning Method**

Requirement: Debris Removal

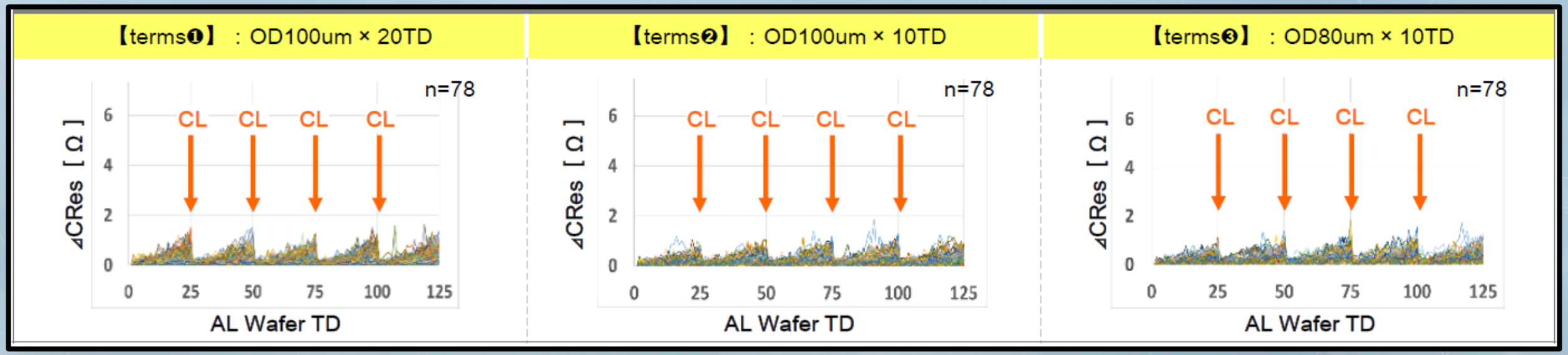
Previous Design: Debris removal after 20 TD, 100OD



Aluminum debris is removed with fewer touchdowns: 10 TD

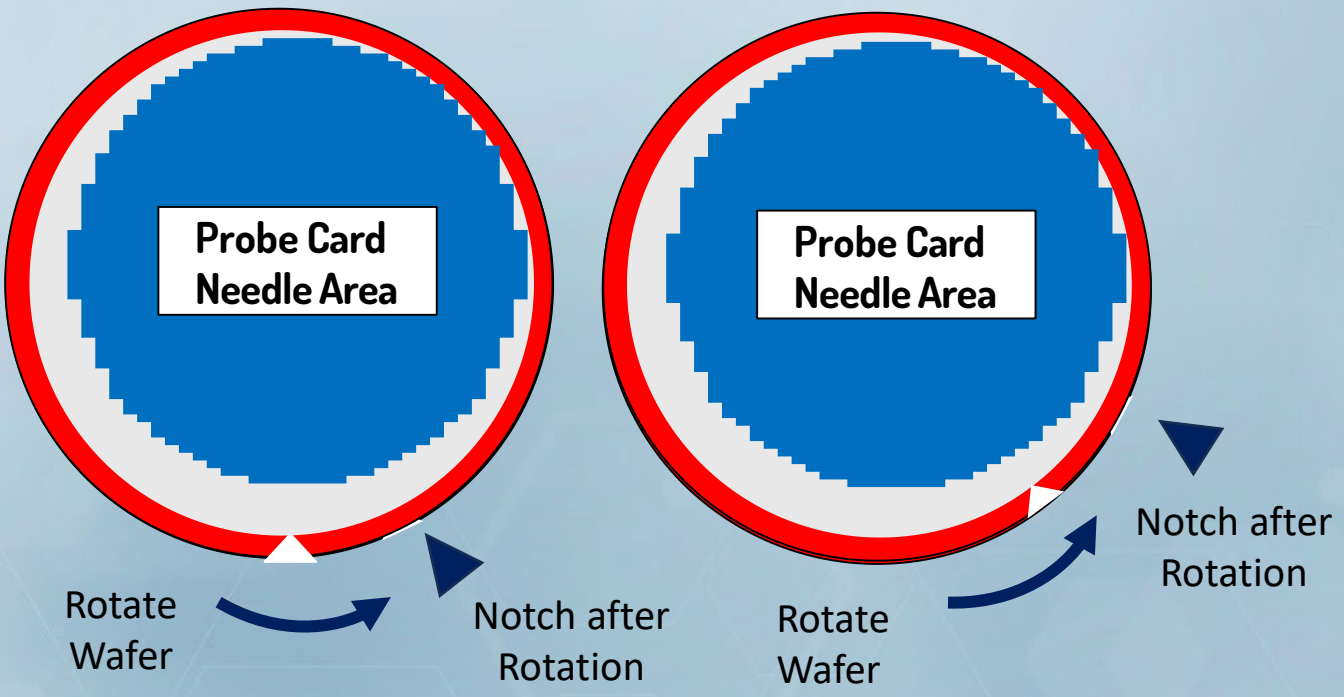
Requirement: CRES Recovery

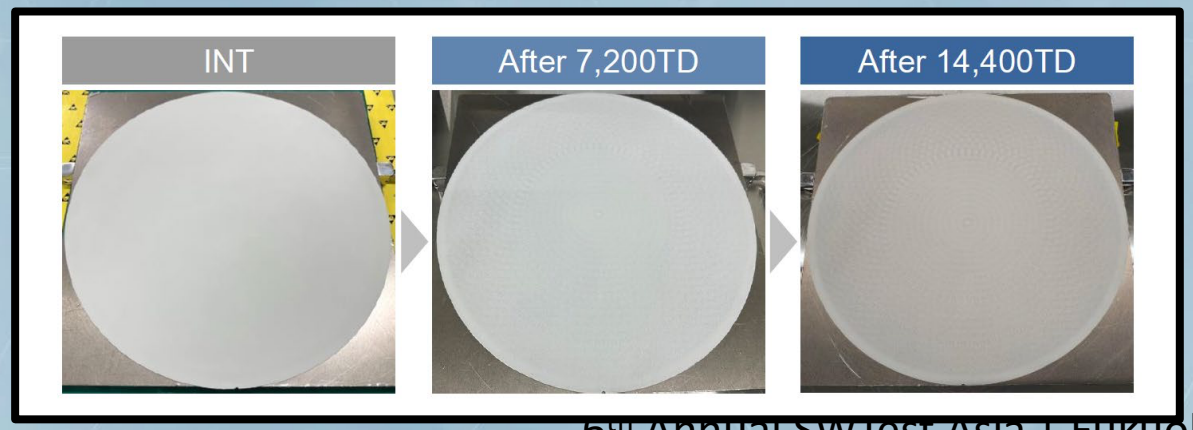
After 14,000 TDs on hybrid cleaning wafer

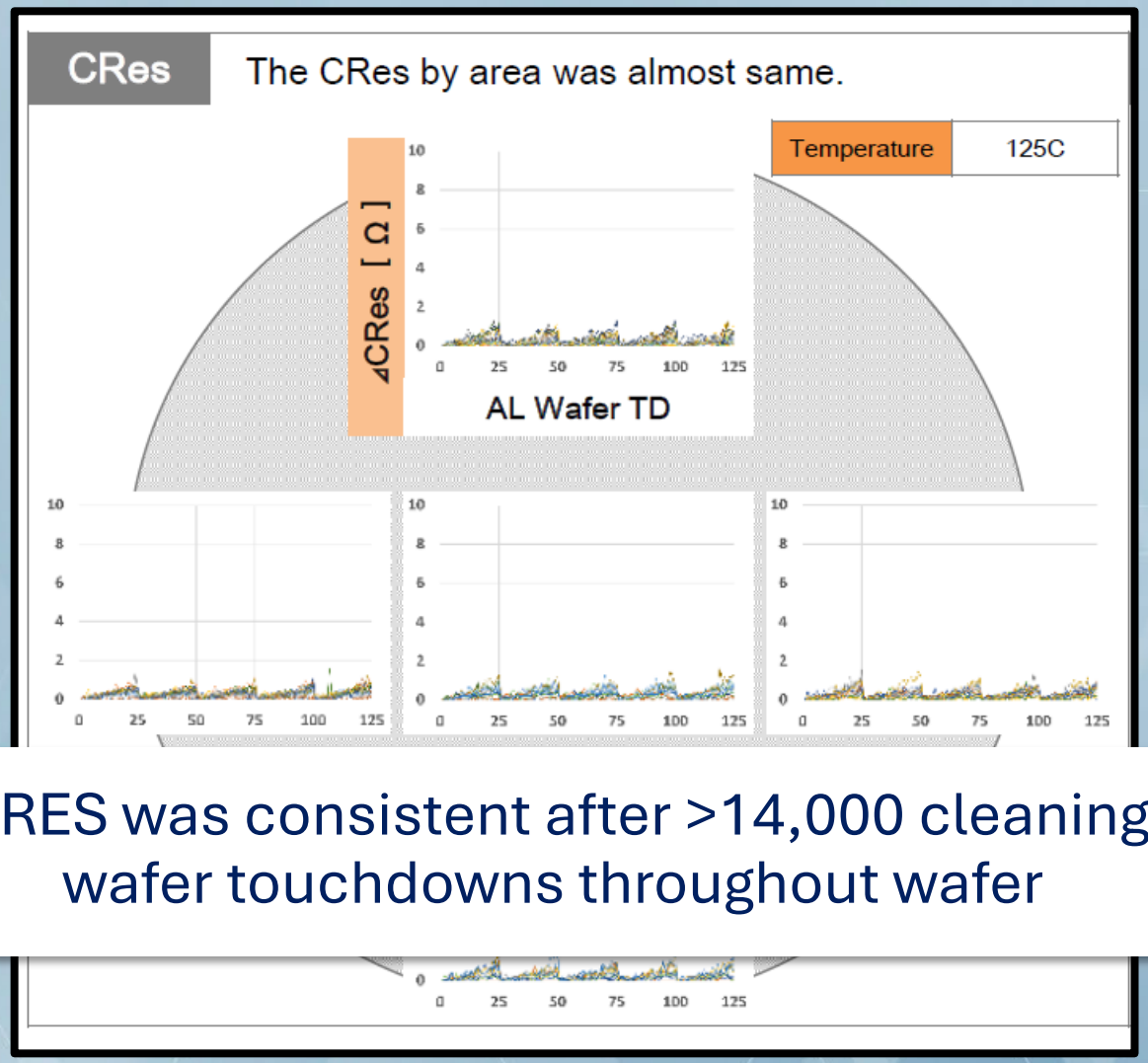


CRES was recoverable using flexible cleaning parameters

Full Wafer CRES Recovery

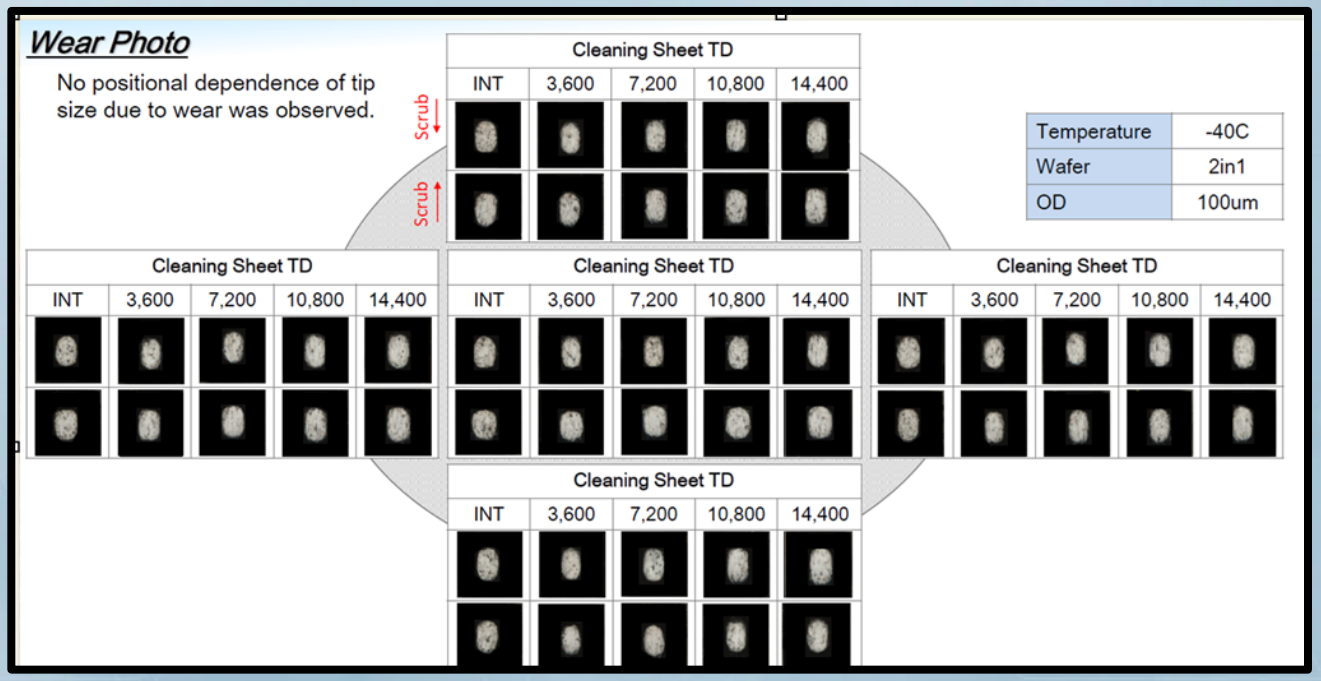


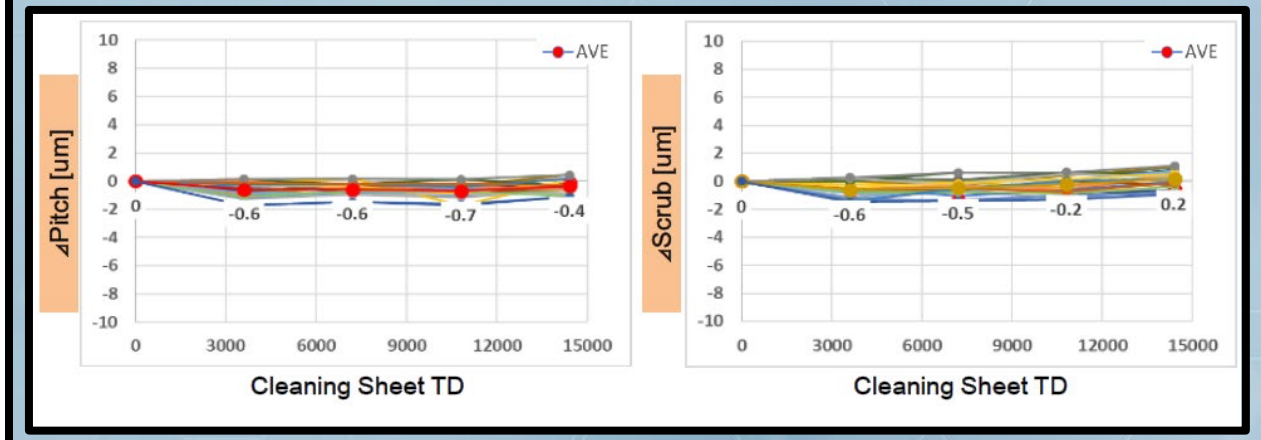




CRES was consistent after >14,000 cleaning wafer touchdowns throughout wafer

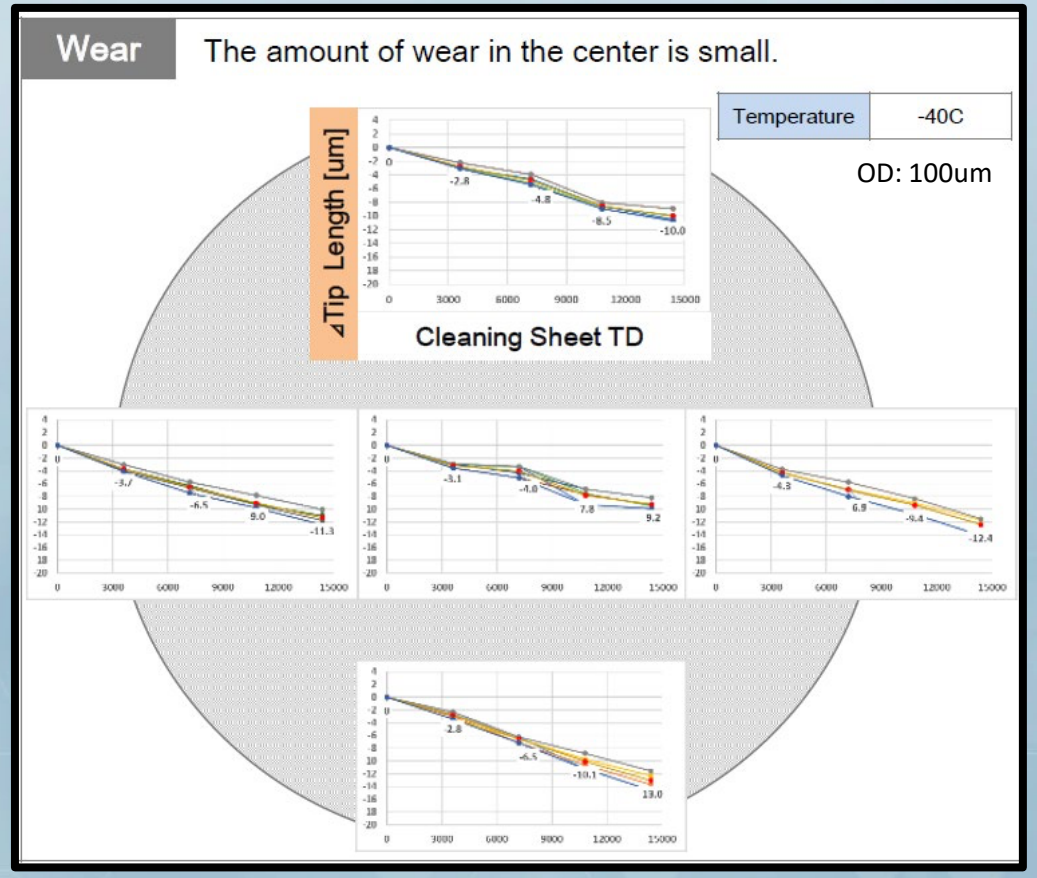
Requirement: Tip Shape Maintenance

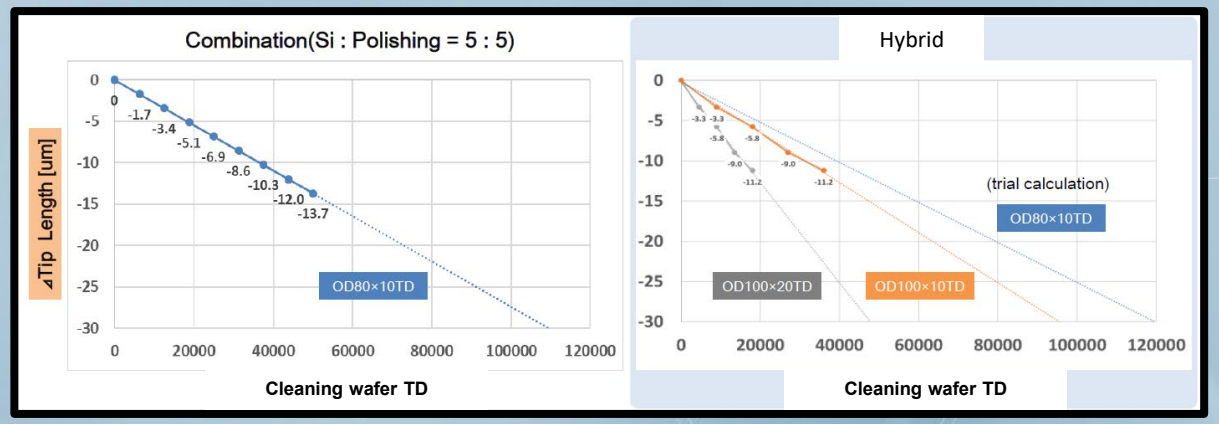




Tip size shows no change during extended use.

Requirement: Probe Card Longevity

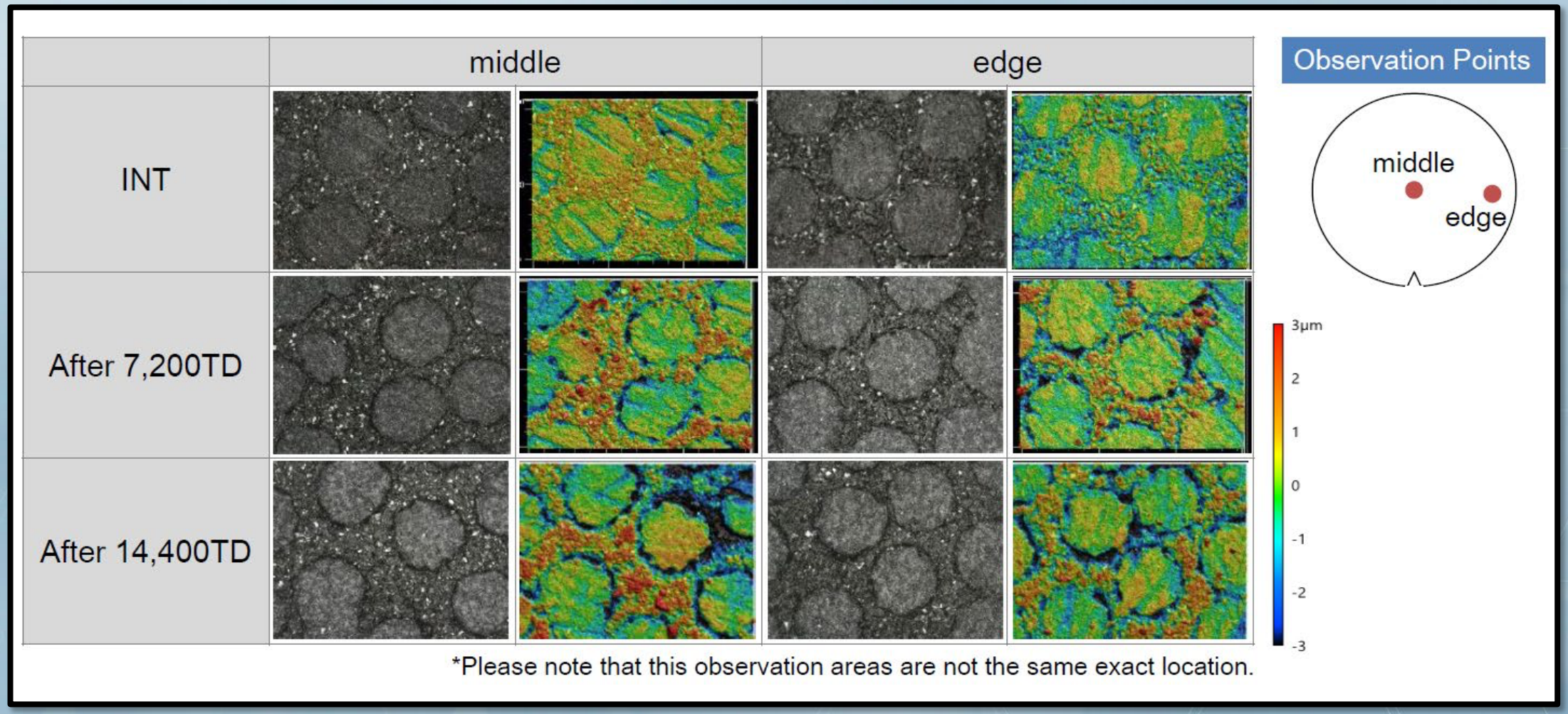




Cleaning Parameters	Previous	Optimized
Cleaning Index	40um	40um
# of Touchdowns	20	10
Over Drive	100um	80um

Optimized Single Hybrid Cleaning Recipe Prolongs Probe Card Longevity

Requirement: Cleaning Wafer Longevity



Surface roughness increases but remains low after use

Next Steps

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Hybrid Cleaning Wafer Solution Summary

Hybrid cleaning solution results in higher yield, lower cost, and longer probe card life for next-generation semiconductor memory testing.

Reduced Cleaning Time & Cost

Single-wafer cleaning cuts time and operational expenses

Improved Efficiency & Yield

Boosts probe card performance and test throughput

Reliable CRES Recovery

Ensures consistent electrical contact over thousands of touchdowns

Extended Probe Card Life

Optimized cleaning maintains probe tip shape and extends card life

Acknowledgements

- Miki Nomura
- Yuki Nakamura
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- Shohei Sawamura
- Patrick Mui

- Rembrant Gamboa
- Jerry Broz, PhD