



INNOVATION PUT TO THE TEST



®

FORMFACTOR

Advanced Wafer Probe Solutions

Contact Precision Optimization to Improve Scrub Performance

Ying Wang and Amy Leong

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

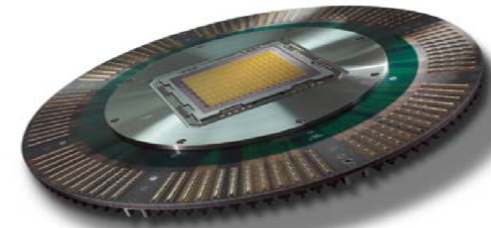
- Low contact resistance

- Tight pitch, small pad capability

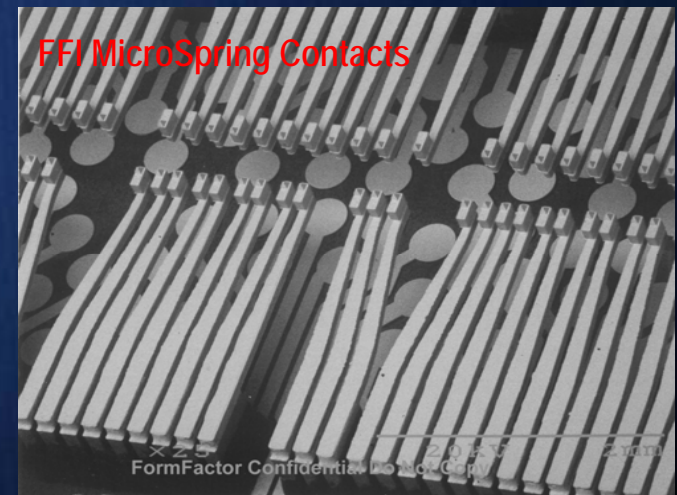
- Wide probing temperature

- Contact Precision = Better Yield

FFI PH150



FFI MicroSpring Contacts



Probing Trends

- *Quotes from Customer Test Floors*

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

Scrub marks deeper than $x \mu\text{m}$ could lead to bad contact reliability

Scrub
Performance
Metric

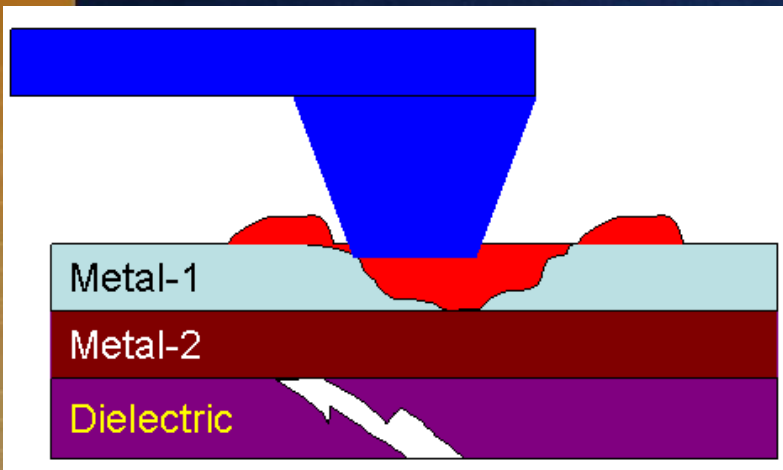
Oxidation of exposed underlayer metal (Cu) will result in lower product yields

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

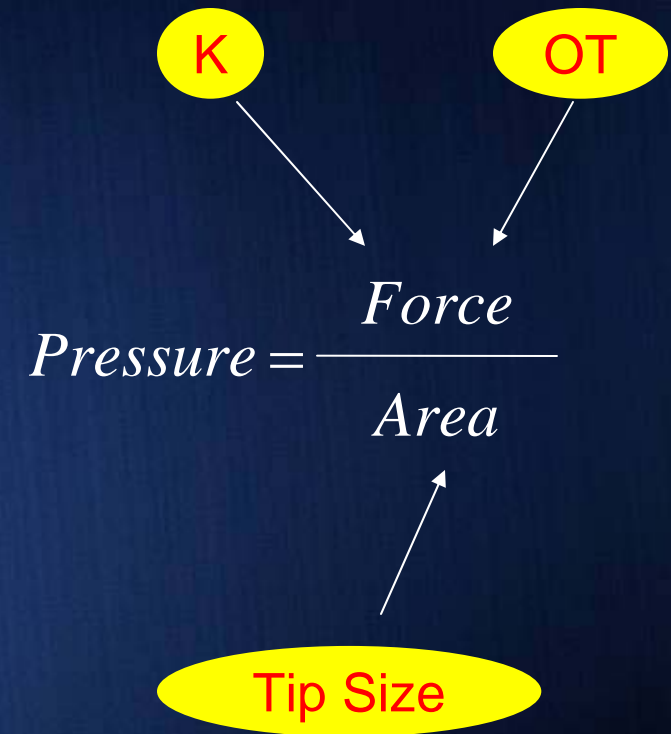
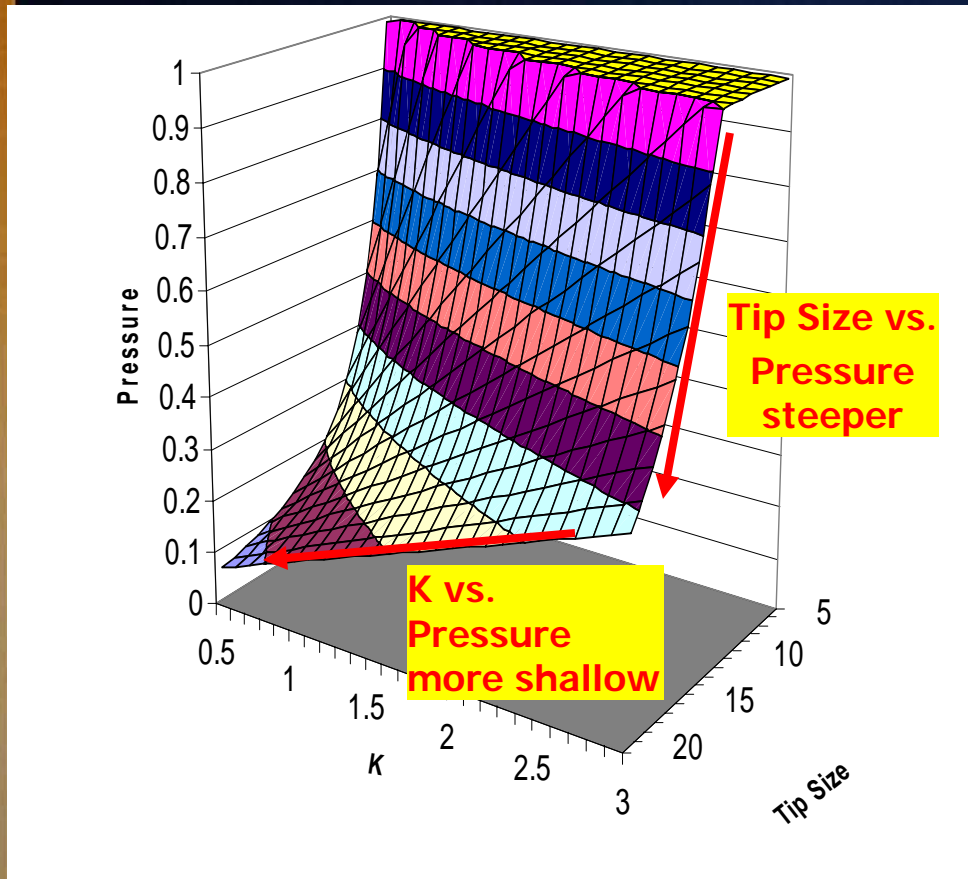
What Our Customers Ask For



- 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

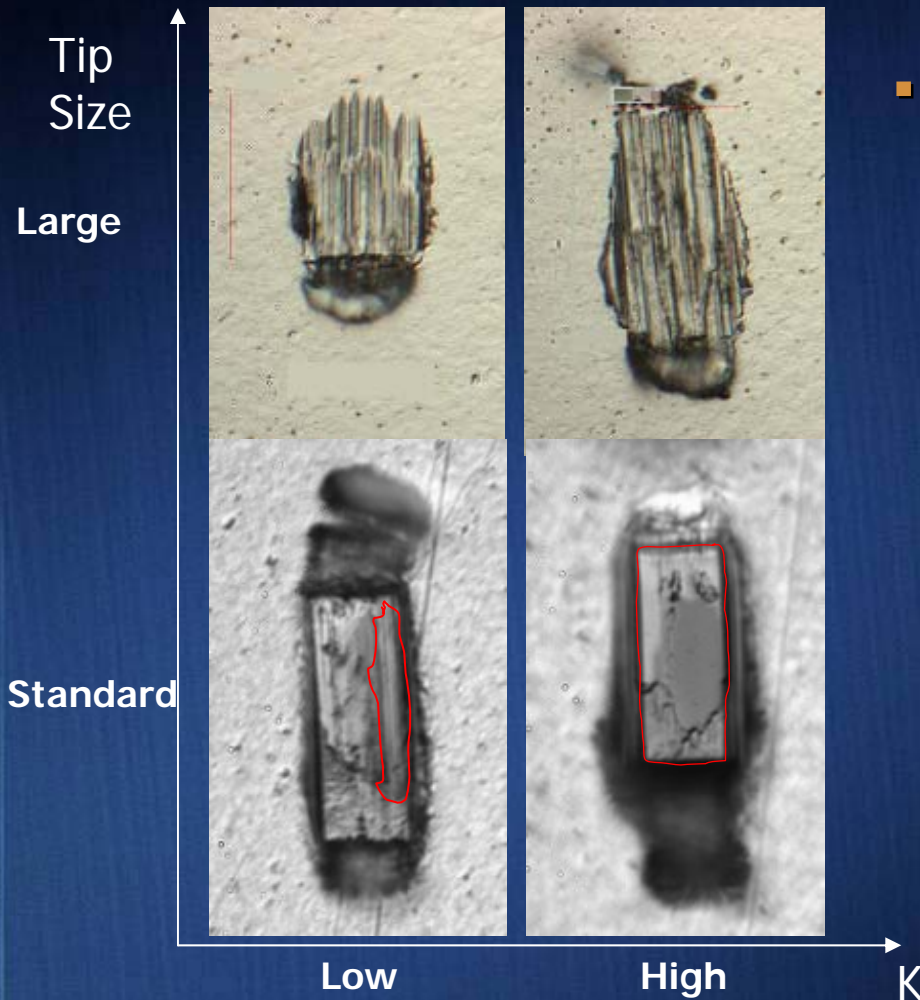


FormFactor SWTW Presentation, 2004

Increasing tip size is most effective in reducing pressure

Scrub Sensitivity Analysis DOE

Background: "Macroscopic" Mechanisms

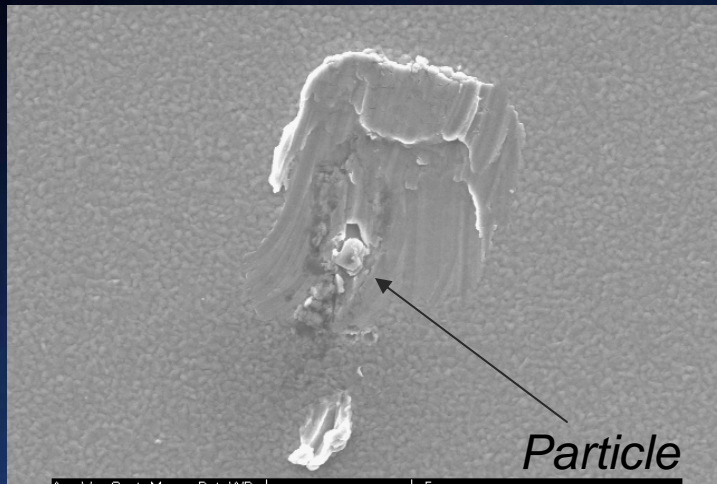


- Macroscopically, punch through level was found to be a direct function of tip pressure
 - Tip area
 - Spring constant
 - Planarity
 - Over travel

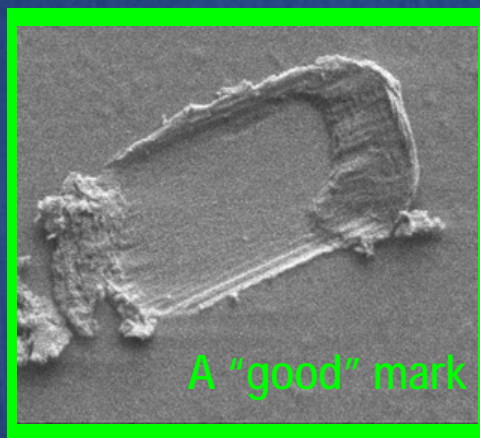
FormFactor SWTW Presentation, 2004

Scrub Sensitivity Analysis DOE

Background: "Microscopic" Mechanisms

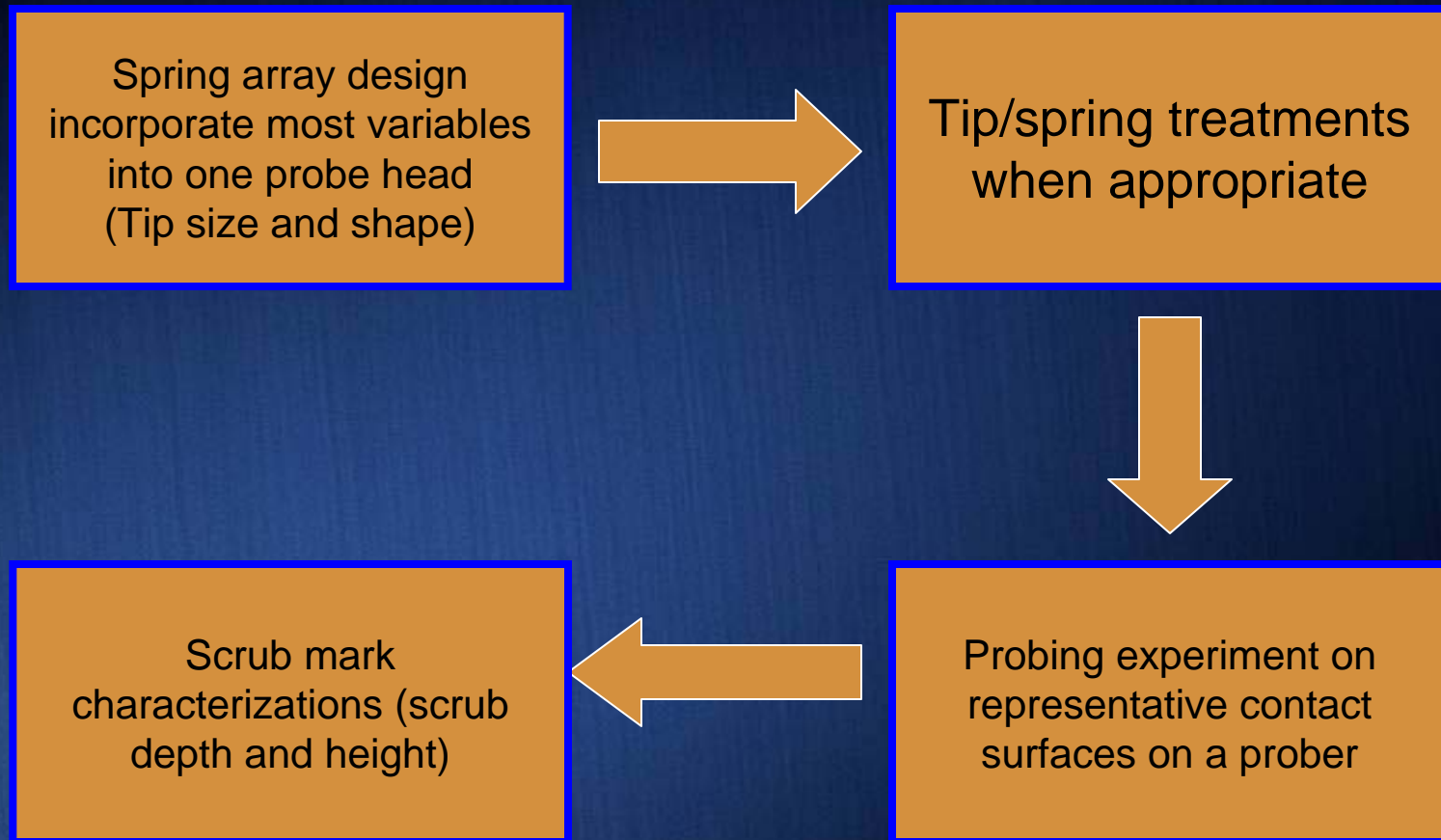


- "Microscopically", punch through can be caused by tip surface roughness and/or particle scratches



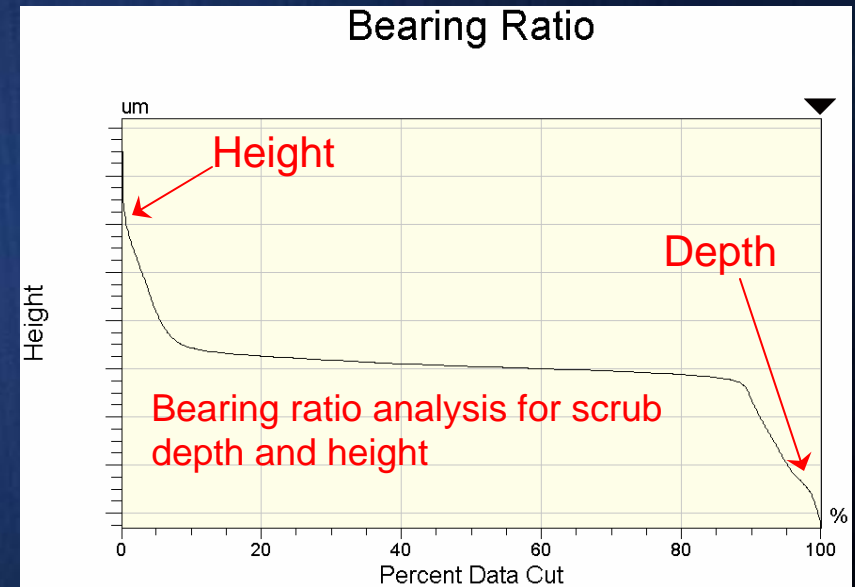
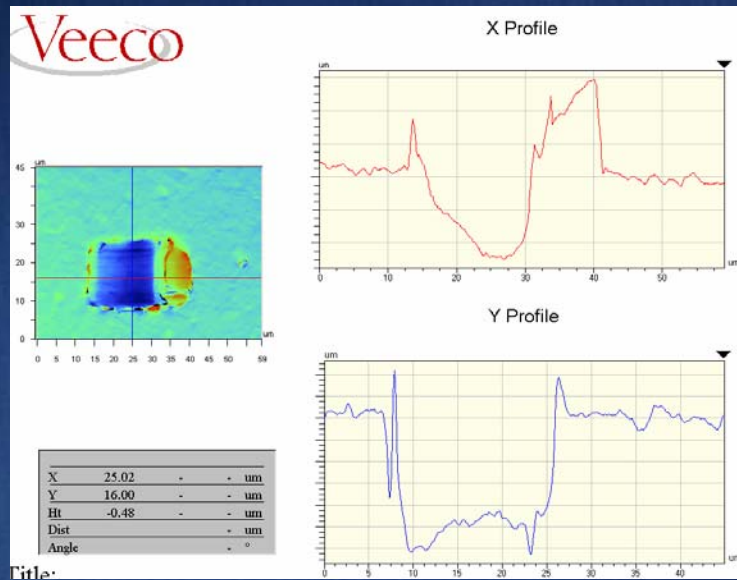
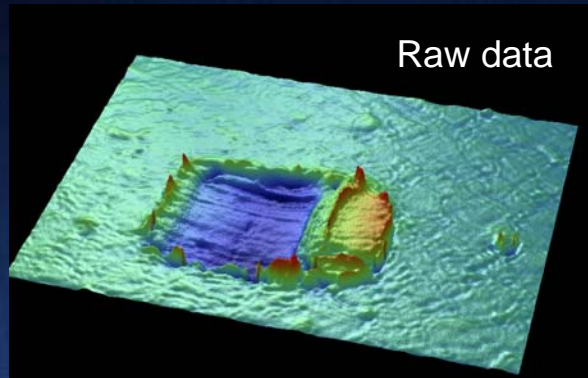
Scrub Sensitivity Analysis DOE

DOE Setup: Procedure



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

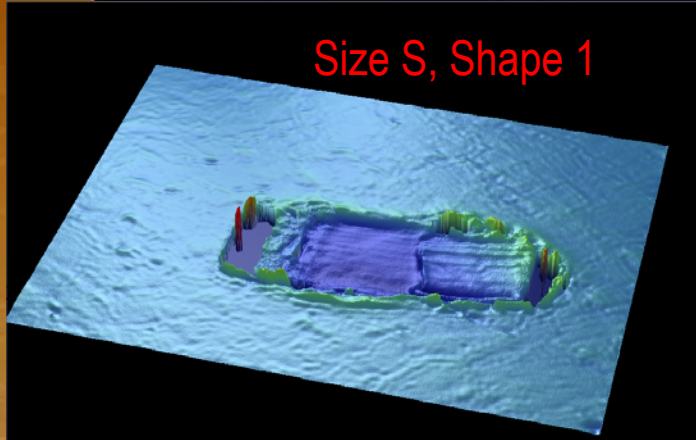
- A DOE was designed to assess the sensitivities of various factors on scrub performance
- Output parameters
 - Scrub depth metric
 - Prow height metric
- Fixed parameters for the DOE
 - Prober conditions
 - Over drive
 - Micro-spring contact architectures
 - Probing pad material and stackup

Scrub Sensitivity Analysis DOE

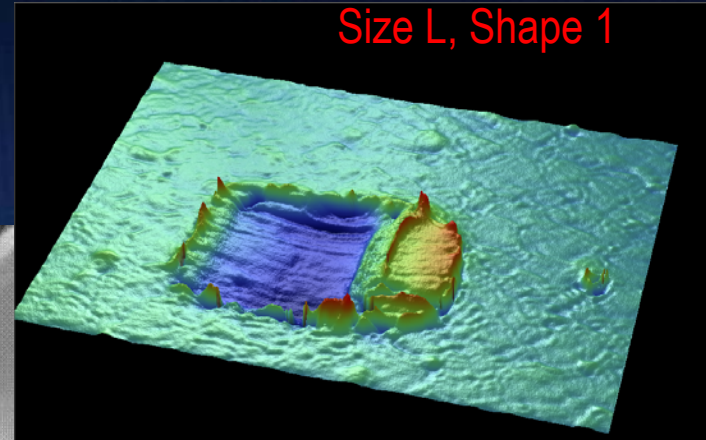
Results: Example scrub marks from various tip designs

Shape

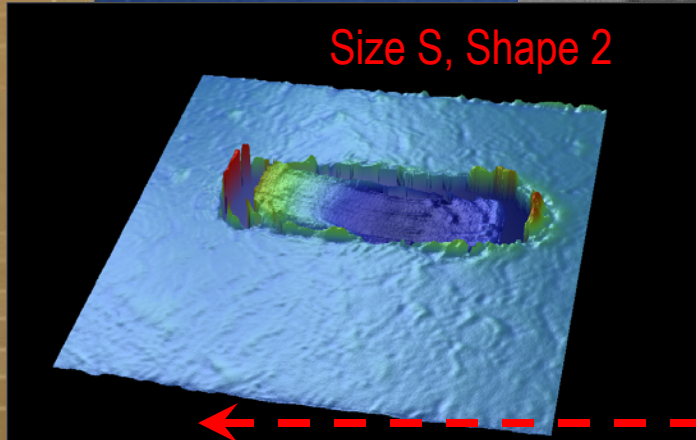
Size S, Shape 1



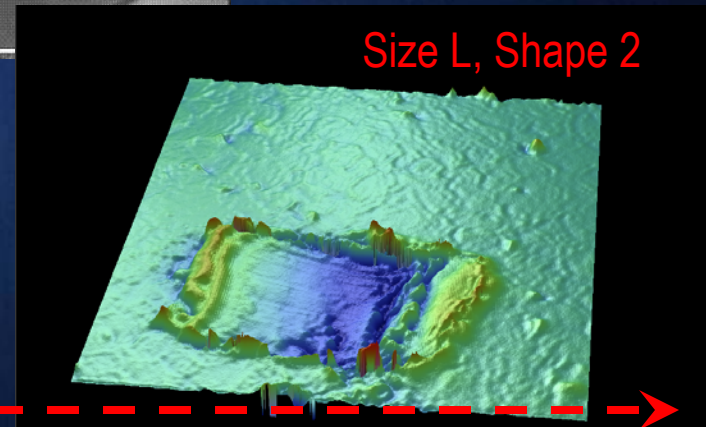
Size L, Shape 1



Size S, Shape 2



Size L, Shape 2

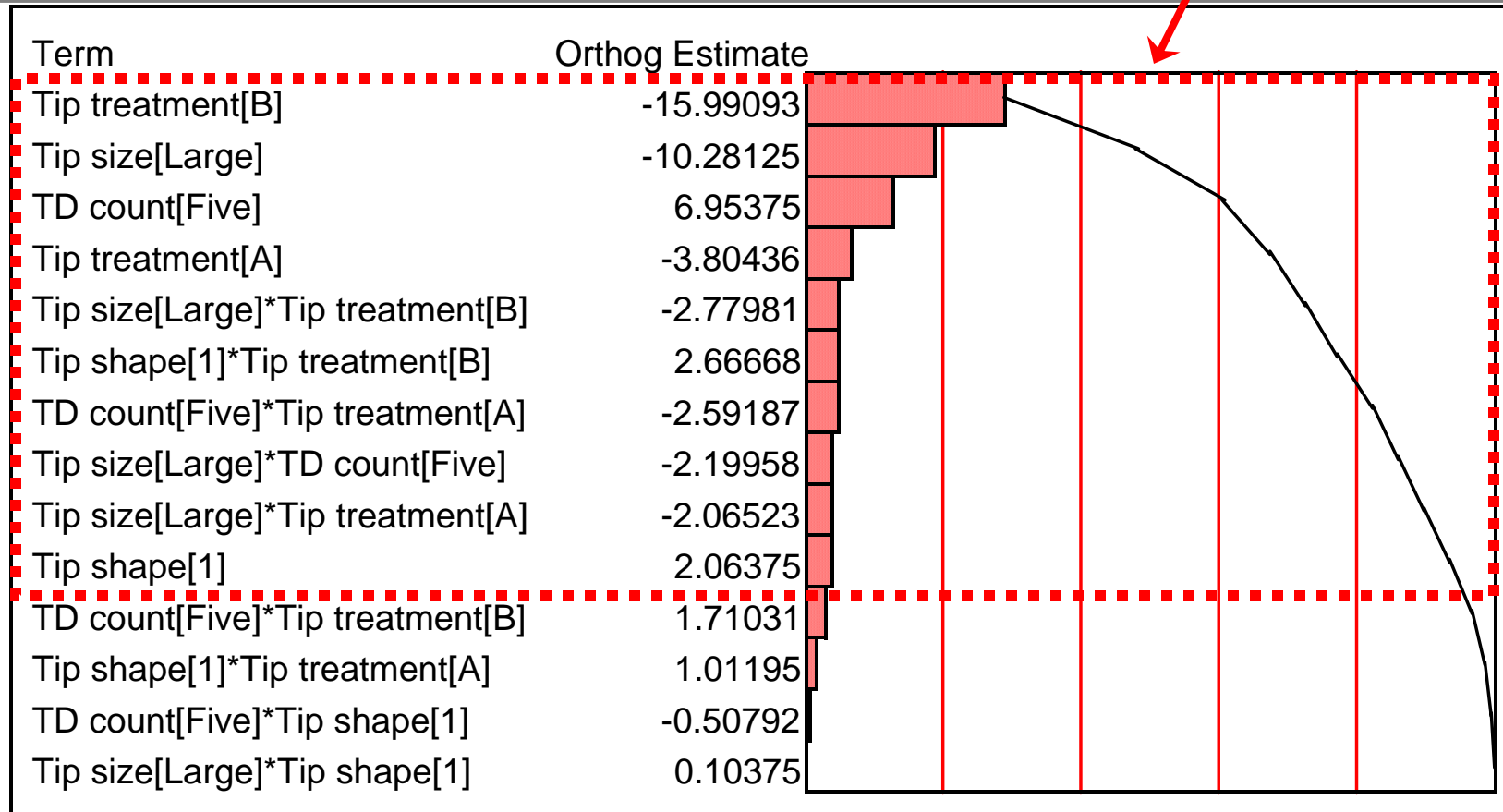


Size

Scrub Sensitivity Analysis DOE

Results: "Scrub Depth" Pareto Plot

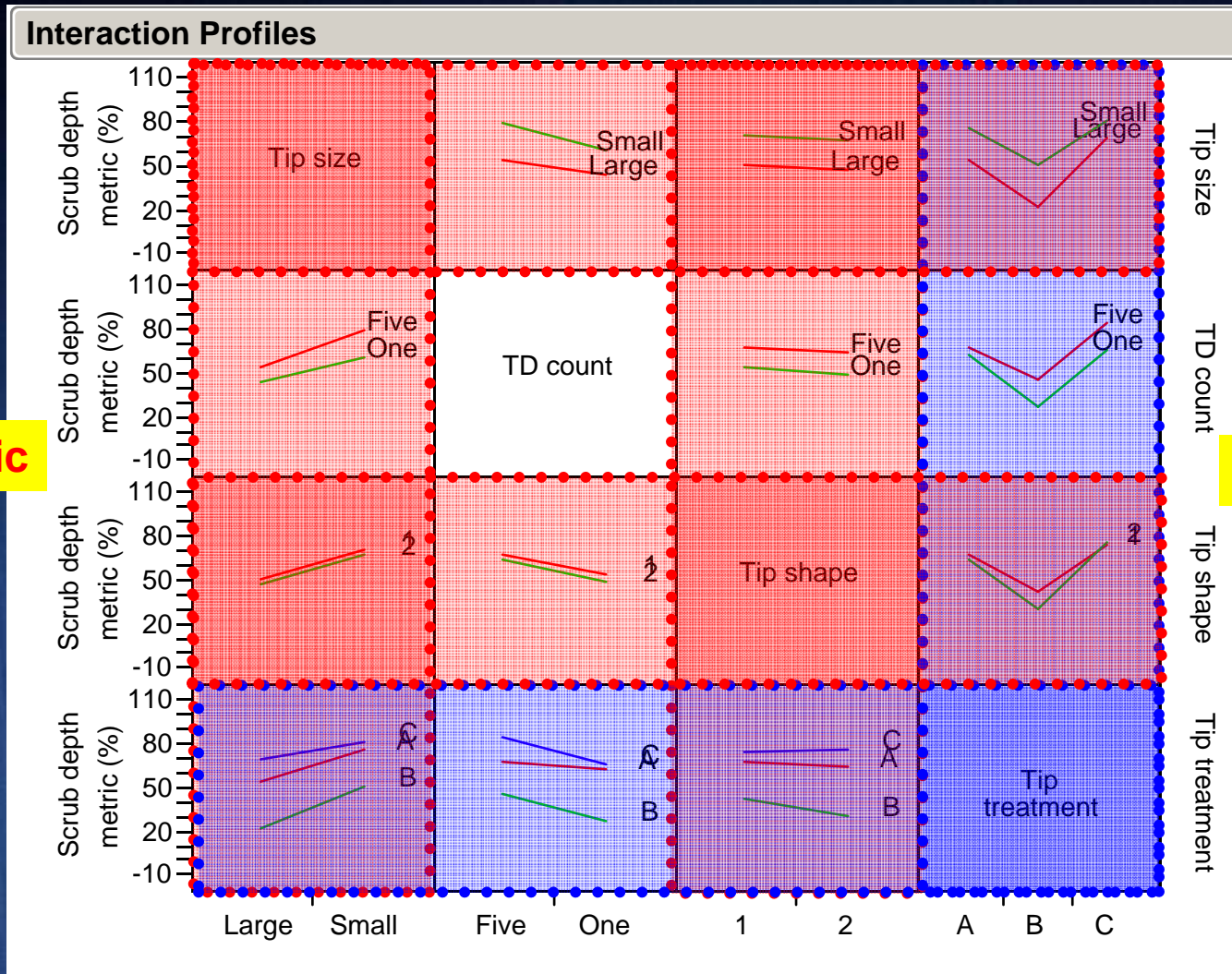
Pareto Plot of Transformed Estimates



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

Scrub Sensitivity Analysis DOE

Results: "Scrub Depth" Interaction Profile



Macroscopic

Microscopic

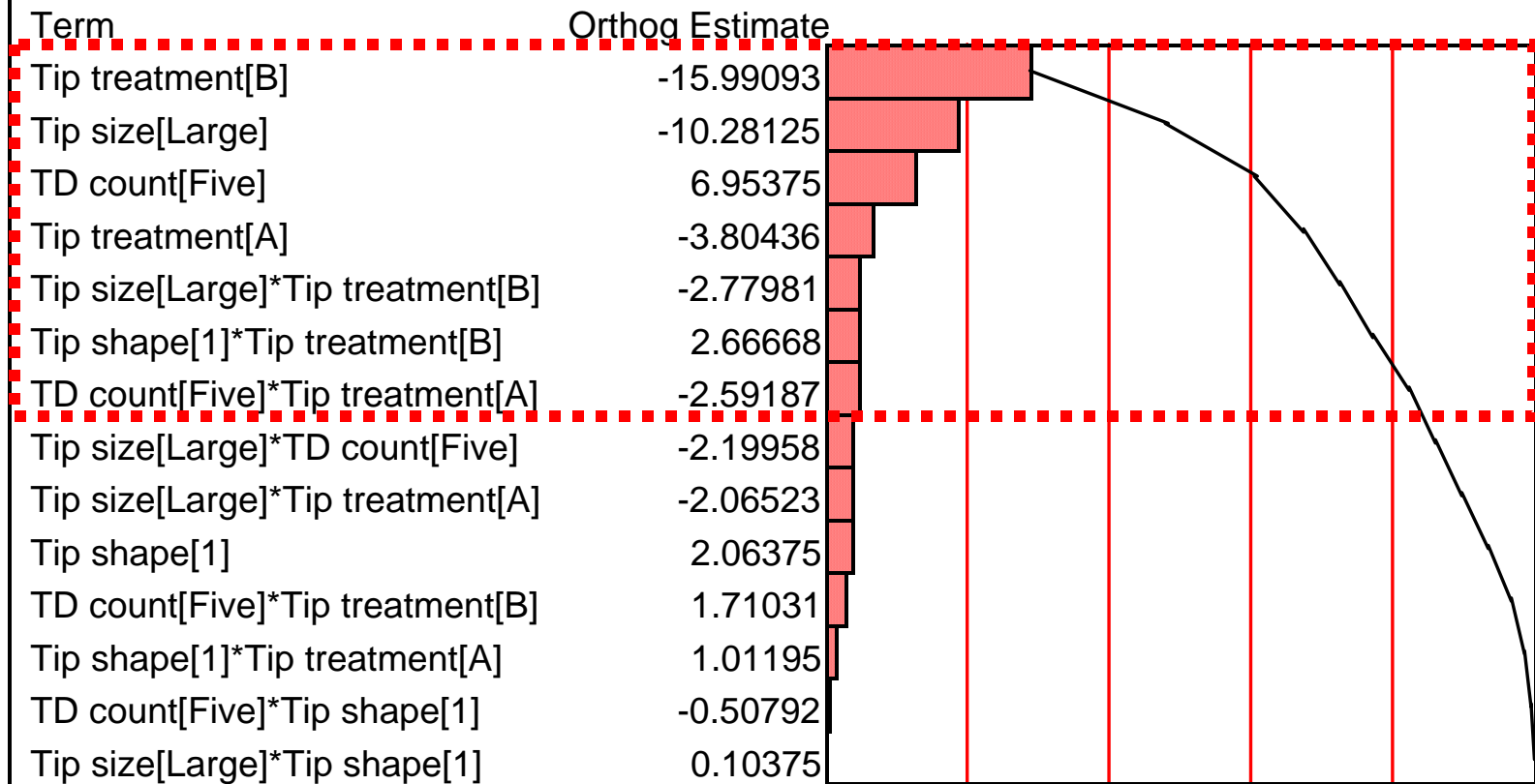
Macroscopic, microscopic factors and their interactions all impact scrub depth

Scrub Sensitivity Analysis DOE

Results: "Prow Height" Pareto Plot

t ratio > 3.0

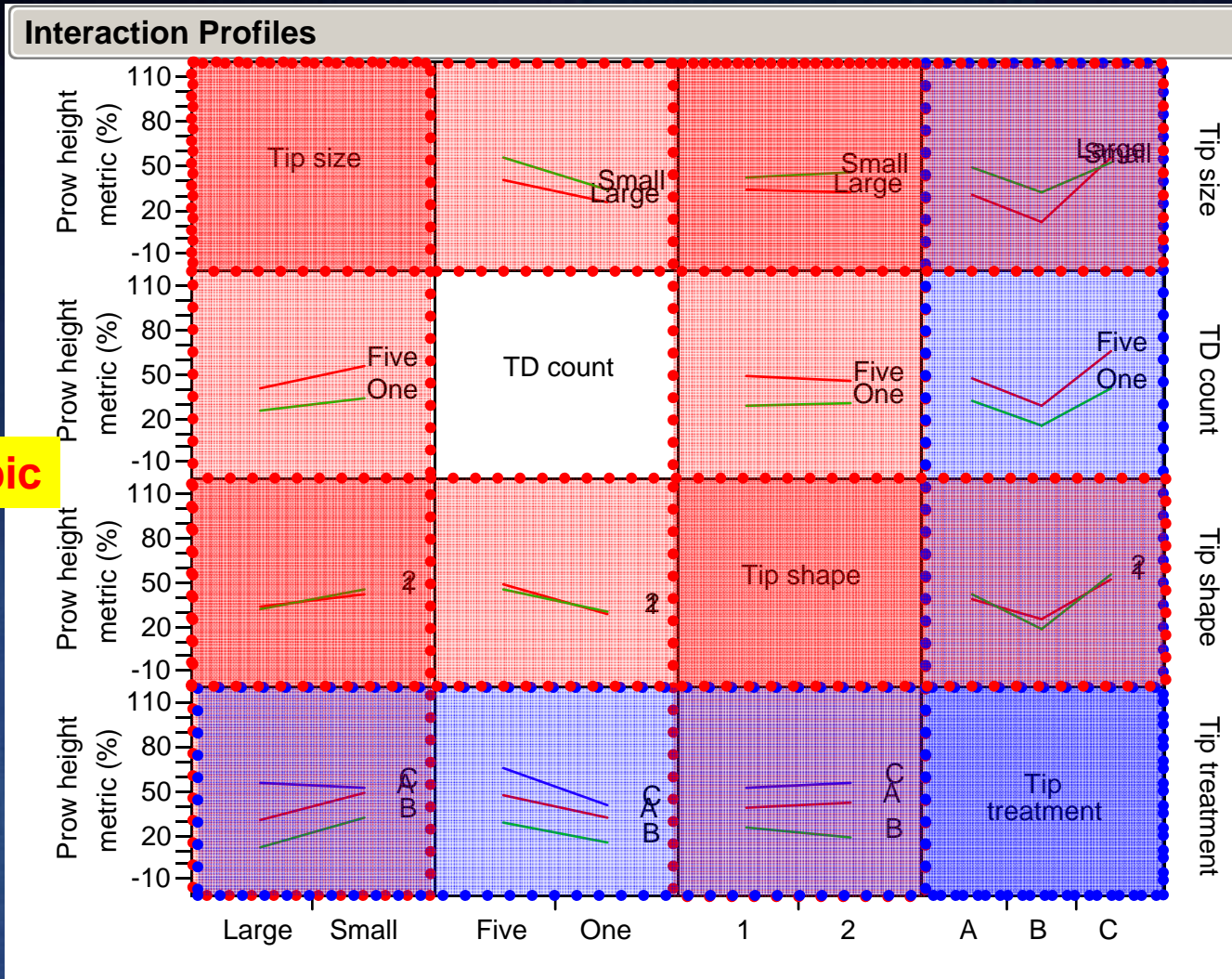
Pareto Plot of Transformed Estimates



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

Scrub Sensitivity Analysis DOE

Results: "Prow Height" Interaction Profile



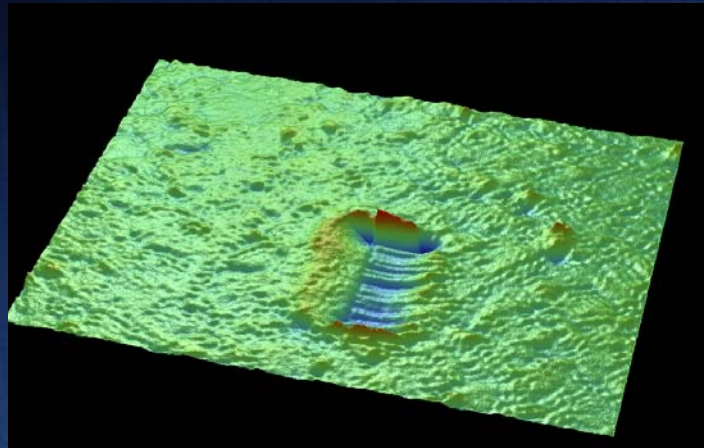
Macroscopic

Microscopic

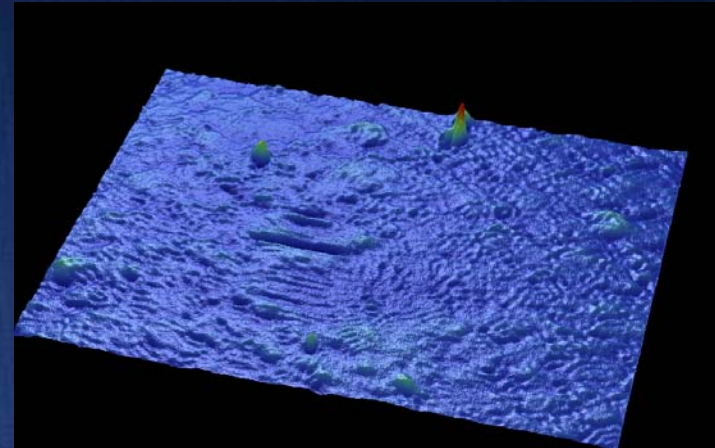
The trends are similar to that of depth metric

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

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

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

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

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

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

Too much of probing force will result in ILD layer cracking

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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