Maximizing the Performance of an Atypical Cantilever Probe Wire Material

by

Frederick Taber

(Consultant to APS)

ADVANCED PROBING SYSTEMS, INC.

SOUTHWEST TEST WORKSHOP
2006

Frederick Taber, Consultant
34 Kuchler Drive
LaGrangeville, NY 12540
taberconsulting@optonline.net

Before We Begin

- What is An Atypical Probe Wire Material?
- Why Was This Work Undertaken?

Before We Begin

- What is An Atypical Probe Wire Material?

Atypical: "Not typical" (*)

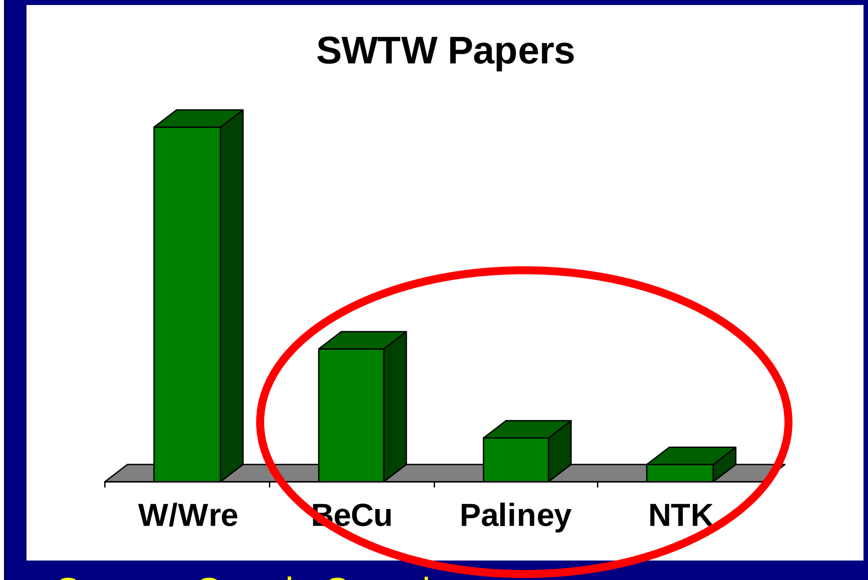
Well, that's not much help

(*) – Webster's Dictionary

What is An Atypical Probe Wire Material?

Probe Related Publications

Probe Industry Usage



Source: Google Search

Tungsten; Tungsten-Rhenium

Paliney®

BeCu

NewTek™

Focus is on NewTek™

Why Was This Work Undertaken?

TODAY

- Probe Card Manufacturers & End Users
  - – Enthusiastic Support By Those Who Have Learned to Work With NewTek™
    - Low & Stable Contact Resistance
    - Less Cleaning
    - Lower Force

Take Steps to Gain Wider Acceptance

Why Was This Work Undertaken?

Maximize What? And Why?

- Accelerate Growth of the Knowledge Base
    - Traditional Materials Have Decades of Learning and Familiarity (and myths!)
    - Custom & Practice Affect Acceptance of New Materials
  - For the Probe Card Manufacturer
    - Optimize The Build Process
  - For Users
    - Provide Introduction & Applications Advice
  - For Client
    - Identify Manufacturing Process Improvements

AGENDA

- A Little Bit of History
- Scope of the Work
- Experiment #1
- Experiment #2
- Summary
- Acknowledgements
- References

A Little Bit of History

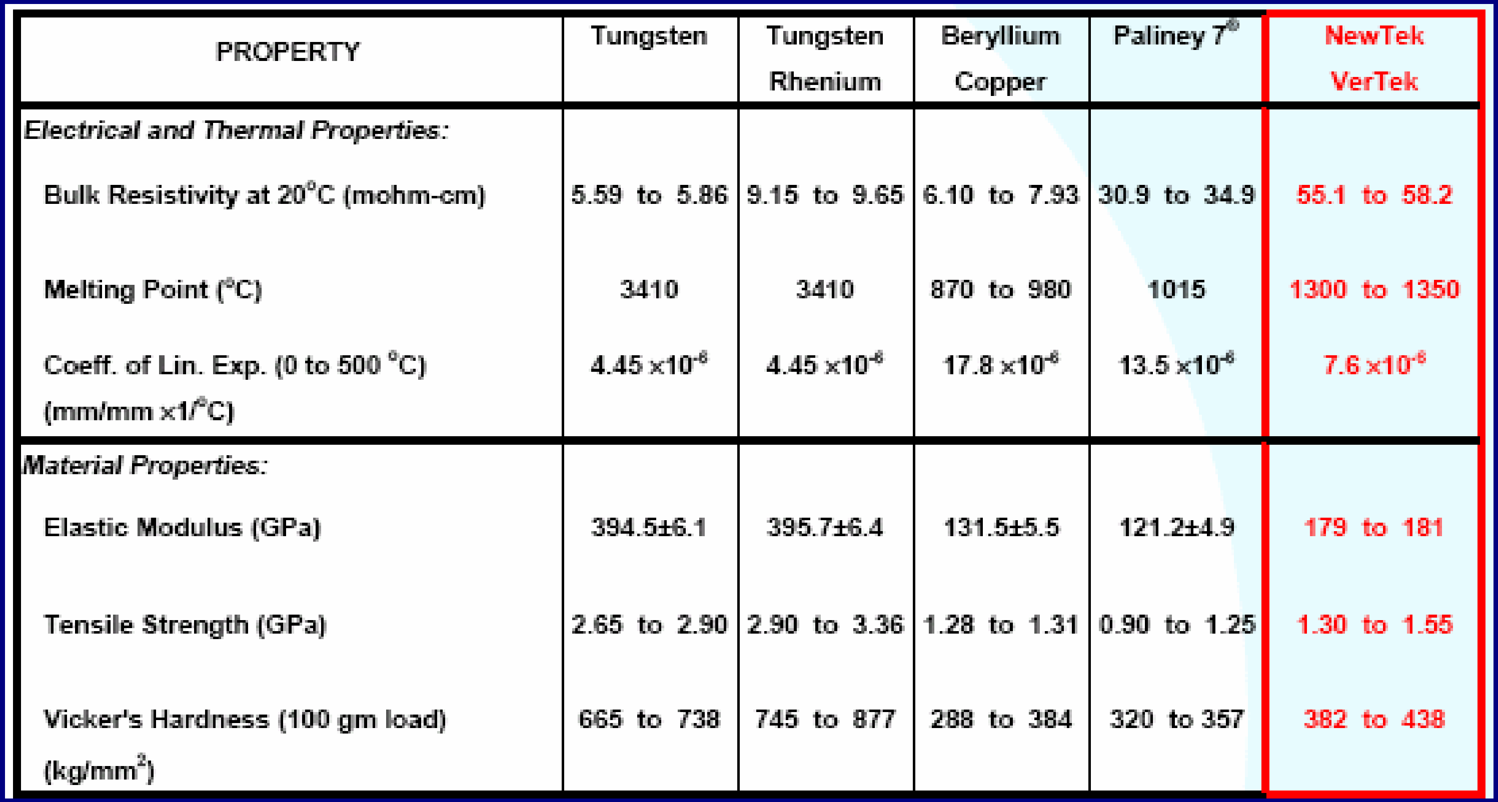
- First Presented at ’99 SWTW
  - “Low and Stable Contact Resistance With Reduced Cleaning…...A Paradigm Shift” by Jerry Broz and Rey Rincon
    - Alpha Testing; Preliminary Beta Testing
- Evaluation Engineering Article – 9/99
  - “Understanding Probe-Contact a-Spot Oxidation During Elevated-Temperature Wafer Test” by Jerry Broz and Rey Rincon

A Little Bit of History

- Presented at ’99 ITC
  - “Probe Contact Resistance Variations During Elevated Temperature Wafer Test” by Jerry Broz and Rey Rincon
    - Preliminary Production Level Beta Testing
- Product Announcement: January 2002

A Little Bit of History

- About NewTek™

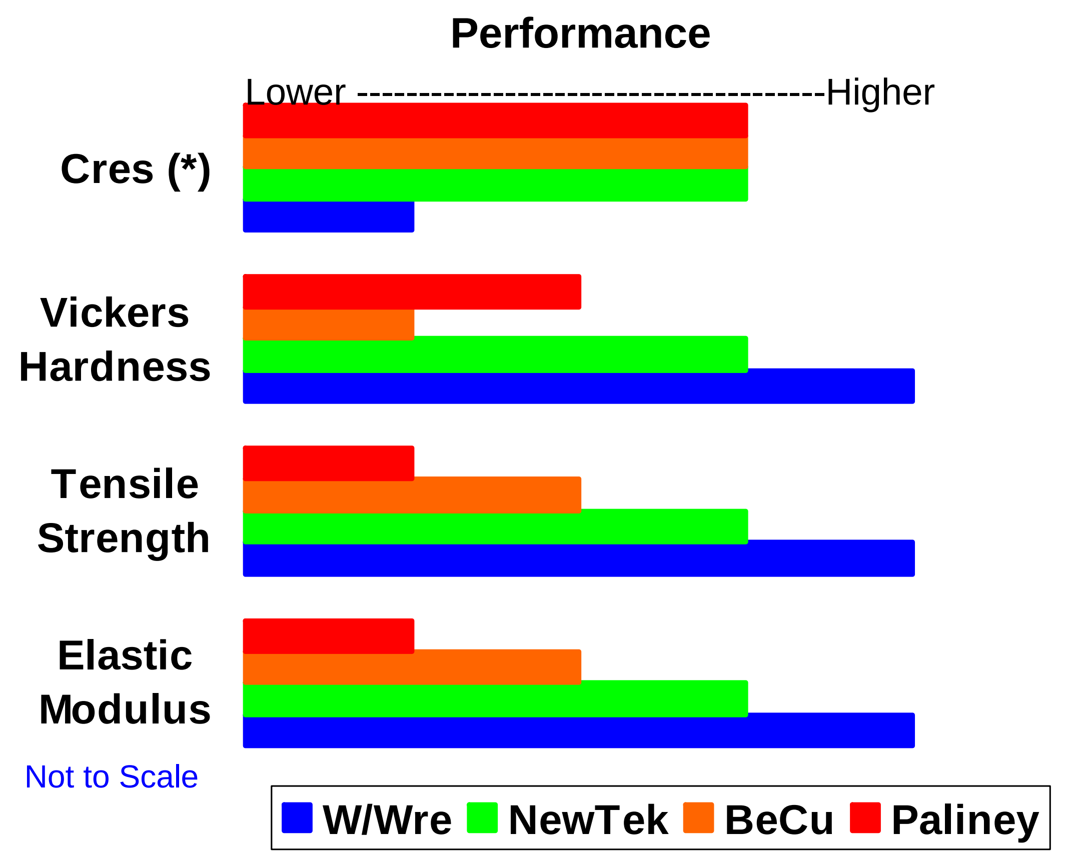


PROPERTY	Tungsten	Tungsten Rhenium	Beryllium Copper	Paliney 7®	NewTek VerTek
Electrical and Thermal Properties:					
Bulk Resistivity at 20°C (mohm-cm)	5.59 to 5.86	9.15 to 9.65	6.10 to 7.93	30.9 to 34.9	55.1 to 58.2
Melting Point (°C)	3410	3410	870 to 980	1015	1300 to 1350
Coeff. of Lin. Exp. (0 to 500 °C) (mm/mm x1/°C)	4.45×10^{-6}	4.45×10^{-6}	17.8×10^{-6}	13.5×10^{-6}	7.6×10^{-6}
Material Properties:					
Elastic Modulus (GPa)	394.5±6.1	395.7±6.4	131.5±5.5	121.2±4.9	179 to 181
Tensile Strength (GPa)	2.65 to 2.90	2.90 to 3.36	1.28 to 1.31	0.90 to 1.25	1.30 to 1.55
Vicker's Hardness (100 gm load) (kg/mm^2)	665 to 738	745 to 877	288 to 384	320 to 357	382 to 438

(*) from earlier referenced work

A Little Bit of History

- About NewTek™ as a Probe Material



(*) from earlier referenced work

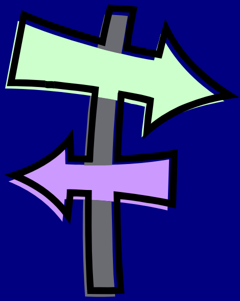
Scope of the Work

- Work in Progress
  - Share Design of Experiments and Data Collected to Date
  - Analysis / Conclusions / Results / Actions are Just Getting Underway
    - A SWTW 2007 Paper?
- Conduct Experiments in 2 Areas
  - Wire Bending
  - CRes & Force

Experiment #1

Wire Bending

- Varied Customer Experiences
  - Observe and Understand the Probe Card Manufacturing Process
    - Caused by a Process Step?
    - Tip & Taper Specifications?
  - Look at the Material Properties & Manufacturing Process
    - Inherent in the Material?
    - Introduced by a Process Step?



Experiment #1

Wire Bending

- An Example of a Manual Wire Bending Tool

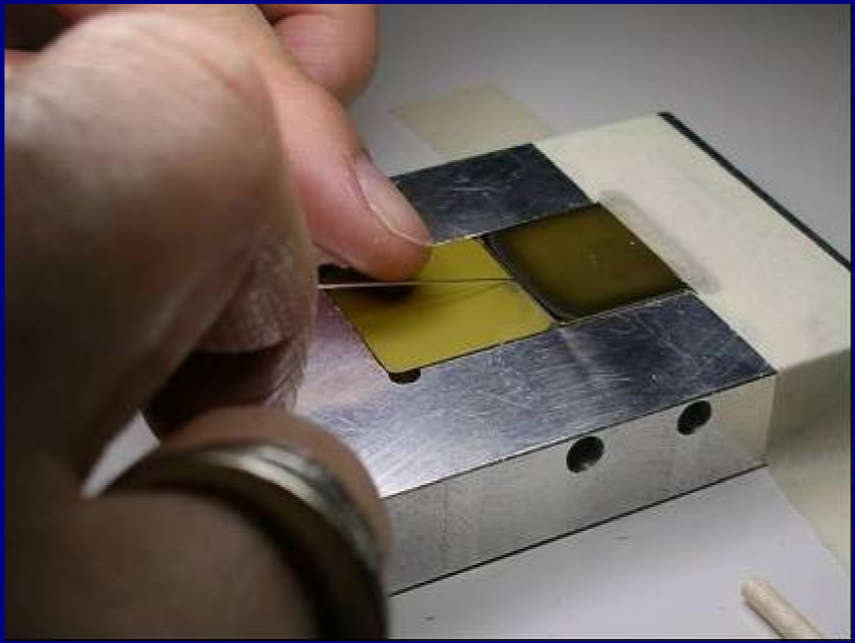
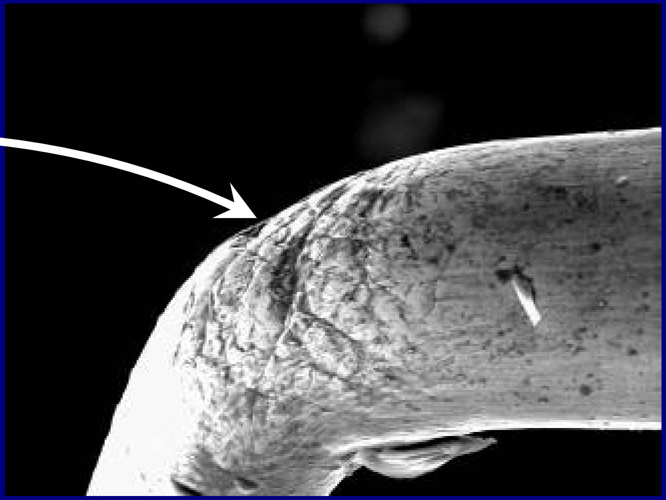


Photo Courtesy of SV Probe

Experiment #1

Wire Bending

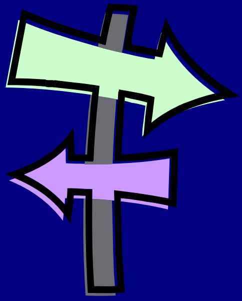
- A Clue: Optical Comparator Showed Flattening at the Knee
  - Post Wire Bending
- Select Relevant Samples for SEM Images
  - Cracking / Slip Deformation Observed



Experiment #1

Wire Bending

- Caused by a Process Step?
- Tip & Taper Specifications?
- Inherent in the Material?
- Introduced by a Process Step?



Conduct Wire Bend Experiments

Experiment #1

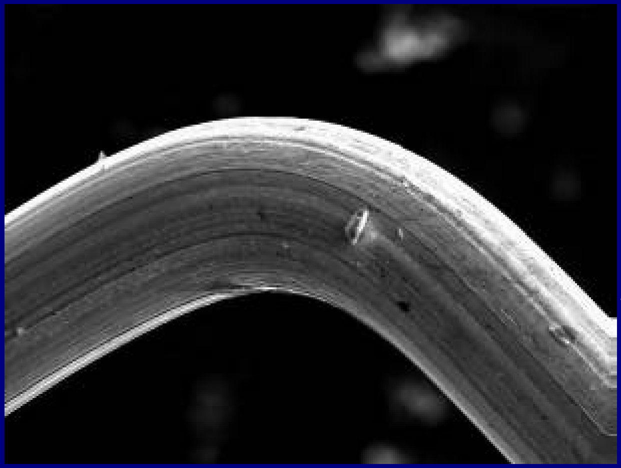
Wire Bending

- Wire Bend Experiment Matrix
  - Multiple Wire Diameters
  - Tapered & Untapered Wires
  - Typical Tip Length(s) & Tip Diameter(s)
  - Two Bending Techniques
  - Bend Angles from 180° (unbent) to 90°+

Experiment #1

Wire Bending

- Untapered Wire; 90° Bend



Bending Technique #1

All Samples

Bending Technique #2

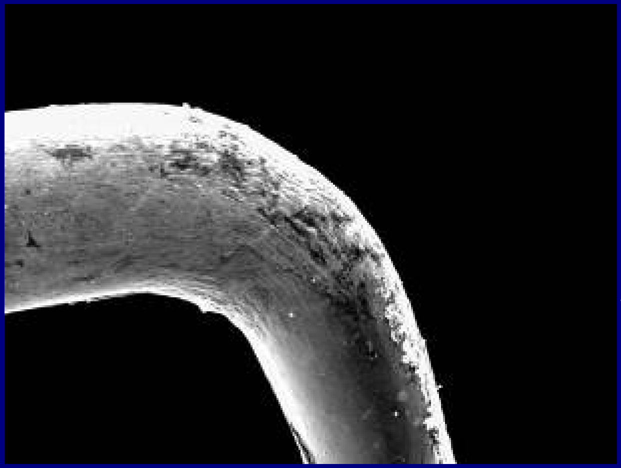
No Cracking / Slip Deformation at All Bend Angles

Excellent Bending With NewTek™ Material

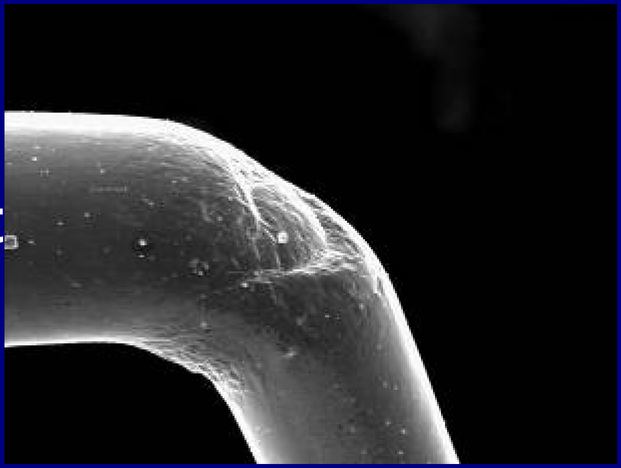
Experiment #1

Wire Bending

- Tapered Wire; 90° Bend



Relevant Samples



Bending Technique #1

Bending Technique #2

Cracking / Slip Deformation Varied by Bend Technique

Taper <u>AND</u> Bend Technique Contribute

Experiment #1

Wire Bending

- Next Steps
  - – Investigate Taper Contribution
    - Recommendations for: shape, length, angle, process, etc.
  - – Develop a Recommended Bending Protocol

To Optimize the Wire Bending

Experiment #2

CRes
Force

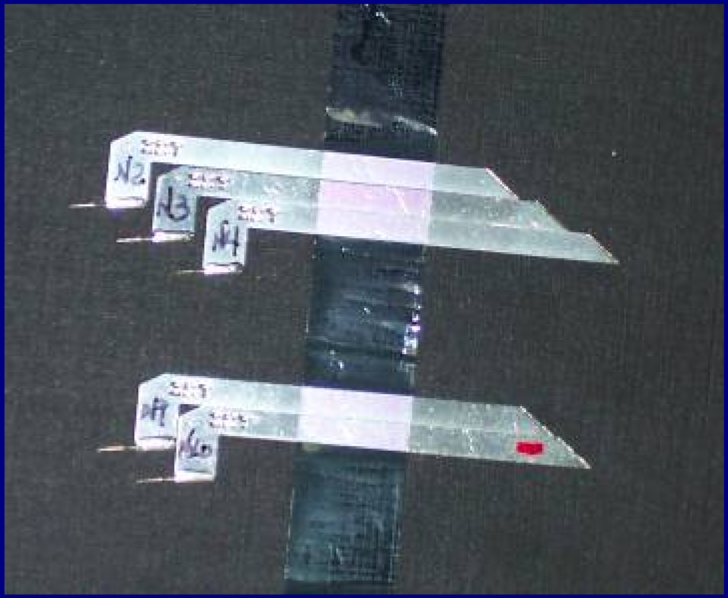
- Another Look at CRes
  - Build on Prior Work
  - Establish a Baseline for Additional Testing
- Quantify Low Probe Force Reputation
- Develop Cleaning Recipes

Compare to WRe

Experiment #2

CRes
Force

- Test Methodology
  - Utilize International Test Solutions' Applications Laboratory
  - Single Probe Mounted on a Blade
  - Collect Resistance, Overtravel and Force Data
    - Blanket Al Wafer
    - Rhodium Plate



Probes Produced by International Contact Technologies

Experiment #2

CRes
Force

- Test Setup
  - Testing Conducted at and by International Test Solutions

- 4-pt. CRes
- Low g Load Cell
- Hi-mag Optical Imaging
- Precision X-Y-Z
- Cleaning Station
- Rhodium Shorting Block

Bench-top Materials Testing System

Photos:

Courtesy of International Test Solutions

Experiment #2

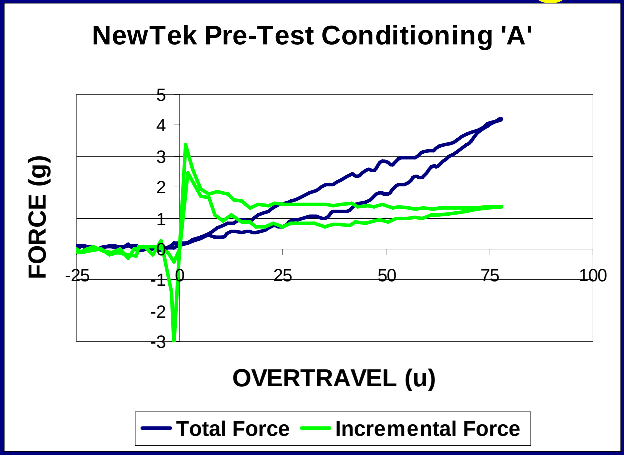
CRes
Force

- Tests Conducted
  - Conditioning
    - A= Right Out of The Box
    - B= Clean After Setup; Before Running Tests
  - Characteristic Curves
    - Overtravel, CRes & Probe Force
    - 3x on Rhodium Plate & Blanket Al Wafer
    - After 0K and 50K Touchdowns
  - Spiral and Micro-Stepping – 50K TD’s
    - Run a Characteristic Measurement Every 250 TD’s

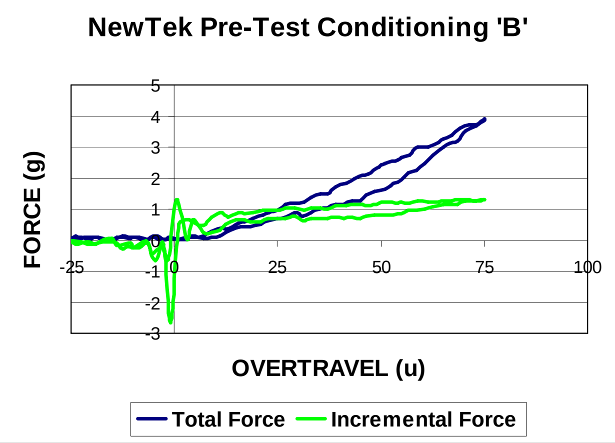
Experiment #2

- Conditioning -

CRes
Force

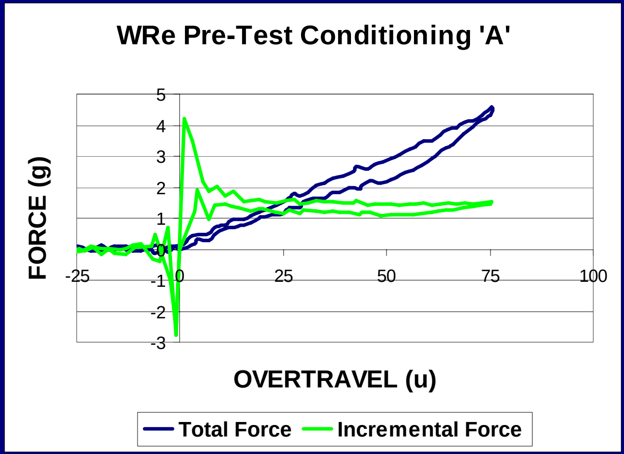

NewTek Pre-Test Conditioning 'A'

NewTek™

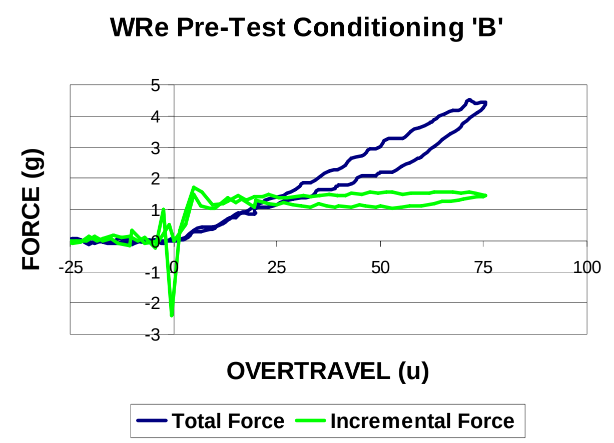

NewTek Pre-Test Conditioning 'B'

Target:
1.5g/mil

All OK


WRe Pre-Test Conditioning 'A'

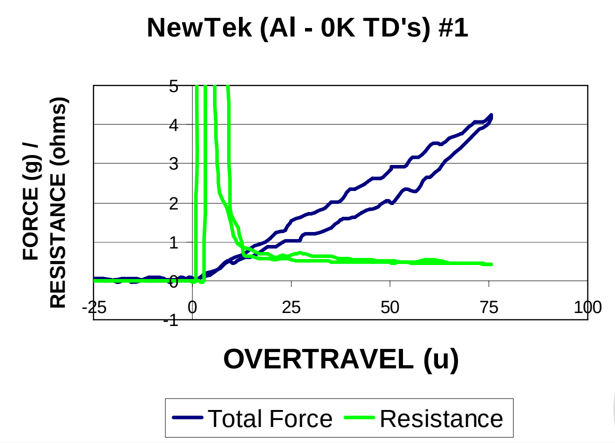
WRe


WRe Pre-Test Conditioning 'B'

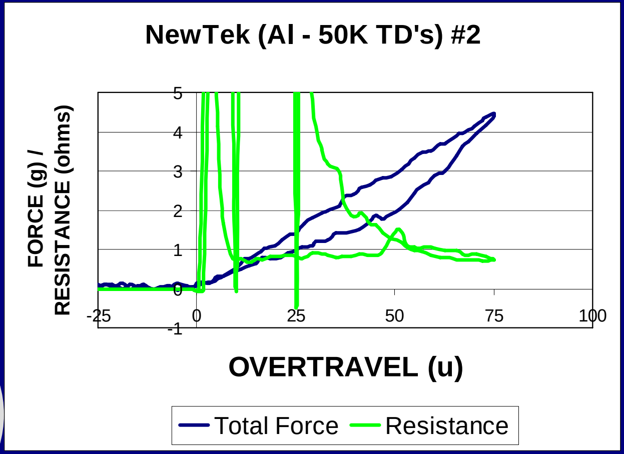
Experiment #2

- Characteristic Curves -

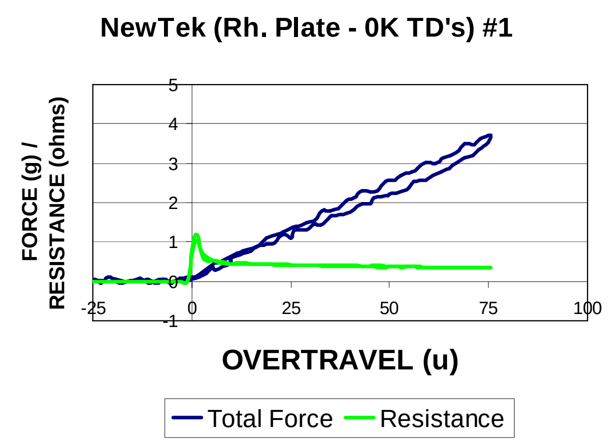
CRes
Force


NewTek (Al - 0K TD's) #1

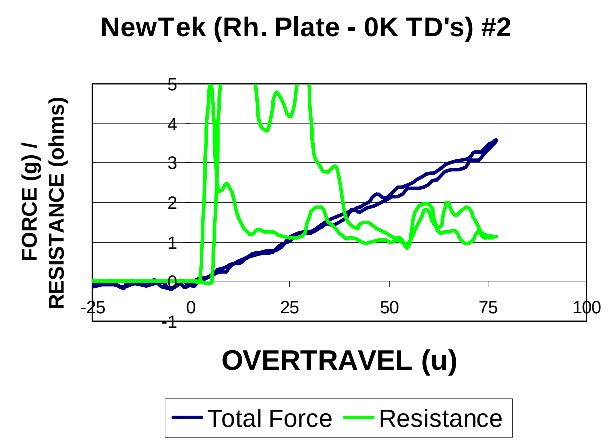
NewTek™


NewTek (Al - 50K TD's) #2

No Cleaning
~.5Ω →+/-1Ω


NewTek (Rh. Plate - 0K TD's) #1

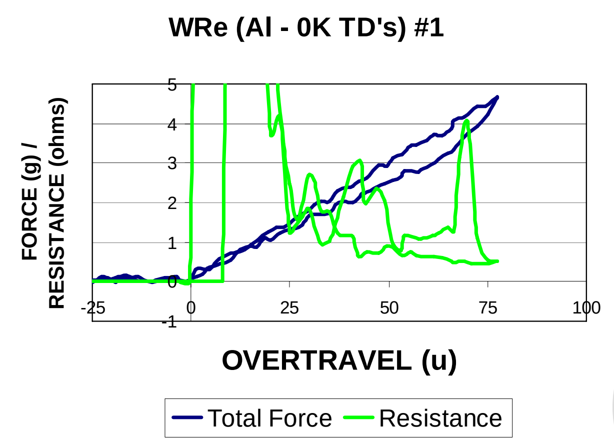
ANALYSIS UNDERWAY


NewTek (Rh. Plate - 0K TD's) #2

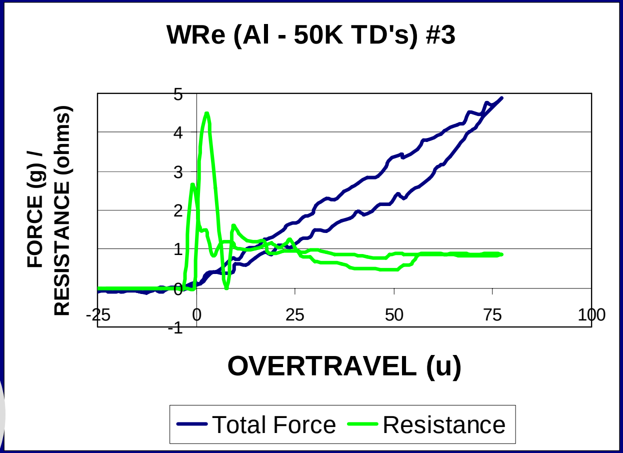
Experiment #2

- Characteristic Curves -

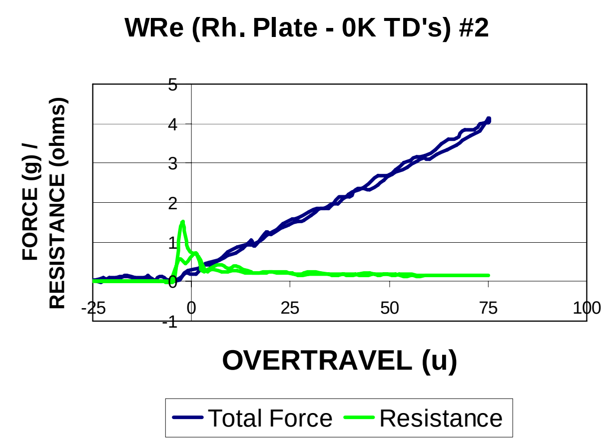
CRes
Force


WRe (Al - 0K TD's) #1

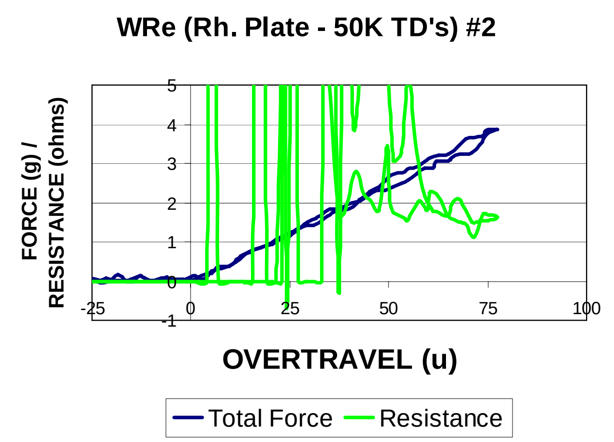
WRe


WRe (Al - 50K TD's) #3

No Cleaning
~.5Ω →+/-1Ω


WRe (Rh. Plate - 0K TD's) #2

ANALYSIS UNDERWAY

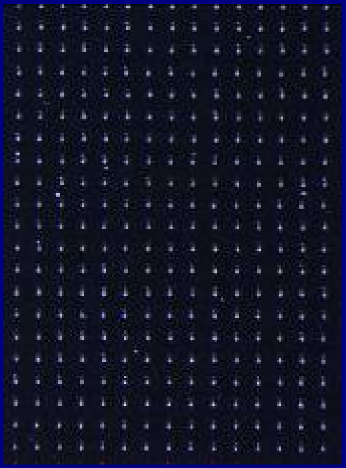

WRe (Rh. Plate - 50K TD's) #2

Experiment #2

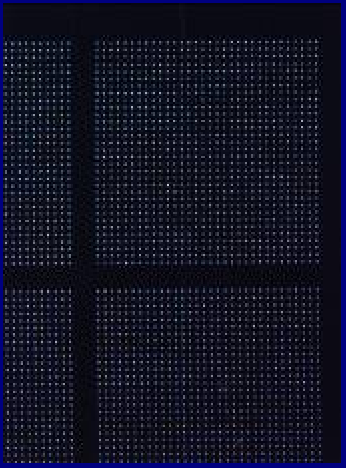
CRes
Force

- Stepping Patterns -

- Spiral Stepping
  - Start @ Center Then Spiral Outward
  - Maximizes TD's per Wafer Coupon
- Micro-Stepping
  - Array 'Chip-site' Like
  - Step Row by Row Within a 'Chip-site'
  - Easily Locate A Specific Probe Mark



Spiral Stepping Scrub Marks



Micro-Stepping Scrub Marks

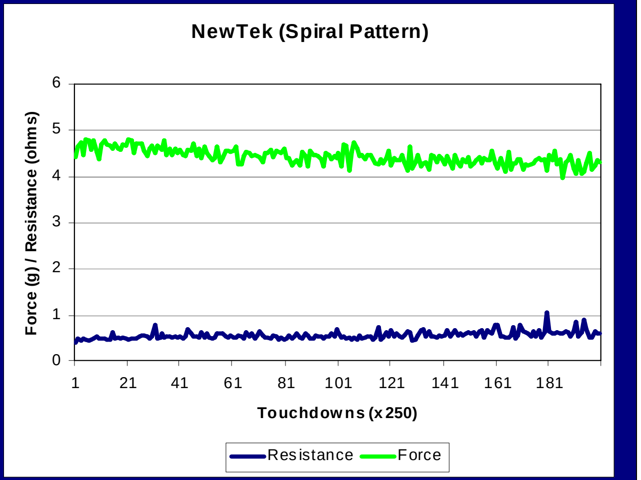
Experiment #2

CRes

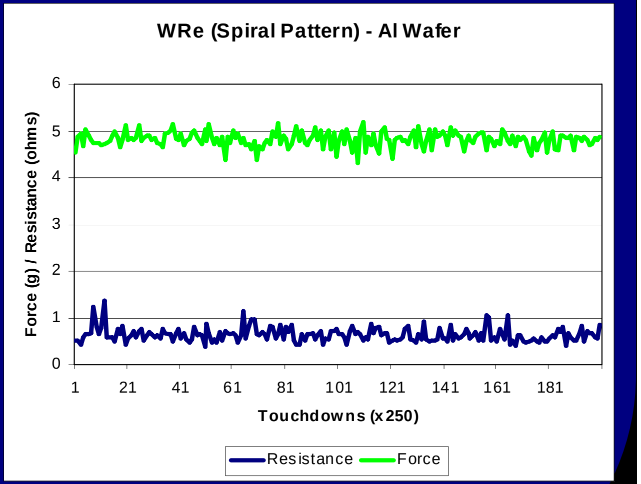
Force

- Spiral Stepping
  - 50K TD's
  - Measure Every 250 TD's
  - Al Wafer

NewTek™



WRe



NewTek™: Lower Stable CRes & Lower Force

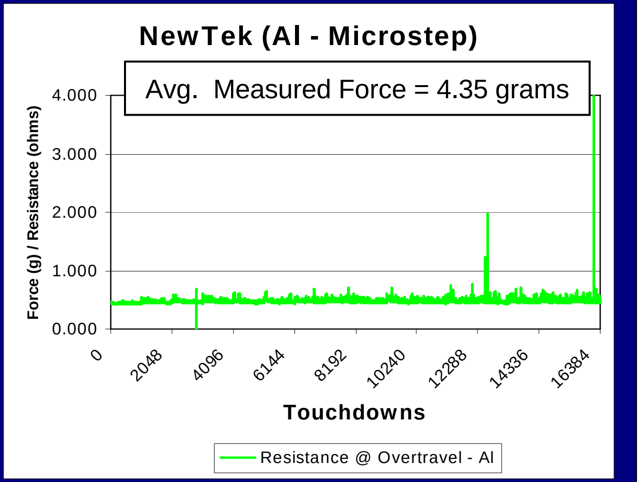
MORE ANALYSIS UNDERWAY

Experiment #2

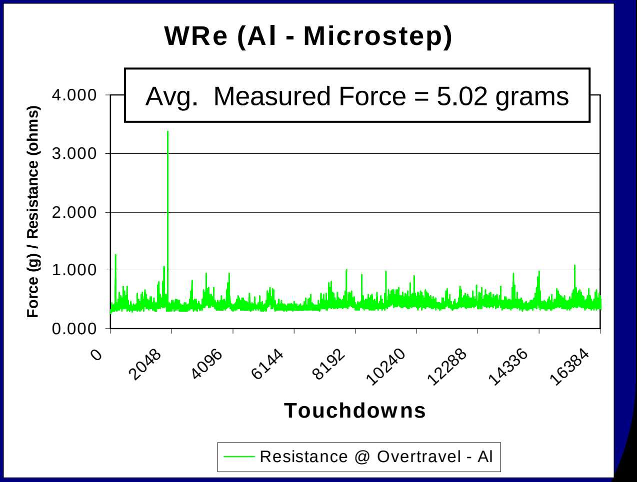
CRes
Force

- Micro-Stepping
  - 16K TD's
  - Measure CRES Every TD
  - Al Wafer
  - 3x Rhodium Plate Every 1K TD's
  - No Cleaning

NewTek™



WRe



NewTek™: Lower Stable CRes & Lower Force

MORE ANALYSIS UNDERWAY

Experiment #2

CRes
Force

- Video Capture
  - Characteristic Curve
  - Spiral Stepping
  - Micro-Stepping

Example:

NewTek™ Characteristic Curve Al @ 0K TD's

Experiment #2

CRes
Force

- Next Steps
  - – Further Analysis of Test Results
    - Data is ‘Hot off the Press’
      - – Early Look For SWTW Audience
  - – Consider Tests for Comparisons to BeCu and Paliney®
  - – Investigate Cleaning Recipes
  - – Potential to do Full Probe In-situ Testing
    - Requires a Partner to Work With

Summary

- Growth of the NewTek™ Knowledge Base
  - Leading to More Understanding By Probe Card Manufacturers and Users
- Developing Optimized Bending Protocols
  - Investigating Taper Contribution
- CRes / Force
  - Experimental Results Very Promising
  - More Analysis Underway
  - Follow-on Direction

Acknowledgements

- SV Probe (Pete Rogan)
  - Support of the Wire Bending Experiment
- International Test Solutions (Jerry Broz, Ph.D. / Gene Humphrey)
  - Support & Execution of CRes /Force Testing
- Gideon Labs (Jack Goho)
  - SEM Images and Analysis
- Bill Williams
  - CRes & Force Test Planning
- International Contact Technologies (Joe Baker)
  - Probe Build (and a lot of guidance)
- Advanced Technology Development Facility (Doug Woodal)
  - Blanket Al Wafer Guidance & Production
- Advanced Probing Systems (Michelle Gesse / Ken Black)
  - Support & Funding of this Project

References

- “Low and Stable Contact Resistance With Reduced Cleaning….A Paradigm Shift”; Jerry J. Broz Ph.D. & Reynaldo M. Rincon 1999 SWTW Proceedings;
- “Probe Contact Resistance Variations During Elevated Temperature Wafer Test”; Jerry J. Broz Ph.D. & Reynaldo M. Rincon; 1999 ITC Proceedings
- “Failure Mechanisms In Probe Card Materials”; Norman J. Armendariz; 1996 SWTW Proceedings
- Understanding Probe Contact a-Spot Oxidation During Elevated Temperature Wafer Test”; Jerry J. Broz, Ph.D. & Reynaldo M. Rincon; Evaluation Engineering 09/99
- “Introduction to Probe Cards - How They are Built & Tested”; Rod Schwartz; 1998 SWTW Proceedings
- “Effects of ‘On the Shelf’ Probe Tip Oxidation on Contact Resistance”; Advanced Probing Systems press release 07/1999
- “NewTek™ Probe Needle Material”; Advanced Probing Systems press release 01/2002
- Publicly available datasheets and technical information on various metals used in the probe card industry