Probes Cleaning Effectiveness challenges for fine pitch and high-densities Logic Probe Cards with MEMS tips

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Outline

- **Introduction**
- **Challenges of effectiveness online Needle Cleaning**
  - Overlapping cleaning movement
  - Reuse cleaning foils at limited cleaning substrate
  - Constraints of in-situ cleaning selections
  - Ineffective cleaning leads to dirty tips
  - Consequences of contaminated probe tips
- **Consequences after needle cleaning**
- **Out of the box thinking - possible solutions**
- **Follow-on Works**

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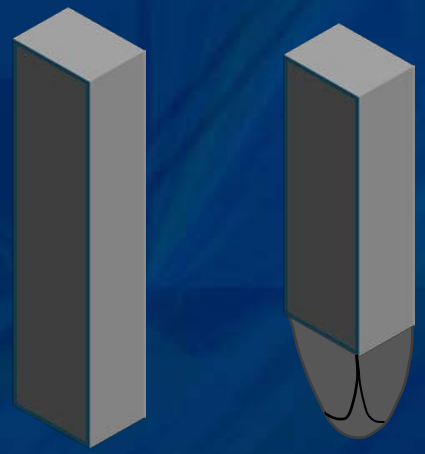
Introduction

- MEMS probes are widely used in logic probe cards.
- MEMS advantages: position accuracy, fine pitch, high pin counts, low contact force, easy maintenance, etc.
- Variety of probe shapes to contact wafer side, such as flat, radius, point, etc.

Micro-Electrical-Mechanical Systems



Introduction

- Debris build-up occurs on probe tips during testing. And on-line cleaning is required to maintain good contact.
- In the presentation today, we will be focusing on vertical and flat type of probes to contact Cu-pillar bumps.
- After several on-line cleaning cycles, what happens to probe tips?
- What's the best of cleaning process?

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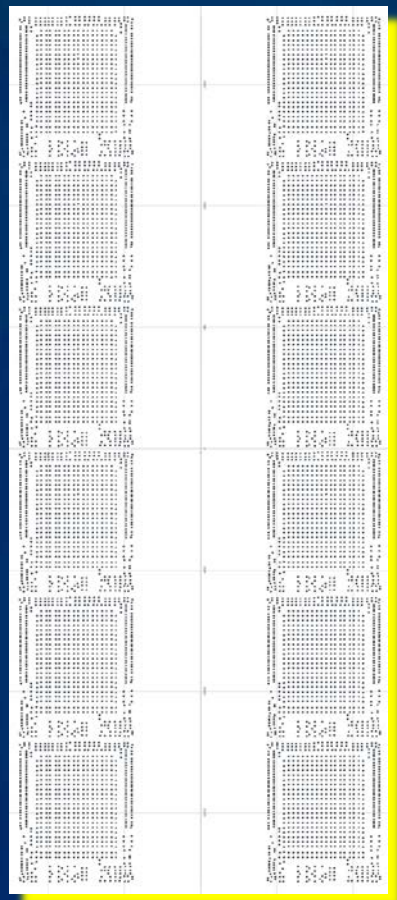
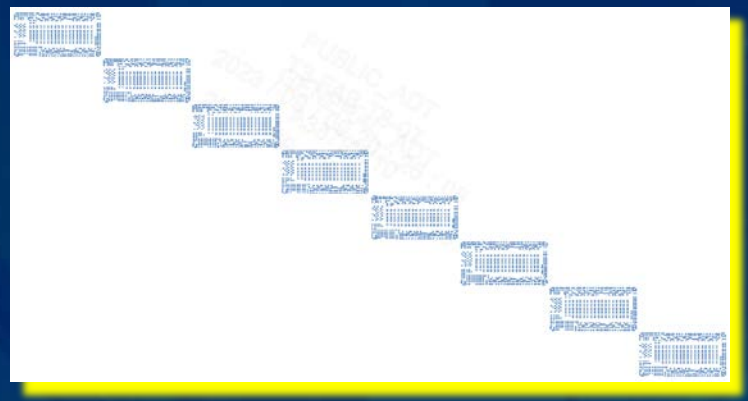
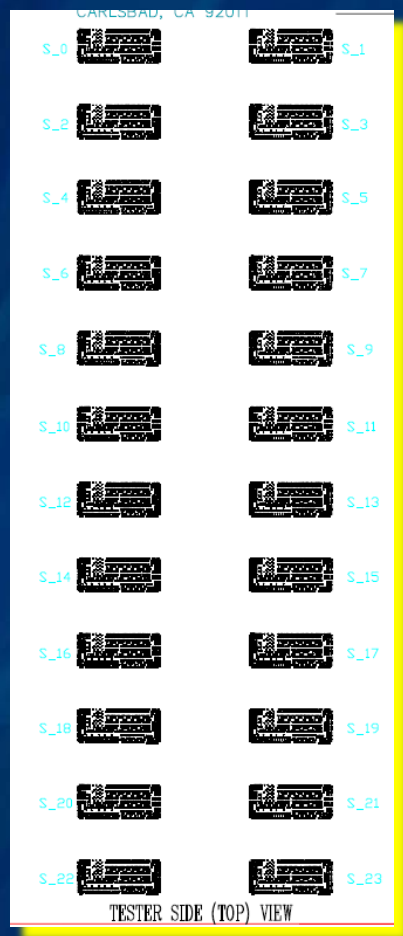
Challenges of Effectiveness on Needle Cleaning

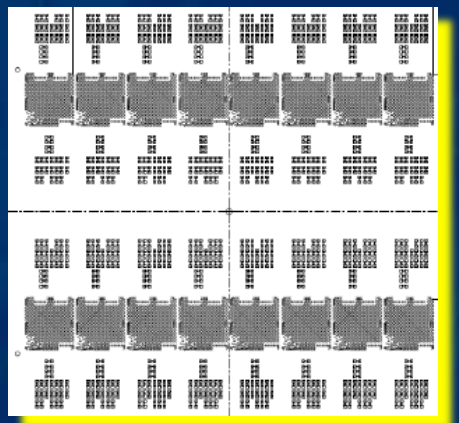
- **MEMS probe cards are frequently designed for fine pitch, high density, high parallelism, and high pin count devices.**

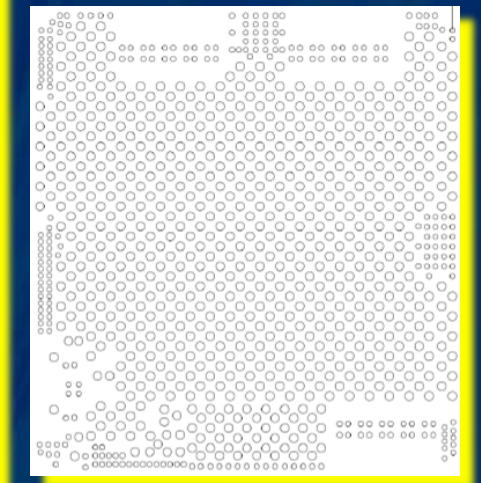




Fine pitch and high density < 80um
High Pin Counts > 8K pins
High Parallelism > 8 DUTs or more



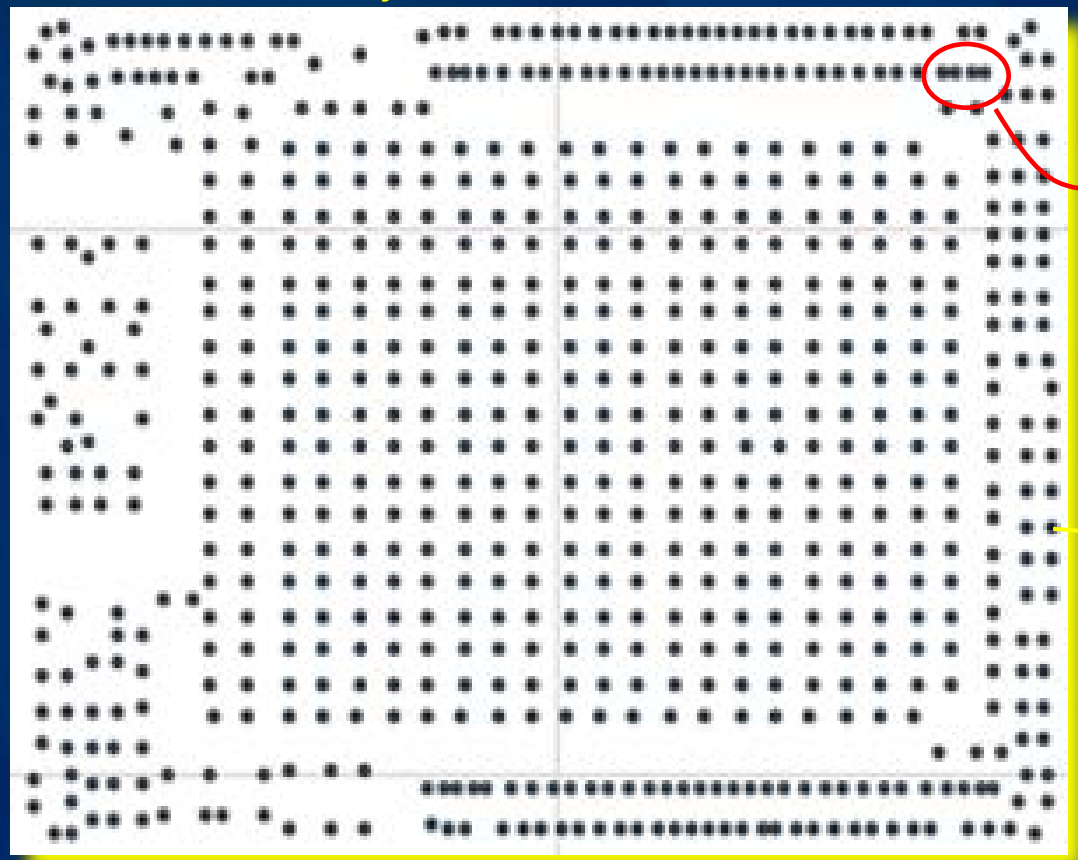




Challenges of Effectiveness on Needle Cleaning

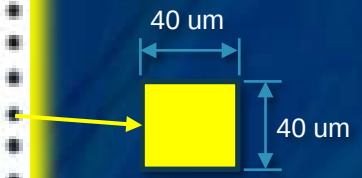
- **Example #1: Single cleaning movement, no overlapping.**
  - **Moving distance calculated accurately.**

Needles layout on one of DUTs



Minimum clearance= 50um

Needle size

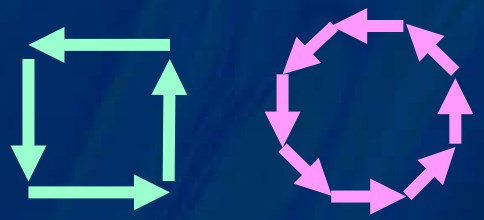


Cleaning movement:
At X direction < 40~50um

At Y direction < 80~100um

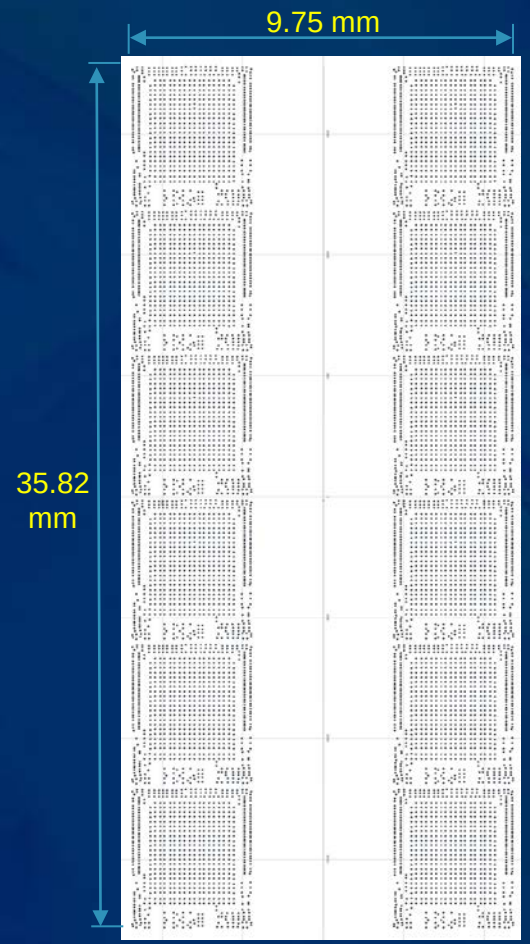
At X+Y direction < 40~50um

At Octagon direction < 40~50um

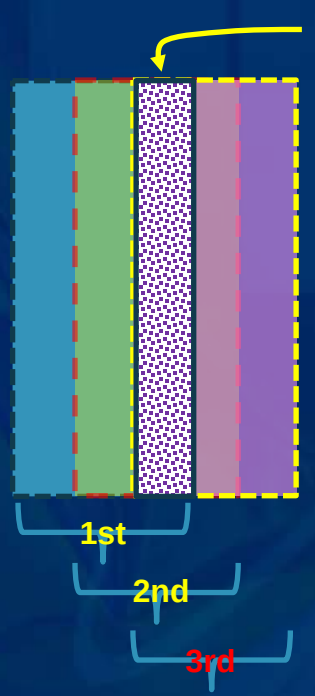


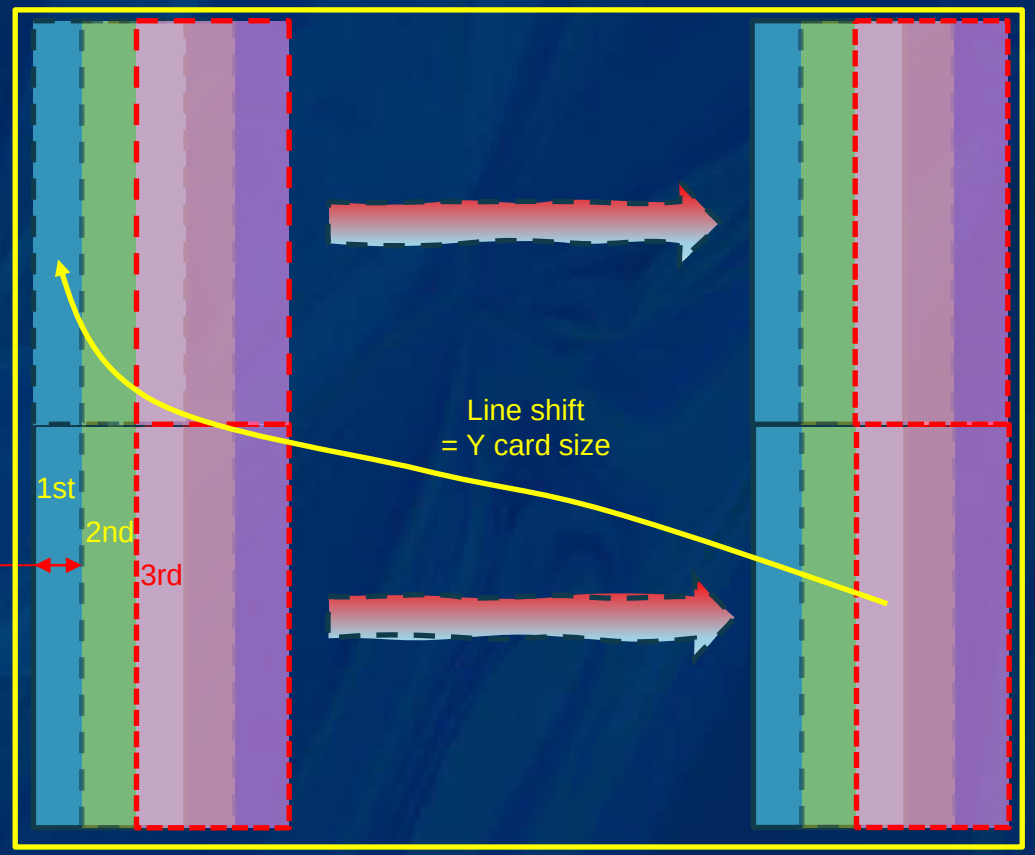
Challenges of Effectiveness on Needle Cleaning

- **Example #2: > 3rd TD, overlapping occurs on cleaning material**
  - Most probes touch dirty area of cleaning foils.

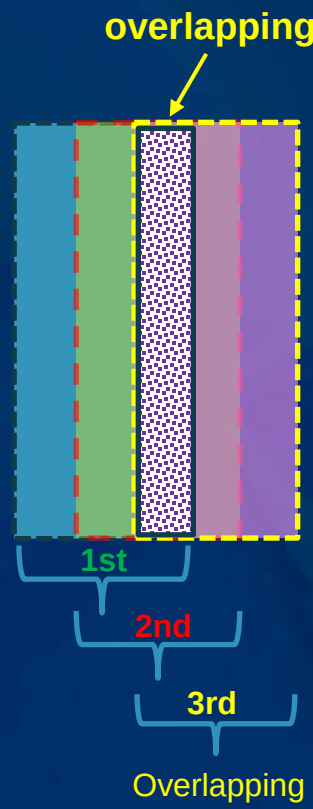


Layout: X=2, Y=6, 12 DUTs, X skip 1
Probe diameter = 40 x 40 (um)
Probe Tip Shape: Flat
Pitch: < 80um
Number of Probes: > 8K

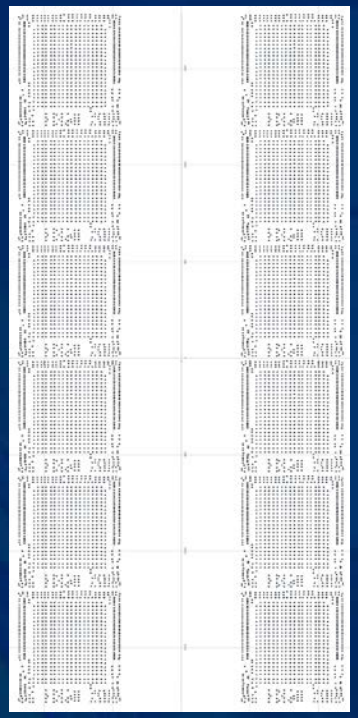




• Why do we care overlapping at needle cleaning?

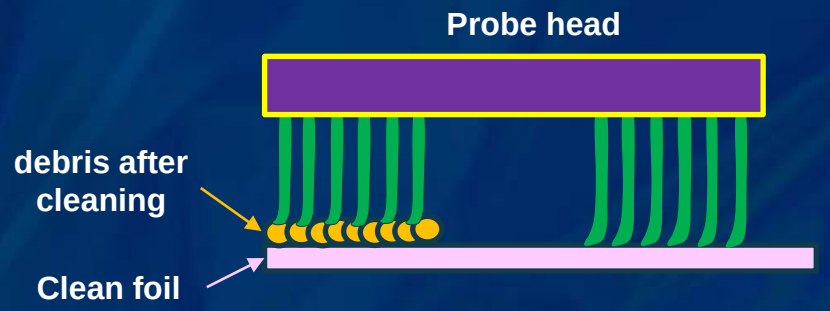


Left side will be touching dirty foil



Right side will touch a cleaner foil

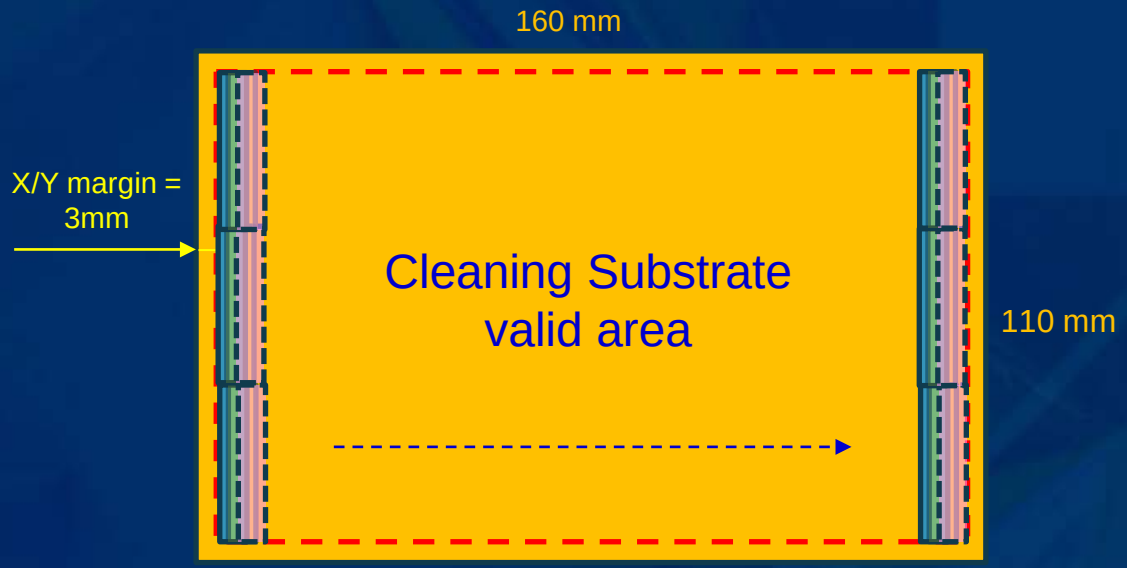
Microscopic feature of cleaning movement

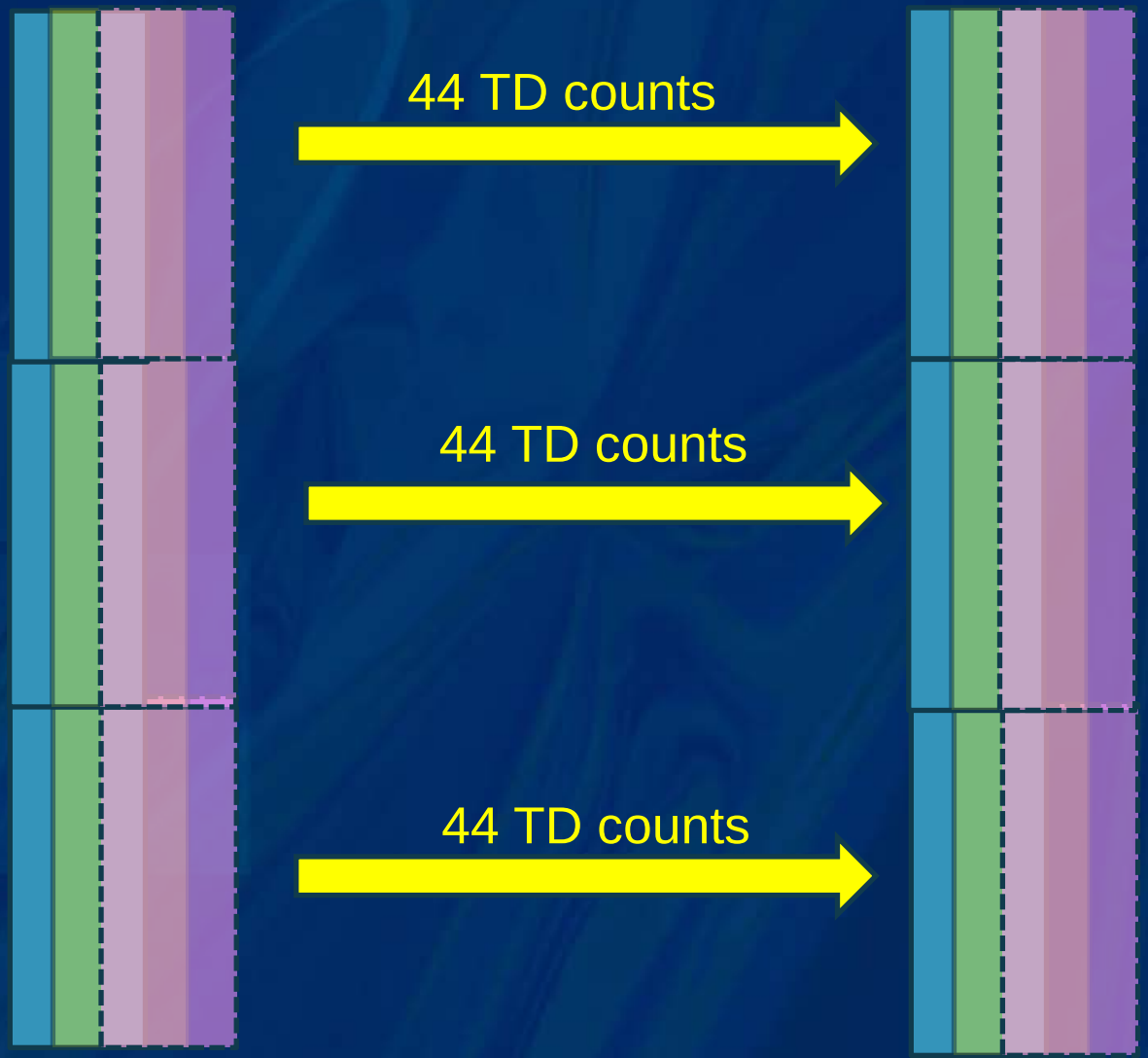


Compared to left side of DUTs, right side of probe tips will always be touching new foil area and scratched stronger. Cleaning effectiveness in between and probe length will cause adverse effects in the long run.

Reuse cleaning foil at limited cleaning substrate

TD counts at X direction : 154 / 3.5 = 44
TD counts at Y direction : 104 / 35.82 = 3
One cycle can ONLY use 44x3=132 cleaning TD
The prevailing practice is to reuse the same cleaning foil touching the same positions. And recycle material several times without replacing.
This clean paper will be getting dirty again.



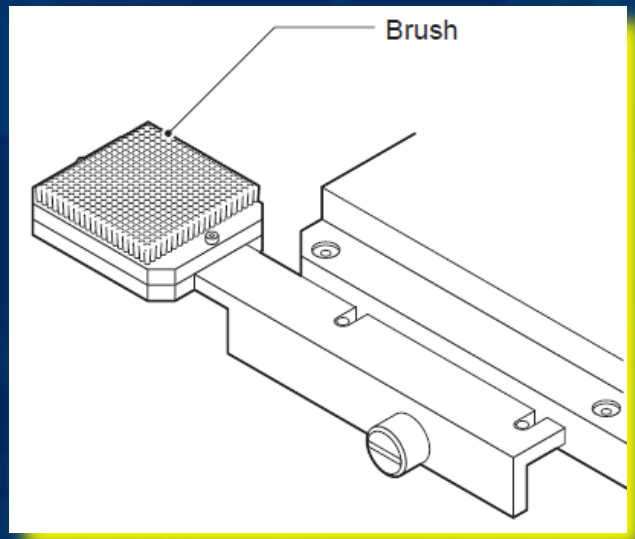


Constraints of In-situ cleaning selections

With current prober configurations, no obvious way to use large area and multiple lapping films at the same time. No obvious way to use liquid or chemical materials, no obvious way to install other tools for cleaning.

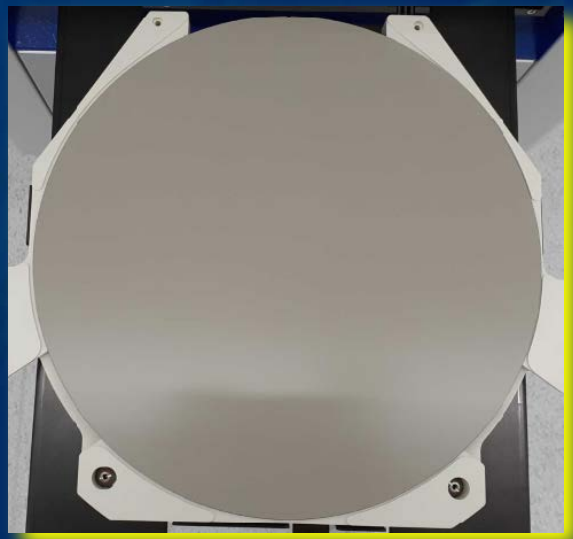
Clean Substrate

Brush



source: Accretech document

Clean wafer

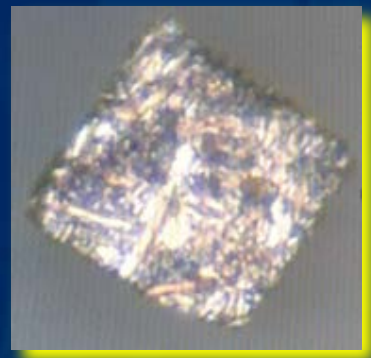


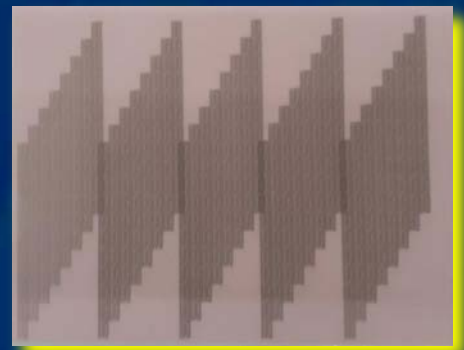
Ineffective cleaning leads to dirty tips

Probe tips get contaminated frequently because of …

- Overlapping at cleaning movement
- Reuse cleaning foil at limited cleaning substrate
- Constraints of cleaning unit selections







Pictures do not necessarily represent Micron's production condition

Consequences of contaminated Probe tips

- Contact issues (a.k.a. CRES instability)
- Affect testing data quality
- Wafer yields drop
- IRT (In-line Retest) rises and Lower OEE (Overall Equipment Effectiveness)
- Push up testing costs
- Affect equipment uptime and prober setup
- Engineers assist needed for setup or troubleshooting
- Lapping needles abrasively required to remove contaminations
- Shorten lifespan of probe cards

…etc.

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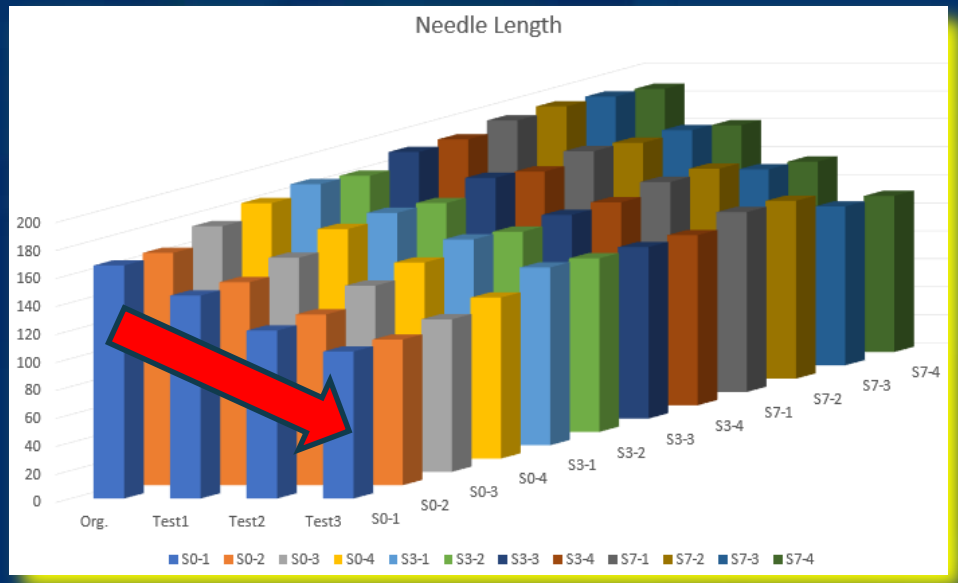
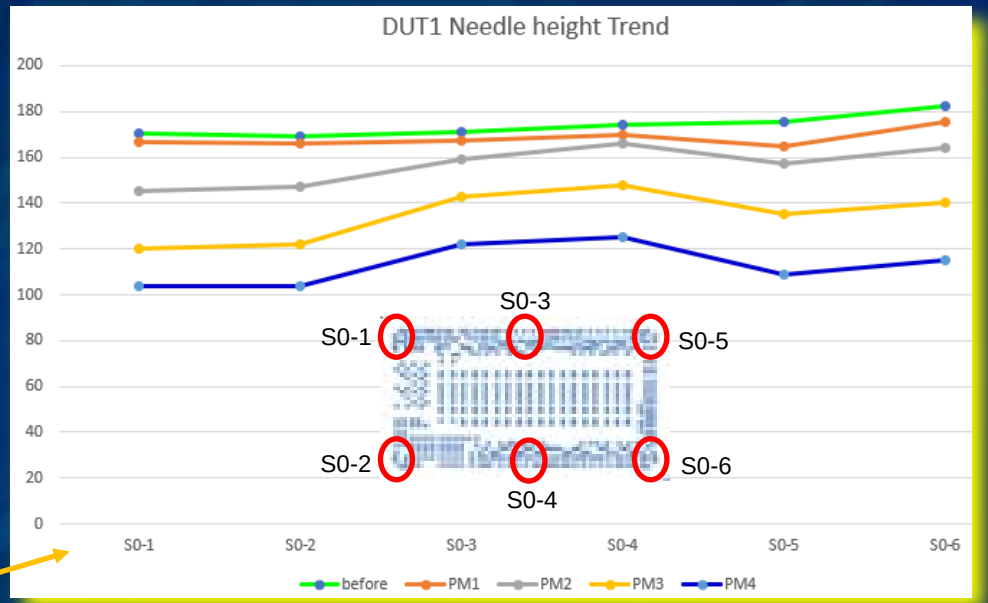
Consequences after needle cleaning

Cleaning conditions: the same COD, frequency, X+Y movement & same paper.

- Probes are getting shorter and shorter.



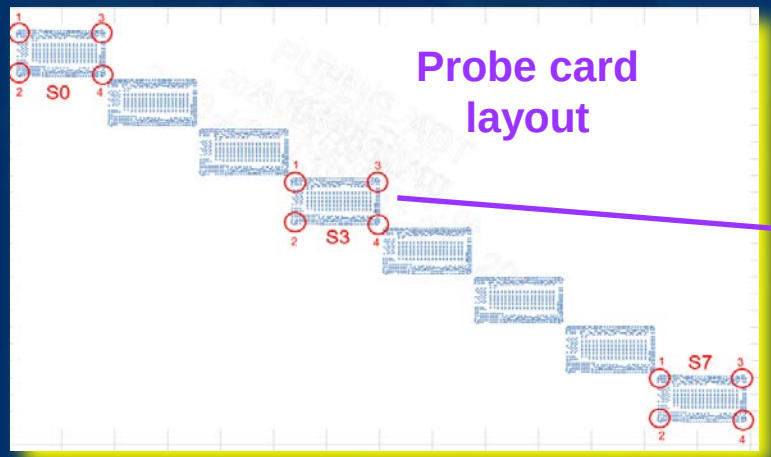


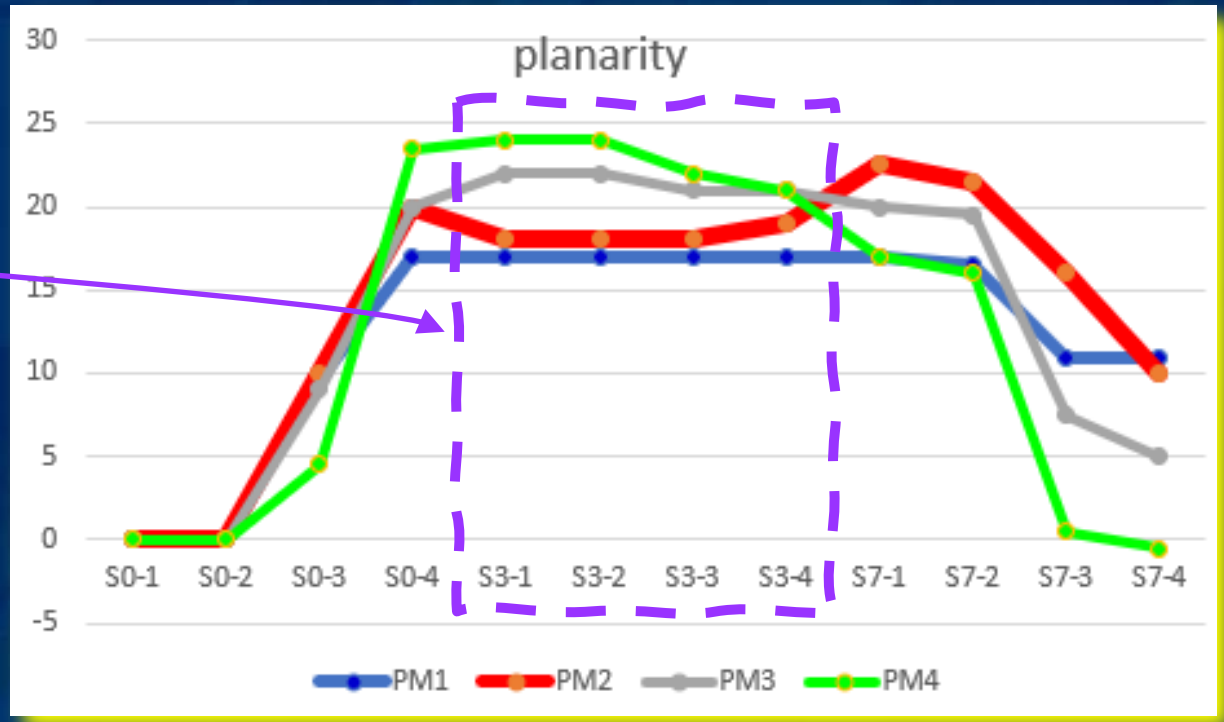
- Probes uneven in one DUT

Consequences after needle cleaning

- **Probes planarity between DUTs is getting worse.**

  Coplanarity between center DUTs and both ends of DUTs will be getting worse along with consecutive cleaning on the same film.

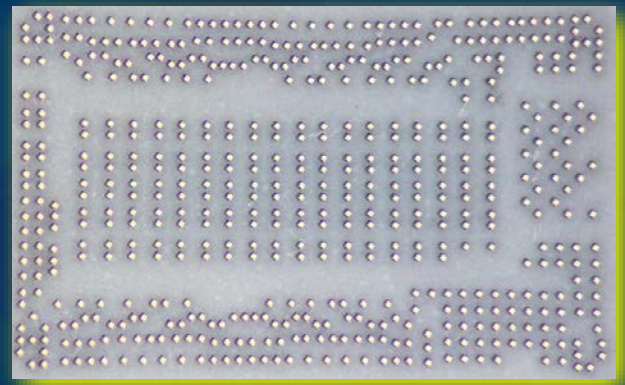


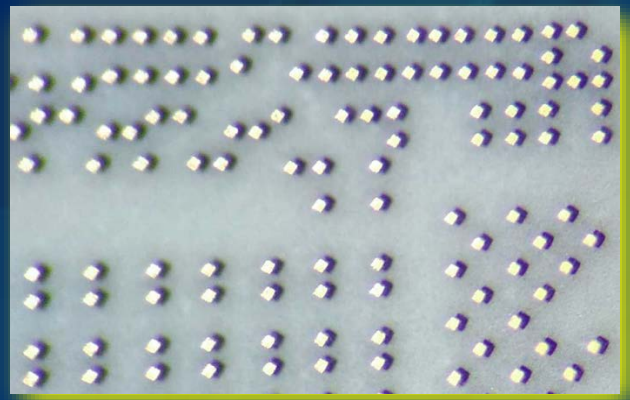


Consequences after needle cleaning

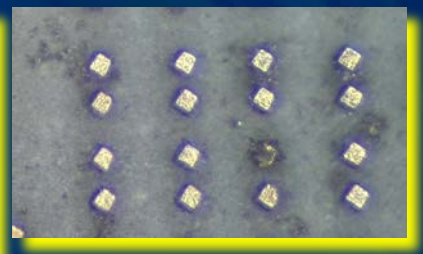
- **Ineffective cleaning**

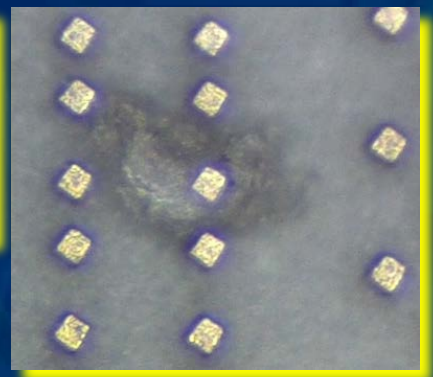
Before Testing, probe tips are clean.

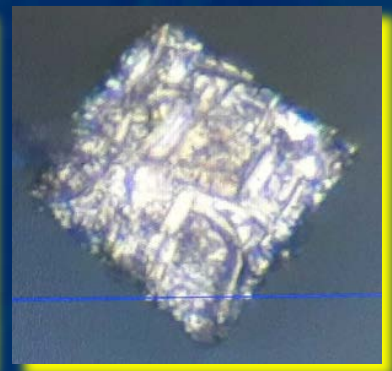


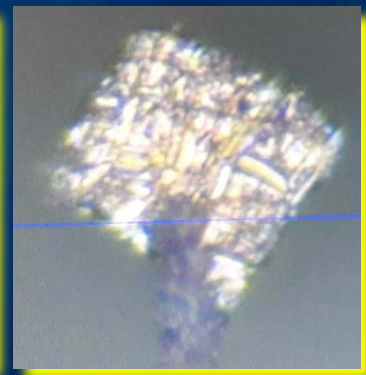


During testing, debris build up despite on-line cleaning being enabled.









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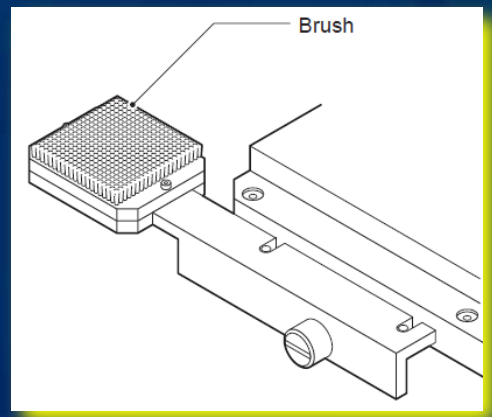
Out of the box thinking possible solutions

Brush clean

- ☹ Feasible for online clean, risk of probe damage & ineffective



Ultrasonic

- ☹ Wet cleaning, liquid, effective for loose debris, unfeasible for online clean

Laser

- ☹ High risk, may affect or damage PH, infeasible for online clean

Chemical

- ☹ Often toxic, high risk and might affect or even damage PH, unfeasible for online clean

Abrasive

- ✓ **Feasible & primary method for online clean.**
- **Drawbacks include: lifespan, maintenance & lower OEE**

What's the best cleaning process?

The better answer could be "NO Cleaning required". ☺

Micron's Challenge to the Industry !

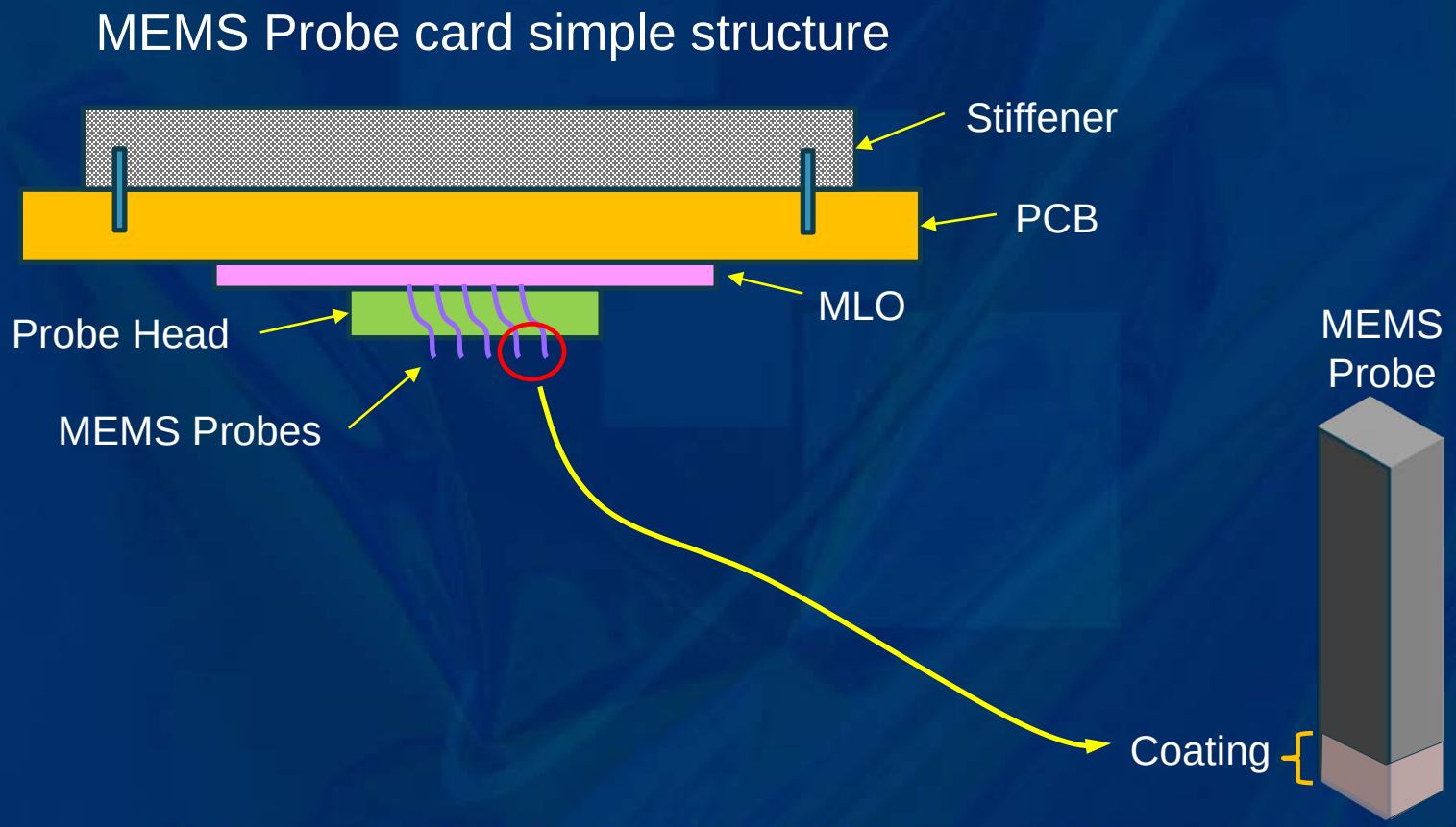
Probe tips sealed with a COATing.

NOTHING STICKS TO
"HAPPY PROBE CARDS"
☺

Teflon, nothing sticks to cookware.

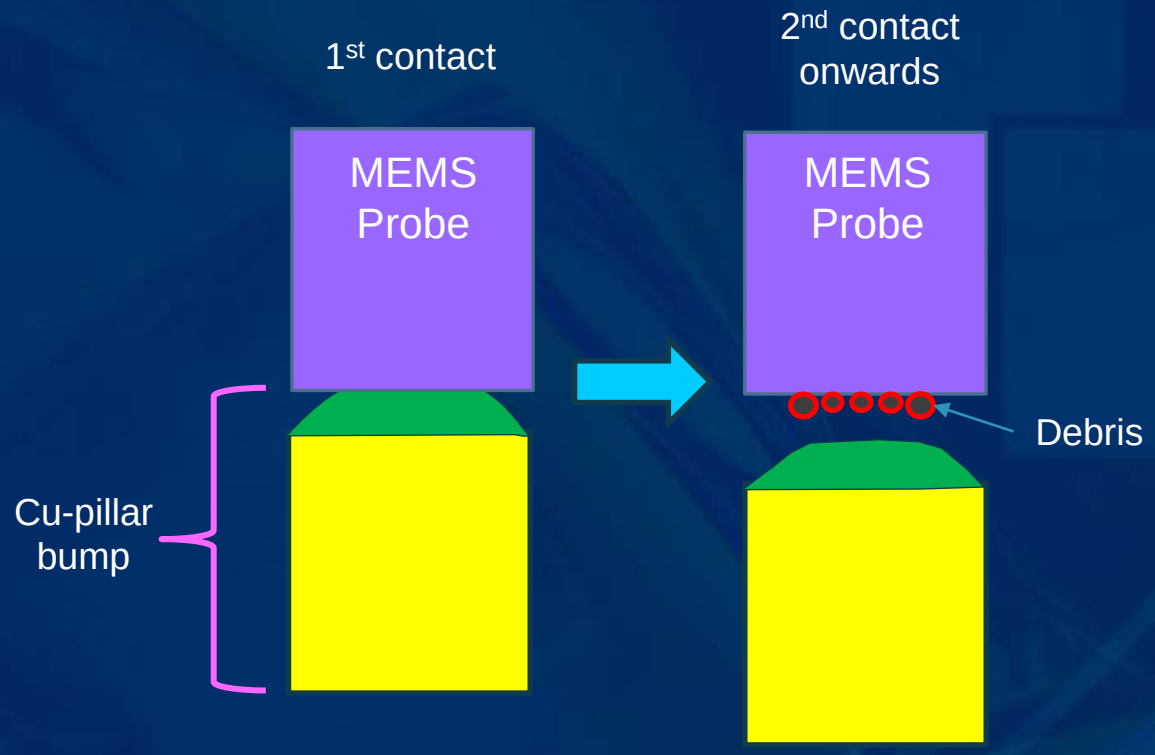
Coating illustration of Probes tips

The coating must be conductive, extremely hard, low-frictional materials and can prevent debris build-up.

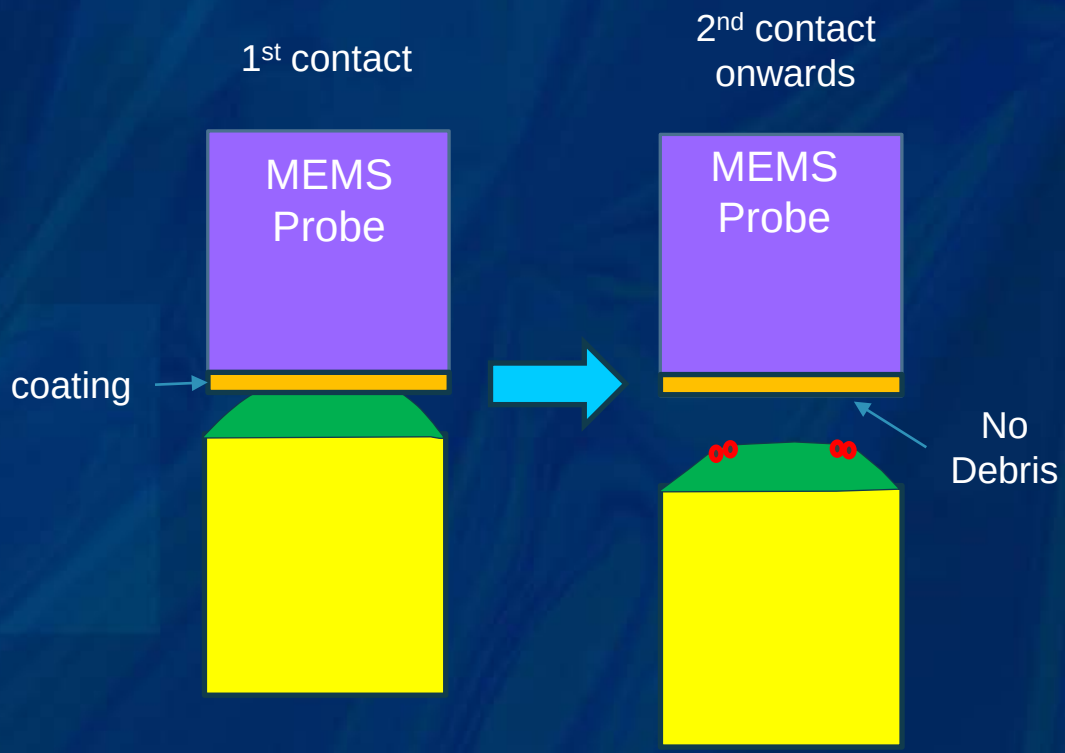


Schematic: Coating prevents debris build-up

Probe tip WITHOUT coating



Probe tip WITH coating



Goal of Coating for NO-Cleaning Probes

Probes won't get contaminated & provide zero wear out.

- ✓ **A reliable CRES**
- ✓ **Excellent First Test Yields**
- ✓ **Less Re-test**
- ✓ **Less probe cards maintenance**
- ✓ **Preserving the overall shape of the probe tip**
- ✓ **Long life-span of probe cards**
- ✓ **A higher OEE**

… etc.

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Follow-On works

- Coating thickness
- Yield performance at high and low temperature testing
- Lifespan of coating at high and low temperature testing
- In-situ simple clean require?
- Clean sheet selection for on-line clean if necessary.
- Off-line PM cycle time and clean tools?
- CRES condition if it is idle for a period of time
- Feasibility to do re-coating for used MEMS probes

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  - **Ardentec**
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