

Maximizing the Performance of an Atypical Cantilever Probe Wire Material

by
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(Consultant to APS)



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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?

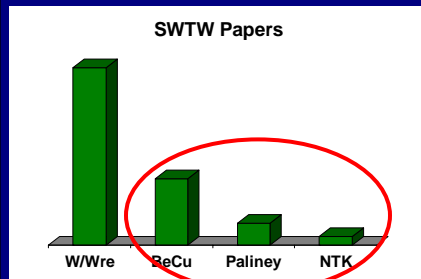
Atypical: "Not typical" (*)

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

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5

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

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6

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

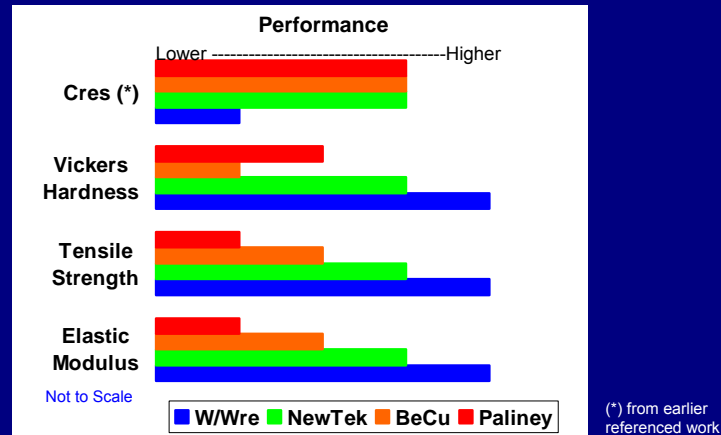
- About NewTek™

PROPERTY	Tungsten	Tungsten Rhenium	Beryllium Copper	Paliney 7 [®]	NewTek VerTek
<i>Electrical and Thermal Properties:</i>					
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 x 1/°C)	4.45 x 10 ⁻⁶	4.45 x 10 ⁻⁶	17.8 x 10 ⁻⁶	13.5 x 10 ⁻⁶	7.6 x 10 ⁻⁶
<i>Material Properties:</i>					
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



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11

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

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12

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?



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13

Experiment #1

Wire Bending

- **An Example of a Manual Wire Bending Tool**

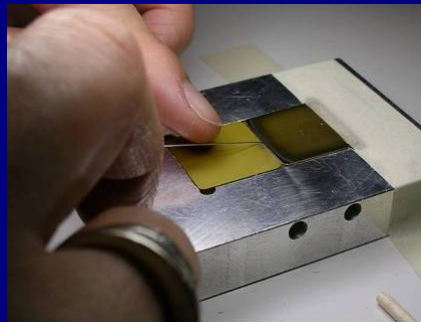


Photo Courtesy of SV Probe

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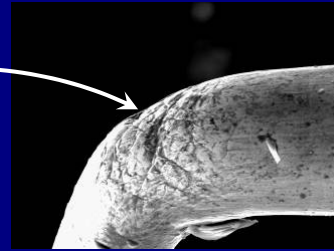
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14

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



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15

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

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16

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°+



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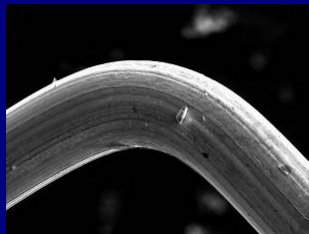
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17

Experiment #1

Wire Bending

- Untapered Wire; 90° Bend



Bending Technique #1



Bending Technique #2

All
Samples

No Cracking / Slip Deformation at All Bend Angles

Excellent Bending With NewTek™ Material

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18


Experiment #1

Wire Bending

- Tapered Wire; 90° Bend



Bending Technique #1



Bending Technique #2

Relevant Samples

Cracking / Slip Deformation Varied by Bend Technique

Taper AND Bend Technique Contribute

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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

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Experiment #2

CRes
Force

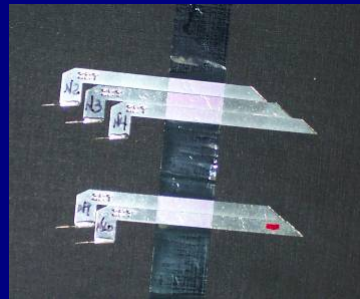
- Another Look at CRes
 - Build on Prior Work
 - Establish a Baseline for Additional Testing
- Quantify Low Probe Force Reputation
- Develop Cleaning Recipes

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

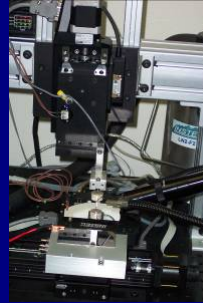


Probes Produced by International Contact Technologies

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

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23

Experiment #2

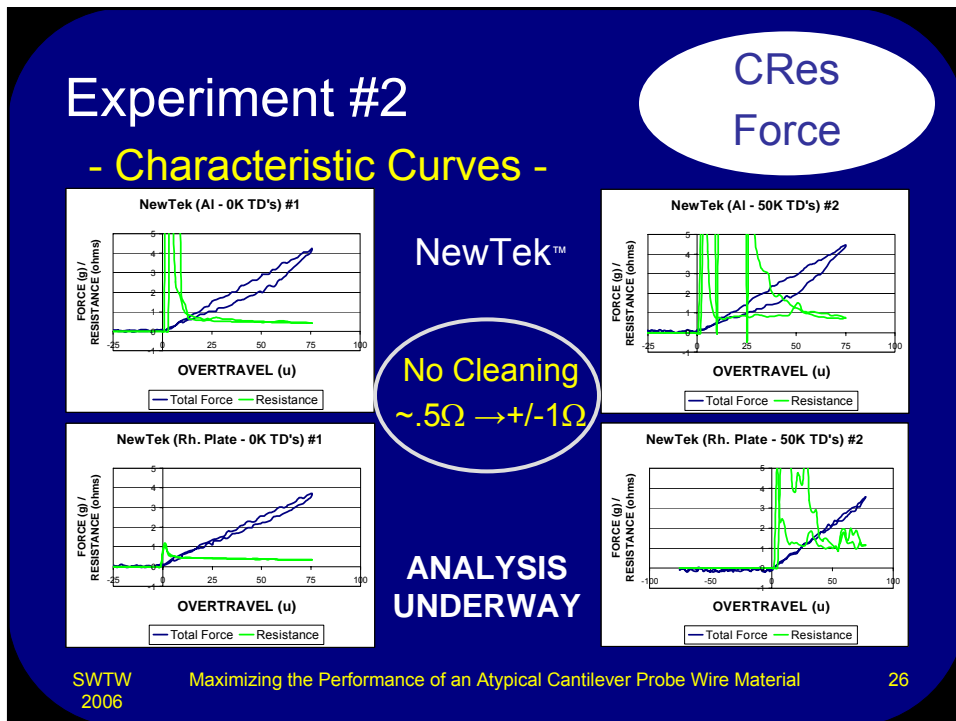
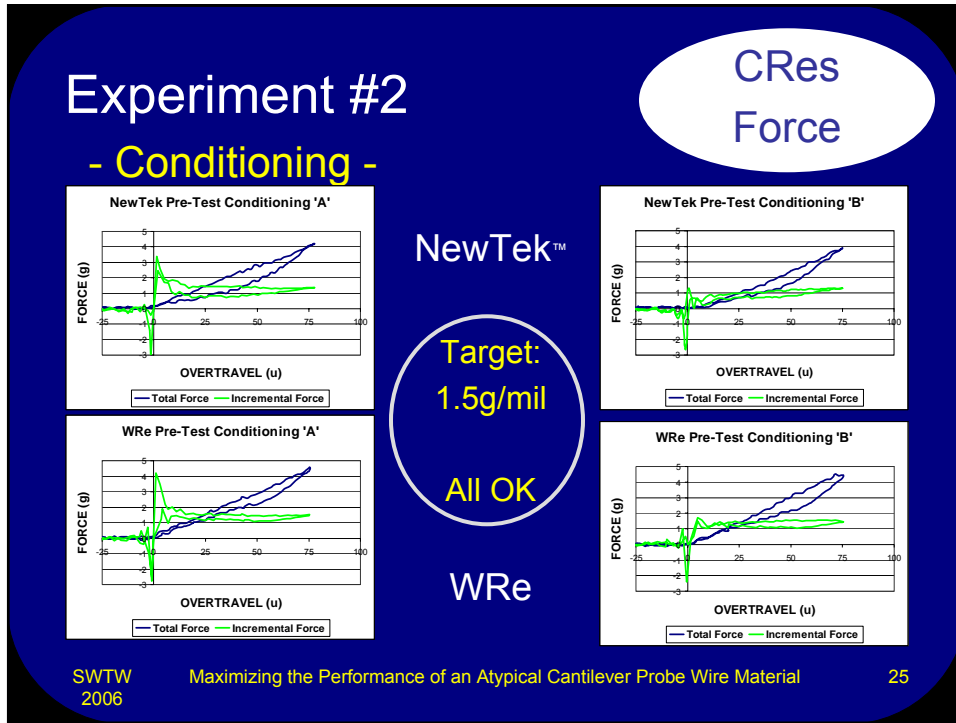
CRes
Force

- **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

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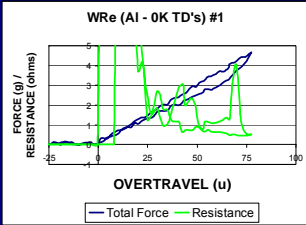
24



Experiment #2

- Characteristic Curves -

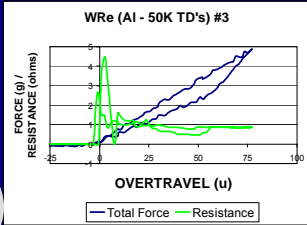
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Force



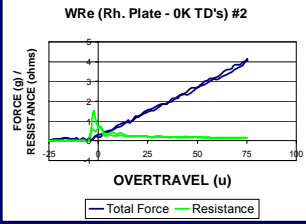
WRe (Al - 0K TD's) #1

WRe

No Cleaning
~.5Ω → +/-1Ω

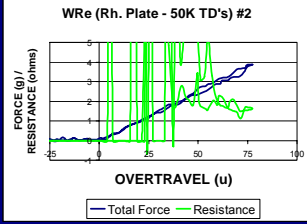


WRe (Al - 50K TD's) #3



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

ANALYSIS
UNDERWAY



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

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27

Experiment #2


- Stepping Patterns -

CRes
Force

- 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

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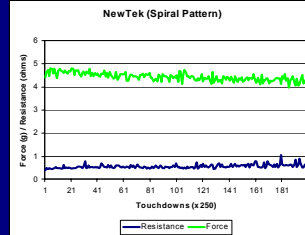
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28

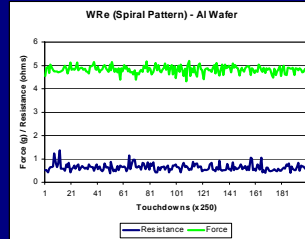
Experiment #2

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

NewTek™



WRe



NewTek™: Lower Stable CRes & Lower Force

MORE ANALYSIS UNDERWAY

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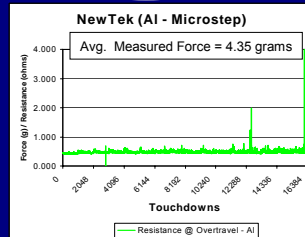
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CRes
Force

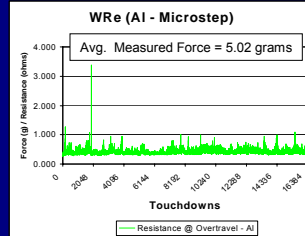
Experiment #2

- **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

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30


CRes
Force

Experiment #2

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

Example:
NewTek™ Characteristic Curve AI @ 0K TD's 

CRes
Force



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31

Experiment #2

- 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

CRes
Force

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32

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

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33

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 AI Wafer Guidance & Production
- **Advanced Probing Systems (Michelle Gesse / Ken Black)**
 - Support & Funding of this Project

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34

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