INNOVATION PUT TO THE TEST

FormFactor®

Advanced Wafer Probe Solutions

Contact Precision Optimization to Improve Scrub Performance

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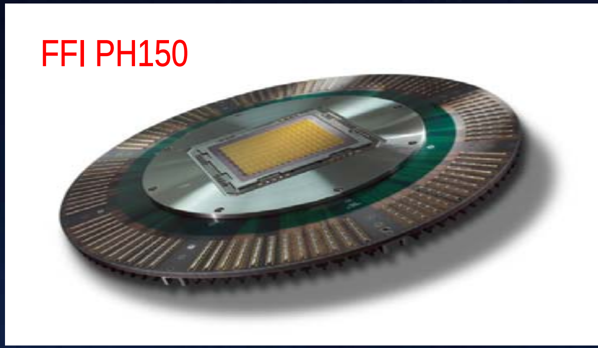
Outline

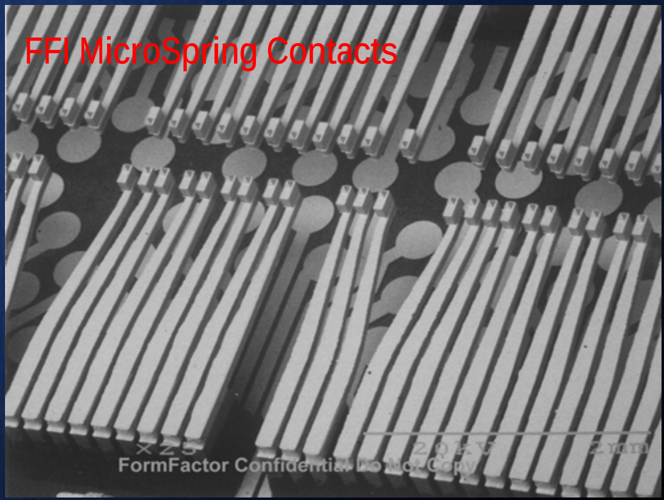
- Probing Trends
- Design of Experiments (DOE) on Scrub Sensitivity Analysis
  - Objectives
  - Background
  - DOE Setup
  - Results
- Conclusions
- Acknowledgements

Probing Trends

Probing Contact Precision



- Contact Precision
  - Precise and reproducible contact on probe pads to ensure maximum yield at wafer test and subsequent process steps
    - Low probing pressure (minimum pad damage)
    - Small scrub mark
    - X-y precision
    - Low contact resistance
    - Tight pitch, small pad capability
    - Wide probing temperature
- Contact Precision = Better Yield



Probing Trends

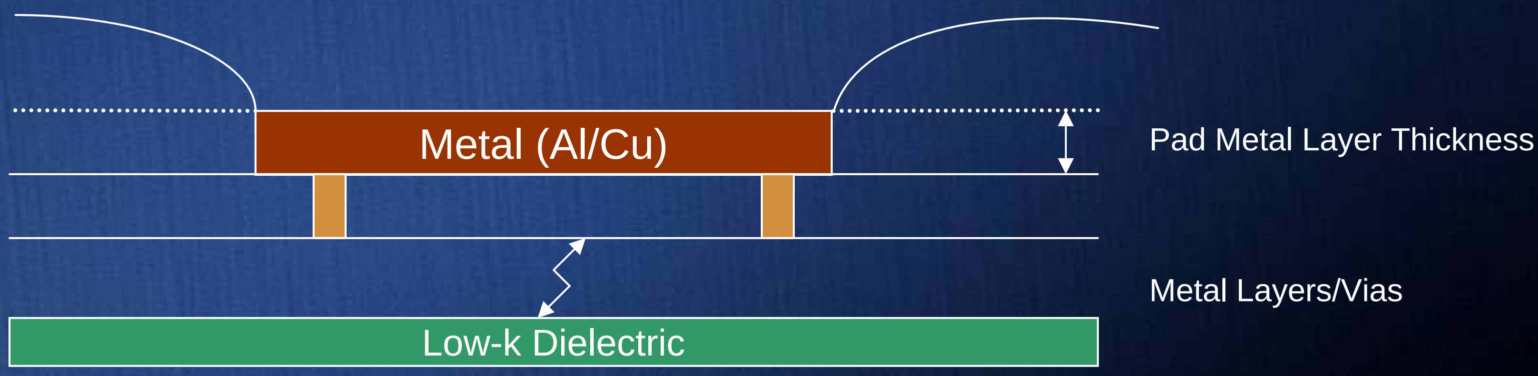
Industry Trends Drive Probing Challenges

Industrial Trends

- Continuous shrinkage in pad dimensions
- Thinner pad metal layer moving below 0.7um
- Lower k ILD structures

Probing Challenges

- Minimize yield loss due to
  - Unreliable wire-bond from deep scrub and large particles
  - Probing damage at upper metal layers such as cracks



Al Probe Pad Cross-section View

Probing Trends

- Quotes from Customer Test Floors

Scrub Performance Metric

The deeper the scrub, the higher failure percentage of ball-non-stick

Scrub marks deeper than x μm could lead to bad contact reliability

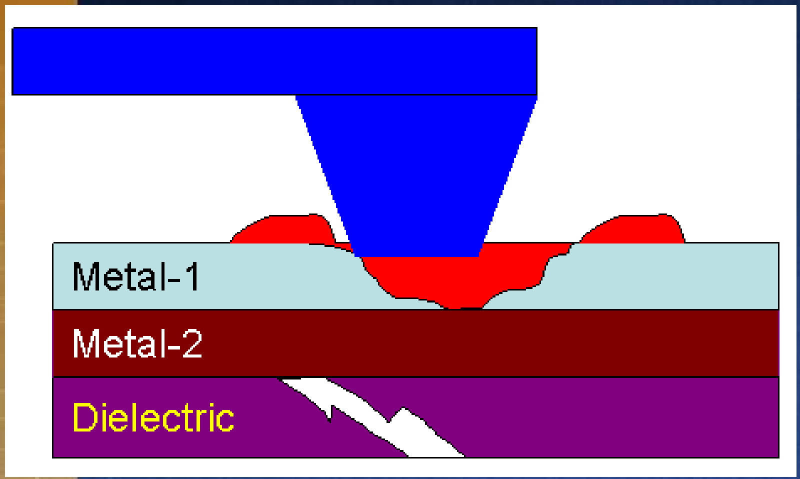
Oxidation of exposed underlayer metal (Cu) will result in lower product yields

Too much of probing force will result in ILD layer cracking

Build-up at end/start of scrub may be a detrimental factor

Probing Trends

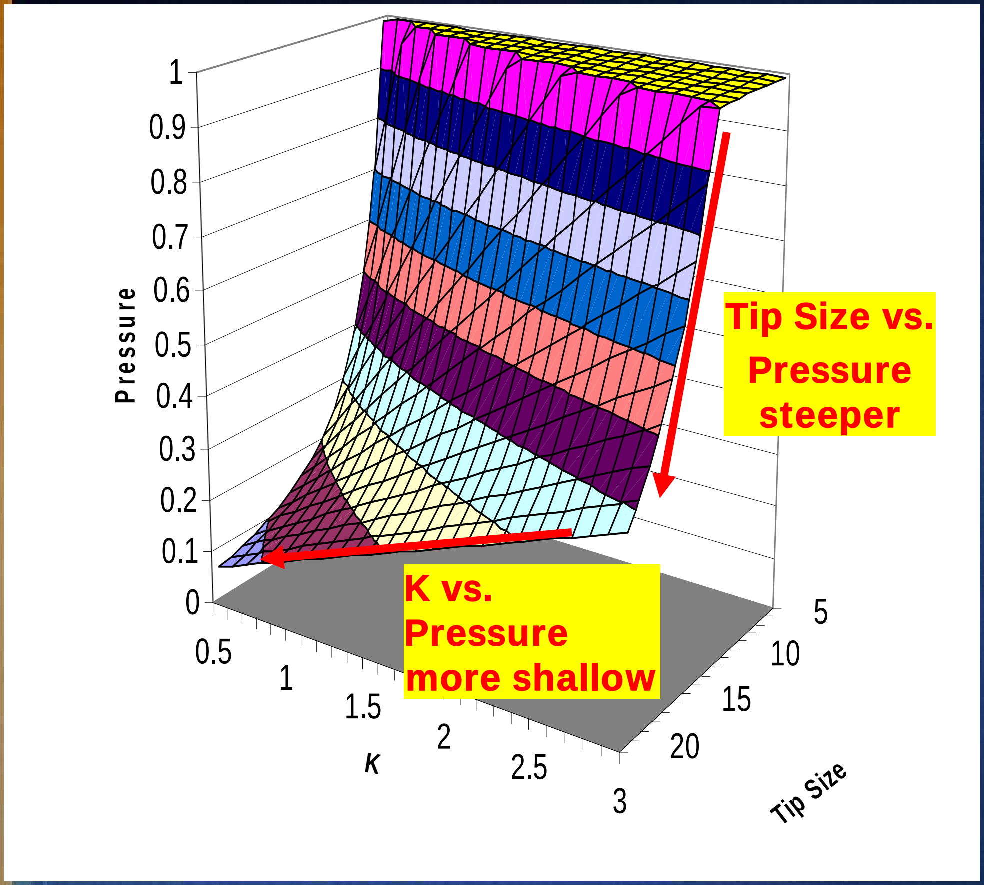
What Our Customers Ask For

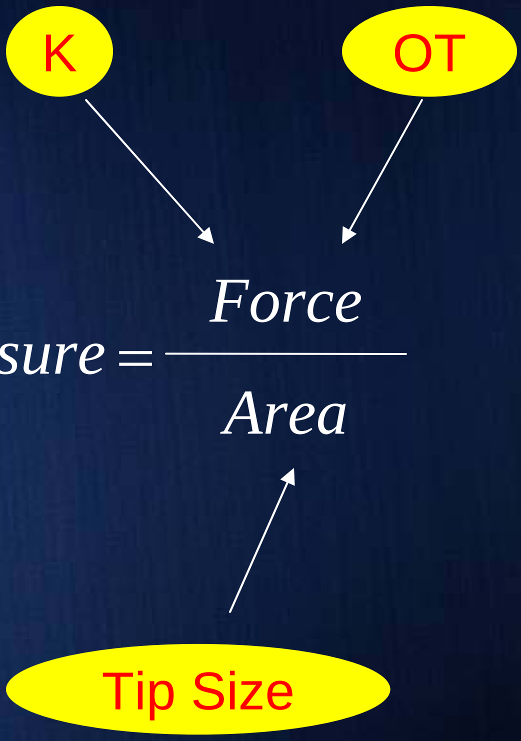


- Customer qualification requirements
  - *"No ILD cracking"*
  - *"Maximum scrub depth lower than a µm after b times consecutive probing"*
  - *"Maximum prow height larger than c µm after d times consecutive probing"*
  - *"No underlayer metal exposures after e number of touchdowns"*
  - (*a*, *b*, *c*, *d*, and *e* are customer's specific)
- ***Scrub mark goals***
  - *Minimum scrub depth, and*
  - *Minimum prow height*

Scrub Sensitivity Analysis DOE

Background: "Macroscopic" Mechanisms





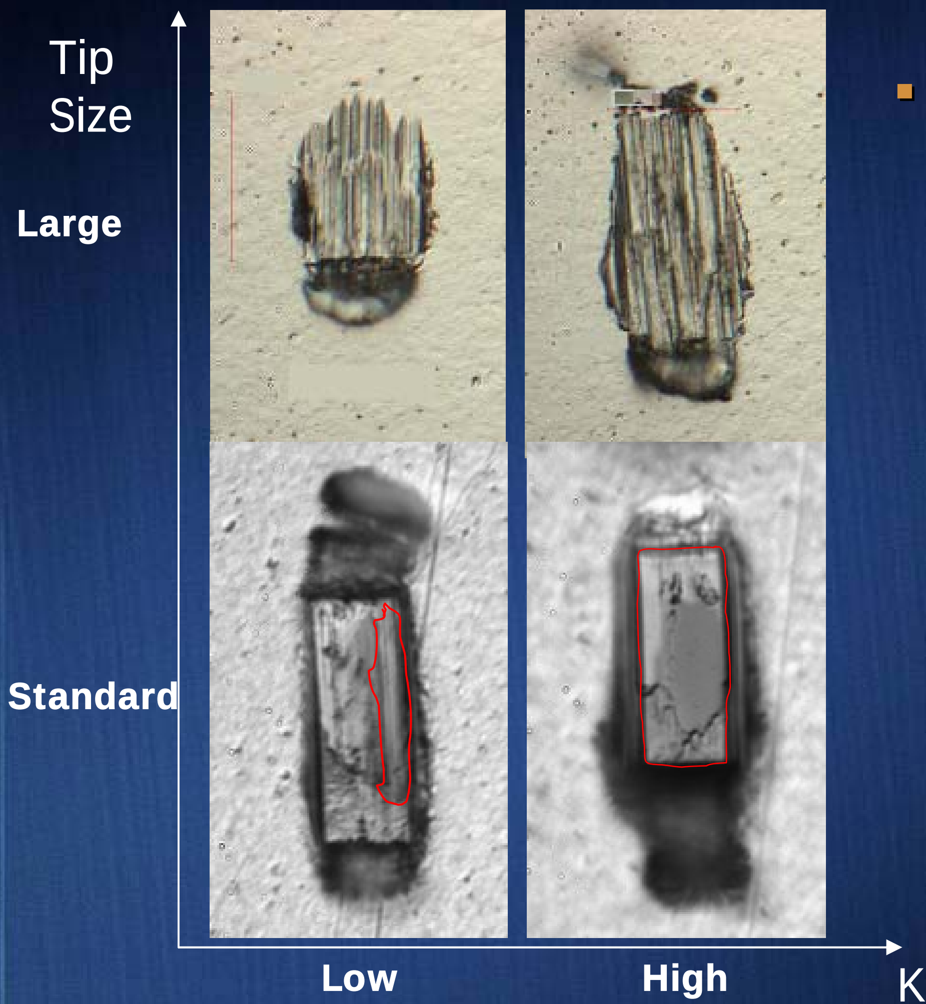
$$Pressure = \frac{Force}{Area}$$

FormFactor SWTW Presentation, 2004

Increasing tip size is most effective in reducing pressure

Scrub Sensitivity Analysis DOE

Background: “Macroscopic” Mechanisms

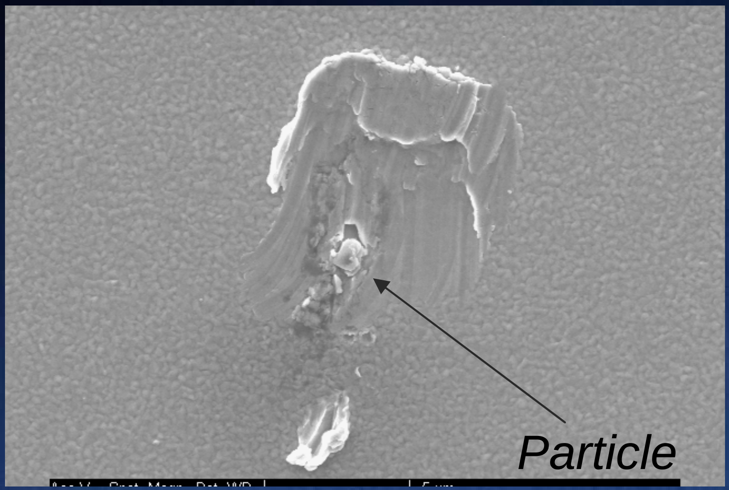


- Macroscopically, punch through level was found to be a direct function of tip pressure
  - Tip area
  - Spring constant
  - Planarity
  - Over travel

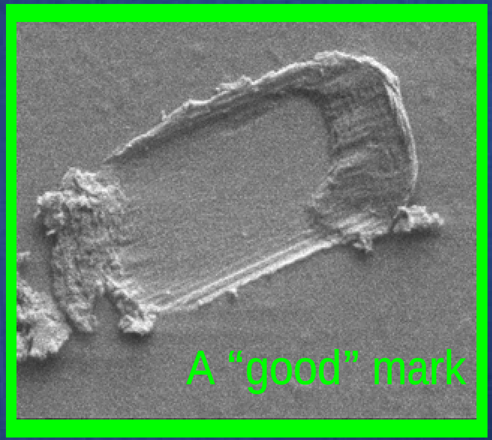
FormFactor SWTW Presentation, 2004

Scrub Sensitivity Analysis DOE

Background: "Microscopic" Mechanisms



- "Microscopically", punch through can be caused by tip surface roughness and/or particle scratches



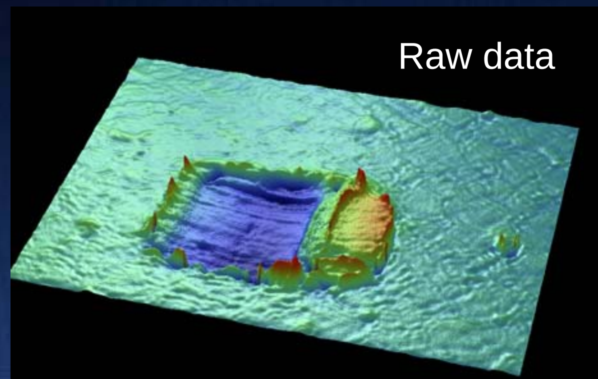
Scrub Sensitivity Analysis DOE

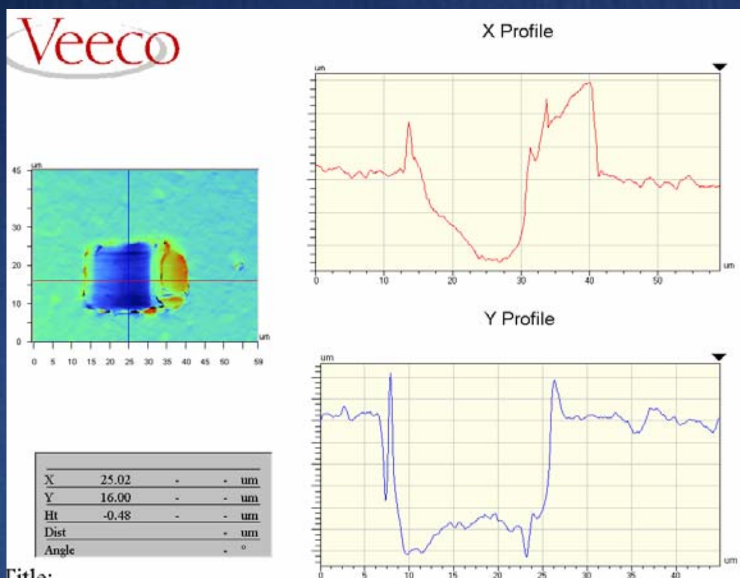
DOE Setup: Procedure

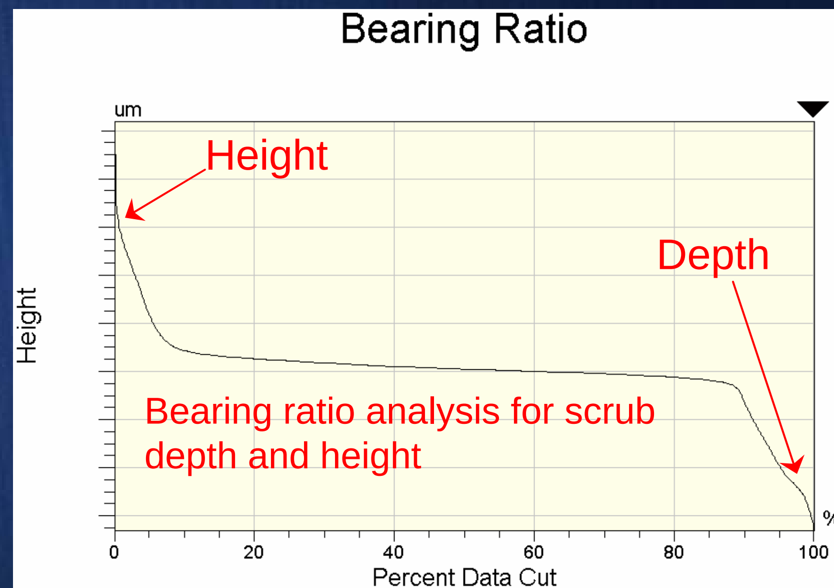
1. Spring array design incorporate most variables into one probe head (Tip size and shape)
2. Tip/spring treatments when appropriate
3. Probing experiment on representative contact surfaces on a prober
4. Scrub mark characterizations (scrub depth and height)

Scrub Sensitivity Analysis DOE

DOE Setup: Scrub Mark Characterization







Both height and depth values were generated based on "Bearing Ratio" analyses

Scrub Sensitivity Analysis DOE

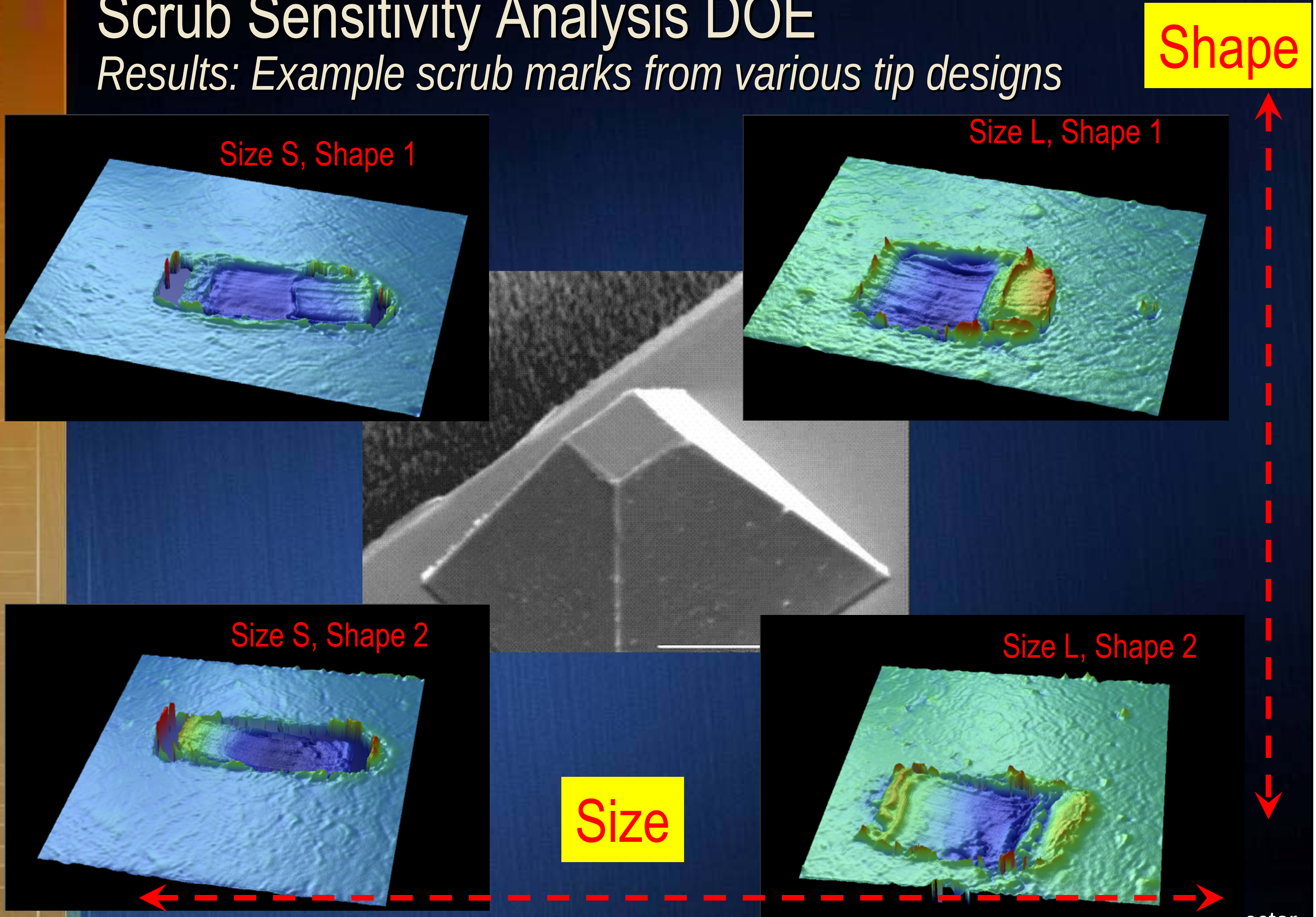
DOE Setup: Matrix

	Tip size	Tip shape	TD count
Tip Treatment Condition “A”	X	X	X
Tip Treatment Condition “B”	X	X	X
Tip Treatment Condition “C”	X	X	X

- A DOE was designed to assess the sensitivities of various factors on scrub performance
- Output parameters
  - Scrub depth metric
  - Prow height metric
- Fixed parameters for the DOE
  - Prober conditions
  - Over drive
  - Micro-spring contact architectures
  - Probing pad material and stackup

Scrub Sensitivity Analysis DOE

Results: Example scrub marks from various tip designs

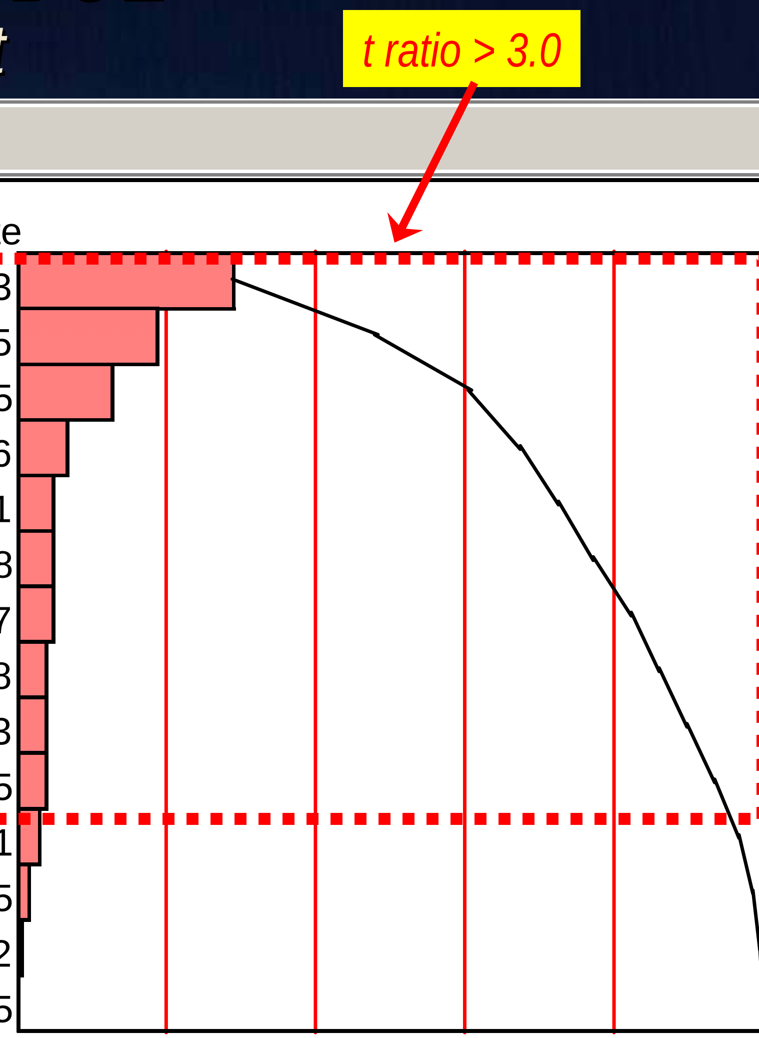


Scrub Sensitivity Analysis DOE

Results: "Scrub Depth" Pareto Plot

Pareto Plot of Transformed Estimates

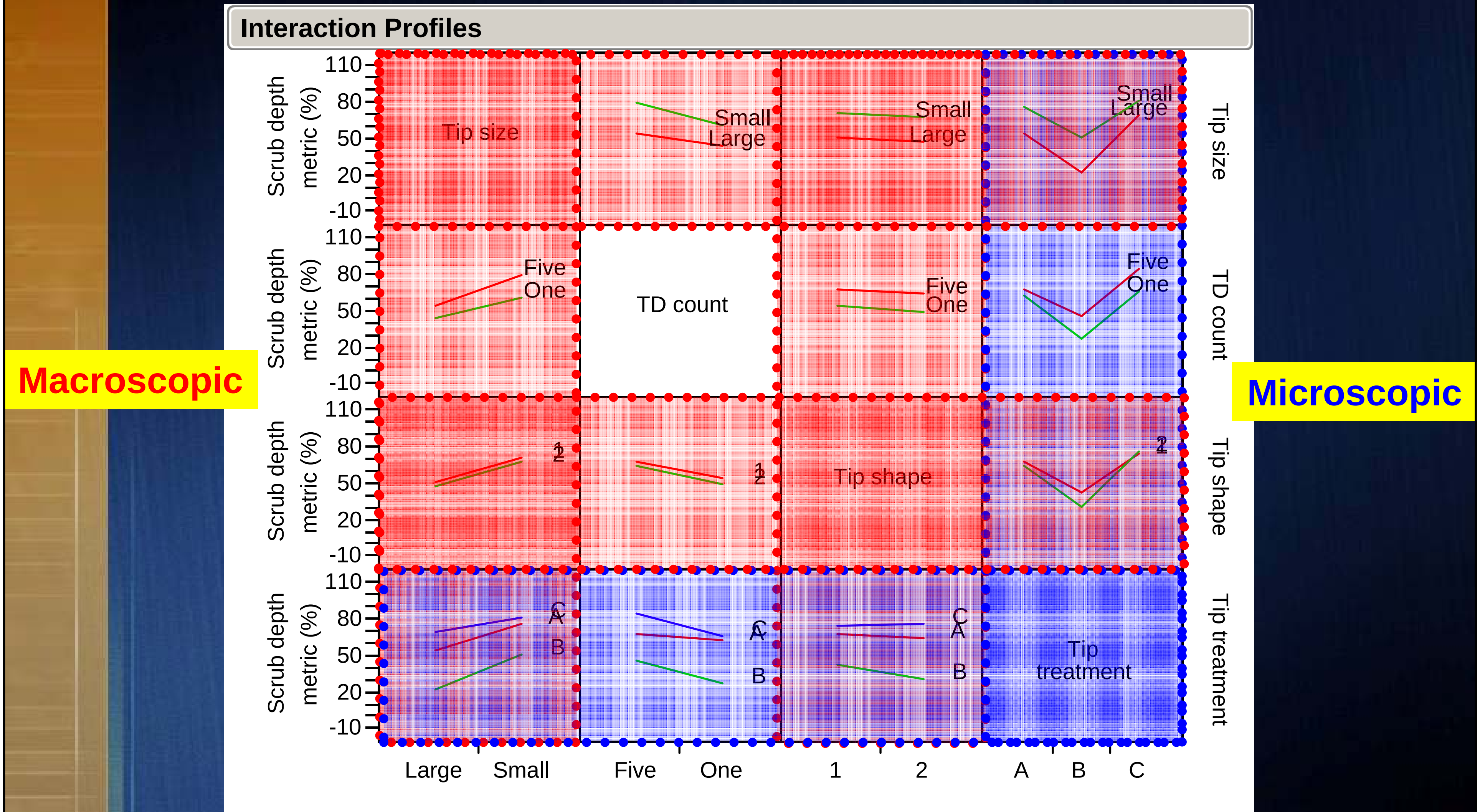
Term	Orthog Estimate
Tip treatment[B]	-15.99093
Tip size[Large]	-10.28125
TD count[Five]	6.95375
Tip treatment[A]	-3.80436
Tip size[Large]*Tip treatment[B]	-2.77981
Tip shape[1]*Tip treatment[B]	2.66668
TD count[Five]*Tip treatment[A]	-2.59187
Tip size[Large]*TD count[Five]	-2.19958
Tip size[Large]*Tip treatment[A]	-2.06523
Tip shape[1]	2.06375
TD count[Five]*Tip treatment[B]	1.71031
Tip shape[1]*Tip treatment[A]	1.01195
TD count[Five]*Tip shape[1]	-0.50792
Tip size[Large]*Tip shape[1]	0.10375



Significant factors for scrub depth: Tip conditions, tip size, TD count, and Interactions

Scrub Sensitivity Analysis DOE

Results: "Scrub Depth" Interaction Profile



Macroscopic, microscopic factors and their interactions all impact scrub depth

Scrub Sensitivity Analysis DOE

Results: “Prow Height” Pareto Plot

t ratio > 3.0

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Tip treatment[B]	-15.99093
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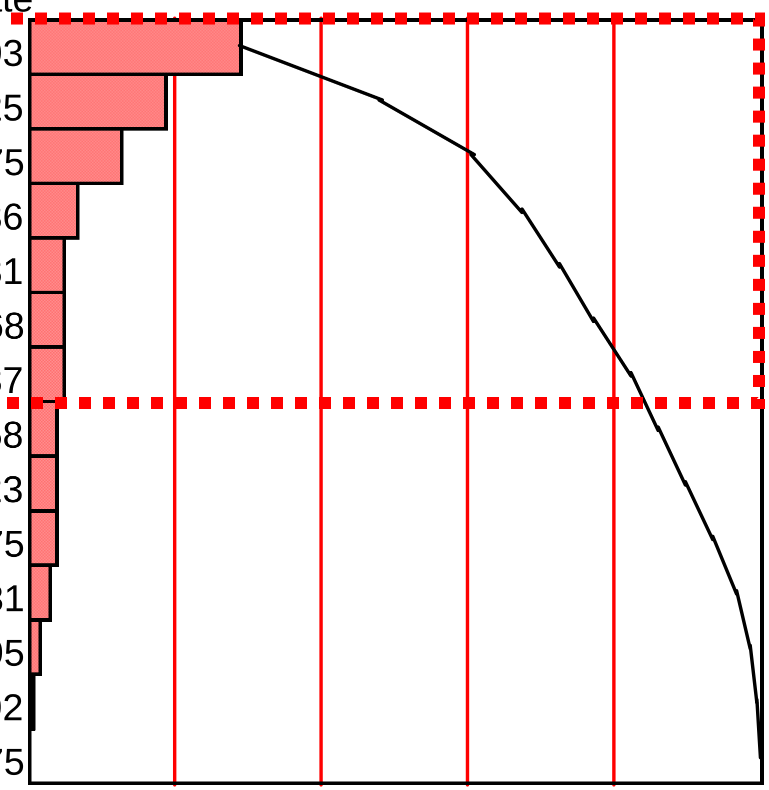
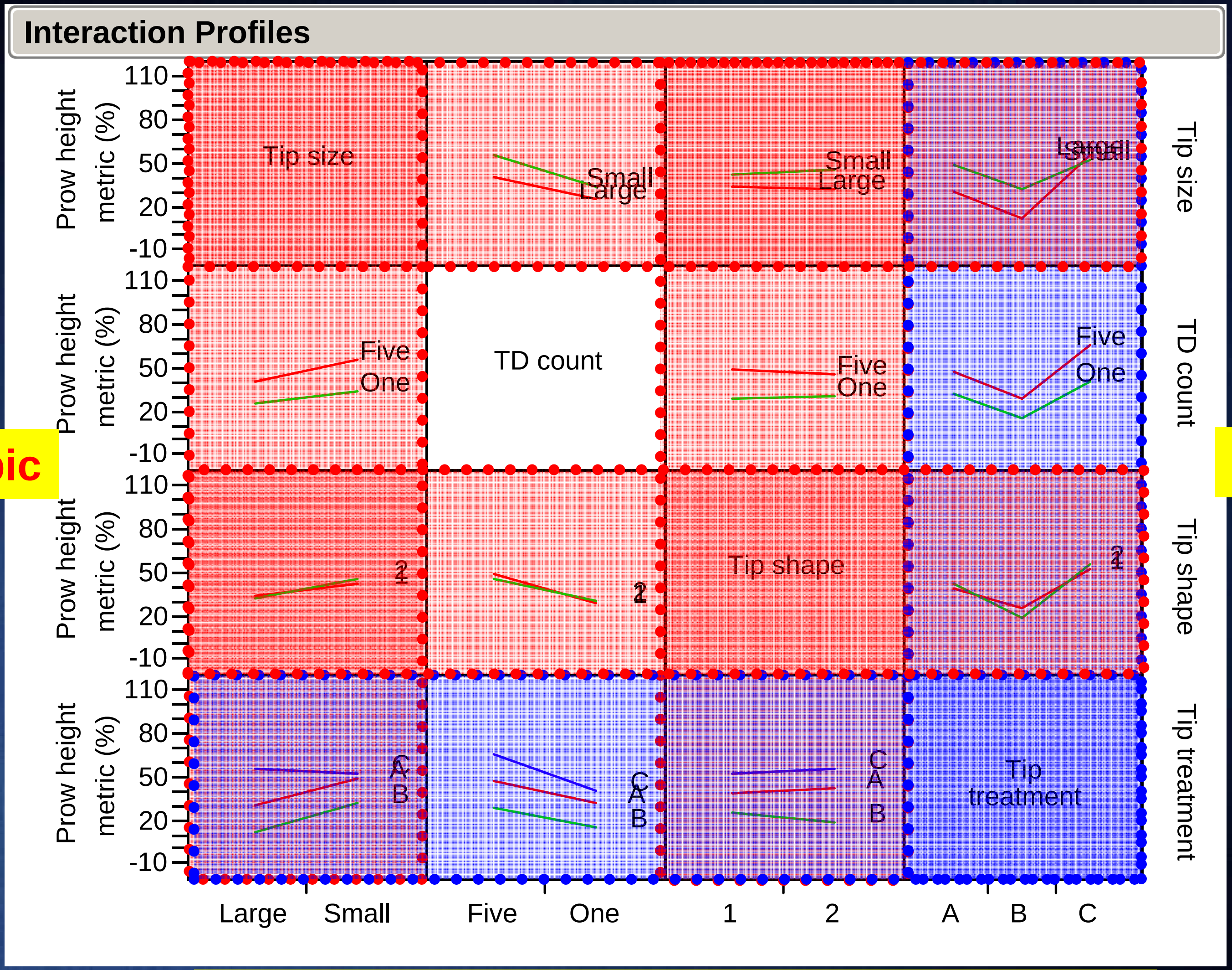


TD count, tip conditions, and tip size all contribute to the prow height metric

Scrub Sensitivity Analysis DOE

Results: “Prow Height” Interaction Profile



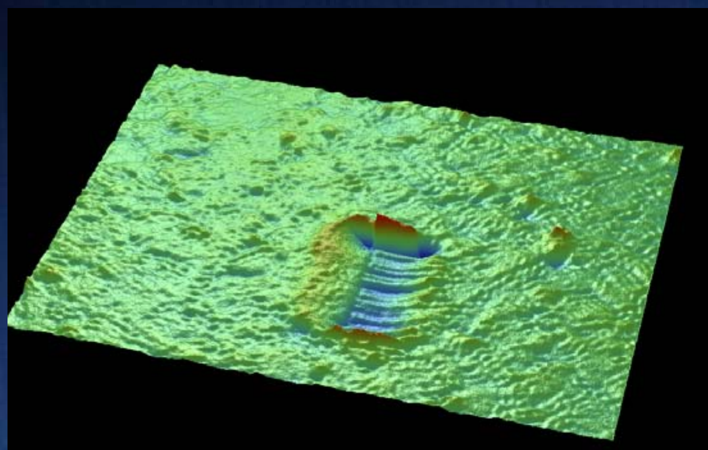
Macroscopic

Microscopic

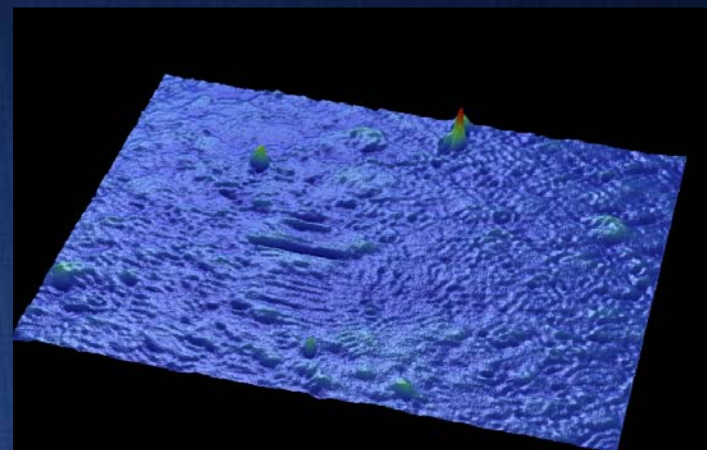
The trends are similar to that of depth metric

Scrub Sensitivity Analysis DOE

Results: Tip Treatment Impact on Scrub



Tip Treatment A



Tip Treatment B

MicroSpring with optimized tip treatment B demonstrated much improved scrub performance

What We Can Do to Help

In-depth collaborations between FFI and our customers will enable contact precision and product yield optimization

The deeper the scrub, the higher failure percentage of ball-non-stick

Scrub marks deeper than x mm could lead to bad contact reliability

Oxidation of exposed underlayer metal (Cu) will result in lower product yields

Too much of probing force will result in ILD layer cracking

Build-up at end/start of scrub may be a detrimental factor

Conclusions

- Probing contact precision is critical to improve device yield
  - Minimize yield loss from unreliable wire bond and under-layer damage
  - Contact precision defines multi-dimensional future probing requirement
- FFI MicroSpring contact scrub depth can be optimized by tip size and tip treatments to minimize probing pads damages
  - Optimized MicroSpring contacts showed excellent scrub performance
  - Tip shape does not seem to be a significant factor affecting the scrub performance
- FormFactor has proven design capabilities and applications experts to customize our technology to meet customers' future probing challenges.

Acknowledgements

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