SWTEST
PROBE TODAY, FOR TOMORROW
2024 CONFERENCE

Study of Contamination and Key Parameters in Wafer Vertical Probe Card Testing

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TECHNOPROBE
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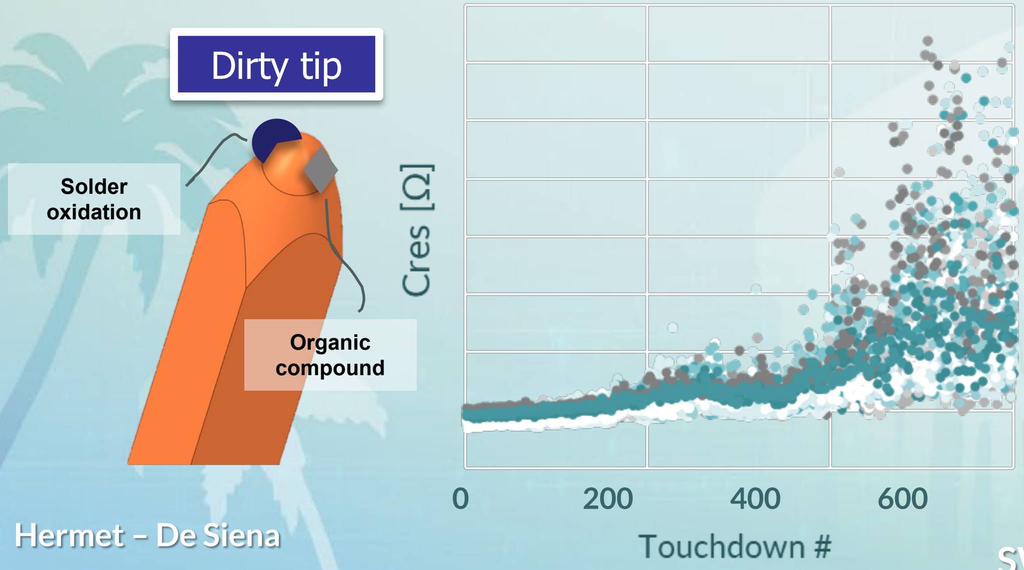
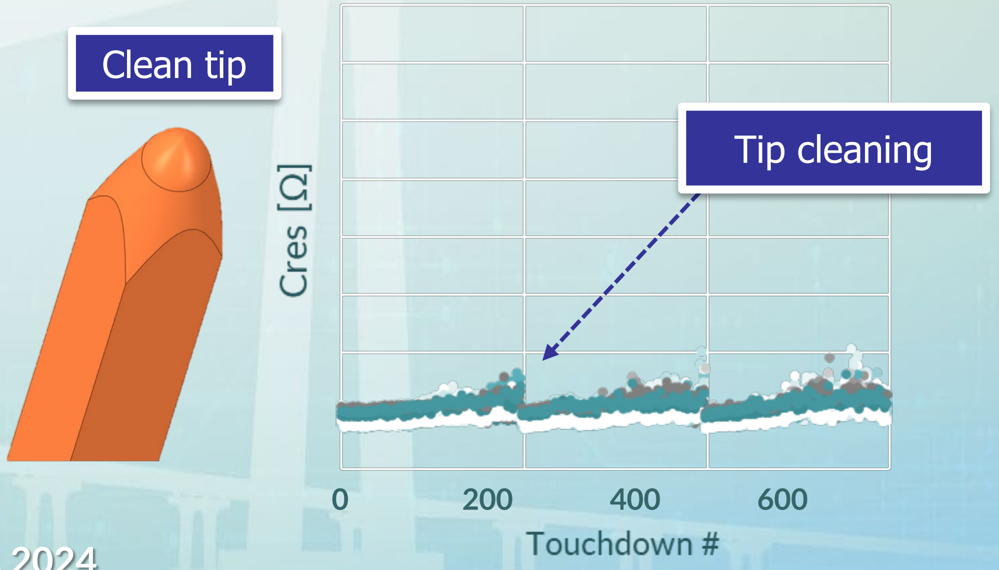
Outline

- Introduction
- Goals
- Experimental setup
- Influence of current
- Influence of force
- Influence of initial tip surface conditions
- Conclusions
- Follow-On work
- References & Acknowledgements

Introduction

- Contamination is well known to cause failures in the world of semiconductor testing. Nevertheless, the nature, source and influence of this contamination is not always clearly identified.
- These contaminations are particles or films whose micrometric size makes them difficult to detect and inspect. They are generally found on tips surface, causing testing issues. But we sometimes forget that these contaminants are mobile in a test cell and can also affect the device under test.





Goals

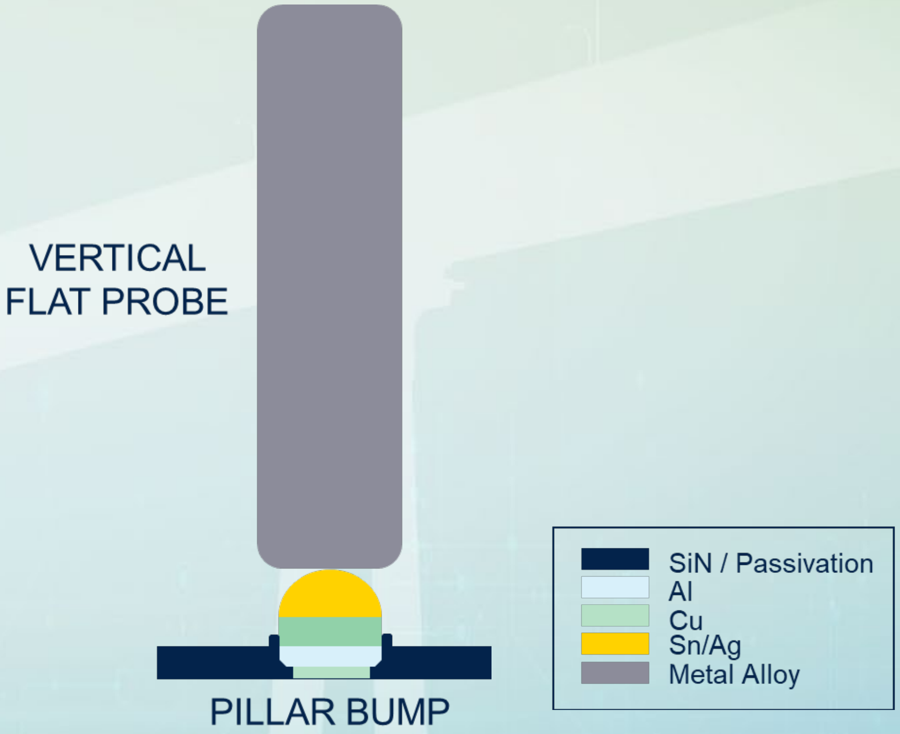
1. Seeking for key parameters playing a role in contamination and electrical performance (contact resistance CRES).
2. Understanding the various contamination phenomenon and their impact.

Long Term Goal

Developing innovative probe cards, improve their use and think new cleaning protocols.

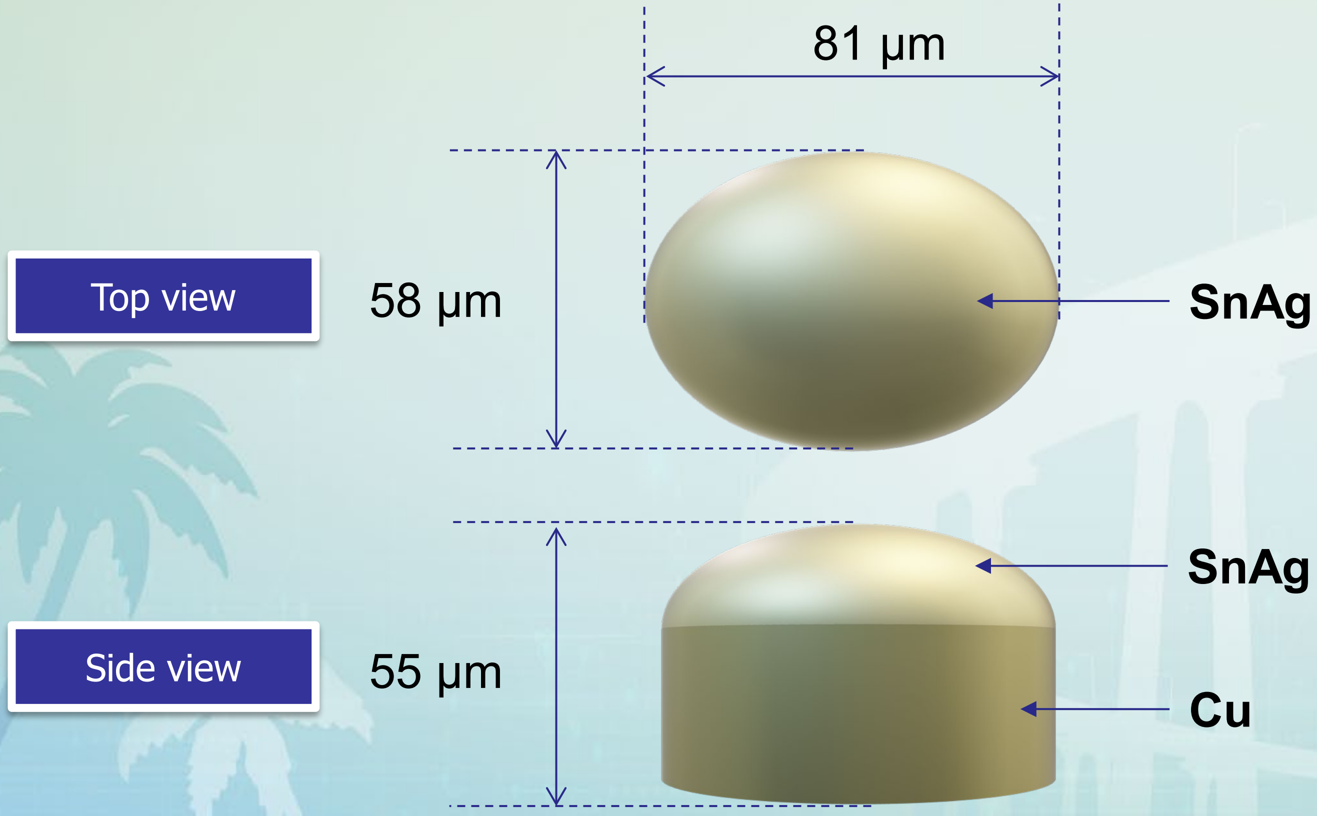
Studied Parameters

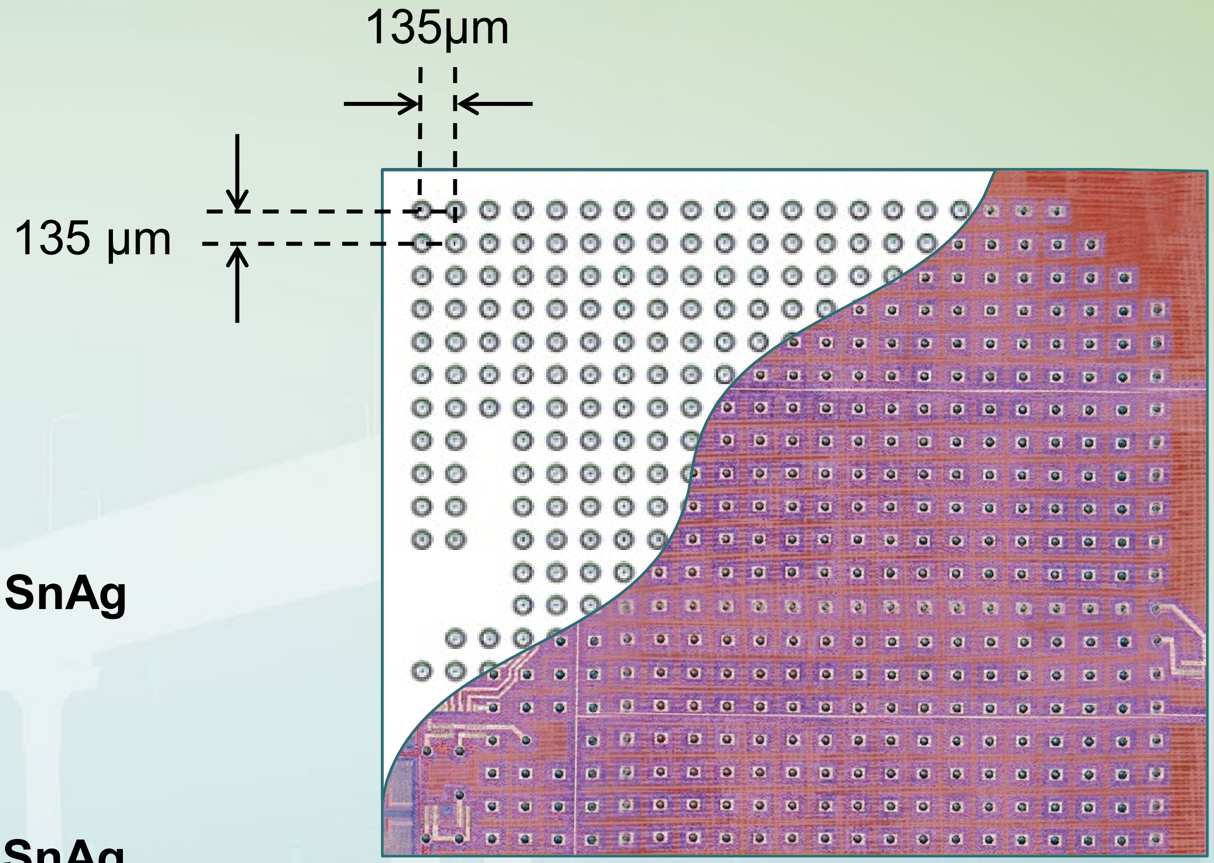
- Experimental trials have been conducted on the following parameters in order to evaluate their influence on contamination and test performance:
  - Current intensity
    - Spacing from 0.25mA to 250mA
  - Force induced by probe length
    - Impact of free length vs free tip length
  - Initial tip surface conditions
    - Rough vs mirror-like tip surface



Experimental Setup

- **Tested Product:**
  - STMicroelectronics Product
  - SnAg Copper Pillar Bump (Oblong)

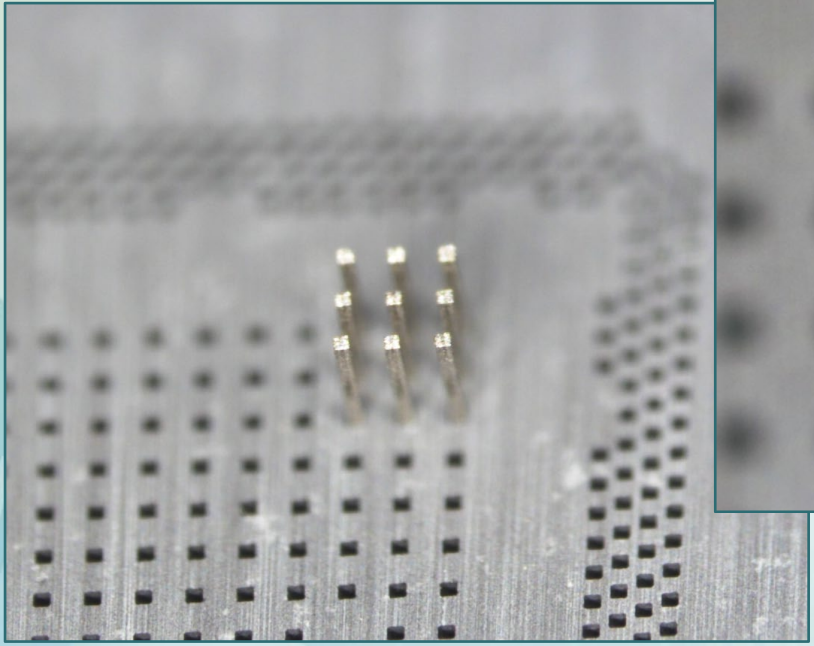


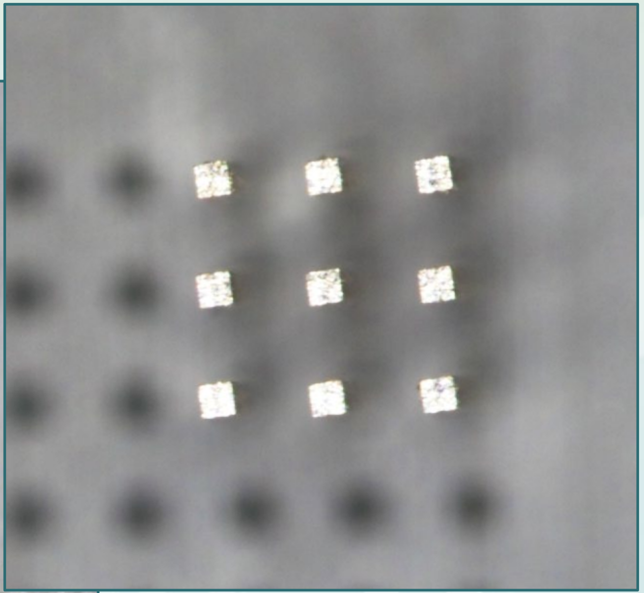


Pillar Bump Cartography on DIE

Experimental Setup

- Vertical Probe Card test vehicle:
  - TPEG S90 SA2 XLT Flat Technology





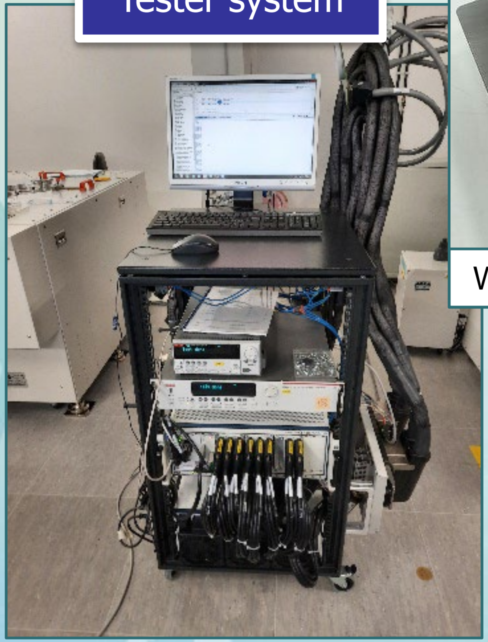
Technology name	TPEG™ S90 SA2 FLAT XLT
Needle Length	4700 μm
Tip finishing	Flat
XLT	Yes
Force (at 75um OT)	2.5 g
Pin Current (CCC)	1450 mA
Probe dimension	55x55 μm^2
Min pitch: Linear	90 μm
Min pitch: FA regular	90 μm
Min pitch: FA any angle	110 μm
Temperature range	-45 to +175°C
Probe alloy	SA2
Probe resistance	58 mOhm
Max working OD	100 μm

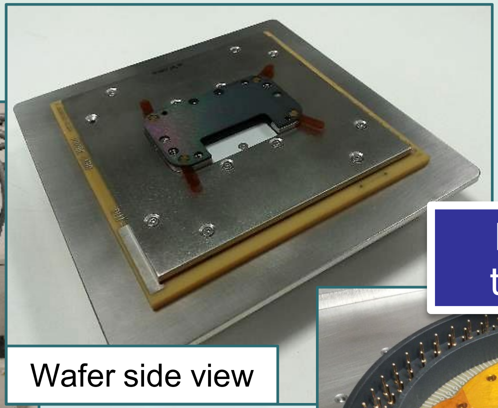
Experimental Setup

- **Test Cell and Functioning Mode:**
  - Accretech UF3000 Prober
  - Specific Setup: STMicroelectronics Probing Parameters
  - Keithley Multimeter: CRES Measurement with forced current

Cleaning	No
Probing Overdrive	80 µm
Temperature	+30°C

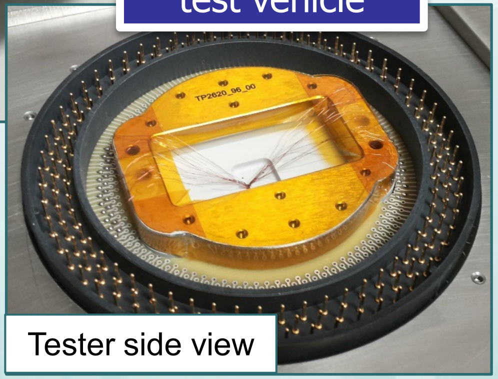
Tester system



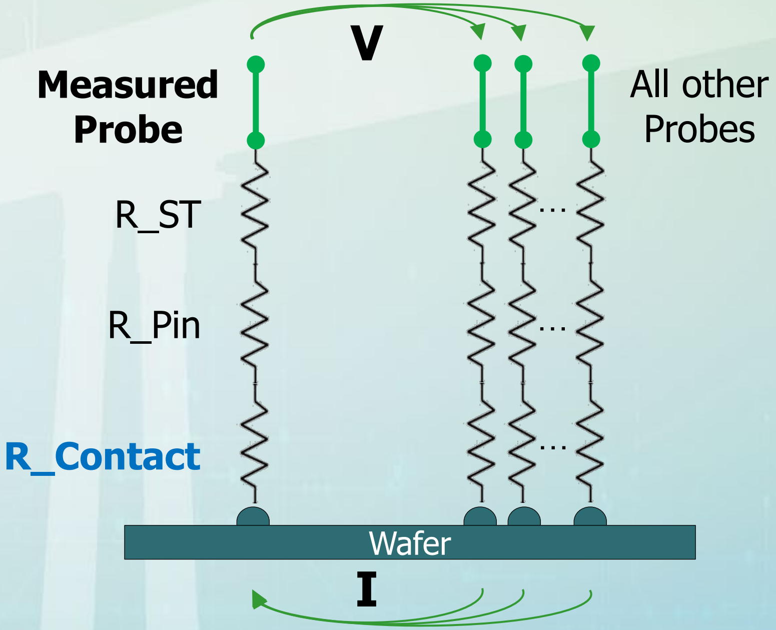


Wafer side view

Probe card test vehicle



Tester side view

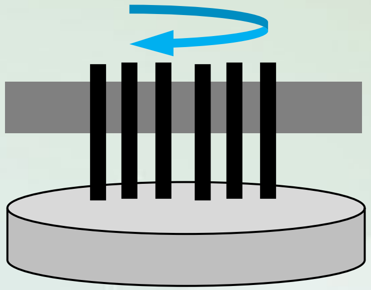


$$CRES = R_{ST} + R_{pin} + \boldsymbol{R_{contact}}\ [\Omega]$$

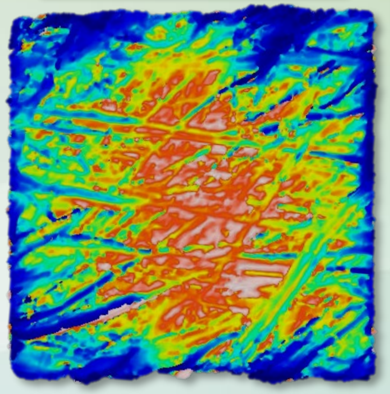
Experimental setup

- **Lapping Process:**

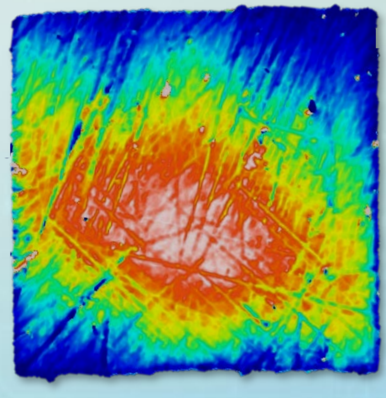
Probe finishing	Cleaning media	Abrasive Size	Abrasive Type
FLAT	3M blue paper 266X	9µm	AlO_2
FLAT	3M pink paper 266X	3µm	AlO_2
FLAT	3M green paper 265X	1µm	AlO_2



9µm grit



1µm grit



- **Inspection Tools & Software:**
  - Morphological inspection
  - Contamination identification
  - Chemical semi-quantification

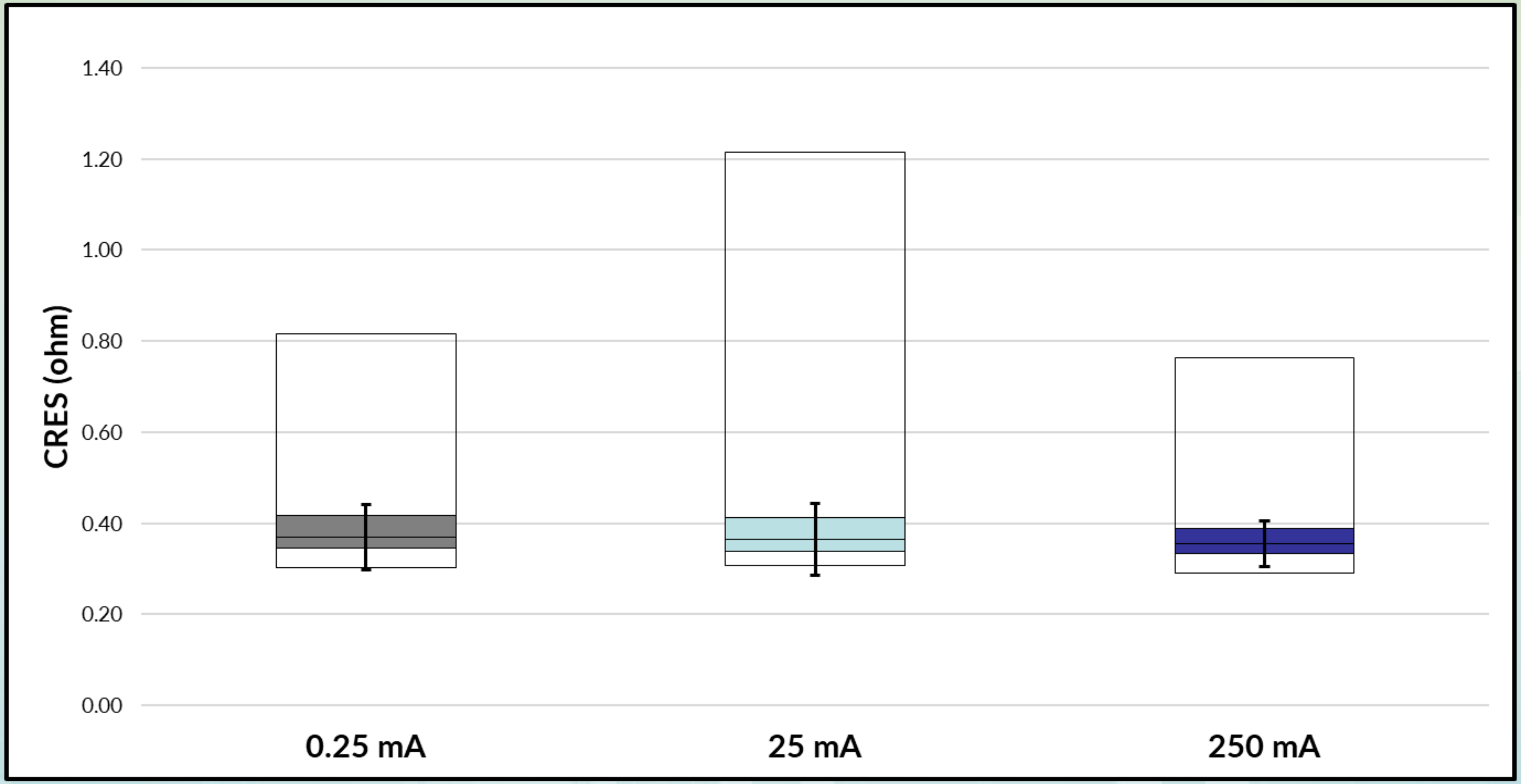
  SEM-EDX Microscope

  - Contact surface measurement
  - Surface roughness measurement
  - Contamination volume estimation

  Confocal Microscope
  + Gwyddion

Influence of Current

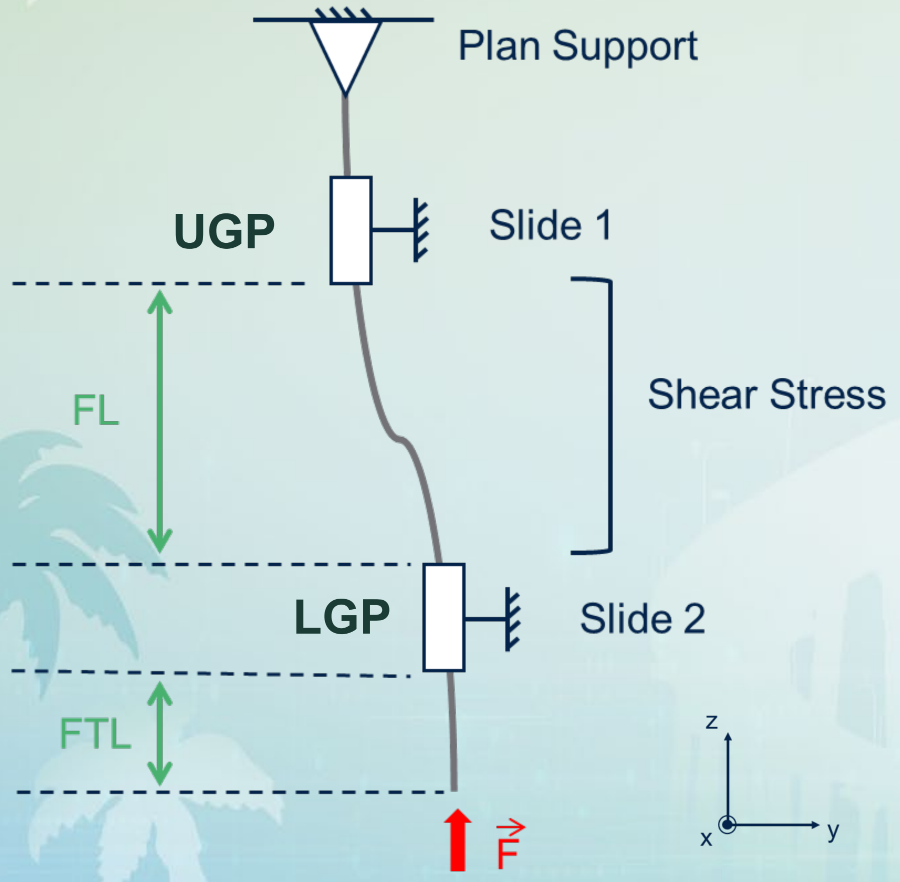
- Single Current Test over 1000 Touchdowns



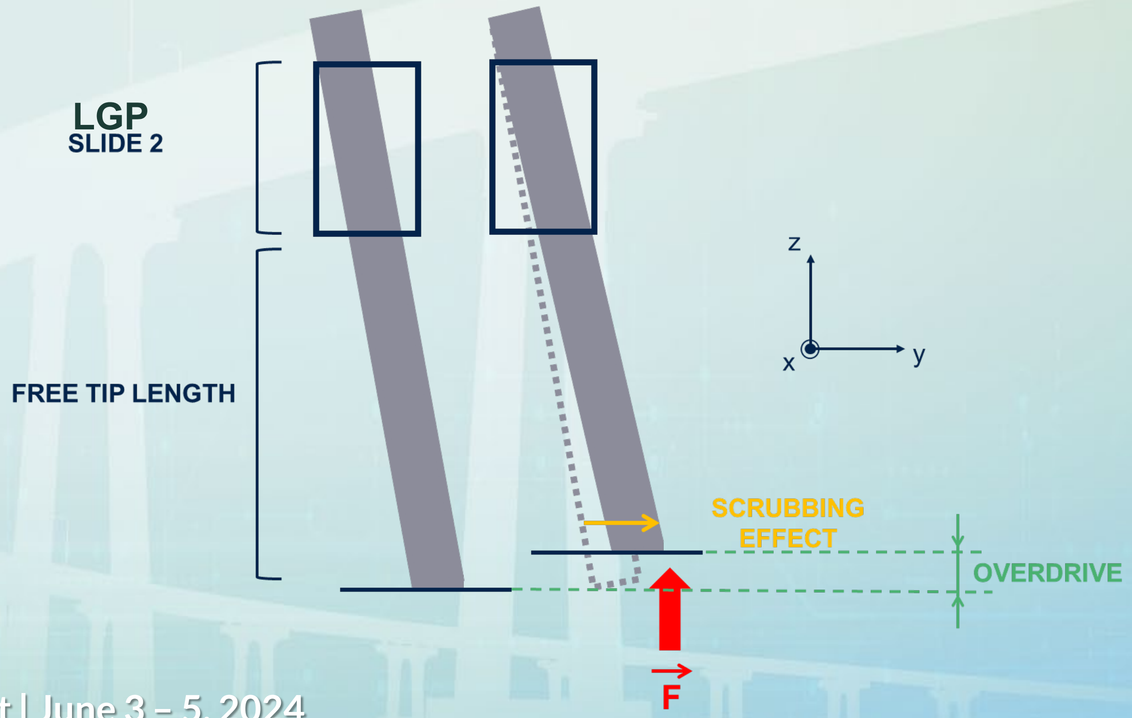
No difference observed in terms of tip surface contamination

Influence of Force Induced by Probe Length

- Presentation of the Studied System :
  - Vertical Probe Behavior

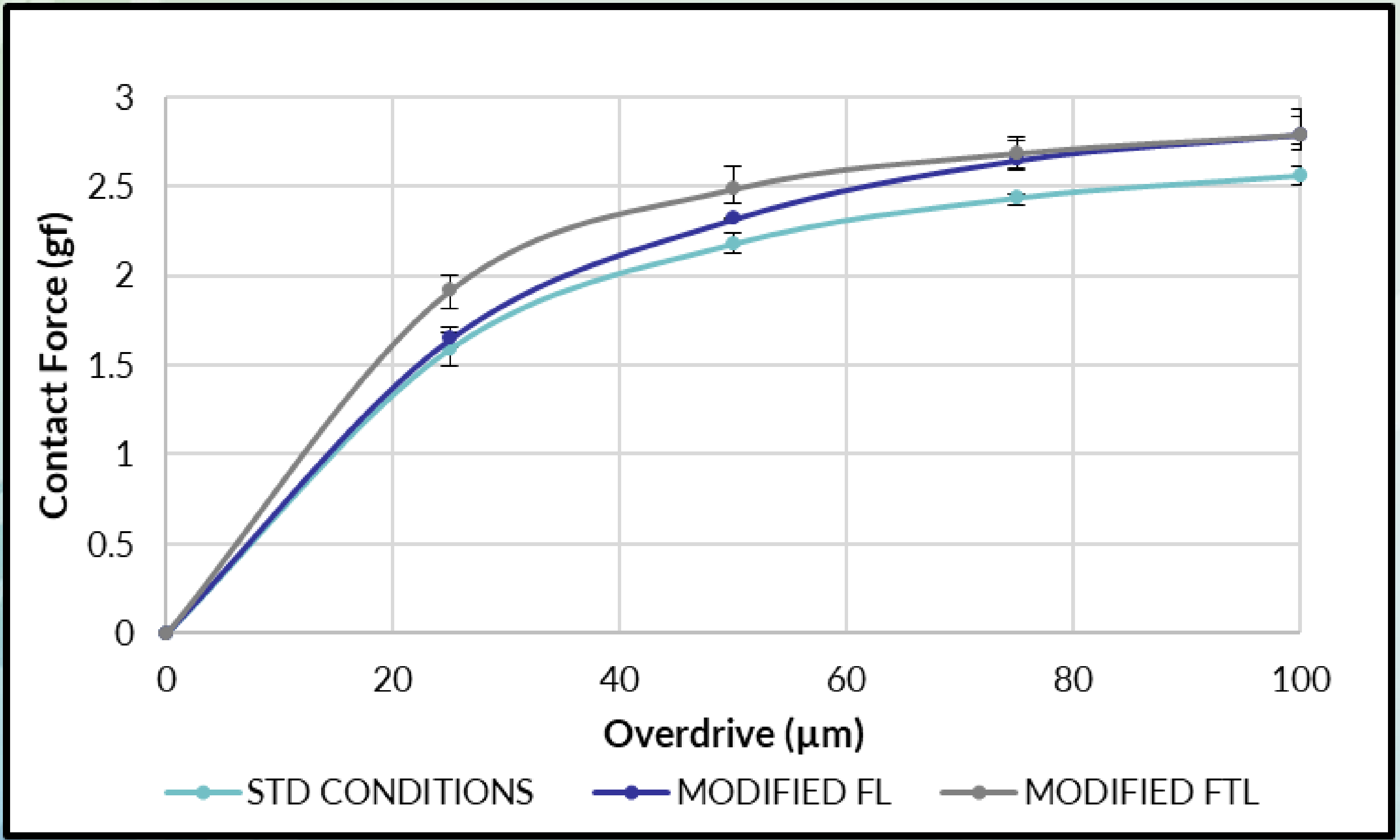


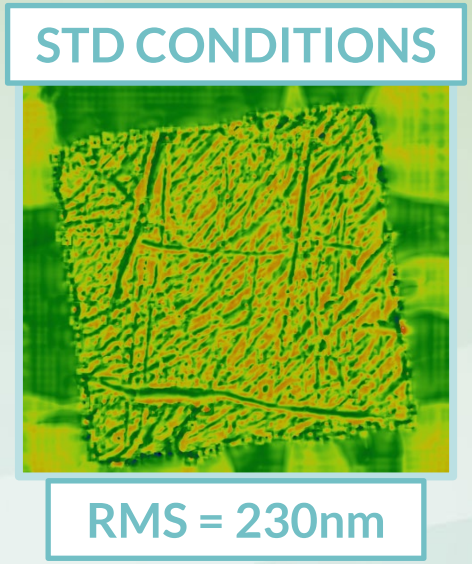
Initial Probe Parameters			
Test	Standard Conditions	Modified FL	Modified FTL
Free Length (µm)	FL	FL – 5%	FL – 5%
Free Tip Length (µm)	FTL	FTL	FTL – 60%
Contact Force at 75µm (gf)	2.43	2.65	2.68
Average Initial Tip Roughness RMS (nm)	230	227	250

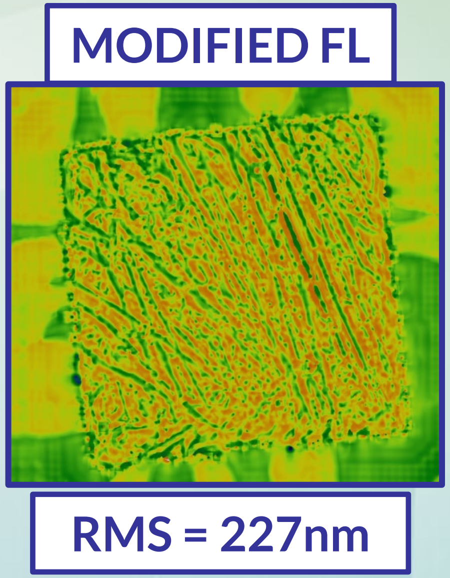


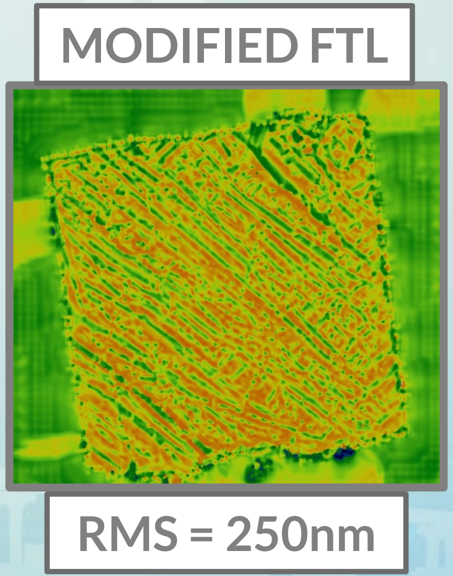
Influence of Force Induced by Probe Length

- Initial Force and Surface Roughness



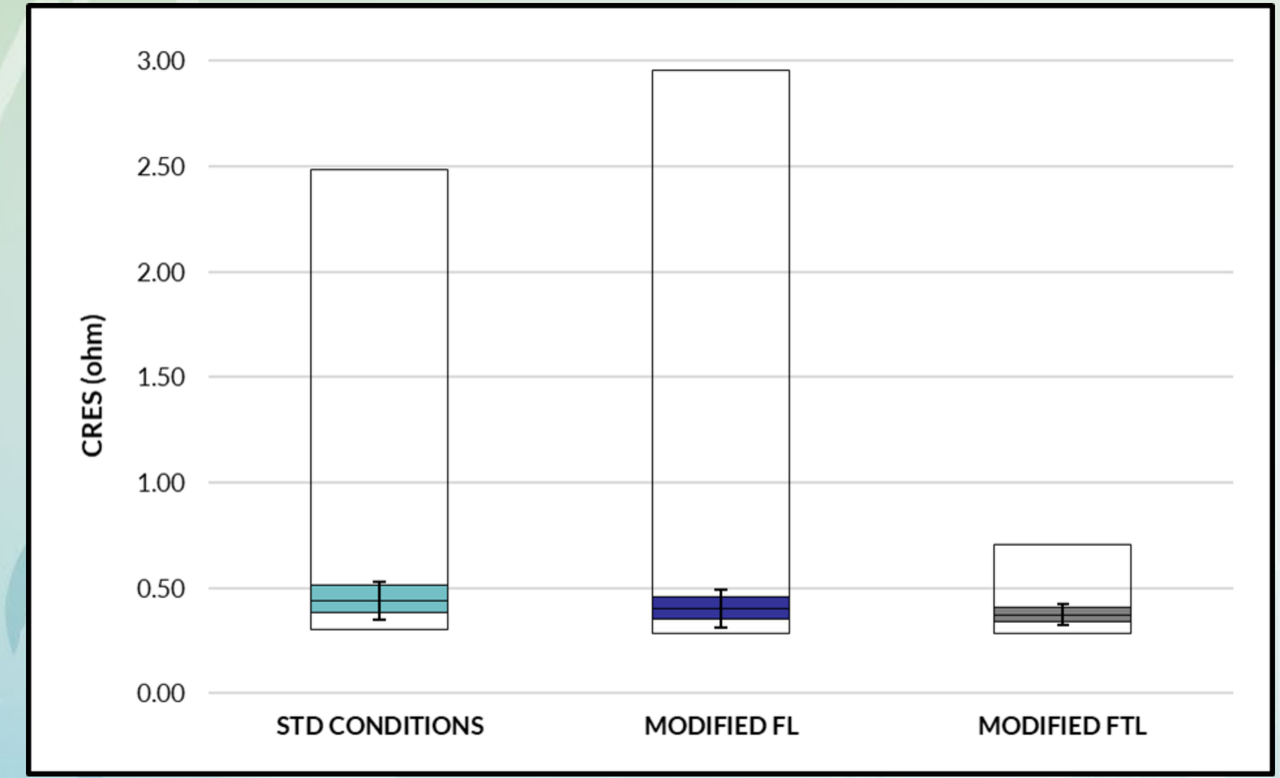


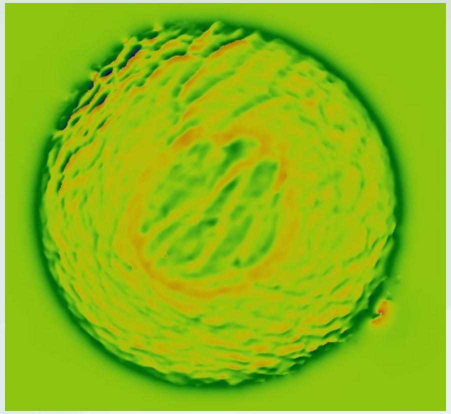


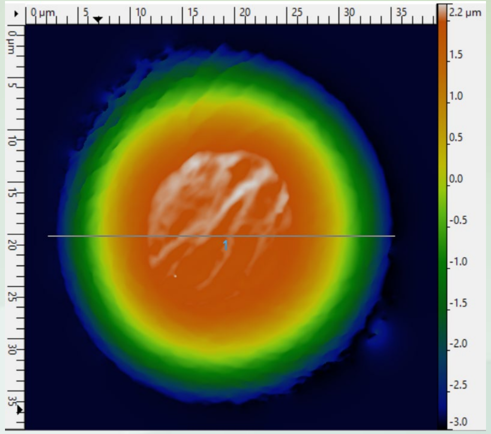


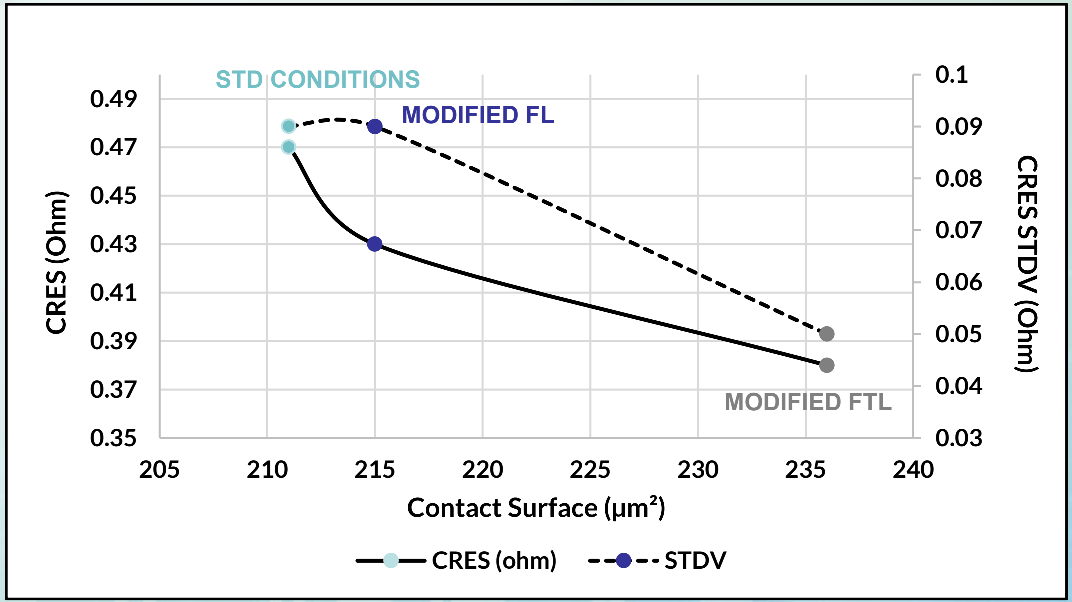
Influence of Force Induced by Probe Length

- ## CRES Results and Surface Contact Correlation





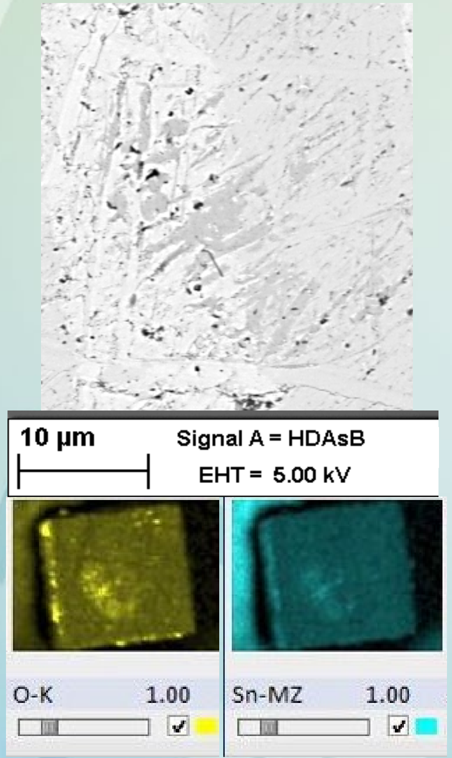




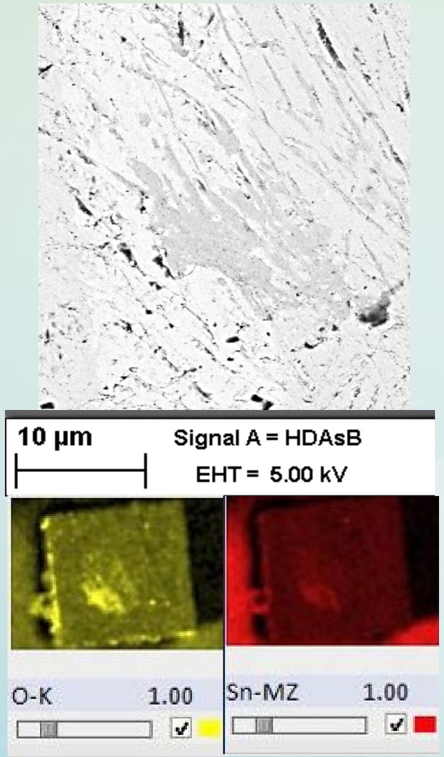
Influence of Force Induced by Probe Length

- **Tip Surface Contamination :**

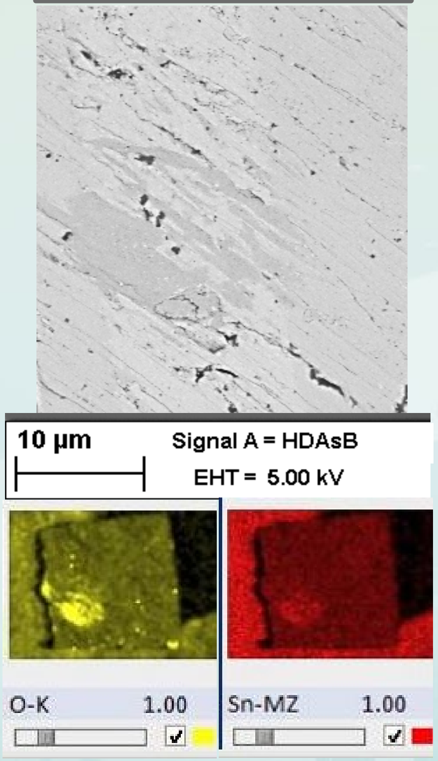
STD CONDITIONS

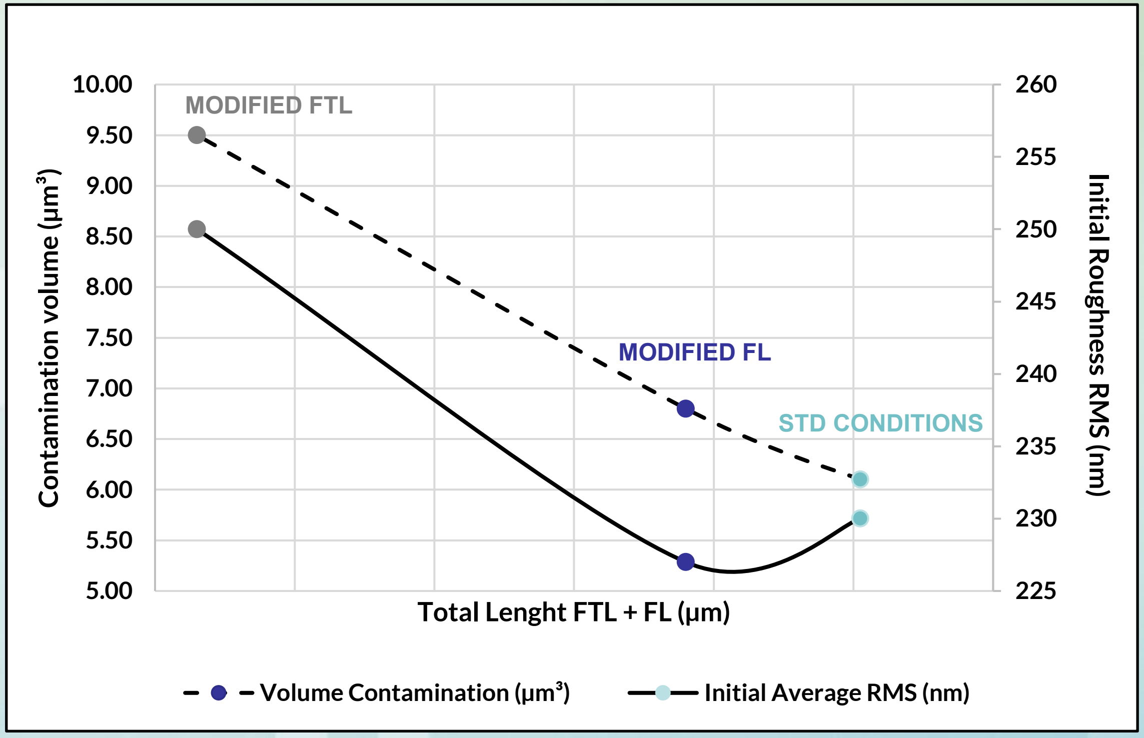


MODIFIED FL



MODIFIED FTL

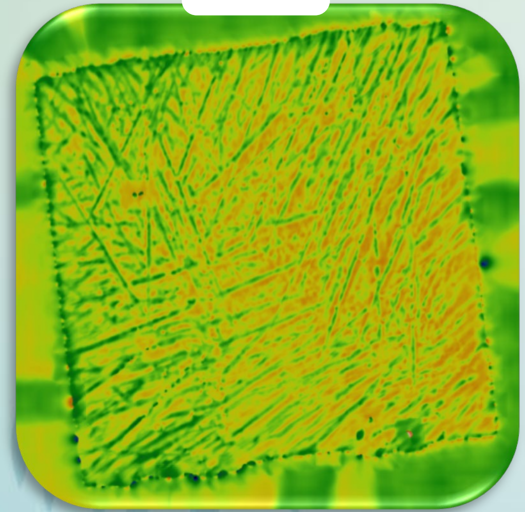




Influence of Initial Tip Surface Conditioning

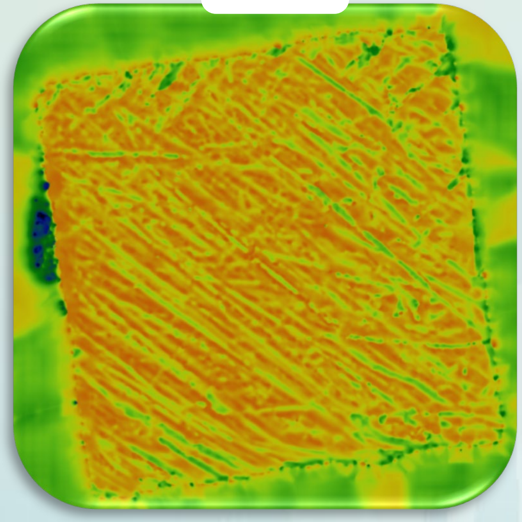
- **Initial Tip Surface Roughness after Lapping**

1µm



RMS Roughness : 100nm

3µm

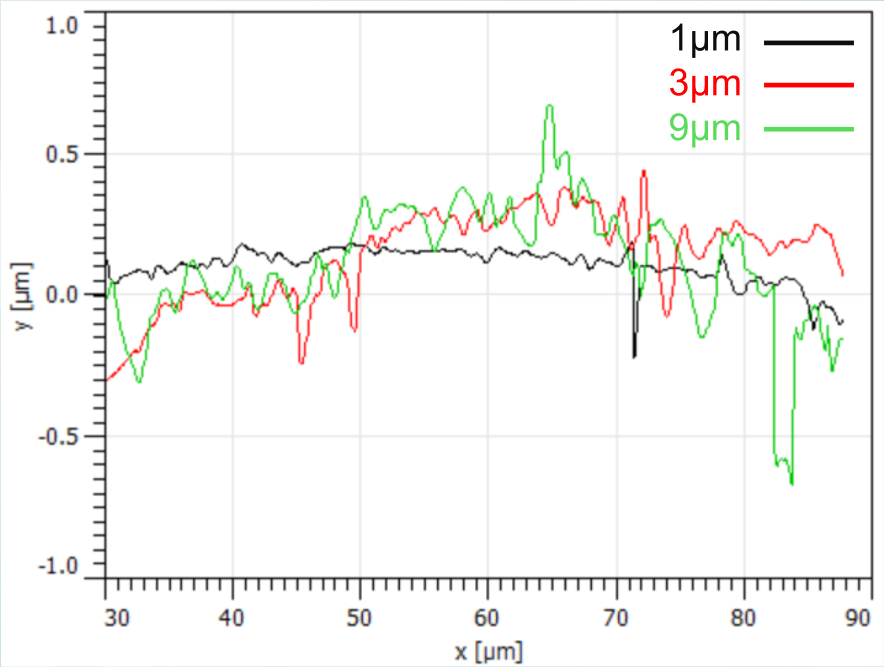


RMS Roughness : 250nm

9µm

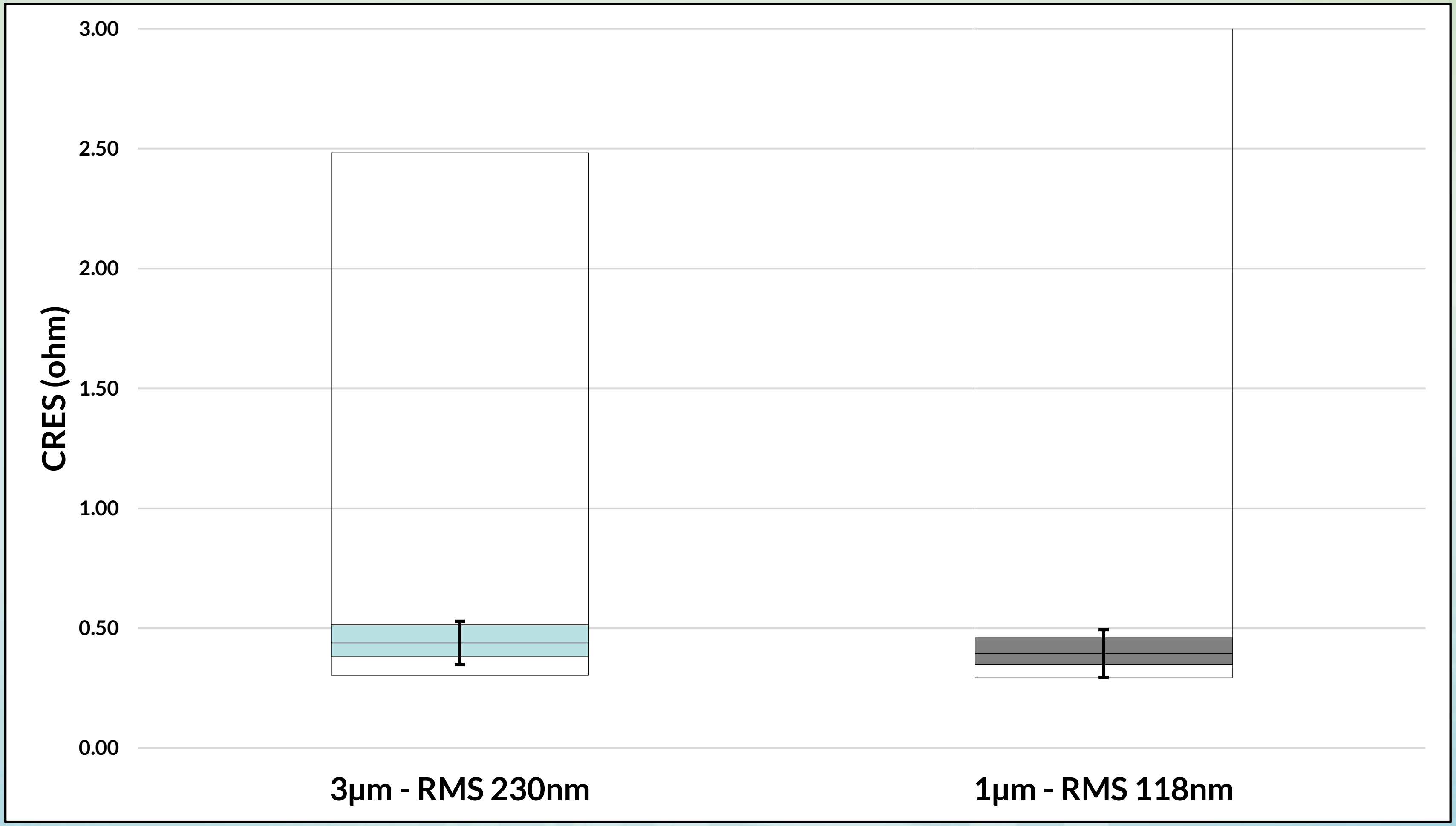
RMS Roughness : 290nm

PROFILE



Influence of Initial Tip Surface Conditioning

- CRES Results



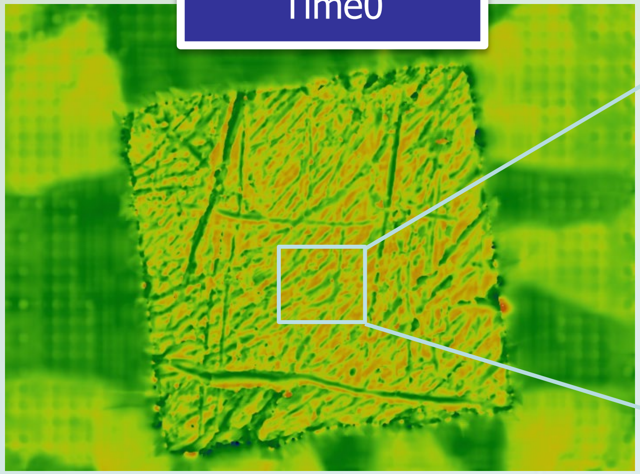
Influence of Initial Tip Surface Conditioning

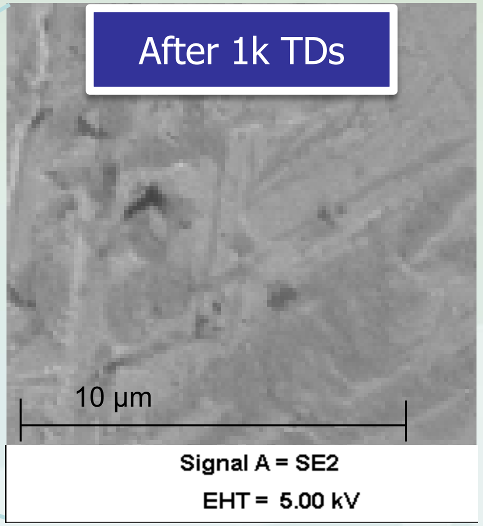
- Initial Tip Surface Roughness after Lapping

Time0

After 1k TDs

3µm
Lapping

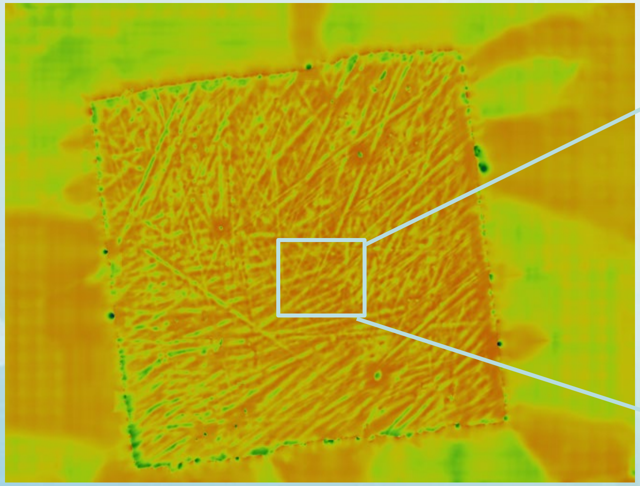


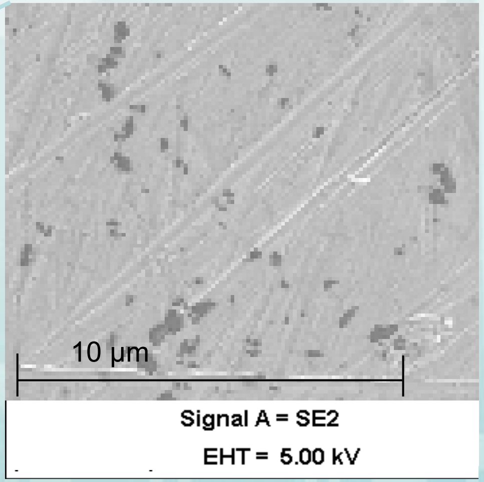


Surface Roughness
RMS = 230 nm

- ✓ Tin Oxyde Contamination
- ✓ Organic Contamination

1µm
Lapping



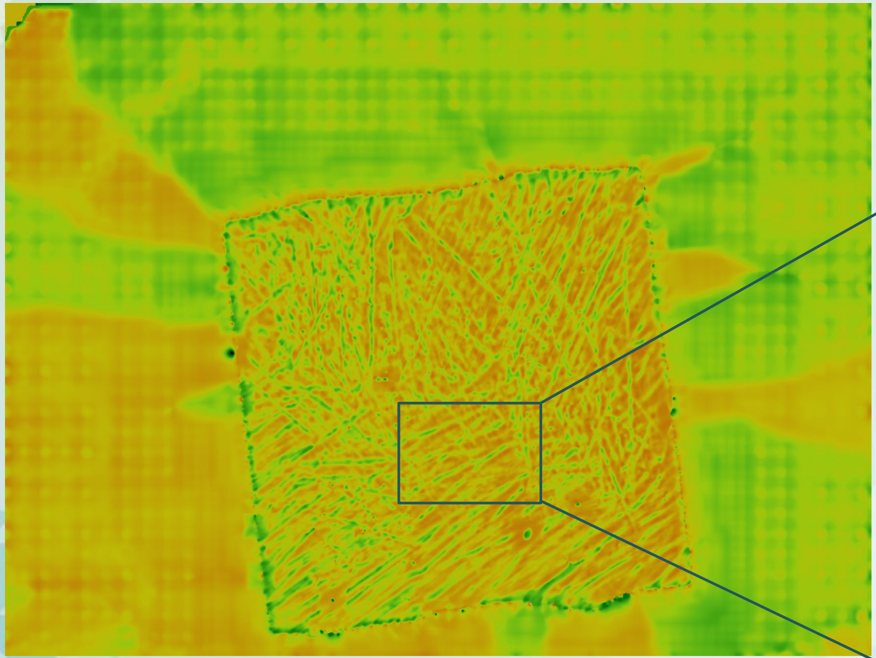


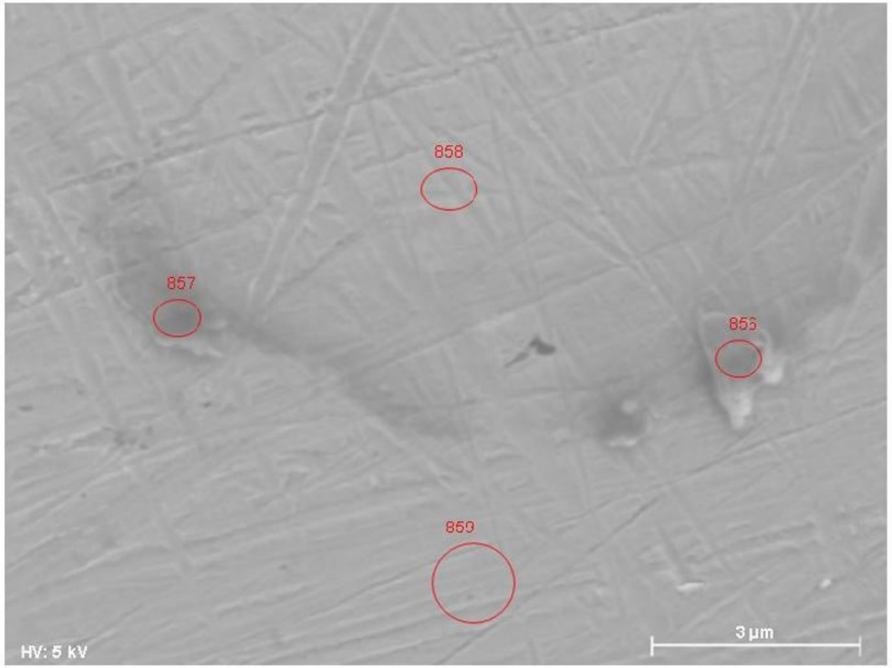
Surface Roughness
RMS = 118 nm

- ✓ Organic Contamination
- ✓ Abrasive Contamination

Influence of Initial Tip Surface Conditioning

- **Frictional Polymerization with 1µm Initial Lapping**





Atomic concentration [%]

Spectrum	C	O	Na	Si
857	54.95	7.68	0.73	2.56

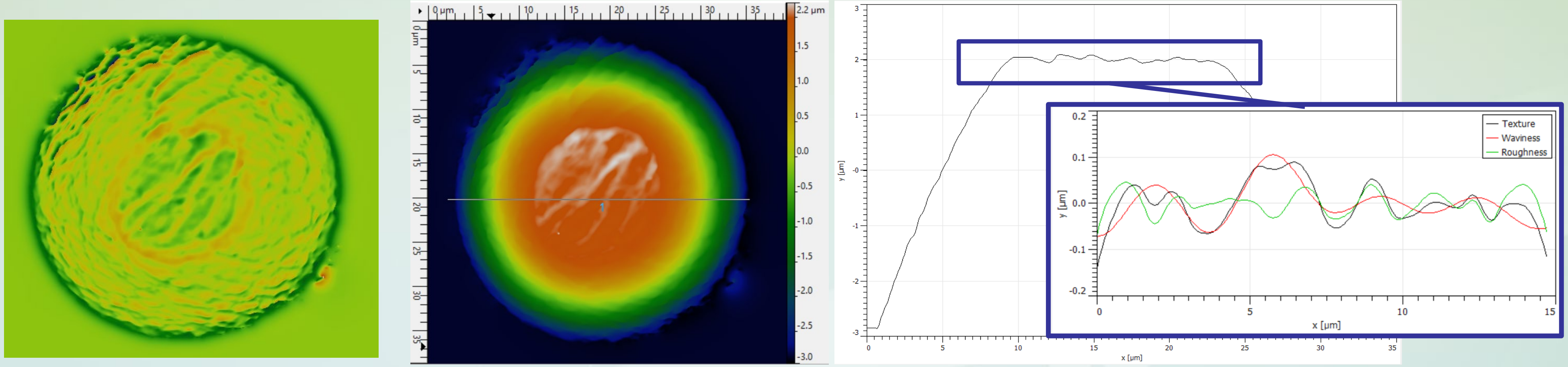
"Frictional polymerization can occur during sliding and fretting with palladium, rhodium and other platinum-group contact metals and alloys due to their catalytic activity. Adsorbed organic air pollutants are converted into complex, solid, insulating contaminants of high molecular weight. Movement enhances this effect, but its role may simply be to dislodge the reaction product, thus producing a continuous conversion to polymers in the area of slide."

[1] Dr. Morton Antle. The Tribology of Contact Finishes for Electronic Connectors Part I: Mechanisms of Friction and Wear. Plating & Surface Finishing, 75 (10), 46-53 (1988)

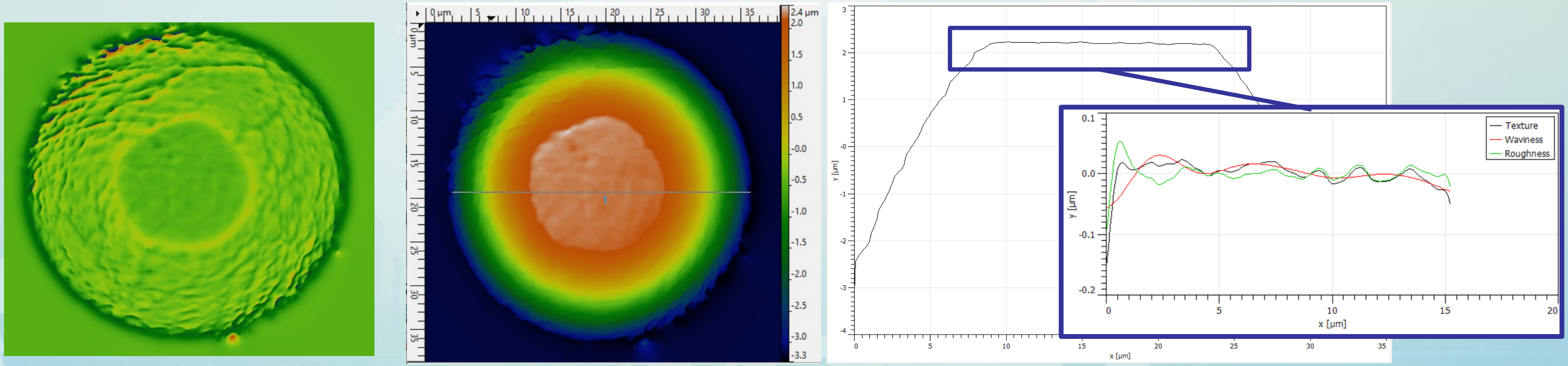
Influence of Initial Tip Surface Conditioning

- **Probe Mark Analysis on Bumps**

3µm Lapping



1µm Lapping



Top View

Profile

Conclusion

- **Influence of Current :**
  - Current has few impact on test performance in our test conditions at 30°C in the following range 0.25-250 mA

- **Influence of Force Induced by Probe Length :**
  - Free Tip Length is a contributing factor in reducing CRES and contact variability
  - Free Length impacts contact force but not CRES results

- **Influence of Initial Tip Surface Conditioning :**
  - Initial tip roughness influence surface contamination phenomenon for equivalent CRES results

Follow-on Work

- **Work on tip surface conditioning:**
  - **What is the best surface for our test conditions (Contamination vs CRES) ?**

  - **How to maintain this surface clean and conductive (cleaning) ?**

    - Paper : type – nature – grain size
    - Cleaning recipe : overdrive – speed – move – frequency
    - New cleaning technology ?

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- Salvatore De Siena

References

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[5] Jung, H-W., Kim, S-J., Kim, Y-J., Kim, J-Y., Lee, J-Y., Park, J-H., Finite element analysis of vertical micro-probe considering Joule-heating effect, International Journal of Fatigue (2017), doi: http://dx.doi.org/10.1016/j.ijfatigue.2017.02.02

[6] J. Broz and R. M. Rincon, "Probe contact resistance variations during elevated temperature wafer test," International Test Conference 1999. Proceedings (IEEE Cat. No.99CH37034), Atlantic City, NJ, USA, 1999, pp. 396-405, doi: 10.1109/TEST.1999.805761.

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Q&A