

Applied Precision

Productivity solutions for a small world

Multi-Tier Probe Cards and Contact Resistance



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Participants

- **SEMATECH**
 - Probes PTAB - Rey Rincon
- **Probe Needles**
 - Advanced Probing Systems, Inc. - Jerry Broz
- **Testing Facilities**
 - Applied Precision, Inc.- Kenneth Sokol, Bryce Ekstrom
 - Sandia National Laboratories - Dave Monroe, Scott Swanson
- **Probe Cards**
 - Wentworth Laboratories Testing Facilities
 - Cerprobe Corporation
 - JEM America
 - Micro-Probe, Inc.
 - Probe Technology Corporation

***This Study is Not
Intended as a
Benchmark
Comparison of Probe
Card Suppliers***

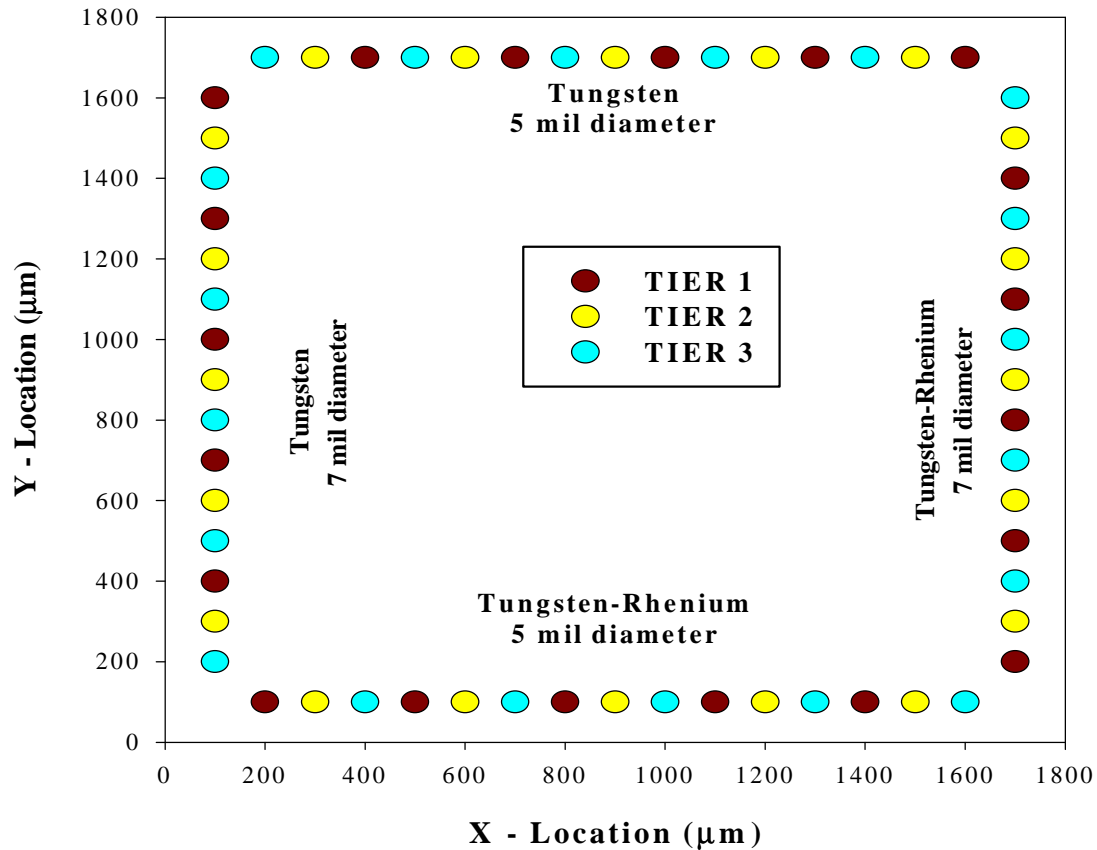
Test Flow

- **3- μ m Abrasive Pad - 2 Probe Cards**
 - 3.0-mil overtravel, linear mode
 - Analyzer metrology performed after 0, 7.5K, and 15K touchdowns
- **Metallized Al Wafer at 30° - 2 Probe Cards**
 - 3.0 mil overtravel, double-touchdown mode
 - Analyzer metrology performed after 0, 250K, and 500K interval
- **Metallized Al Wafer at 85° - 3 Probe Cards**
 - 3.0 mil overtravel, double-touchdown mode
 - Analyzer metrology performed after 0, 250K, and 500K interval

PrecisionPoint VX_2 Analysis

- **Baseline Contact Resistance on Gold plate (3 mils OT)**
 - No Cleaning performed before measurements
 - 20ma of forcing current
- **Clean Probe Card with tungsten carbide cleaning plate**
 - 5 sets of 10 touchdowns at 3 mils overtravel
- **Contact Resistance vs OT (0 to 3.0 mils, 0.25 mil increments)**
 - Gold Plate
 - Aluminized Wafer
- **3 Full Tests**
 - Alignment, Planarity, Probe Tip Diameter,
 - Probe Scrub Length,
 - Probe Force
- **Save Probe Images at every 0.5 mil increments of overtravel**

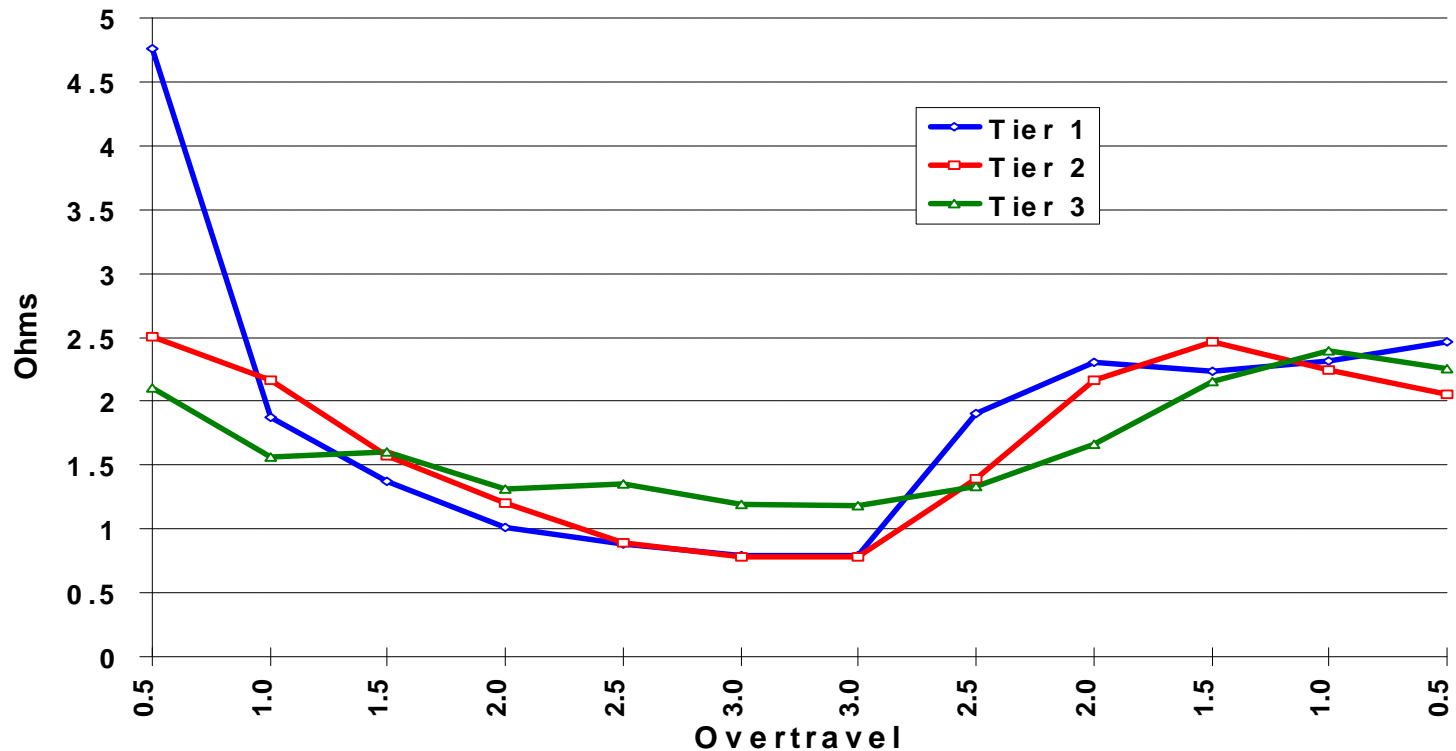
60-Pin Probe Card Design



	Tier 1	Tier 2	Tier 3
Tip Length (mils)	7	14	21
5 mil wire Taper rate (Degrees)	4.1	3.6	3.2
7 mil wire Taper rate (Degrees)	4.5	4	3.6

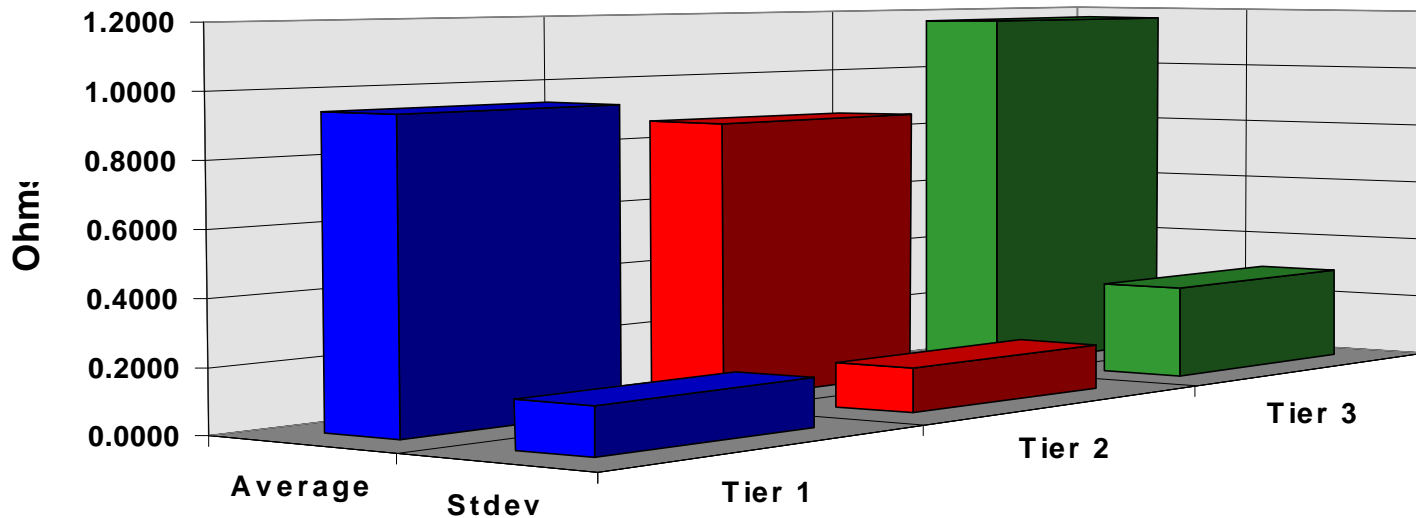
Contact Resistance Observation

Contact Resistance -vs- Overtravel (Al Wafer) by Probe Card Tier



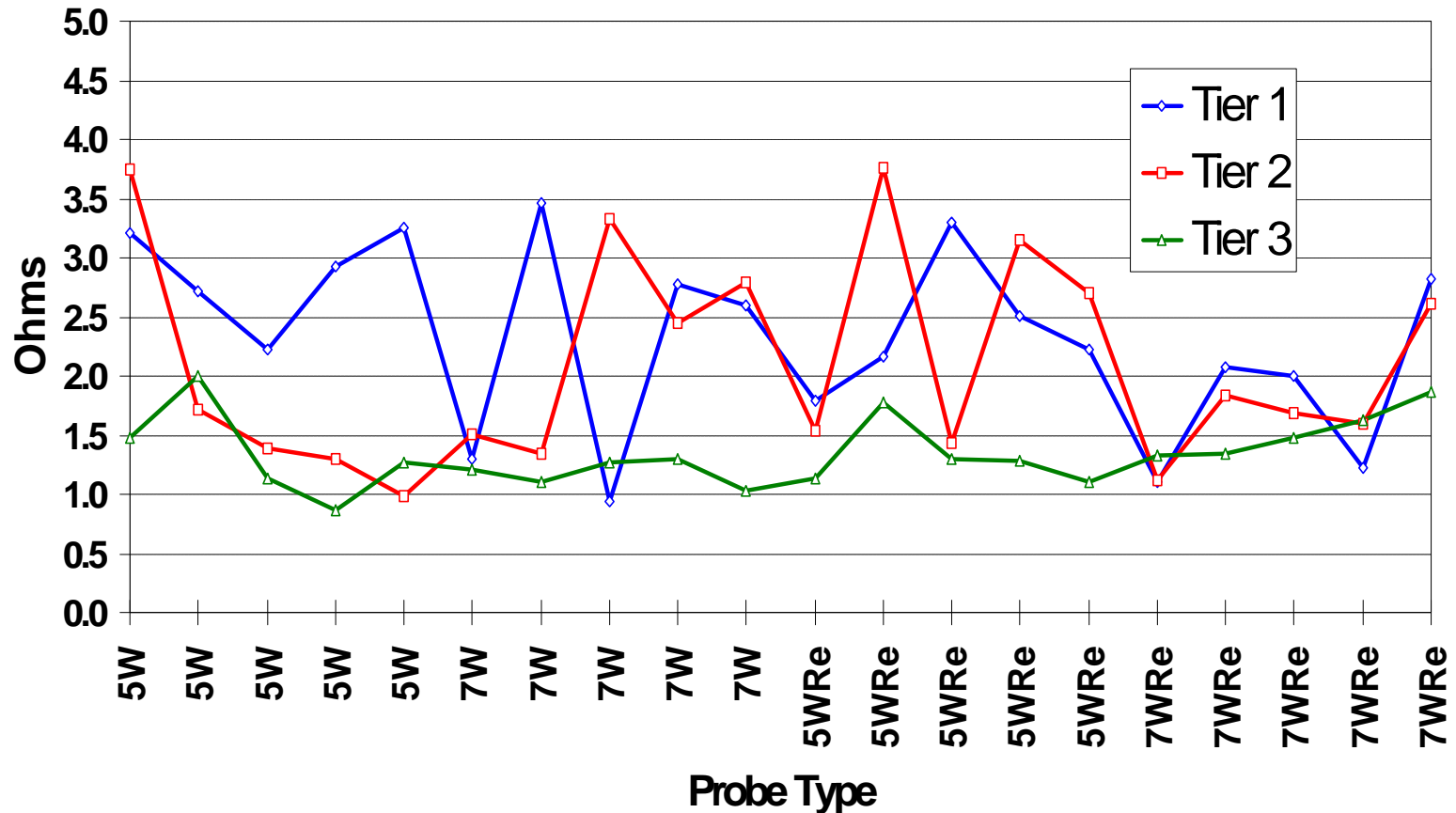
Contact Resistance of Tier 3 is Consistently Higher

Contact Resistance - by Tiers



- **Tier 3 reports higher resistance and variation on AI Wafer**
 - Most probe cards 3rd Tier showed higher contact resistance
 - Resistance measurements on prober matches probe card analyzer
 - 3rd Tier had higher resistance for all test sets (Baseline, 250K, 500K)

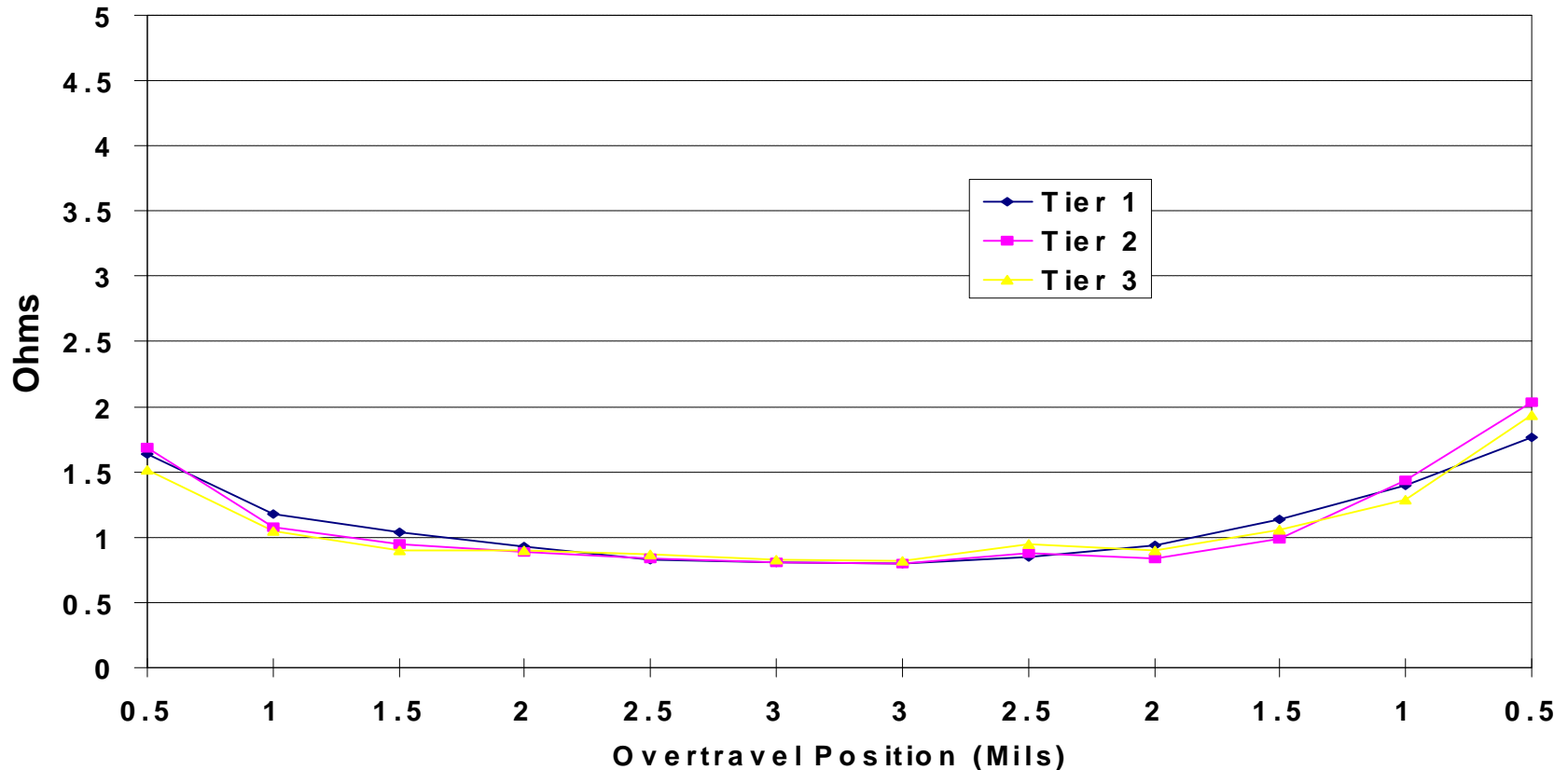
Contact Resistance on Gold Surface



Contact Resistance of Tier 3 is Lower than other Tiers when measured on Gold Plate, before Cleaning.

Contact Resistance on Gold Surface

Contact Resistance -vs- Overtravel (After Cleaning)

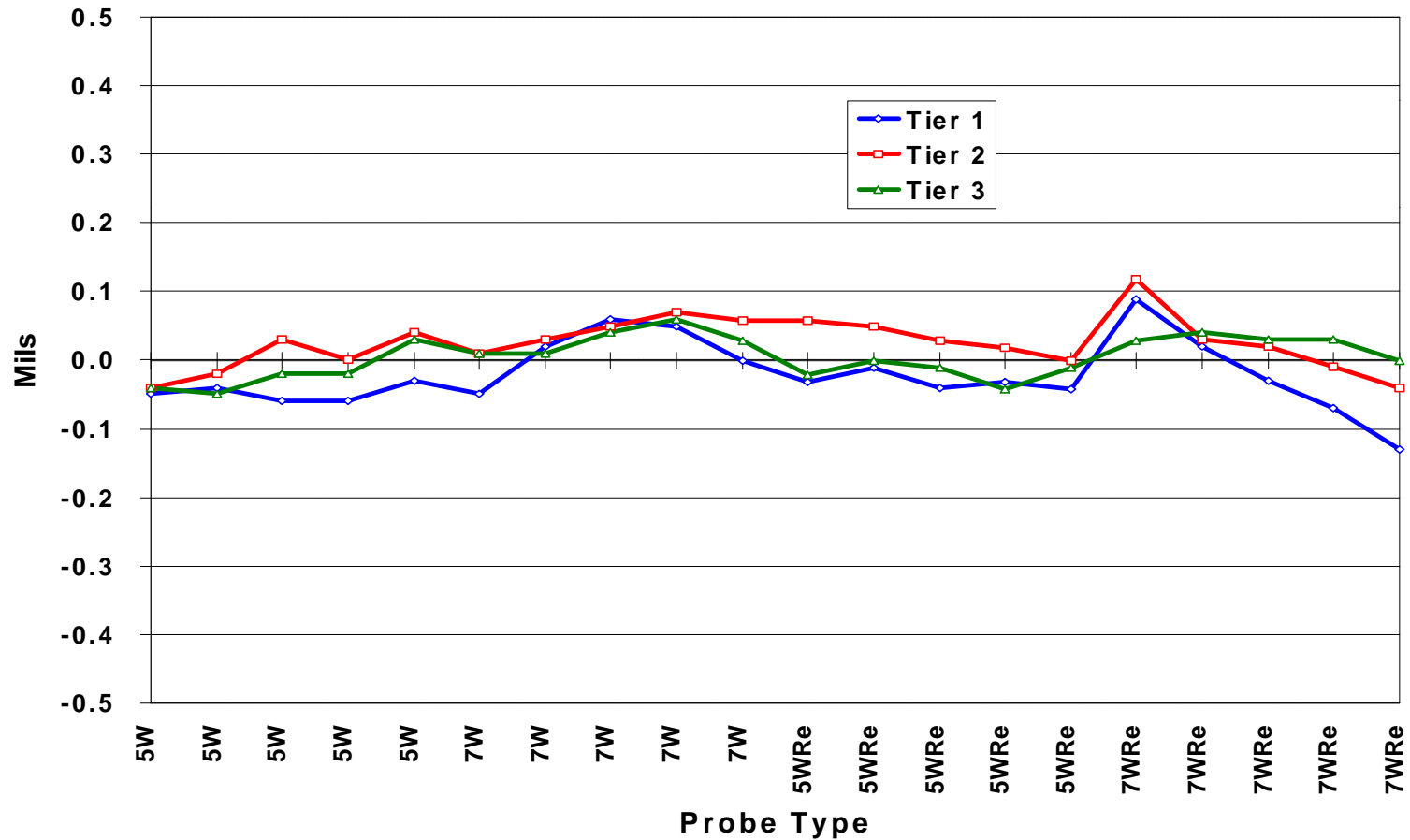


All Tiers Give Equal Results on Gold Plate after Cleaning

Why is 3rd Tier Different ?

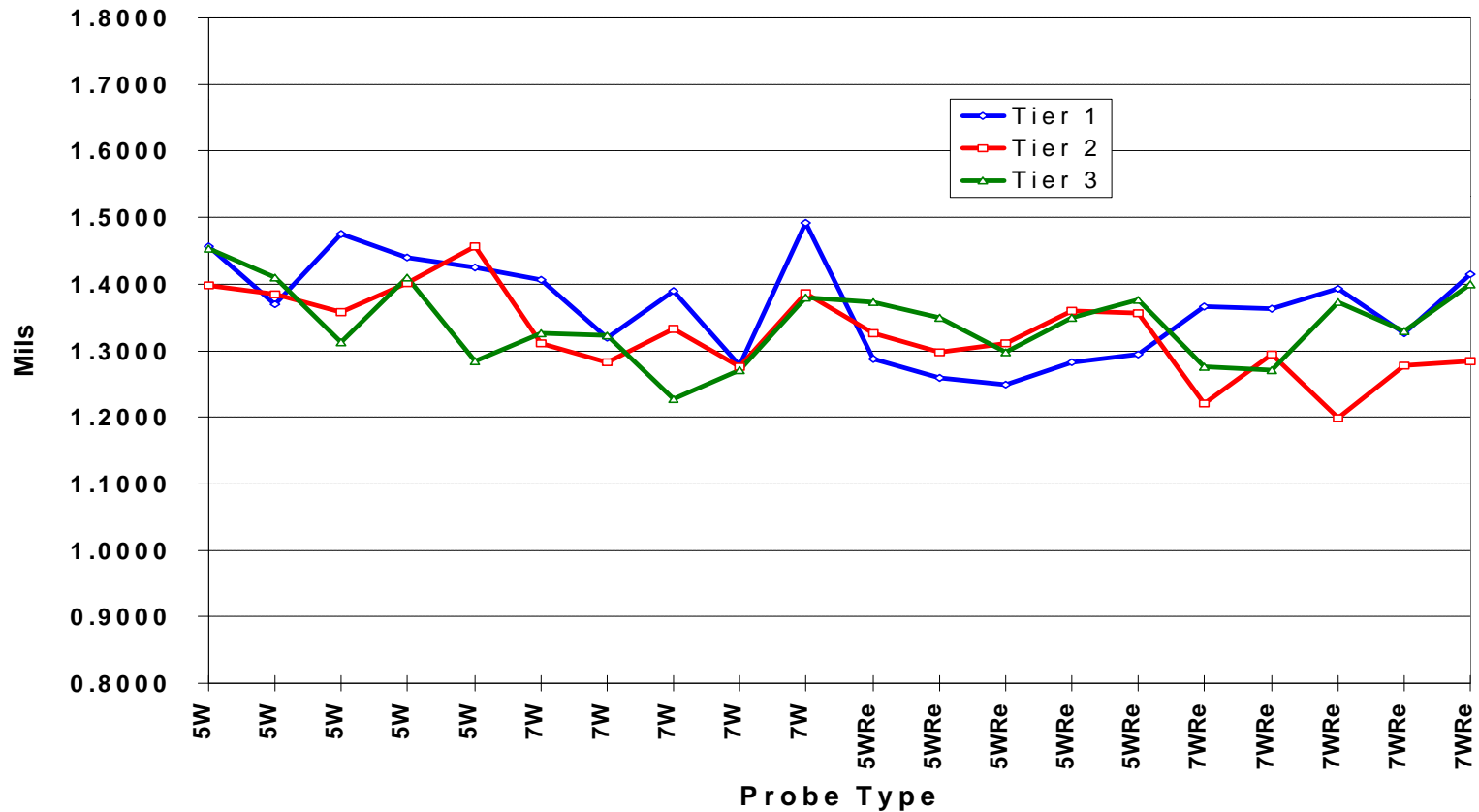
- **Probe Card Properties**
 - Planarity
 - Diameter
 - Probe Force
 - Scrub Length
- **Probe Marks on AI Wafer**
 - Length / Width
 - Depth
- **Analyze Captured Images of the Probe Tips**

Planarity



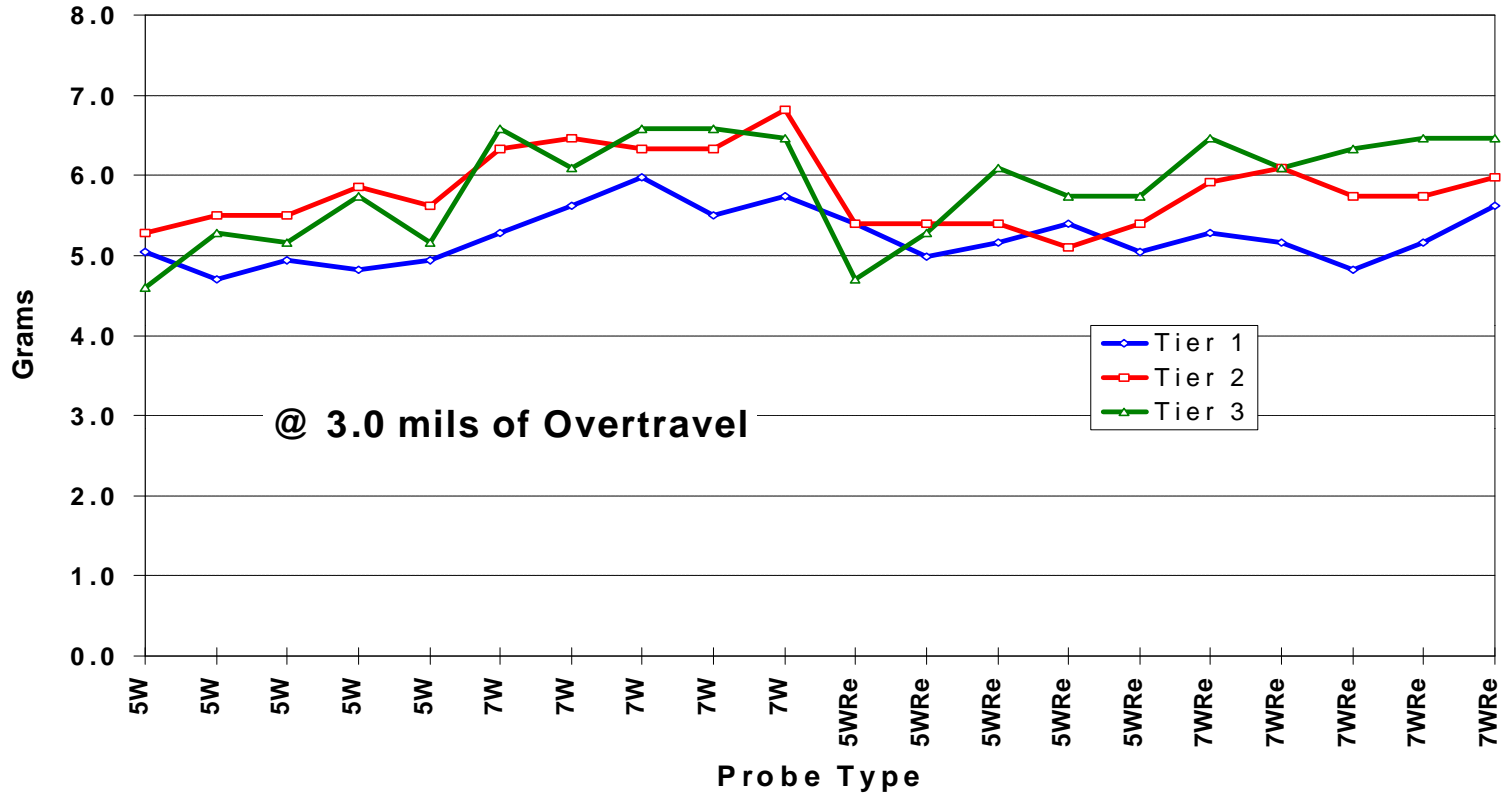
No Significant Difference Between Tiers

Diameter



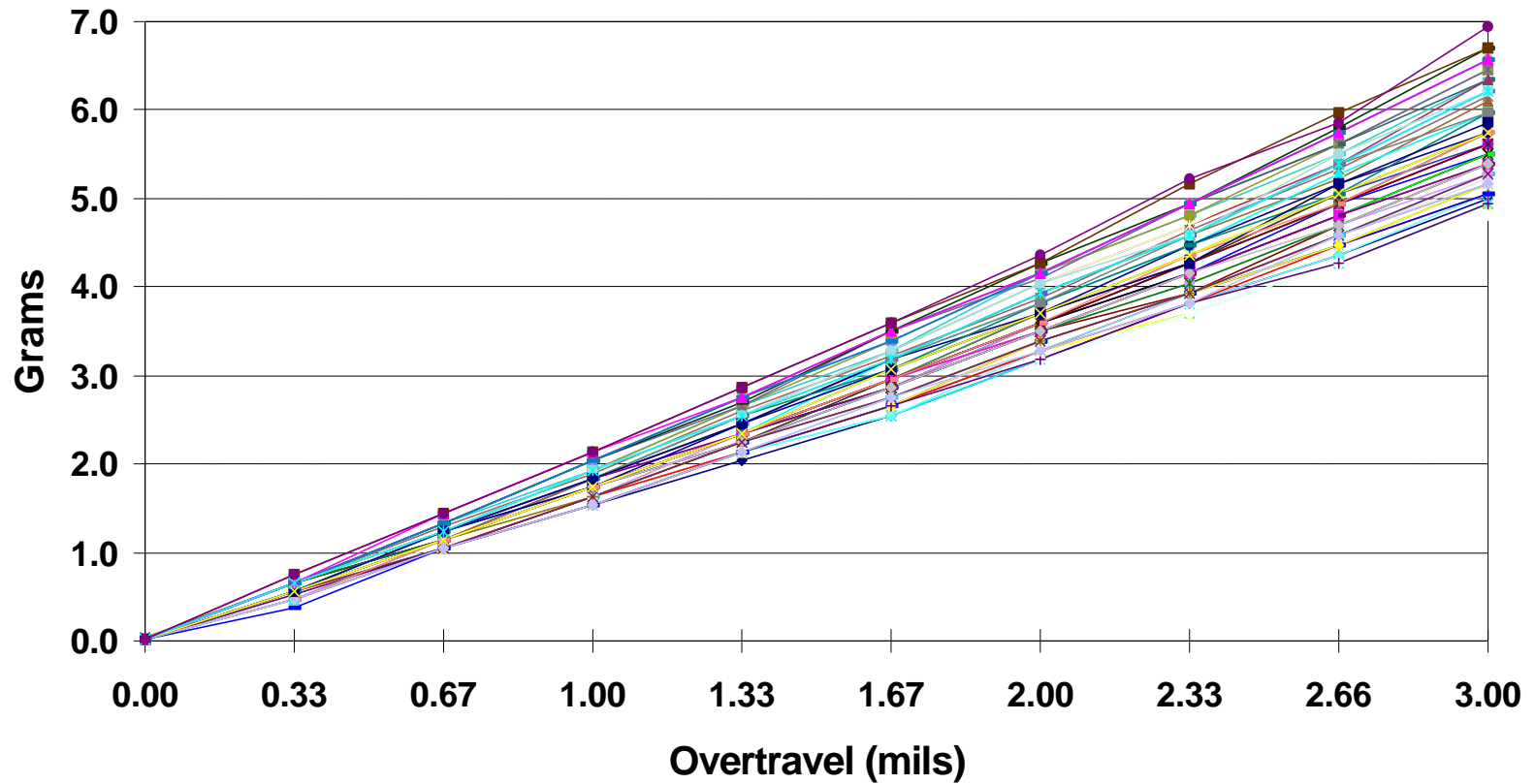
No Significant Difference Between Tiers

Probe Force



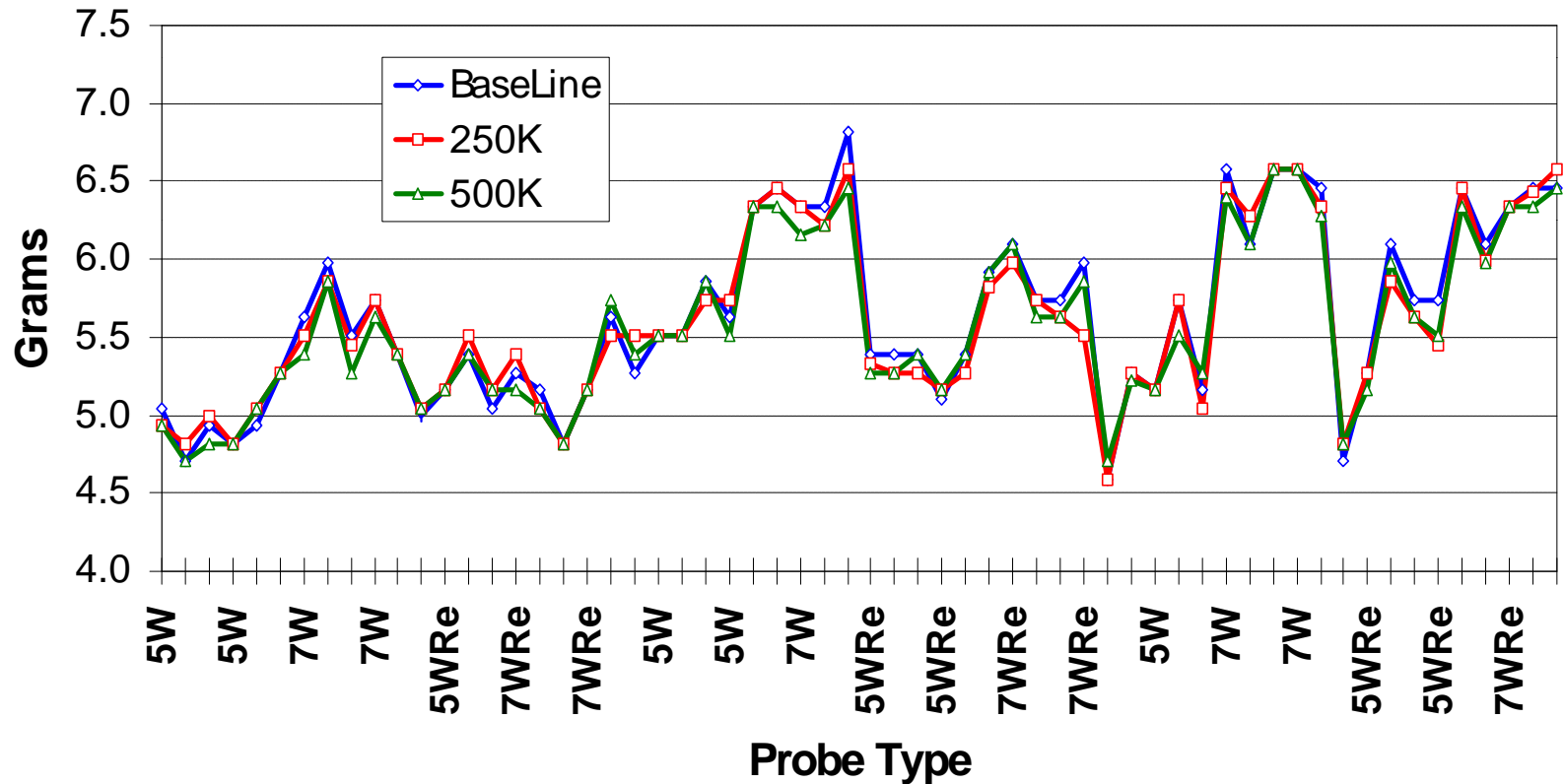
No Significant Difference Between Tiers
Some Variation in Different Probe Types

Probe Force Linearity



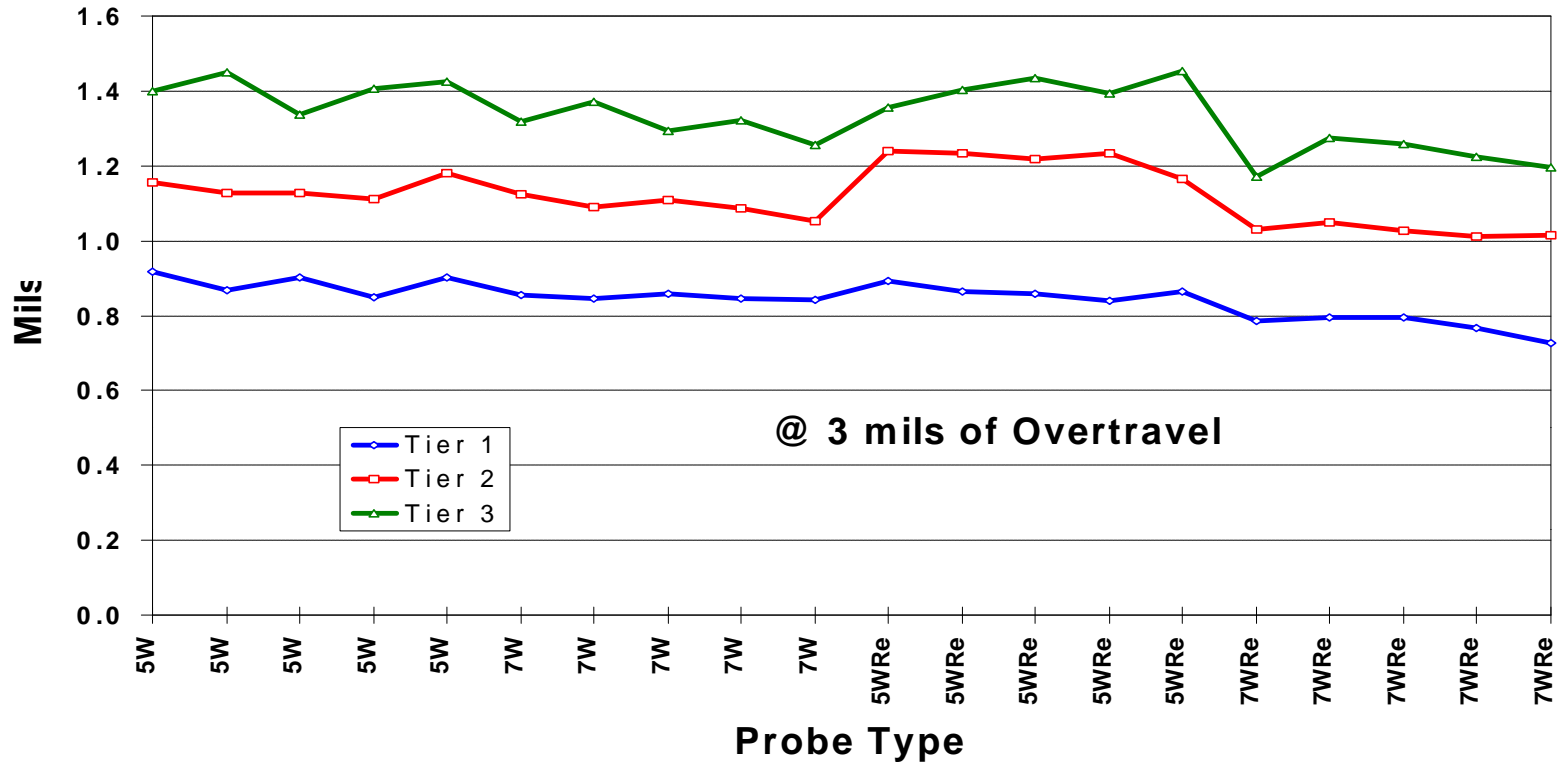
No "Loose" probes
Spring rate of probes very linear

Probe Force Repeatability



Extremely Good Repeatability Throughout Probe Card Life

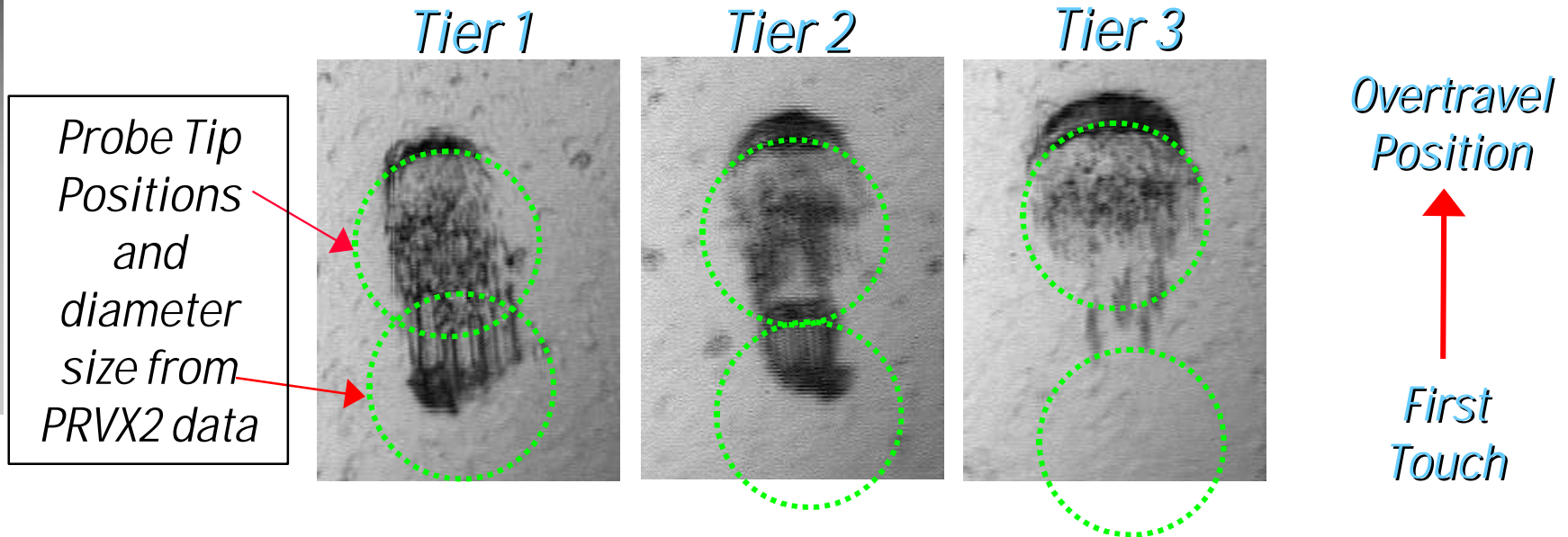
Probe Scrub



20% Difference in Scrub Length Between Tiers

Does this difference cause higher resistance ?

Probe Marks



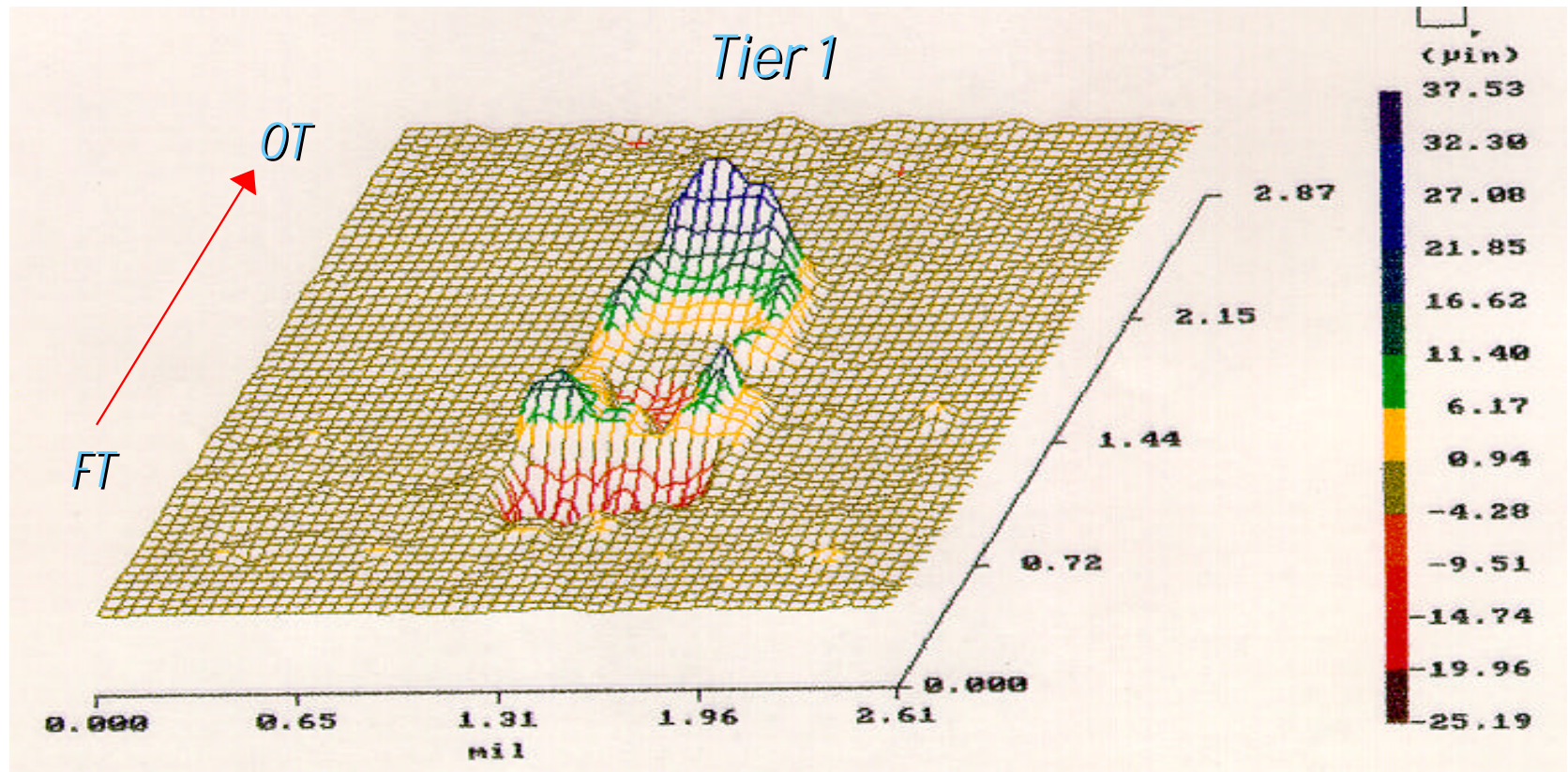
- Tier 1 Width the smallest
- Tier 3 Width the largest
- Tier 3 makes shortest Scrub Mark

	Tier 1	Tier 2	Tier 3
Probe Mark Length (PRVX2)	1.82	1.95	1.55
Probe Scrub Length	2.2	2.45	2.7
Probe Scrub Width	1	1.15	1.3

Counter Intuitive Results...

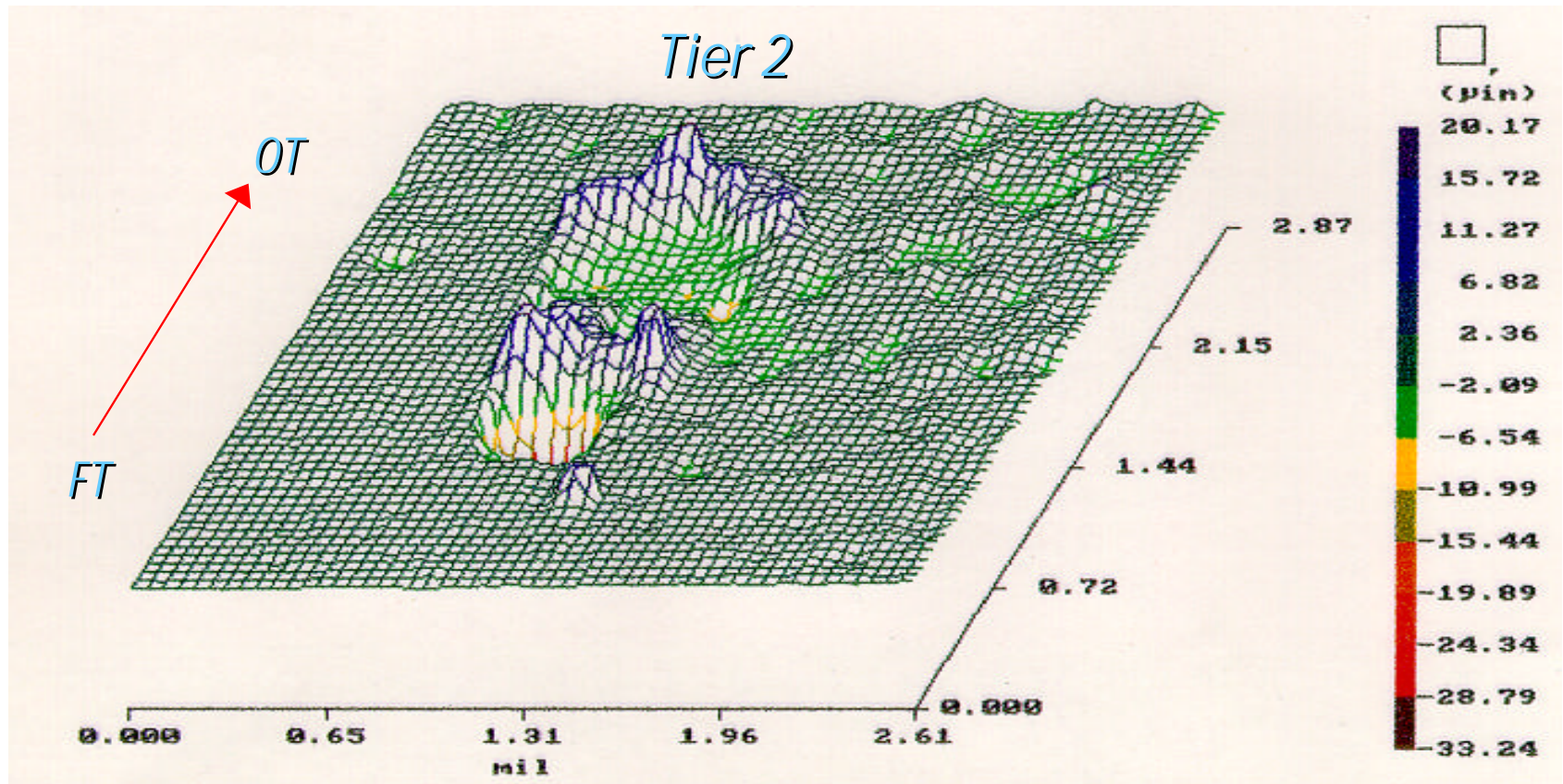
Longest Scrub Makes the Shortest Probe Mark !

Probe Mark



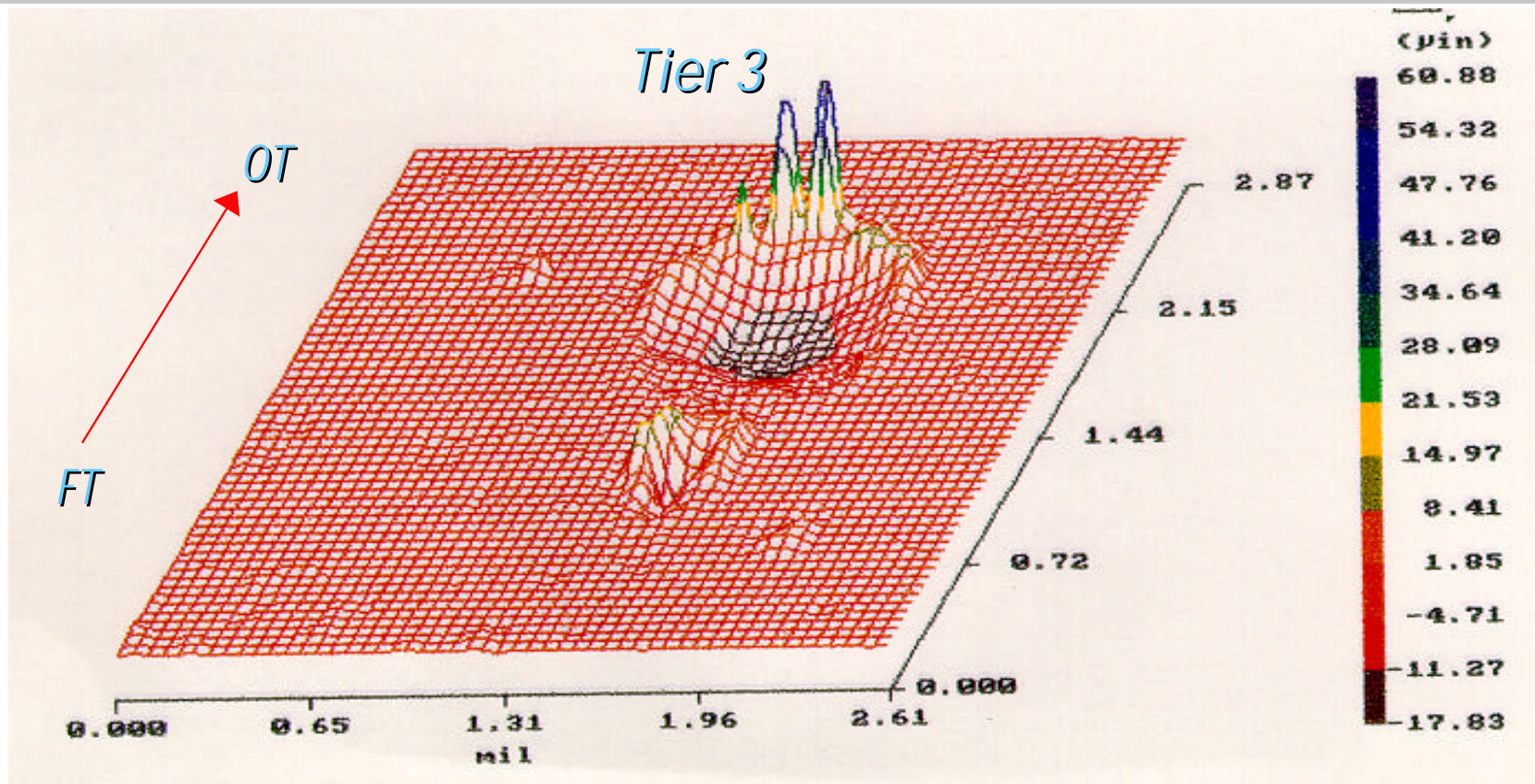
- First Touch Mark - .5 microns deep
- Overtravel Mark is above the surface of the pad
- Width of scrub ~ 1.0 mils

Probe Mark



- First Touch Mark - .5 microns deep
- Overtravel Mark is slightly below the surface of the pad
- Width of scrub ~ 1.15 mils

Probe Mark

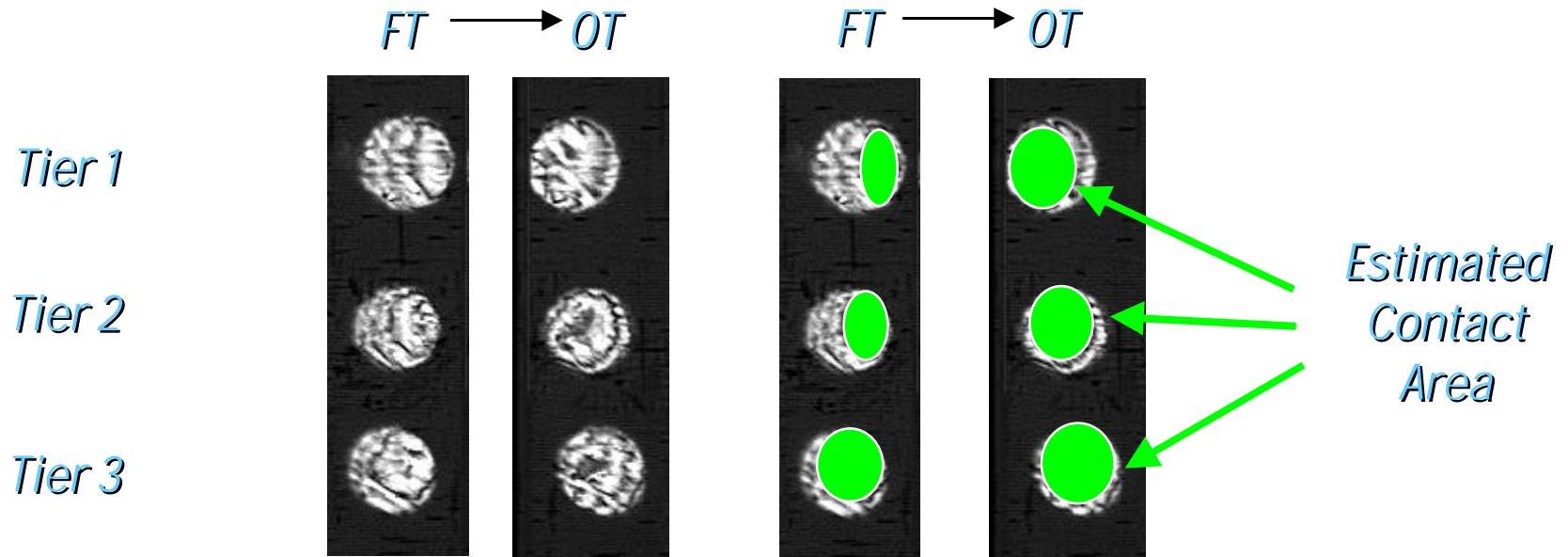


- No first touch mark - Skating effect
- Overtravel position a compression mark (Width 1.3 mils)
- Oxide film not removed from under the probe
- Probable cause of Higher resistance on 3rd tier

Investigation Summary

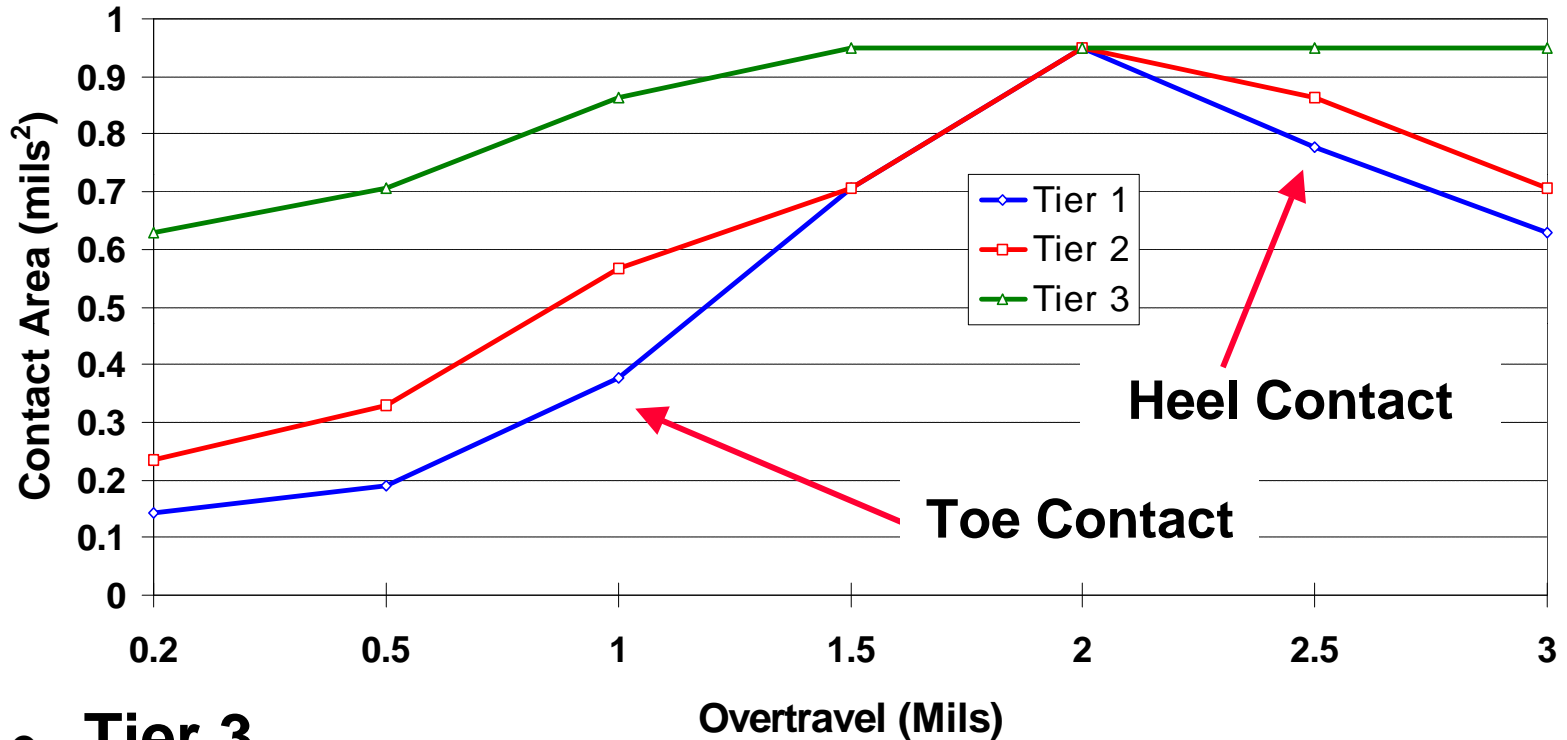
- **Short Scrub mark for the 3rd tier is probable cause of higher resistance.**
- **Why is the 3rd tier Scrub mark shorter?**
 - No significant difference in planarity between Tiers
 - No significant difference in diameter between Tiers
 - No significant difference in probe force
 - 3rd Tier scrubbing the longest but giving the shortest scrub mark

Contact Area



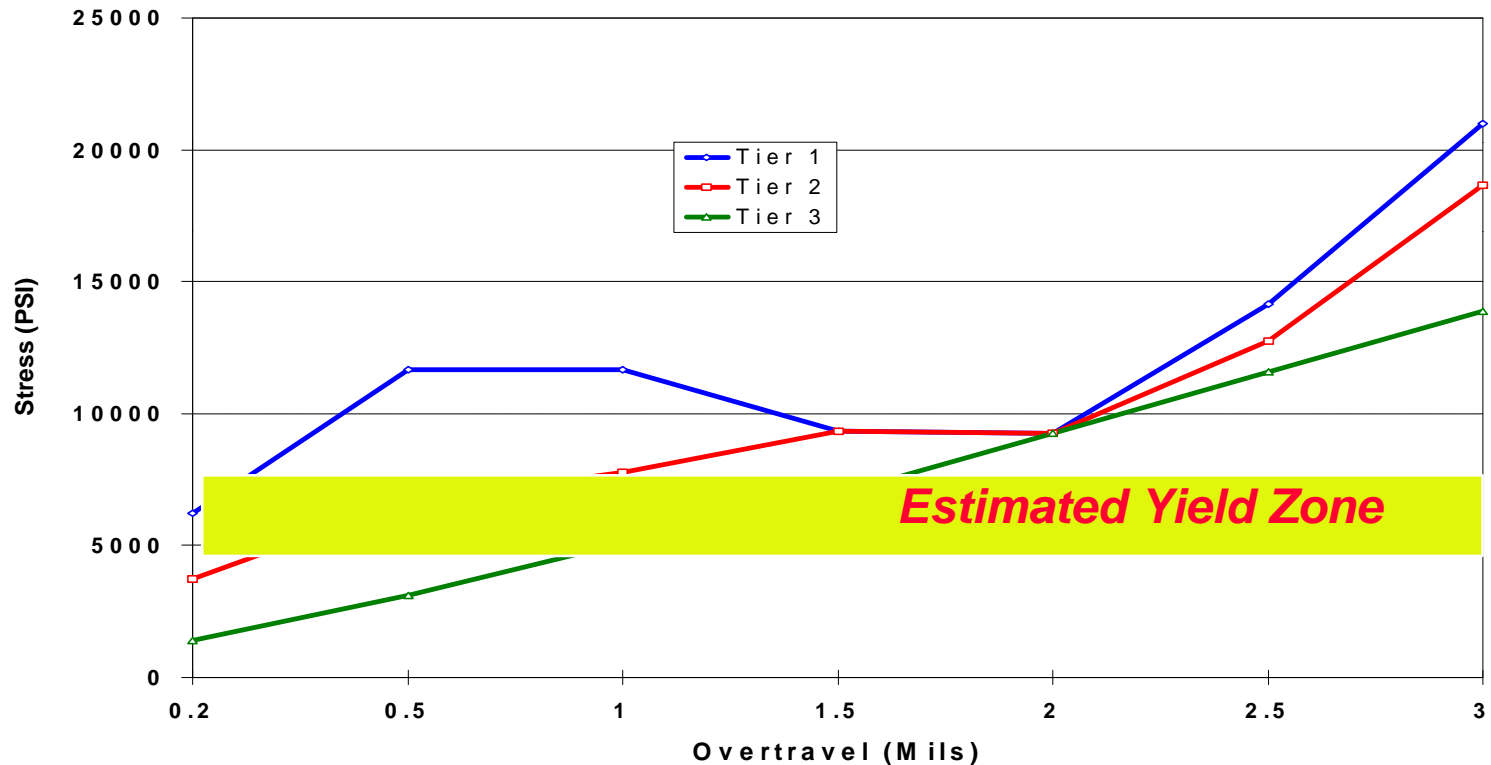
- Tier 1 rotates more from toe to the heel versus other tiers
- Tier 3 hits flush and stays flush during overtravel
- Tip rotation is largest on Tier 1 and smallest on Tier 3

Contact Area



- **Tier 3**
 - small change in contact area vs overtravel
- **Tier 1 and 2**
 - significant rotation from toe to heel.

Stress versus Overtravel



- Tier 3 does not break yield point of annealed Aluminum until after 1 mil of overtravel
- Stress Curve correlates to the probe scrub marks observed

Conclusions

- **Important properties of Contact resistance**
 - Stress (PSI) vs Overtravel / Low PSI causes short scrub marks
 - Shorter scrubs give higher contact resistance values
 - Probe Contact area
 - Probe Tip Rotation
 - Balanced Probe Force and equal tip diameter does not mean equal contact resistance between Tiers.

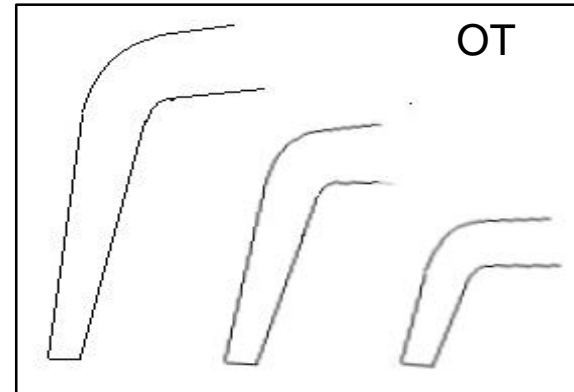
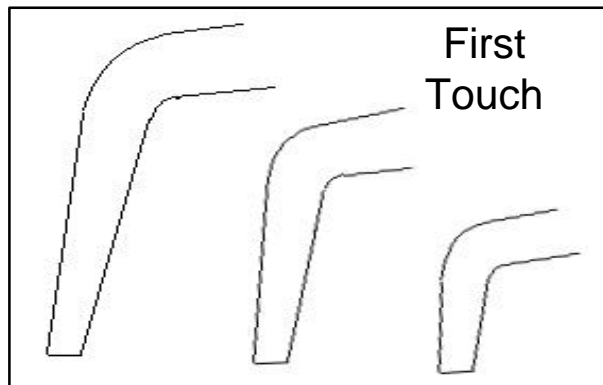
Future Research

- **Probe Geometry effects on Contact Resistance**
 - Tip Profile
 - Diameter Sizes
 - Rotation of probe tip during overtravel
- **Probing Variables - effects on Contact Resistance**
 - Yield point of annealed Aluminum (Thin Films , Temperature)
 - Stage velocity effects
 - Friction between pad and probe tip.

Tip Contact Area Theory

Why are Contact Areas Different ?

- Probe Deflection (Tip Angle change)



- Need FEA study to support this
 - Empirical data supports deflection theory
 - If tip angle deflections were constant scrub length differences between tiers would be larger.