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Electrical and Mechanical Characterization of BladeRunner™ Tips on Reflowed Eutectic Bumps

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Texas Instruments

Objective/Outline

Objective

- What are the important parameters for probing reflowed solder bumps with BladeRunner™ tip MicroSpring™ contacts?

Outline

- Nomenclature
- Experimental Setup and Procedure
- Basic Contact theory
- Probe Position Analysis
- 12K touchdown Experiment
- Bump Deformation Analysis
- Conclusion

Nomenclature

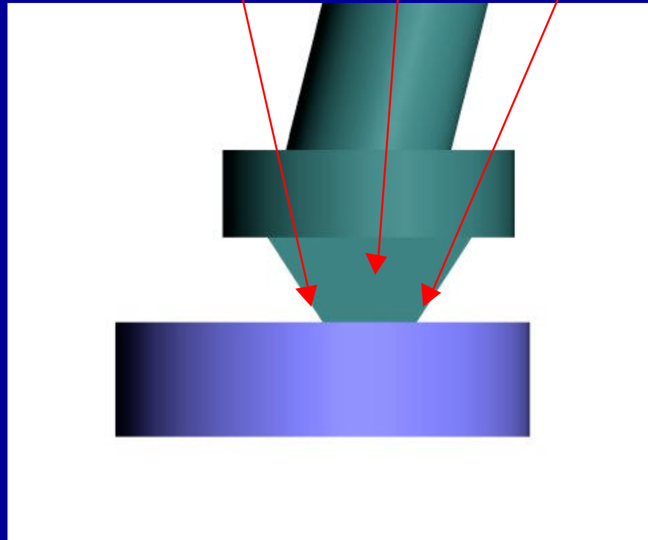
Blade

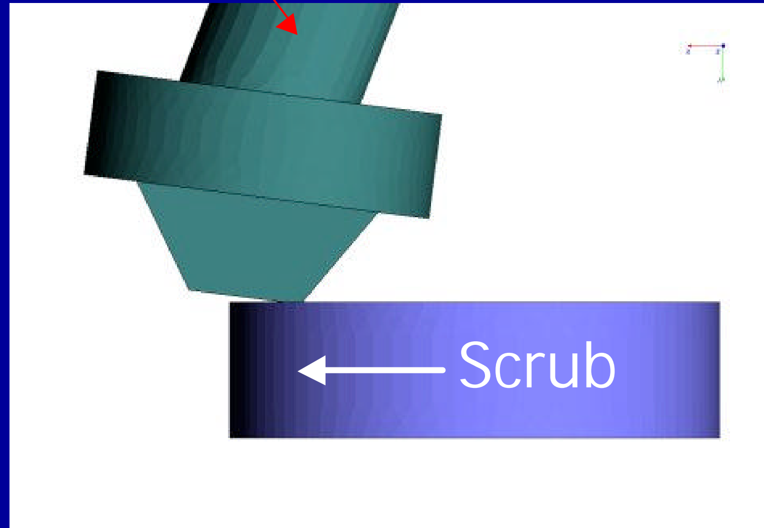
Toe

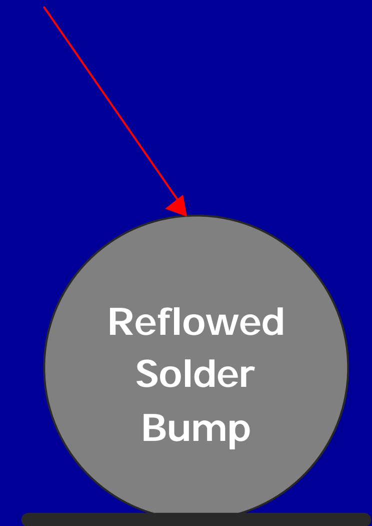
Heel

Spring

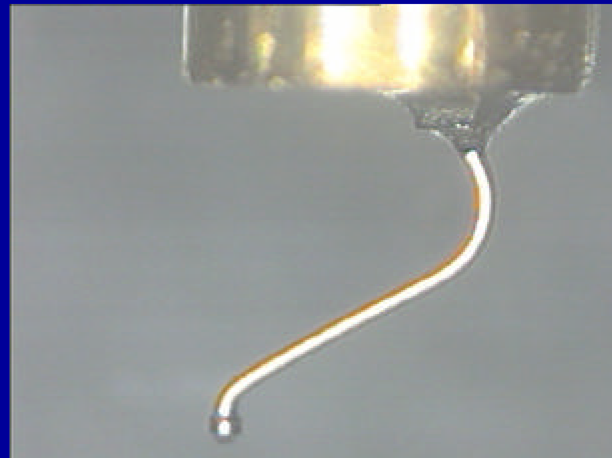
Apex of bump



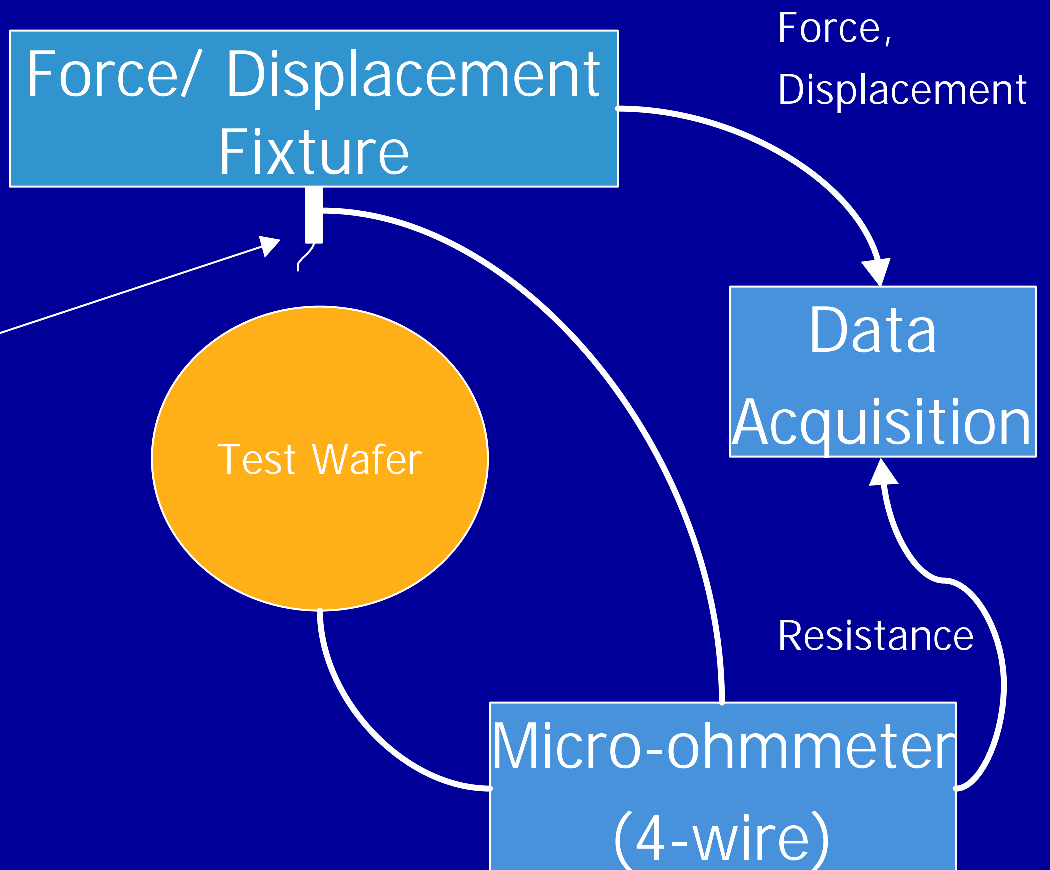




Experimental Setup - Single Spring Probing Schematic



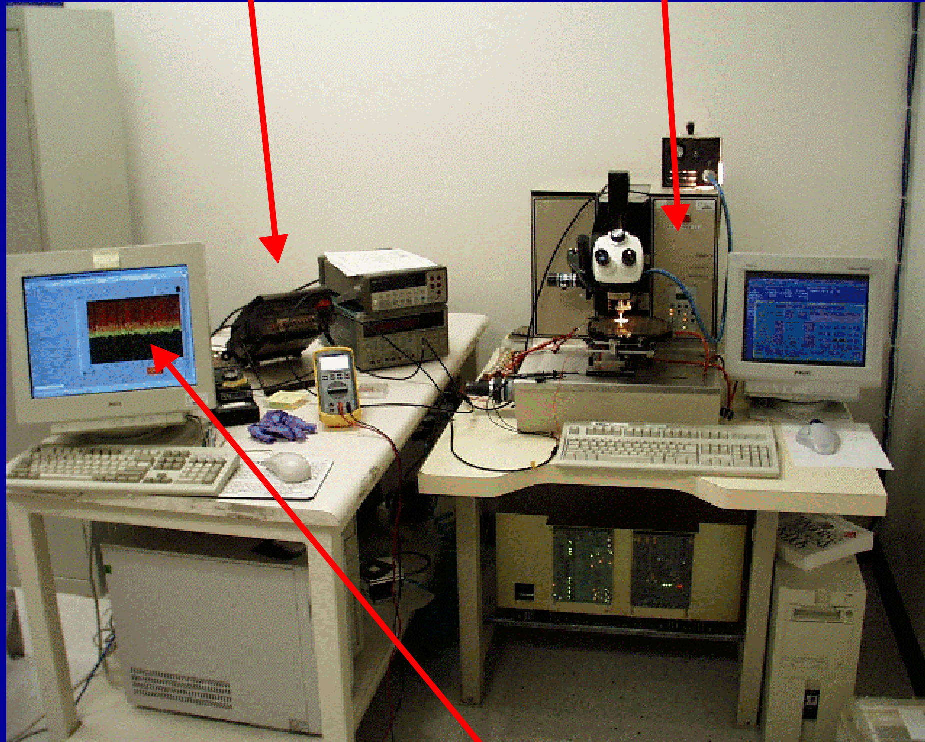
Test Spring



Experimental Setup

Micro-ohmmeter

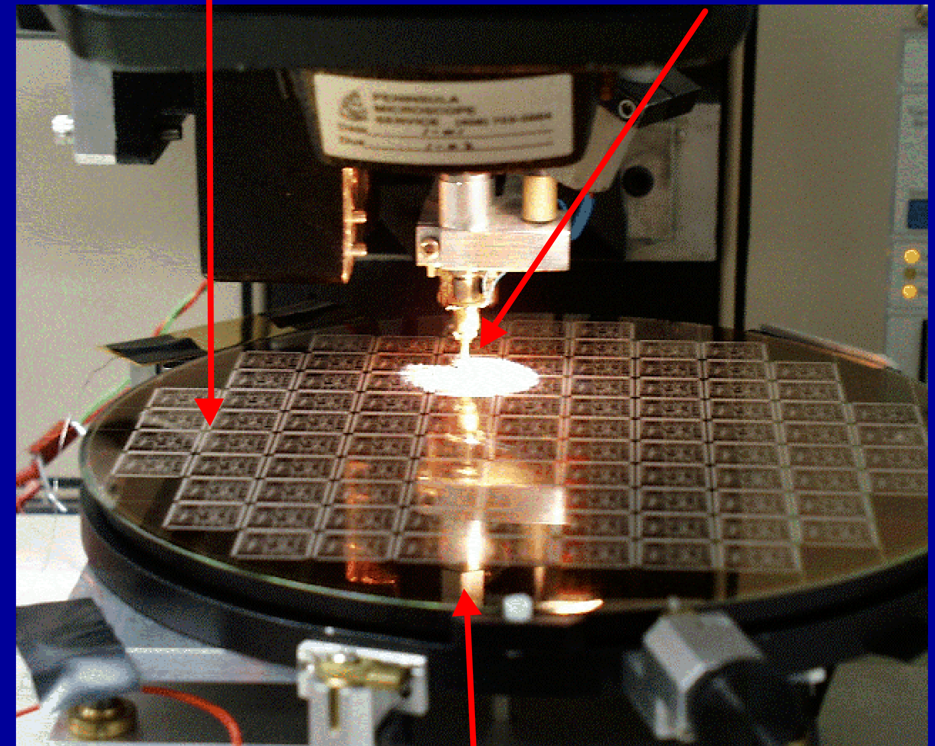
F/δ fixture



Data Acquisition System

Au Check plate

BladeRunner™ tip
MicroSpring™ contact



Test Wafer

Experimental Procedure

- Resistance
  - Keithley 580 Micro-ohmmeter
  - 100μΩ resolution
  - Dry circuit conditions (20mV/100mA max)
- Force
  - 0.2g resolution
- Displacement
  - 0.001 mil resolution in Z
- Single spring probing performed in displacement control (2 mil overdrive past first touch)
- No cleaning operations performed

Fundamental Contact Resistance Model

The Holm equation is of the form:

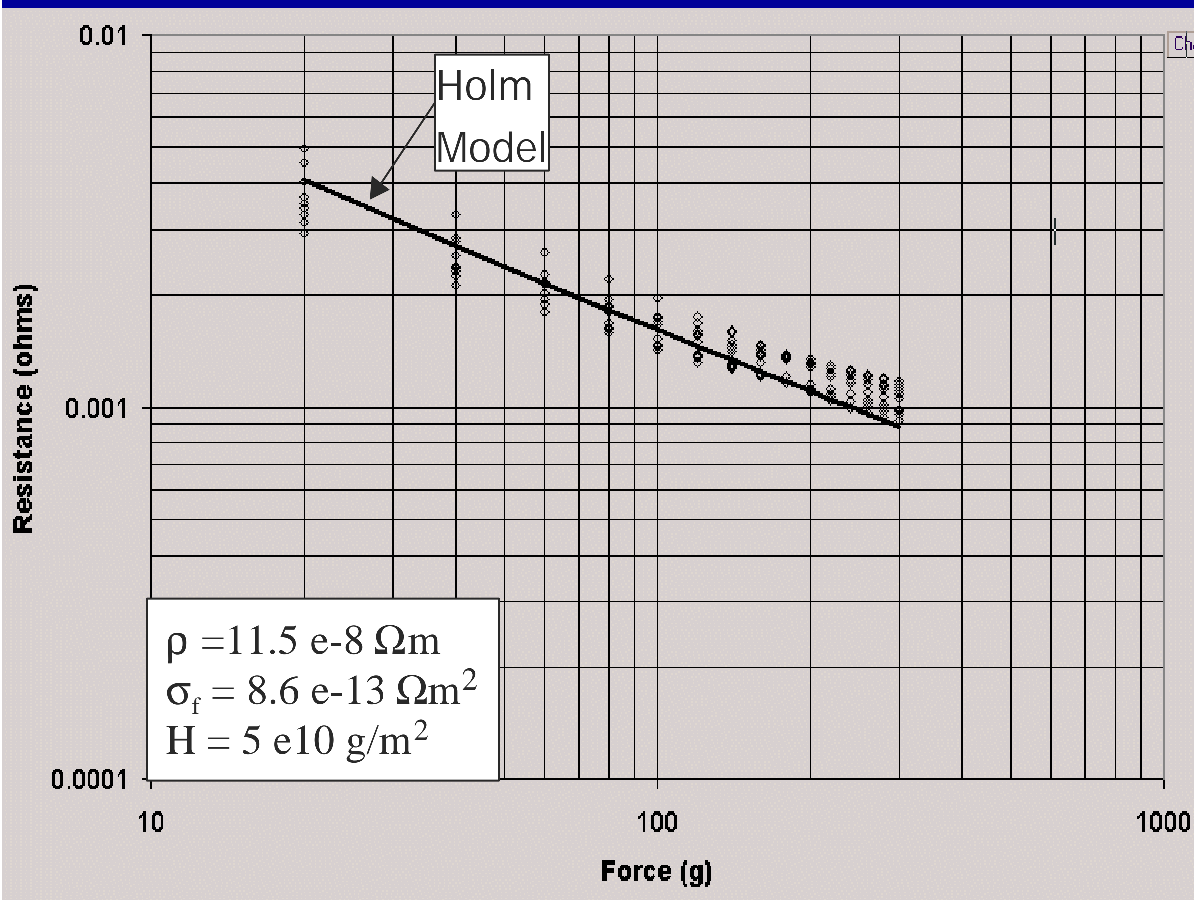
Log-Log Slope of –1/2 (first term) | Log-Log Slope of –1 (second term)

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

Where R_c is contact resistance, ρ is the bulk material resistivity, H is the material hardness, σ_f is the film resistivity, and F is the normal force.

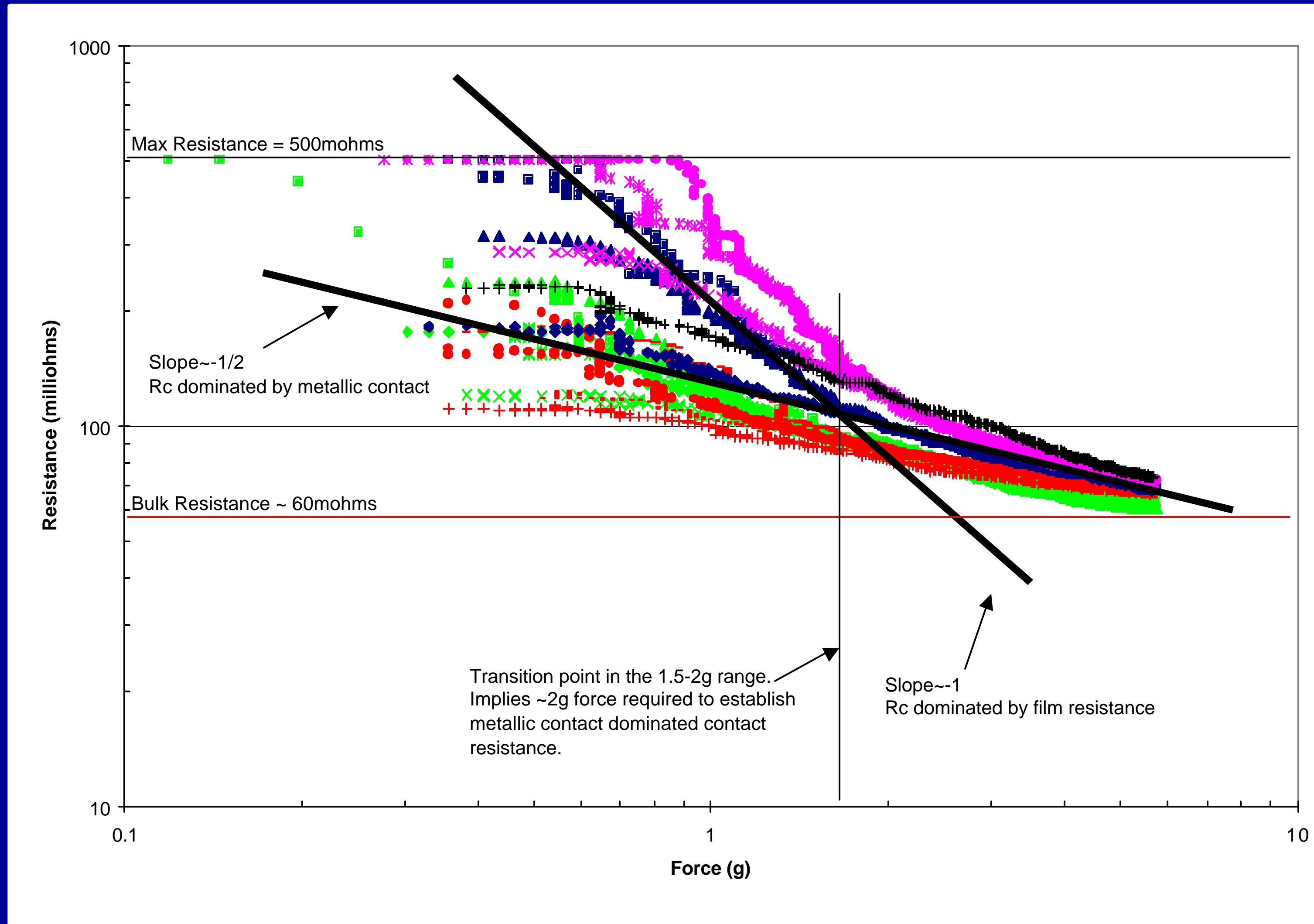
R. Holm, Electric Contacts, Theory and Application, (4th ed.) Berlin/New York: Springer 1967.

Force vs. Resistance – Film Free Case



- Data shown for clean gold contacting clean gold
- Log-Log slope ~-1/2, indicates metallic contact from first term of Holm equation
- Film resistance negligible

Force vs. Resistance - Film Case (solder)



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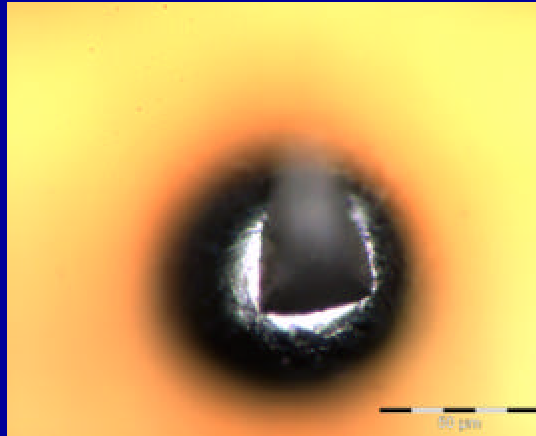
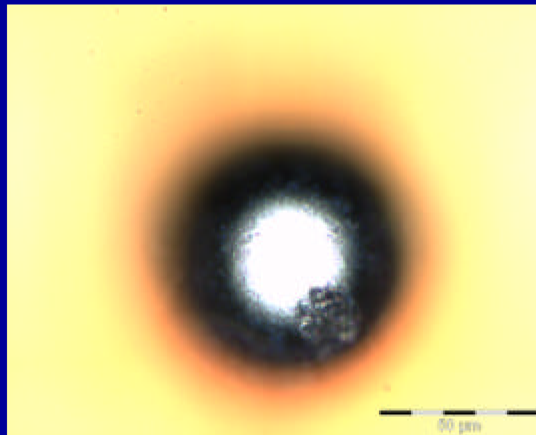
Scrub Position Analysis

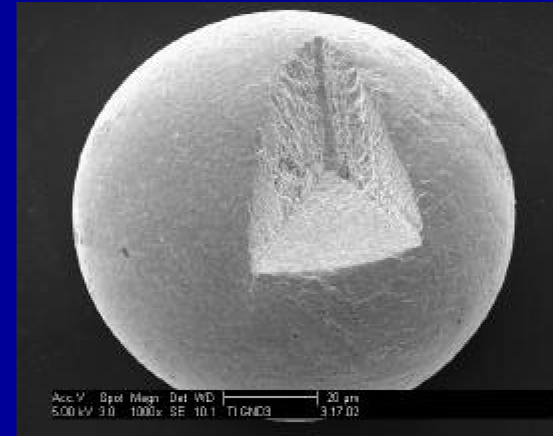
- Same spring used for both bumps.
- Same overtravel used for both bumps. (2 mils)
- Top touchdown was before the apex of the bump.
- Bottom touchdown was after the apex of the bump.

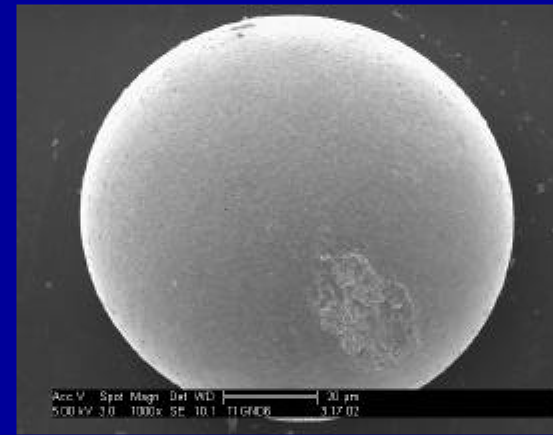
Optical



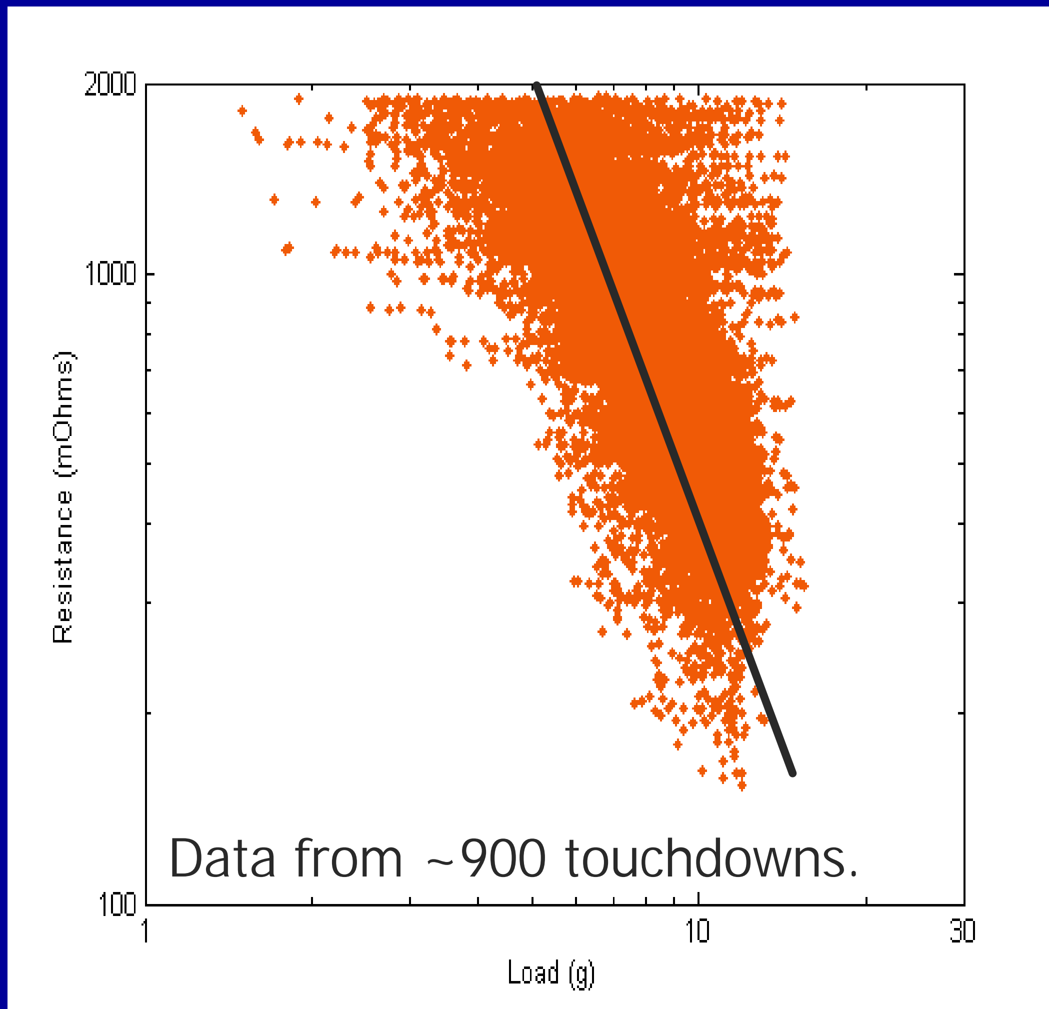


SEM

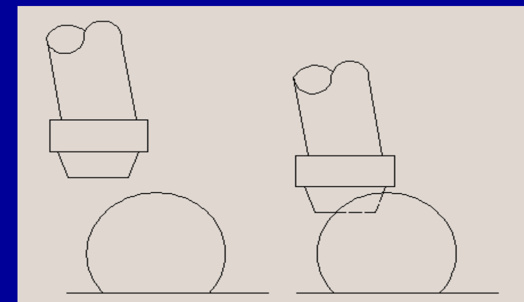




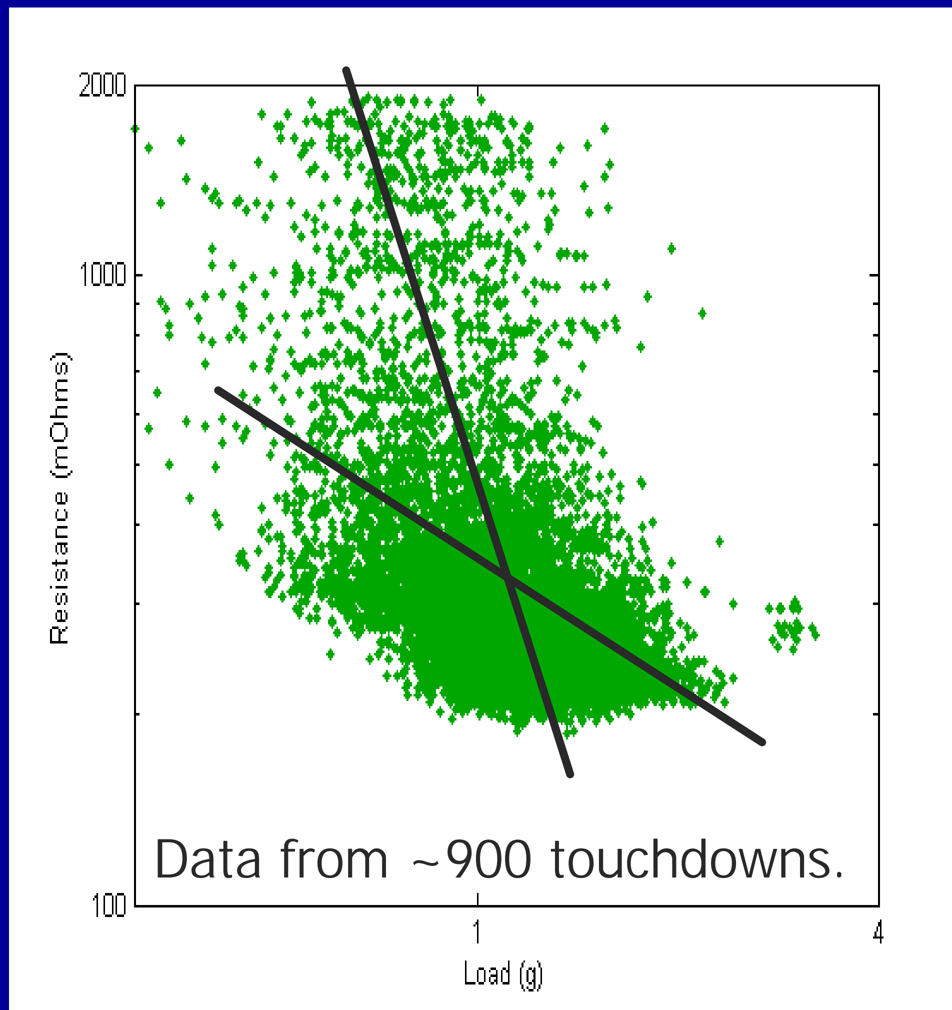
Case 1. First Touch Prior to Bump Apex



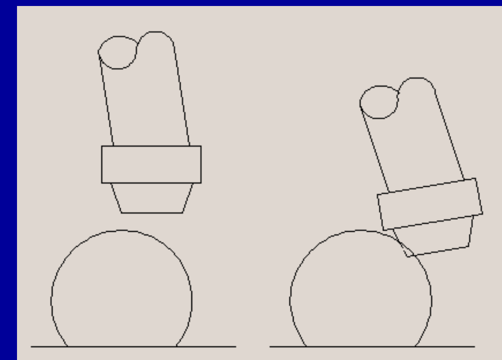
- Wiping action was limited
- Forces in 10-12g range
- Steep slope indicates contact is in film dominated regime (2nd term of Holm equation)



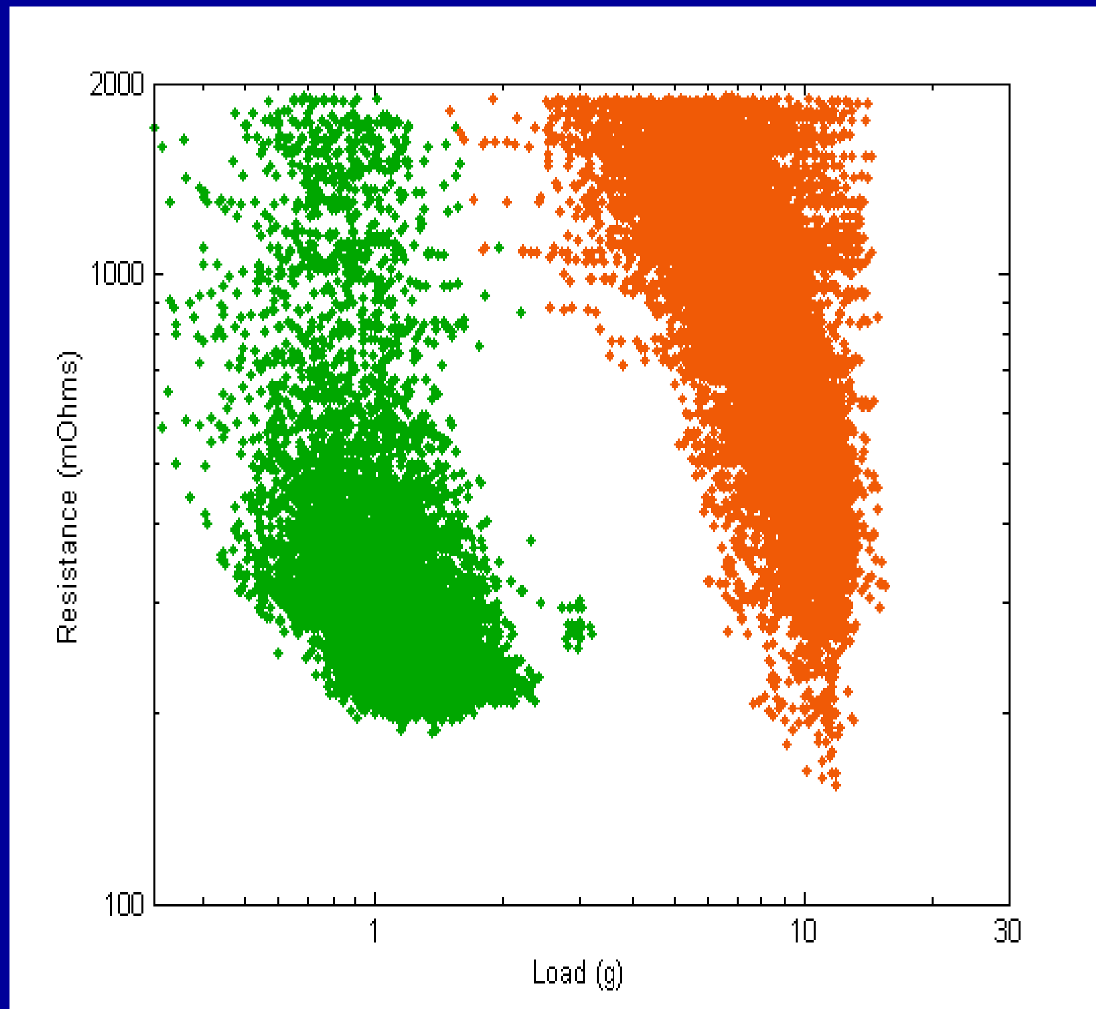
Case 2. First Touch After Bump Apex



- Wiping action maximized
- Forces in 1-3g range
- Slope transition indicates shift from film to metallic dominated contact (2nd to 1st term of Holm equation)

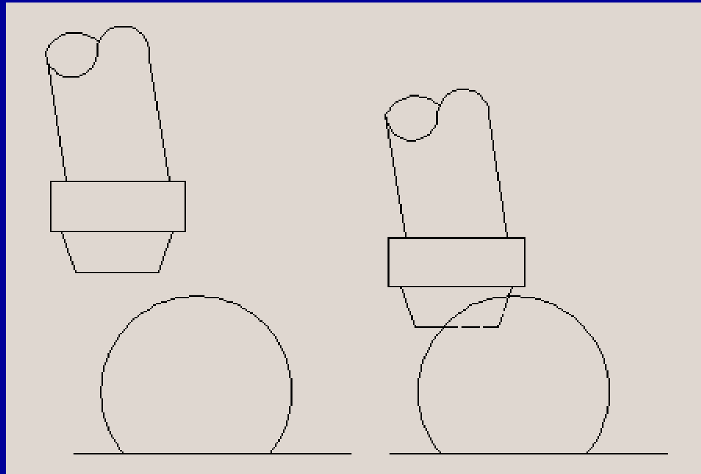


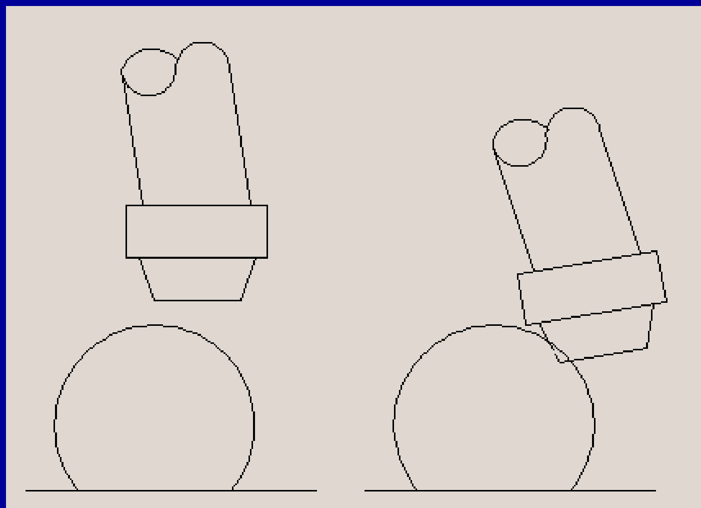
Case Comparison



- Same MicroSpring™ contact
- Same overdrive (2 mil past first touch)
- Difference is scrub
  - Accelerates transition to metallic contact
  - Allows stable Cres at lower forces

Scrub Position Summary





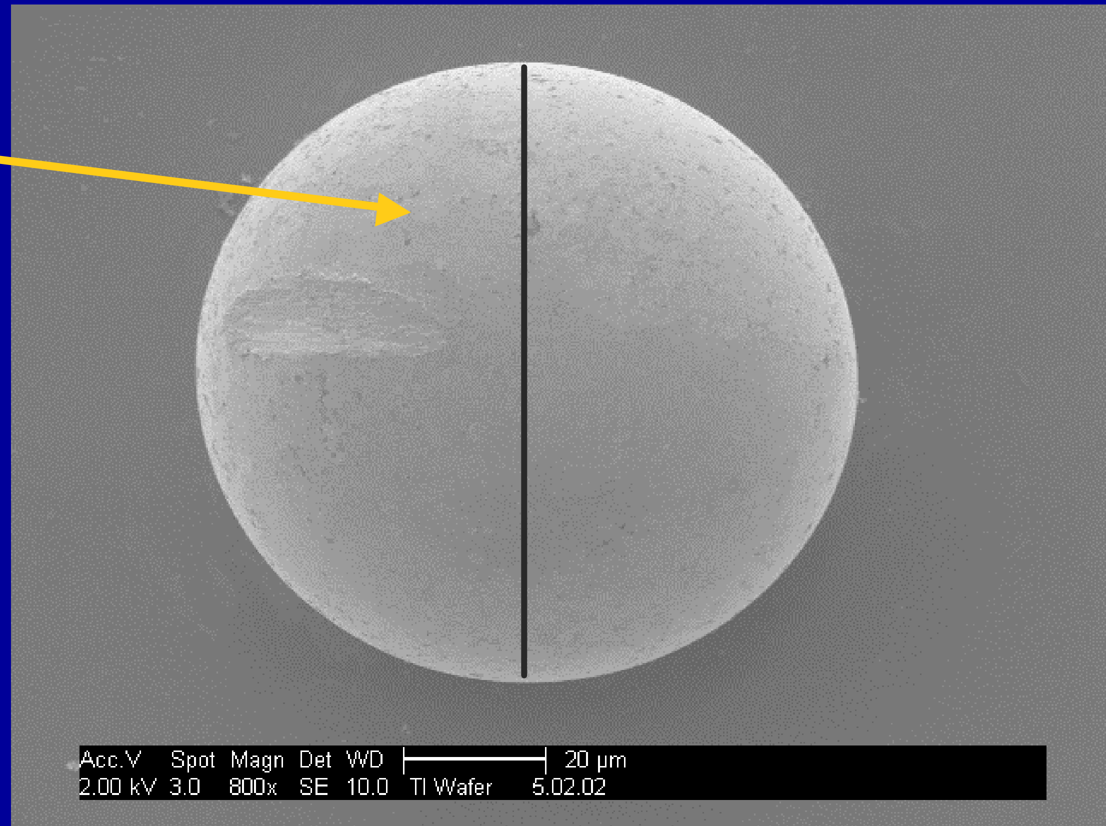
For the same overtravel,

- First touch prior to apex:
  - Higher force
  - Less wipe
  - More volume displacement
  - Cres decrease by increasing amount of film area in contact
- First touch after apex:
  - Lower force
  - More wipe
  - Less volume displacement
  - Cres decrease by cutting through films to make metallic contact

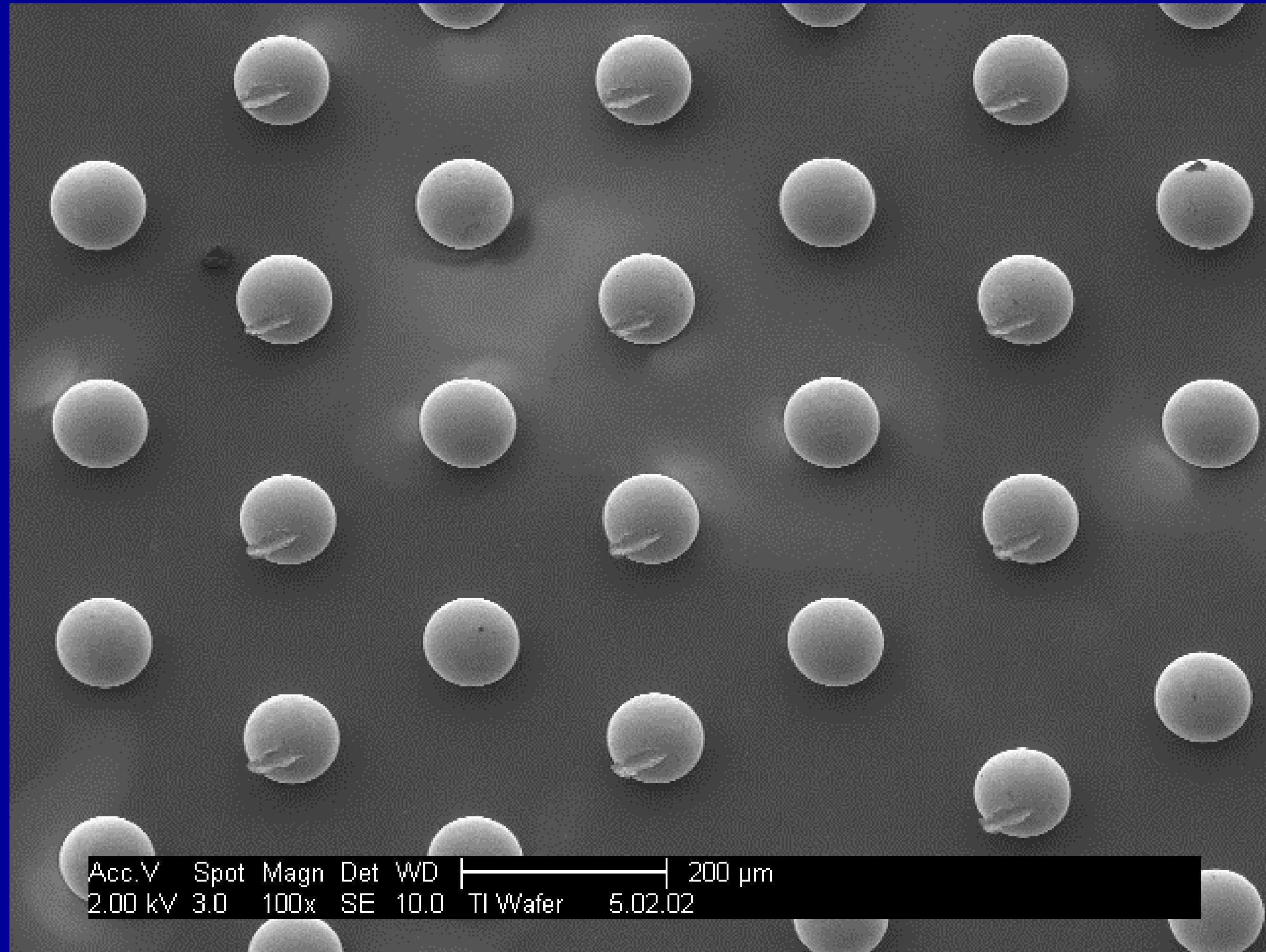
Optimal "Targeting" for First Touch

Scrub Direction

Contact in this area (past the apex) is optimal



Probed Bumps



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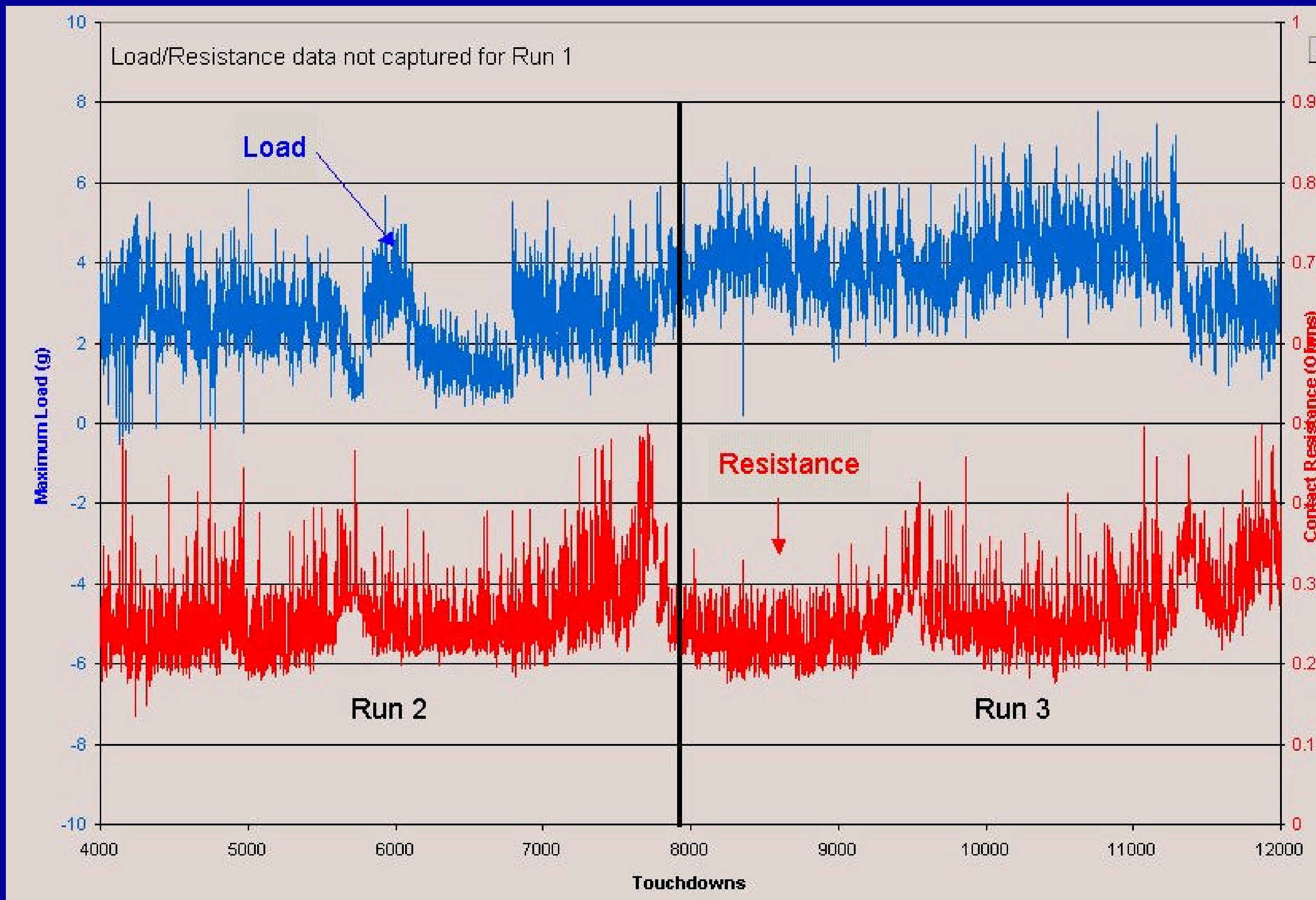
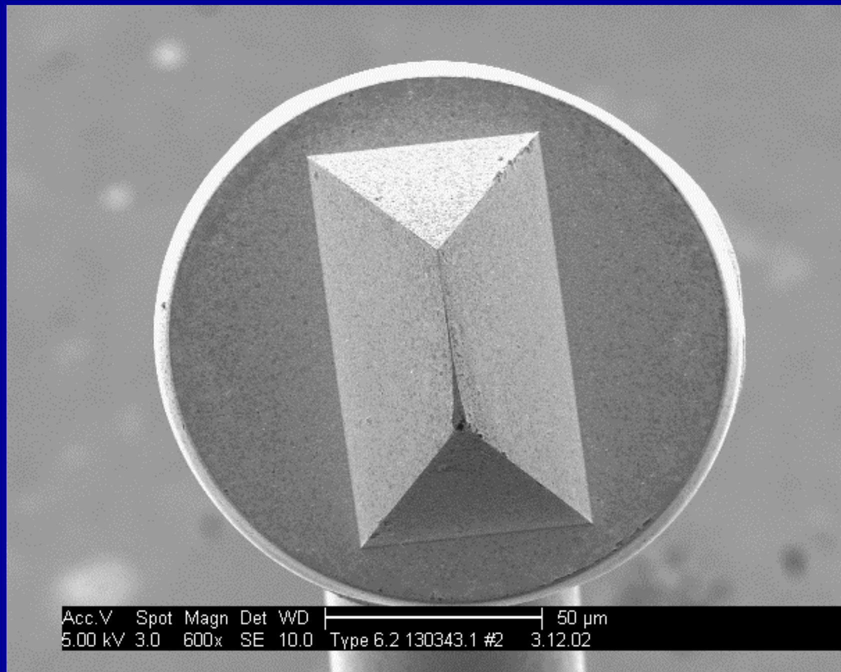
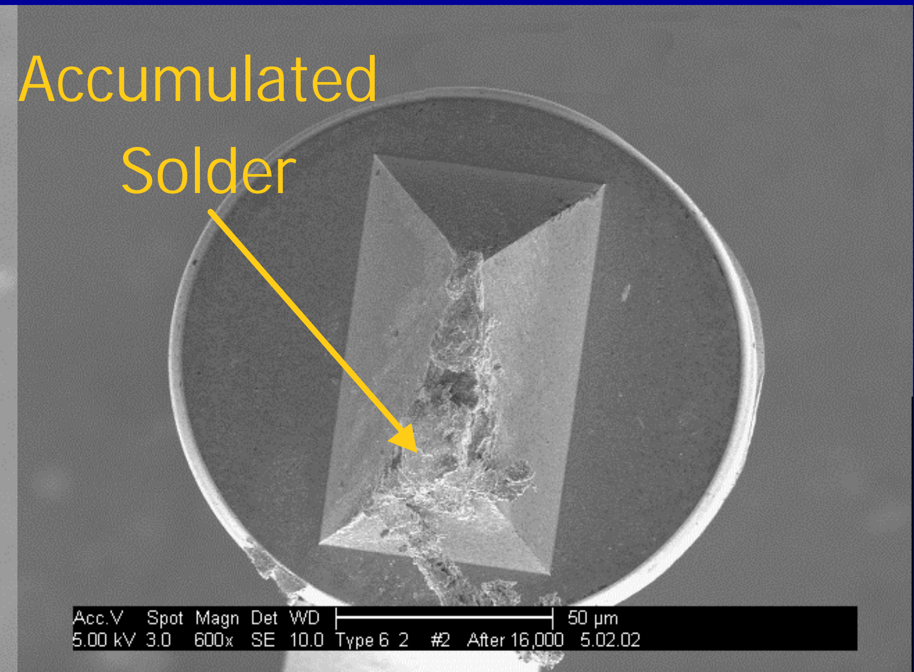
Load/Cres over 12,000 Touchdowns



Tip Before/After 12K Touchdowns





No cleaning performed.

Bump Deformation

- Diameter of bumps measured before and after probing
  - August NSX-95 bump inspection tool.
- Change in diameter of bump was less than resolution of the measurement tool production settings
  - 2.5µm/pixel

Conclusions

- An experimental setup has been designed to quickly evaluate new spring/wafer interactions
- Optimal probe placement has been defined as targeting first Microspring™ contact past the apex of the reflowed bump
  - Minimizes force, resistance, and displaced volume
  - Maximizes scrub
- Proper targeting in conjunction with wiping on the reflowed bump produces lower contact resistance *and* reduces probe force
- 12K touchdowns were performed
  - Measured increase in bump diameter was less than the resolution of the measurement tool
  - Monitored Cres did not increase beyond experimental error

Acknowledgements

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