



®

**FORMFACTOR**

The MicroSpring® Company

# Optimization of MicroSpring® Contact Design Parameters for Low Pressure Probing

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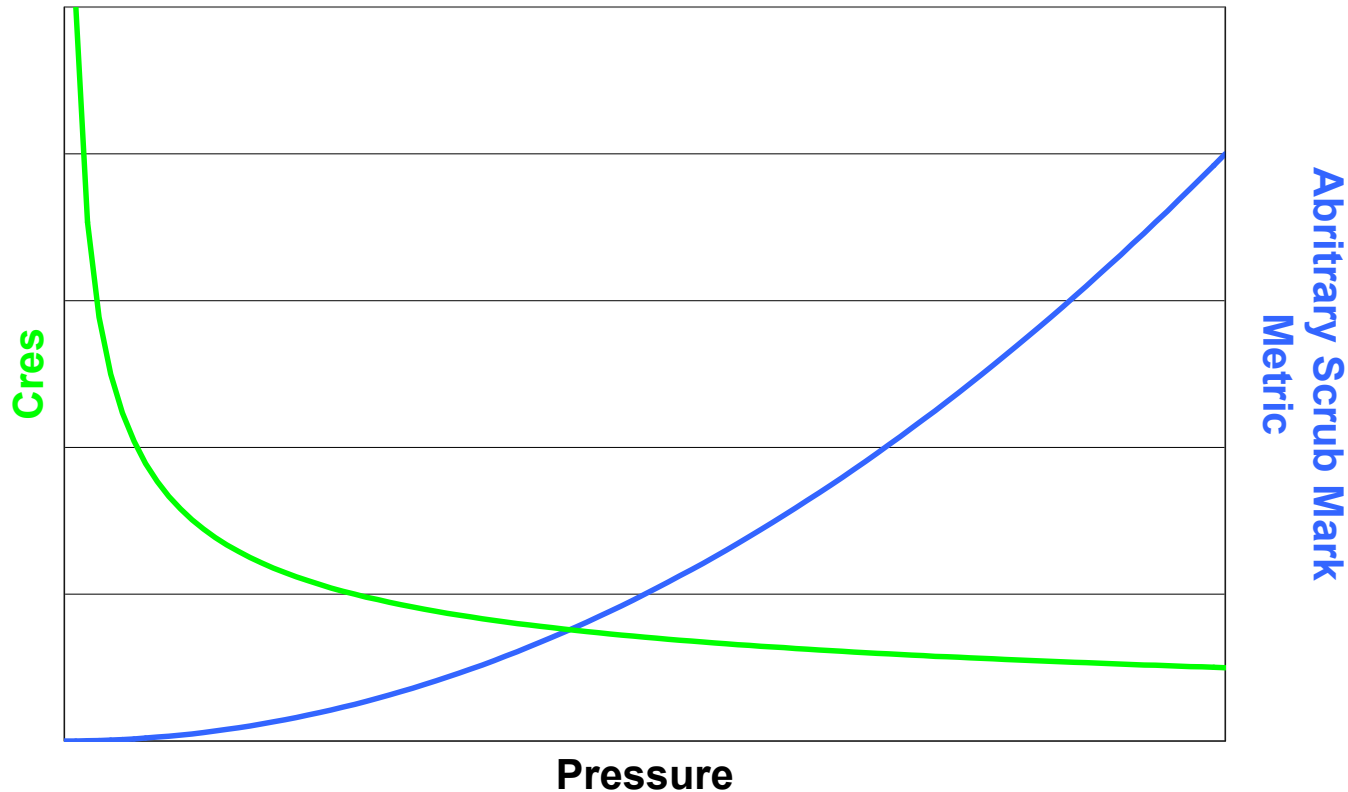
- Industry Driven Probing Requirements
- Probing Operating Space
  - Cres
  - Scrub Mark Metrics
- Case Study
  - Predictive Probing at FormFactor
    - Scrub Mark
    - Cres
  - Customer Validation
- Conclusion

# Industry Trends

- New Bond Pad Stackups
  - Copper metallization
  - Low K dielectric
  - Probing over active area
- Lower Power Devices, driven by mobile products, reduce test margins

# Probing Operating Space

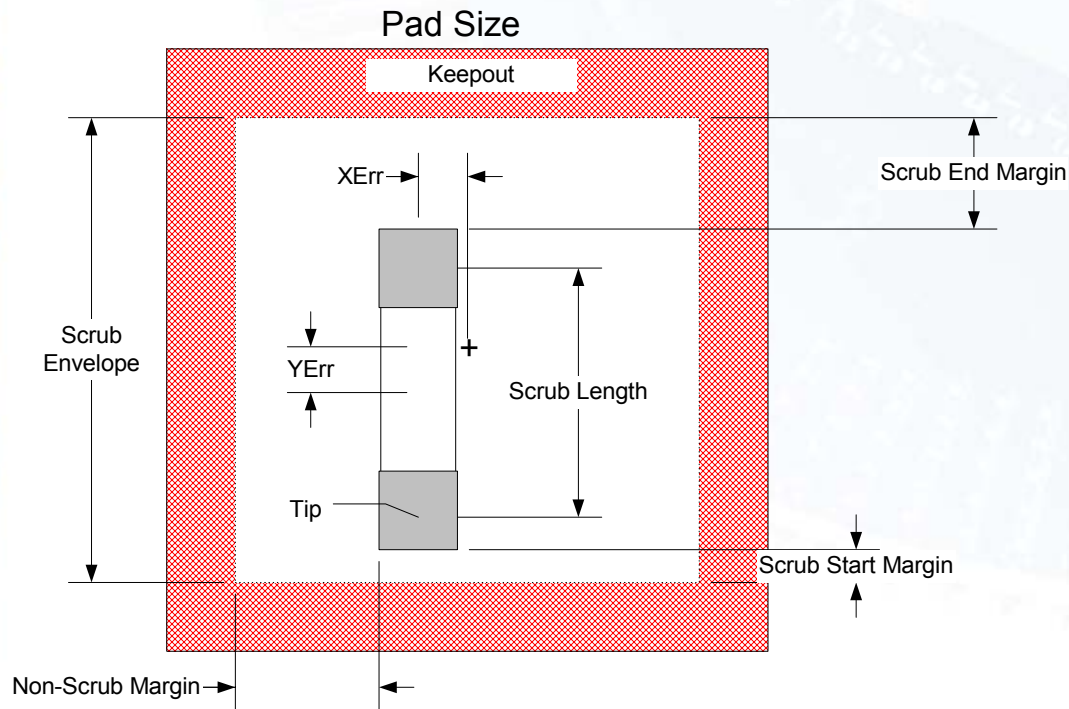
## Cres Vs. Pressure



- Pressure is an independent variable that modulates both Cres and the scrub mark metric.
- Must balance two opposing requirements

# Probing Operating Space

## Scrub Mark Metrics



- Length
  - Expose lower stack metals
  - Package reliability issues
- Width
- Depth
  - Hit passivation
- # of TD's
  - Multiple sorts common
  - Double touch recipes common

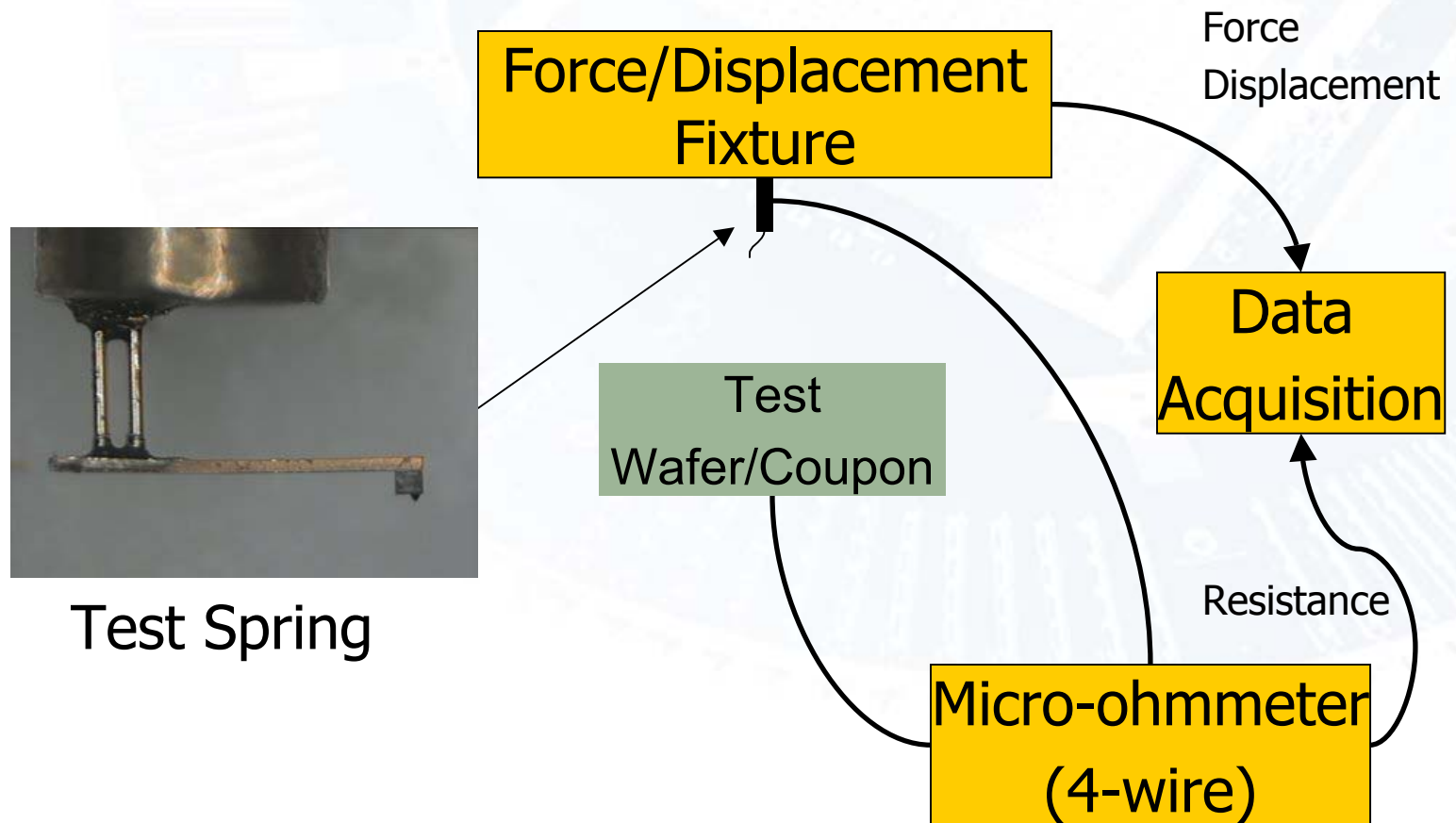
# Case Study

## New Bond Pad Stack-up Metallization

- Requirements:
  - No exposure of base metal after repeated touchdowns
    - Thin Al over base metal
  - Low, stable Cres
- Approach:
  - Predictive Probing at FFI
    - Scrub Characterization
    - Cres
  - Customer Site Validation
    - Scrub Characterization
    - Qualification

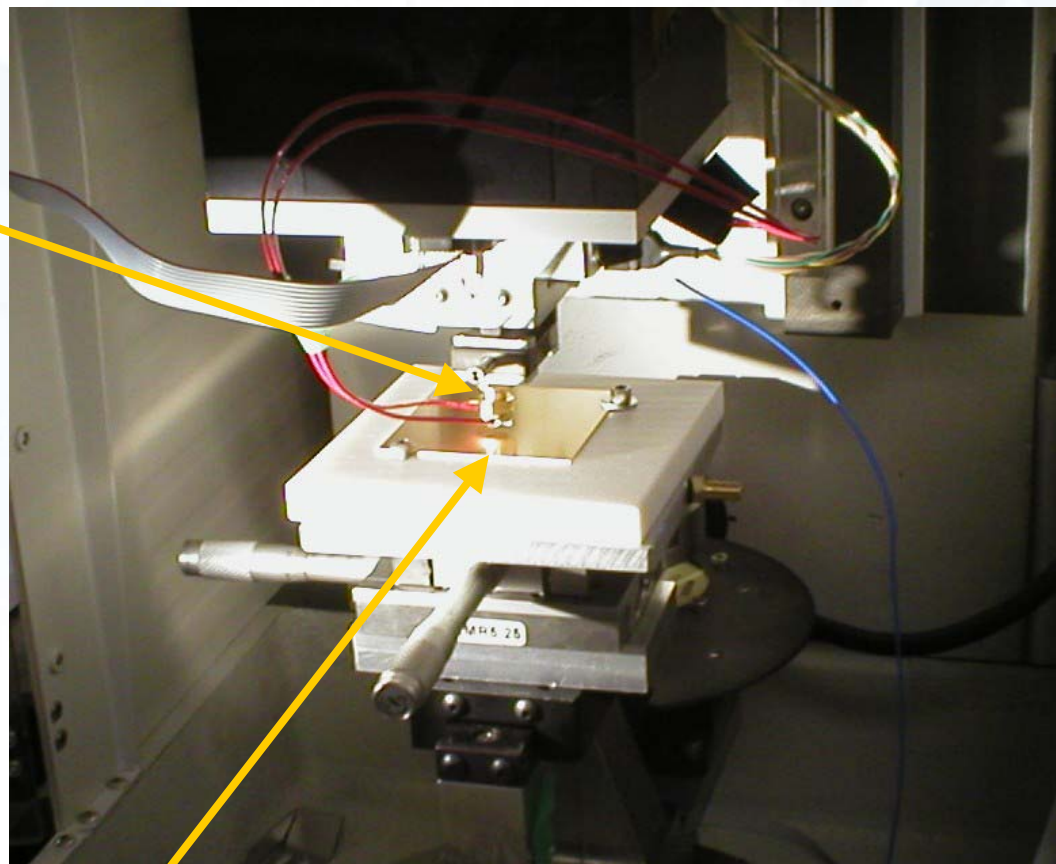
# Experimental Setup

## Predictive Probing at FormFactor



# Experimental Setup

## Predictive Probing at FormFactor

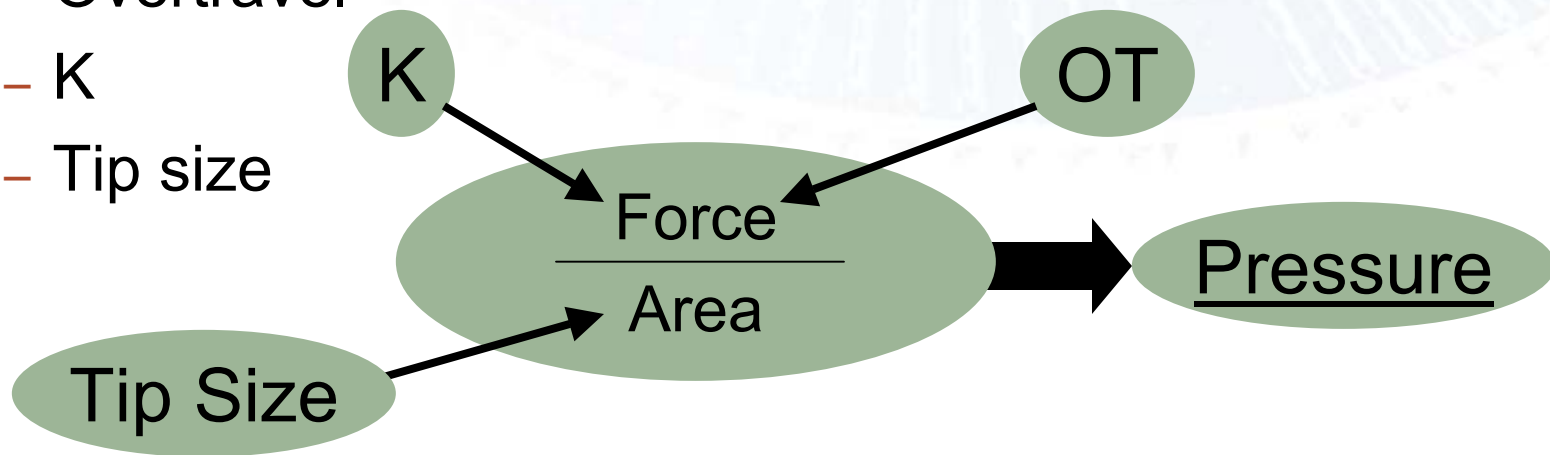


Au plated Cres Test Coupon shown



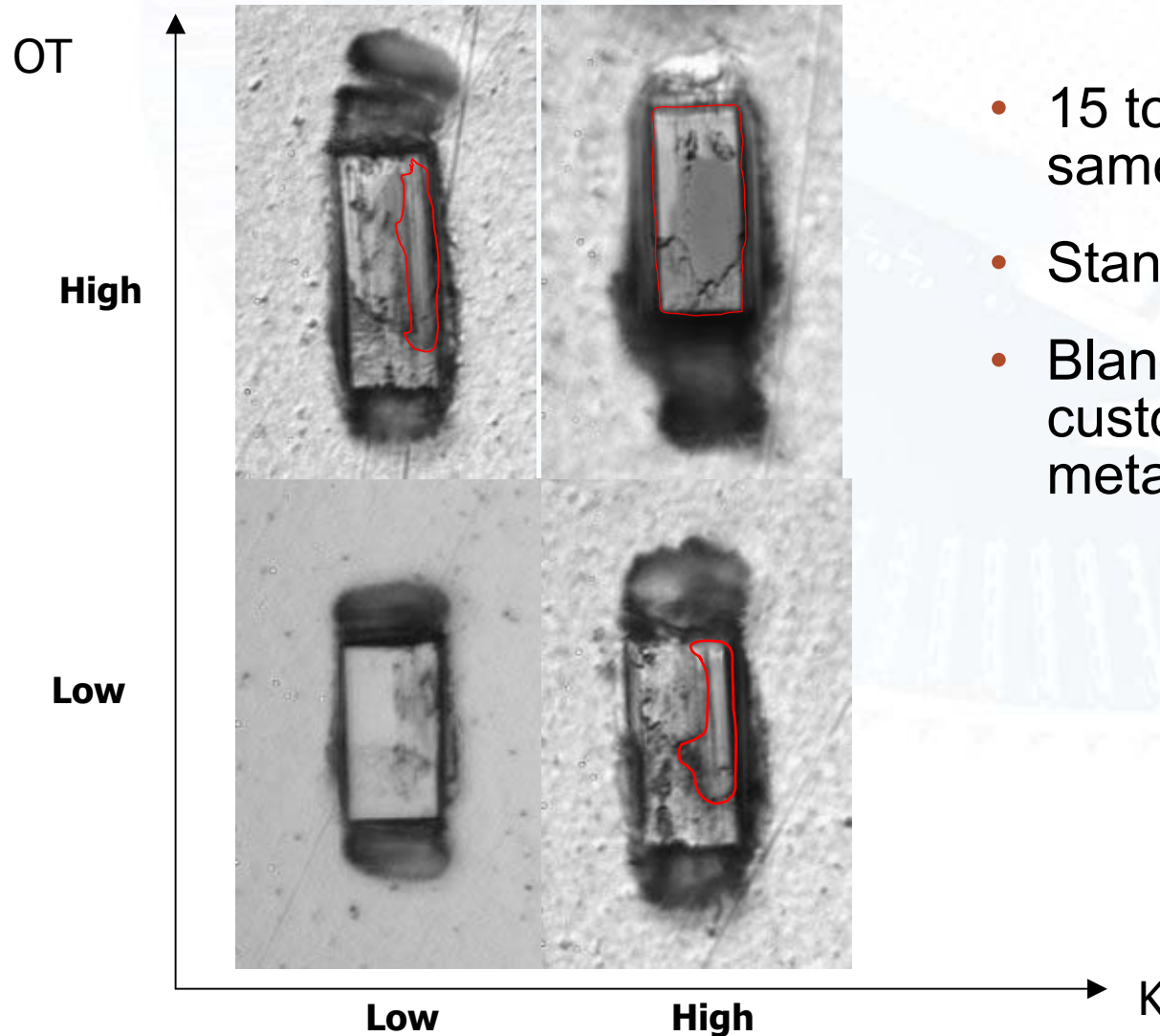
# Predictive Probing Evaluation of Pressure Parameters

- Pressure is a first order variable for both Scrub mark and Cres.
  - Pressure=Applied Force/Contact Area
- FFI design parameters and probing recipes can be optimized to control pressure for specific applications.
  - Overtravel
  - K
  - Tip size



# Predictive Probing Pressure Evaluation

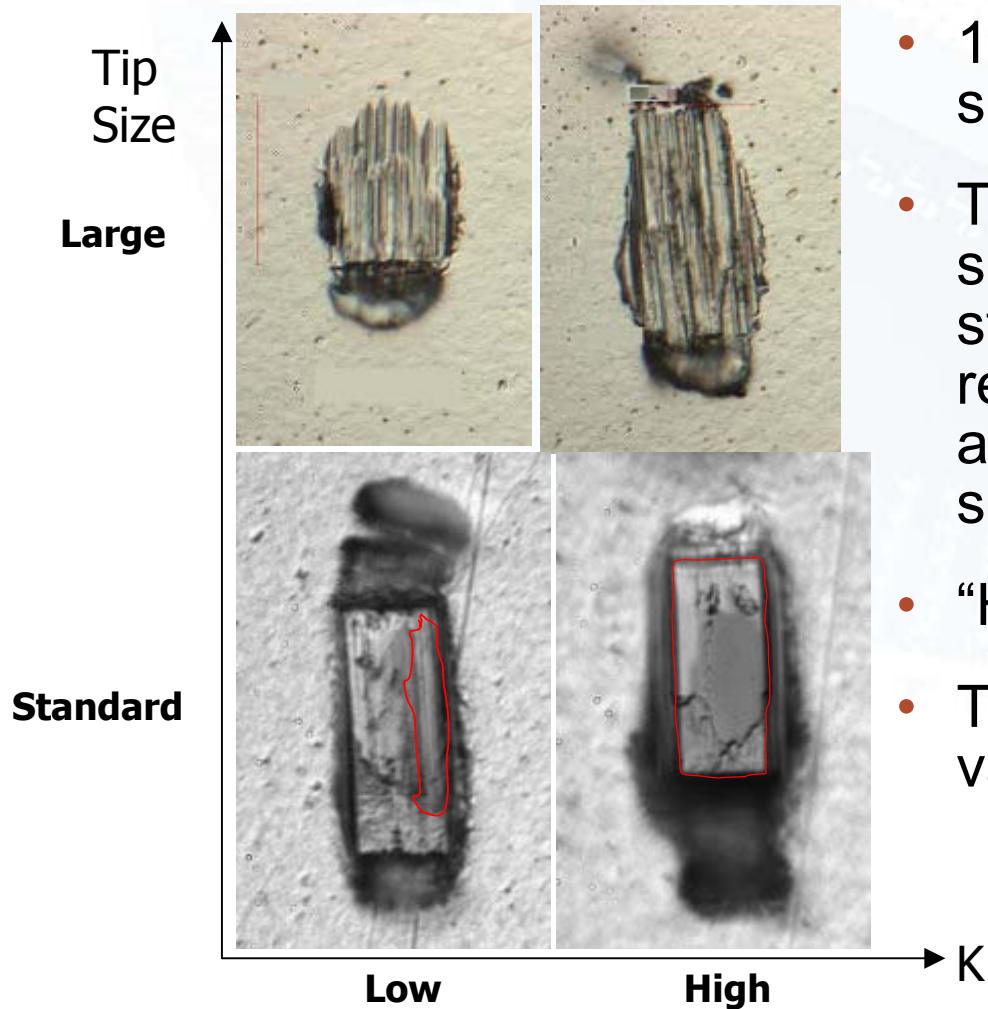
## Effects of K and Overtravel



- 15 touchdowns in same spot
- Standard tip size
- Blanket wafer with customer metallurgy/stack

# Predictive Probing Pressure Evaluation

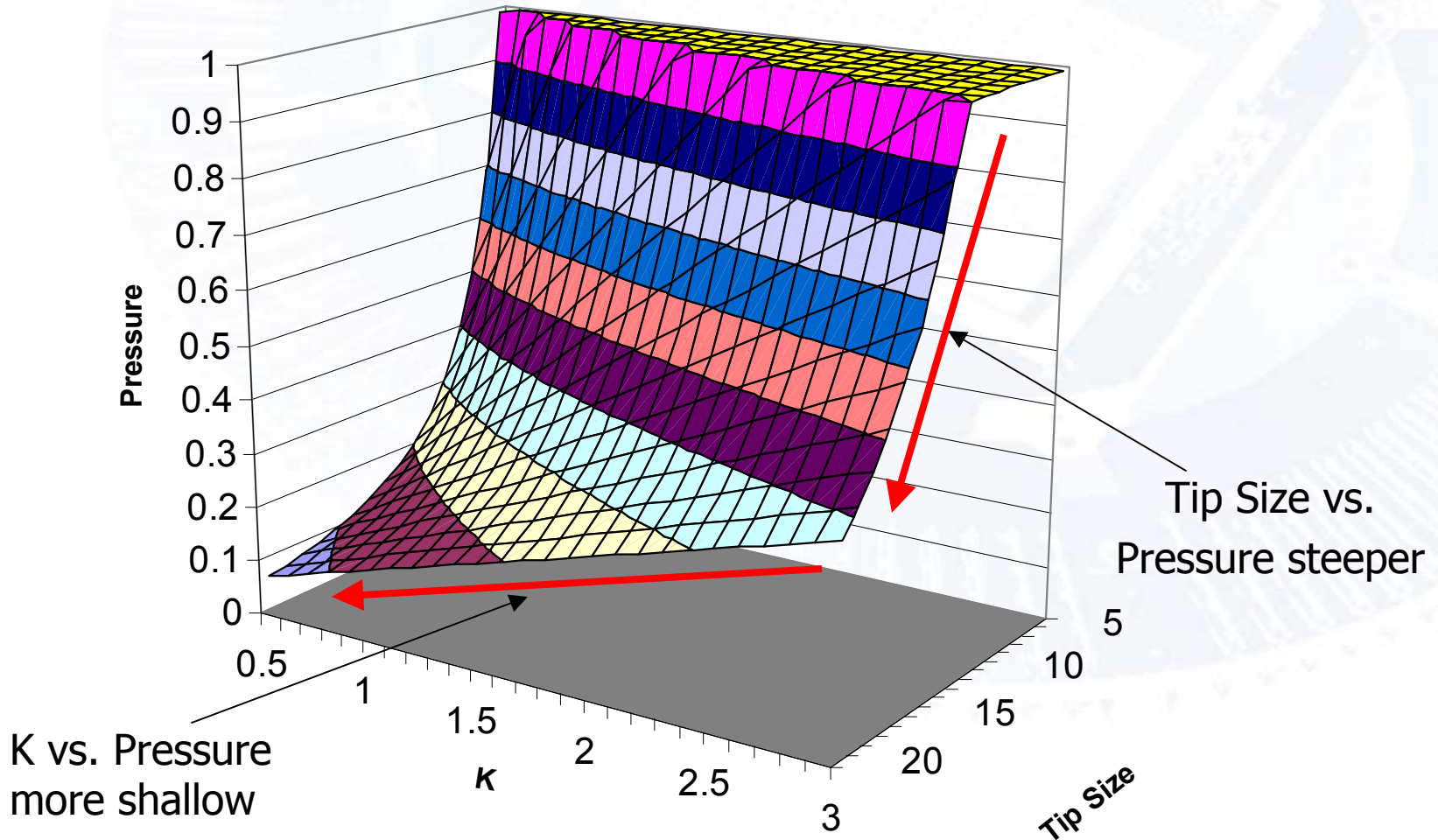
## Effects of K and Tip Size



- 15 touchdowns in same spot
- The low and high g/mil springs were grown from standard to large by repeated touchdowns on a controlled abrasive surface
- “High” OT for all cases.
- Tip size is dominant variable.

# Pressure Surface Relationship

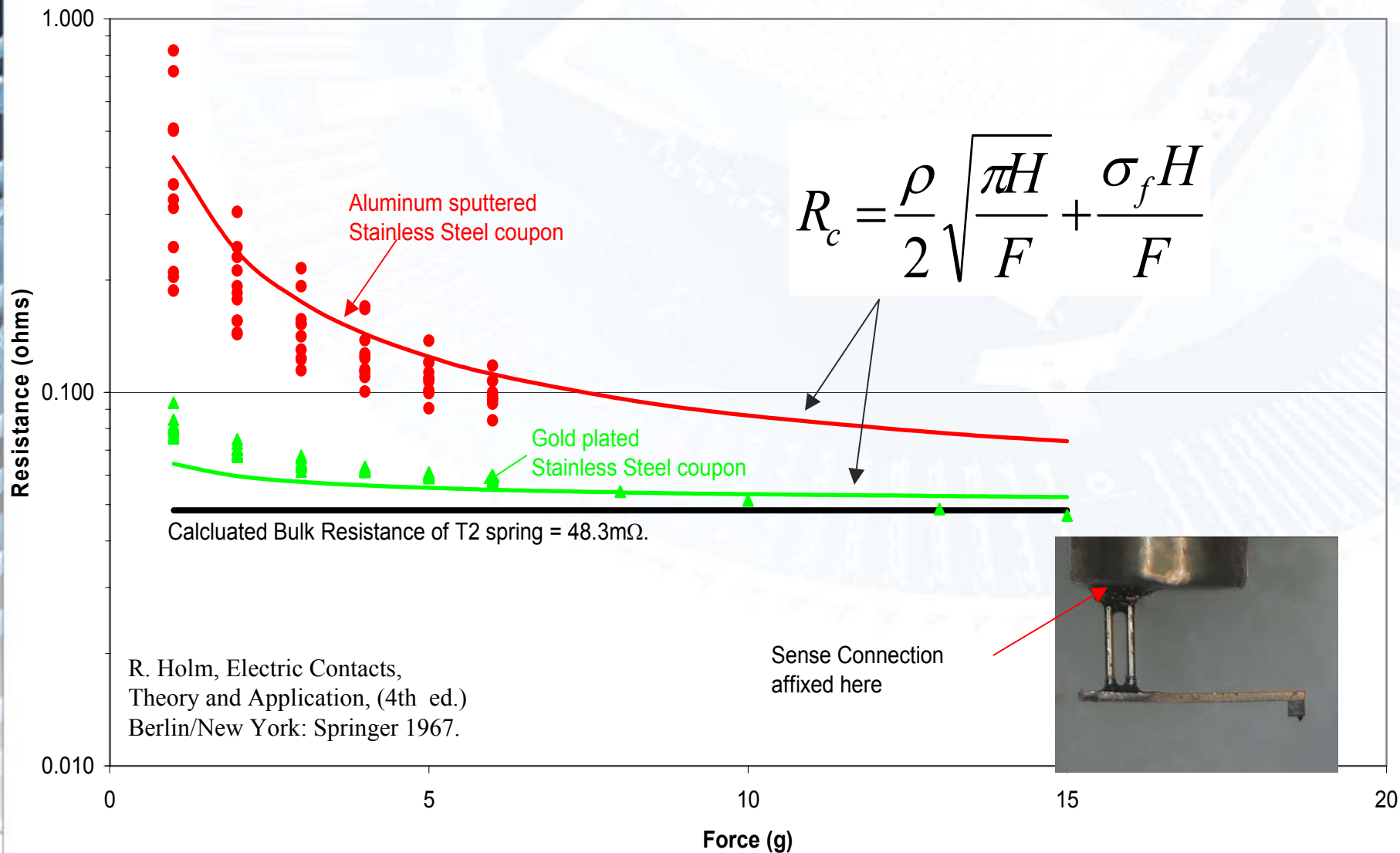
For Constant Overtravel



**Increasing tip size is most effective in reducing pressure.**

# Predictive Probing Cres Evaluation

## Au and Al Coated Substrates



# Predictive Probing Cres Evaluation

## Force vs. Resistance – Holm Theory

$$R_c = \frac{\rho}{2} \sqrt{\frac{\pi H}{F}} + \frac{\sigma_f H}{F}$$

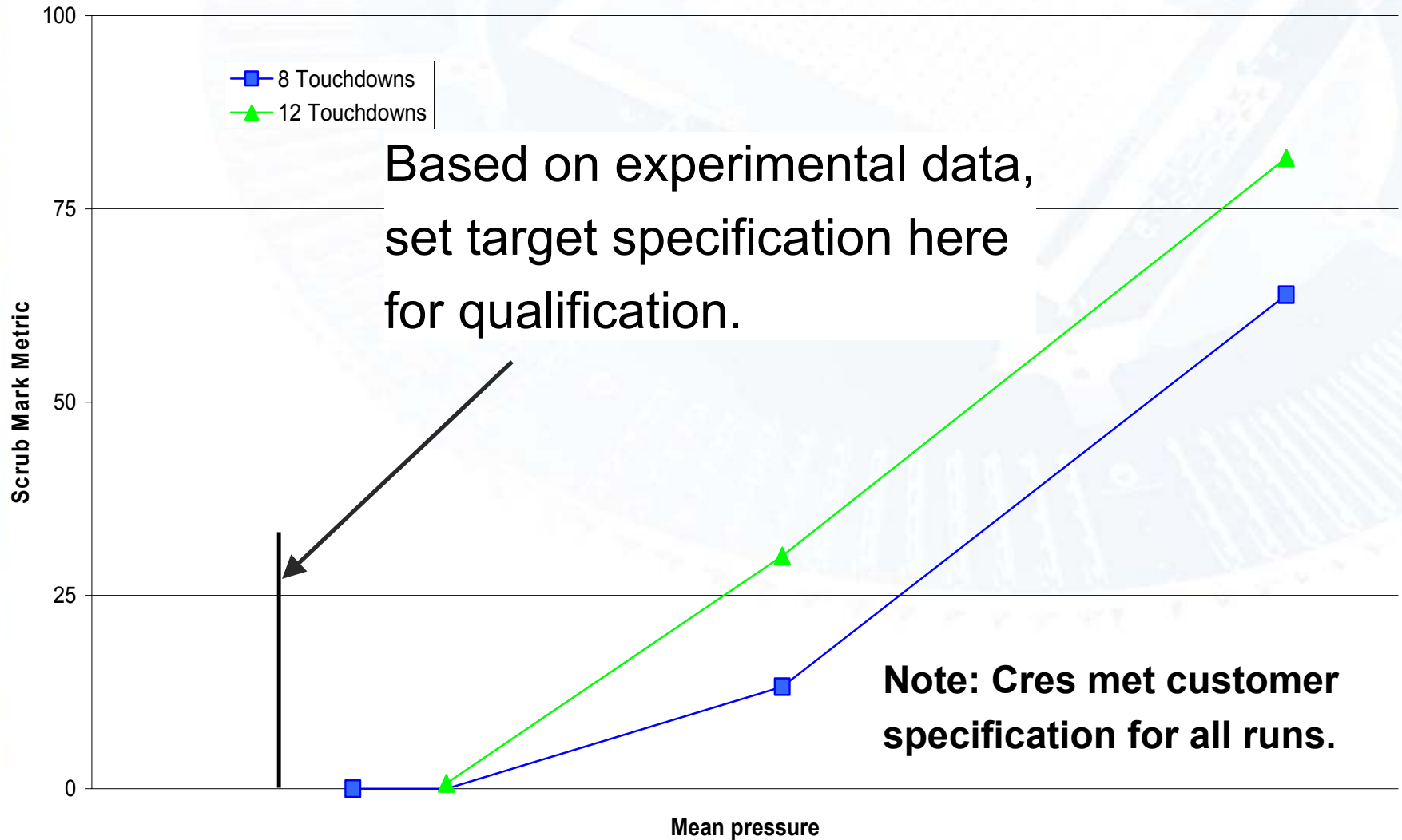
- Aluminum Material Properties (from MatWeb):
  - $H_{al} = 15 \text{ Kg/mm}^2$
  - $\rho_{al} = 2.7\text{E-}6 \text{ } \Omega\text{-cm}$
  - $\sigma_f$  is unknown.
- Since all other variables are known, the film resistivity for the Aluminum case can be estimated from the experimental data.
  - $\sigma_f \sim 2.5\text{E-}7 \text{ } \Omega\text{-cm}^2$
  - Establishing this material parameter allows for more accurate estimates of Cres for future applications.

# Predictive Probing Summary

## Customer Site Evaluation

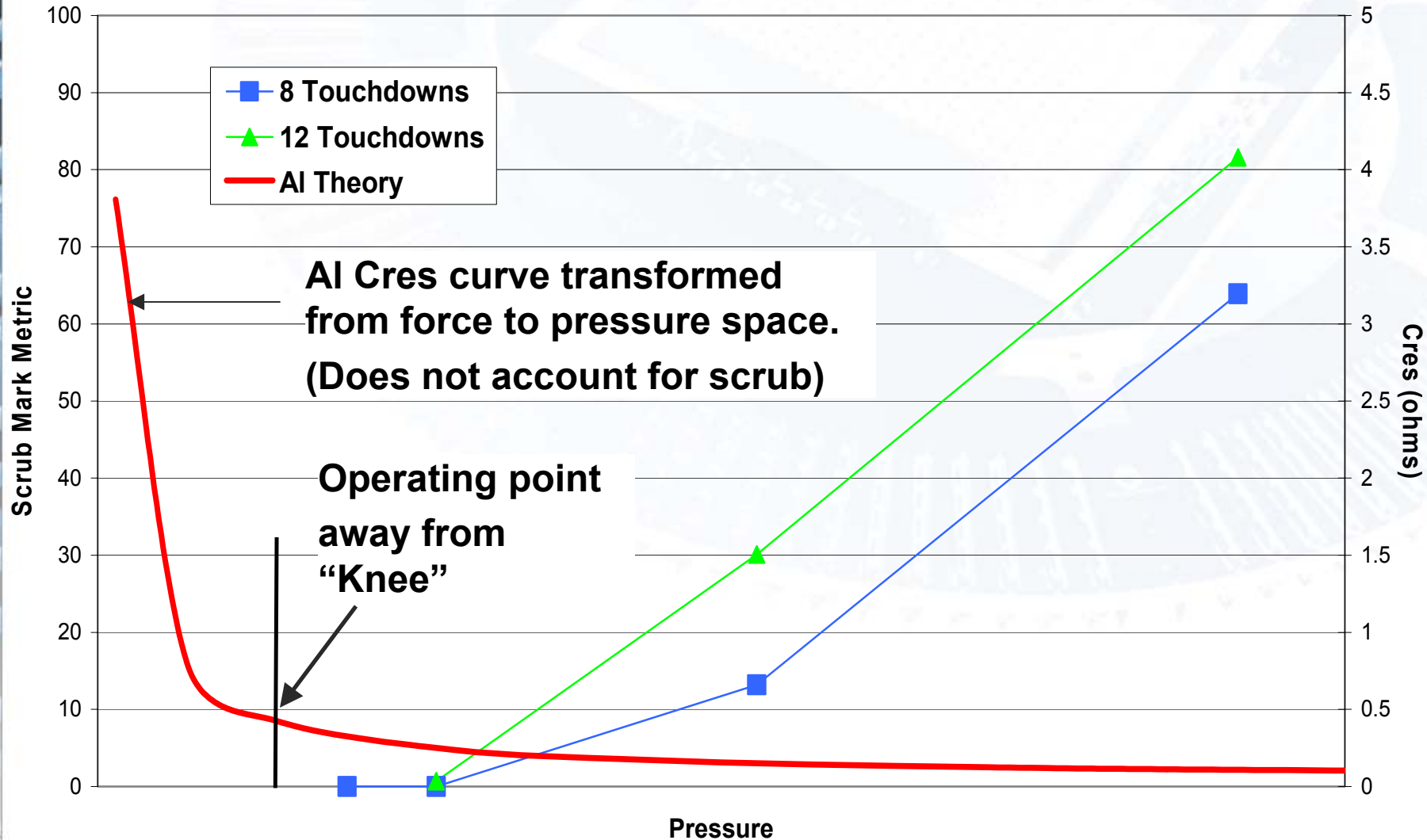
- Predictive Probing Summary
  - Evaluated significant parameters for scrub mark
    - Design parameters selected for field evaluation
  - Characterized Cres to high resolution
- Customer evaluation
  - Several cards were evaluated at customer site
    - Varied K, tip size and number of touchdowns
    - Probed test wafers with production metal stack
    - Cres monitored for all tests
  - Objectives:
    - Define design parameters for qualification
    - Define probing recipe for qualification

# Field Characterization





# Cres/Scrub Mark Metric Vs. Pressure



**AI Cres curve transformed from force to pressure space. (Does not account for scrub)**

**Operating point away from "Knee"**

# Product Qualified

- All Qualification testing passed
  - Lifetime Test
  - ILD damage
  - Scrub Cpk
  - Multiple TD analysis
  - Package reliability

# Conclusion

- FormFactor's MicroSpring Contact probing solution allows for customization for specific applications
  - Overtravel
  - K
  - Tip size
- Predictive Probing enables FFI to simulate customer environments
  - Validated at multiple customers and applications

# Acknowledgments

- Intel
  - Trung Nguyen, Mike Dang, Reuben Gallegos
- FFI
  - Fred Lane, Eric Watje