Maximizing the Performance of an Atypical Cantilever Probe Wire Material

by

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(Consultant to APS)

2006

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Paper #2

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” (*)

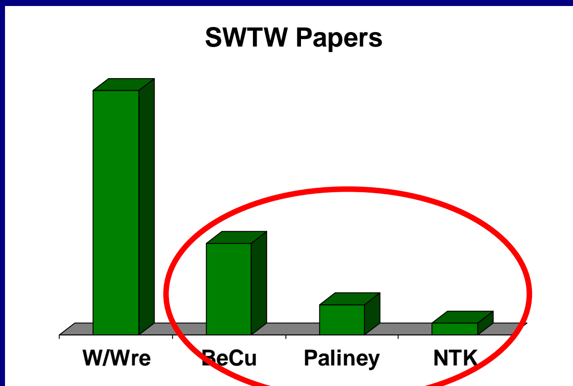
Well, that’s not much help

(*) – 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™

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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

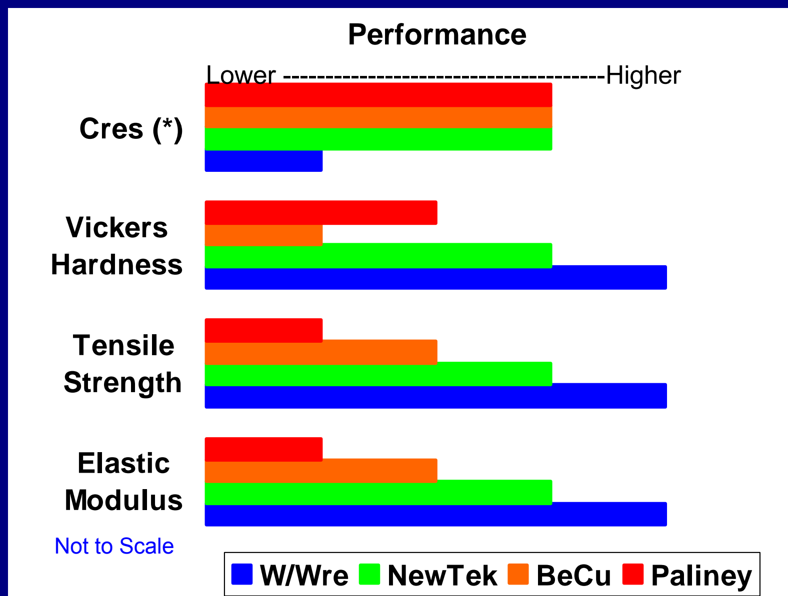
- Presented at ’99 ITC
  - “Probe Contact Resistance Variations During Elevated Temperature Wafer Test” by Jerry Broz and Rey Rincon
    - Preliminary Production Level Beta Testing
- Product Announcement: January 2002

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/mm²)	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
Performance
Lower -----------------------------------Higher
Cres (*)
Vickers Hardness
Tensile Strength
Elastic Modulus
Not to Scale
W/Wre
NewTek
BeCu
Paliney
(*) from earlier referenced work
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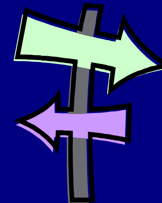
Scope of the Work

- 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?



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Experiment #1

Wire Bending

- An Example of a Manual Wire Bending Tool

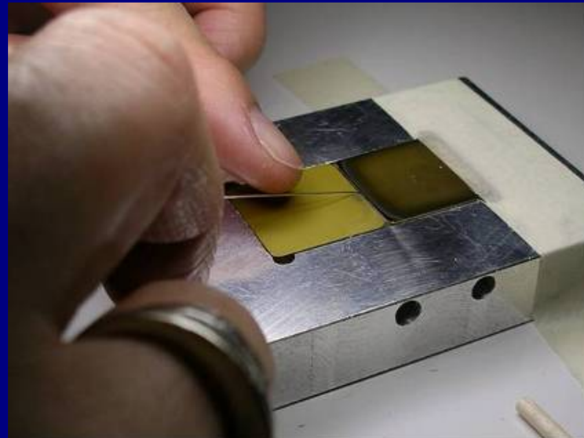

Photo Courtesy of SV Probe

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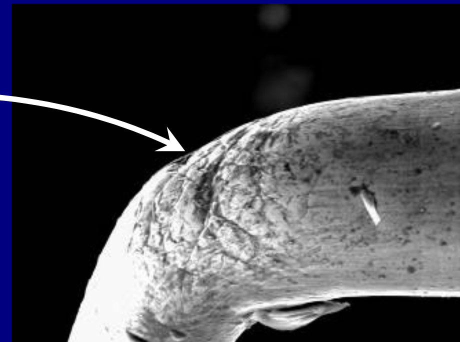
Experiment #1

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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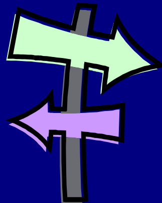
Experiment #1

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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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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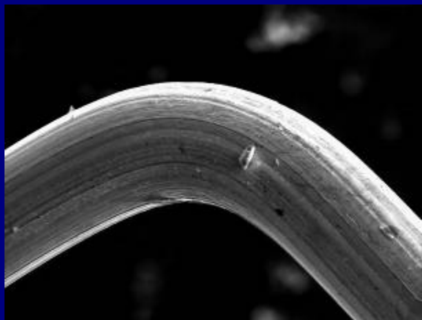
Experiment #1

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

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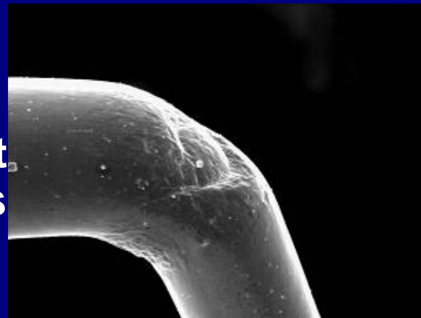
Experiment #1

Wire Bending

- Tapered Wire; 90° Bend

Bending Technique #1

Relevant Samples



Bending Technique #2

Cracking / Slip Deformation Varied by Bend Technique

Taper AND 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

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Experiment #2

CRes
Force

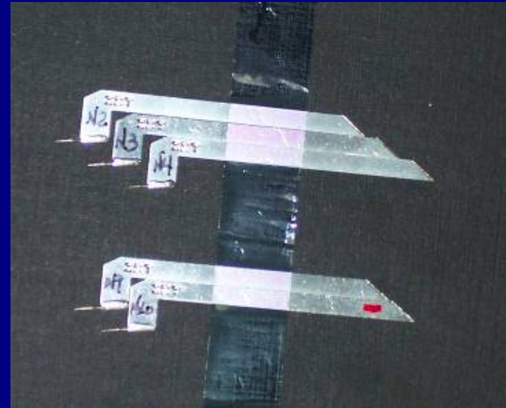
- Another Look at CRes
  - Build on Prior Work
  - Establish a Baseline for Additional Testing
- Quantify Low Probe Force Reputation
- Develop Cleaning Recipes

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

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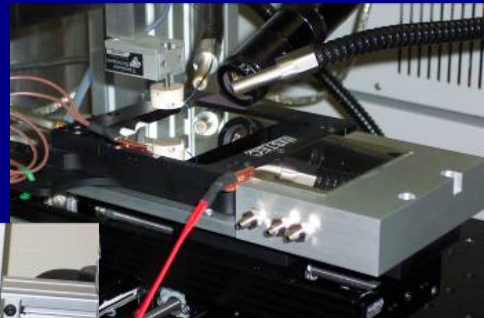
Experiment #2

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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Experiment #2

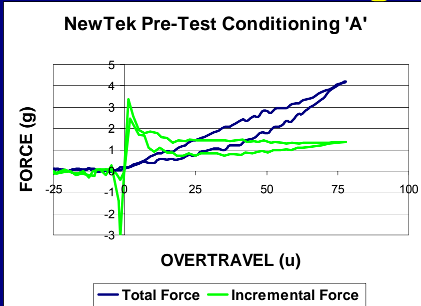
CRes
Force

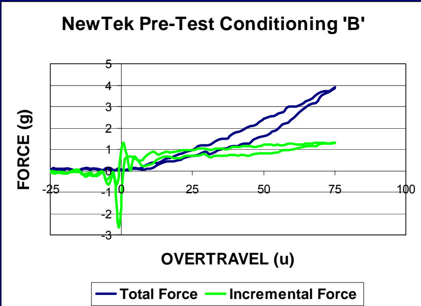
- Tests Conducted
  - Conditioning
    - A= Right Out of The Box
    - B= Clean After Setup; Before Running Tests
  - Characteristic Curves
    - Overtravel, CRes & Probe Force
    - 3x on Rhodium Plate & Blanket Al Wafer
    - After 0K and 50K Touchdowns
  - Spiral and Micro-Stepping – 50K TD's
   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

Experiment #2

- Conditioning -

CRes
Force



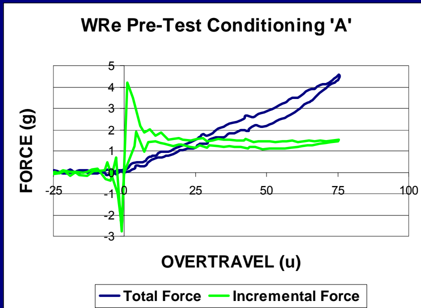


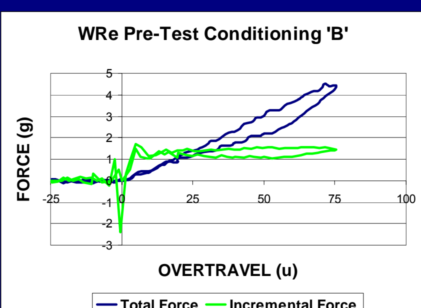
NewTek™

Target:
1.5g/mil

All OK

WRe





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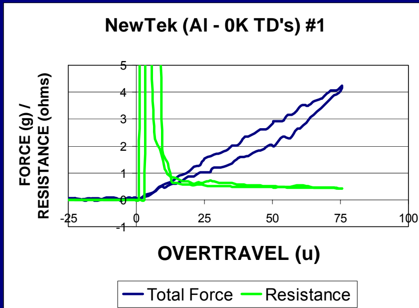
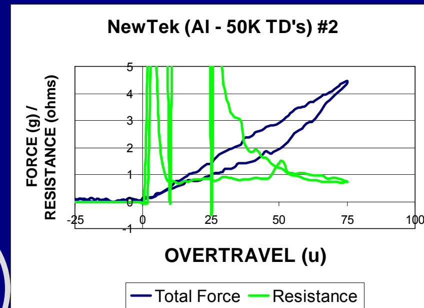
Experiment #2

- Characteristic Curves -

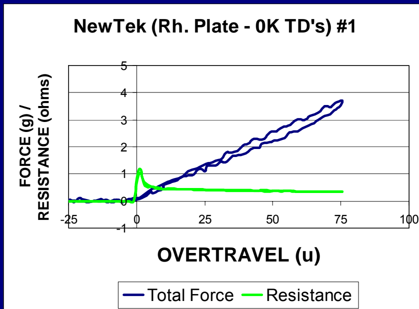
CRes
Force



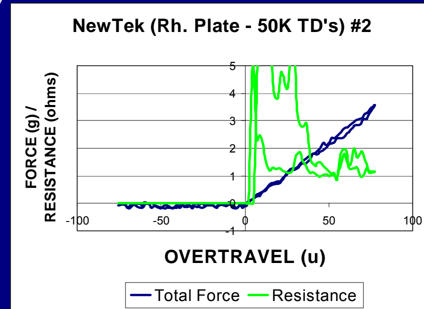
NewTek™



No Cleaning
~.5Ω →+/-1Ω



ANALYSIS UNDERWAY



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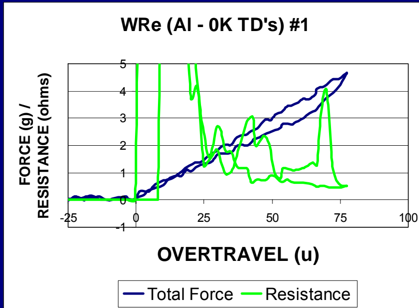
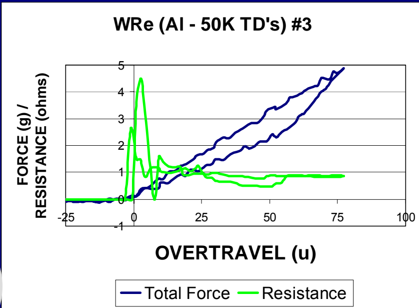
Experiment #2

- Characteristic Curves -

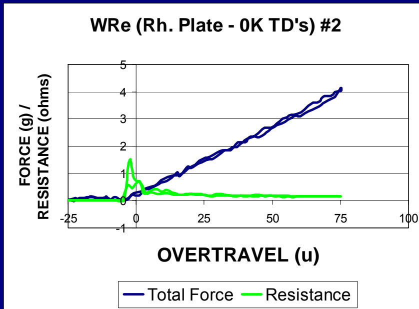
CRes
Force



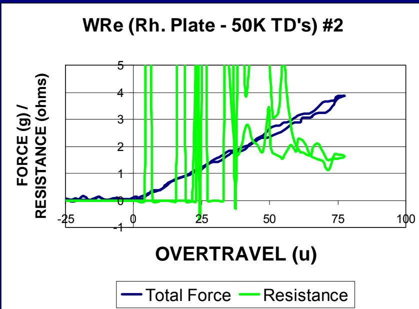
WRe



No Cleaning
~.5Ω →+/-1Ω



ANALYSIS UNDERWAY



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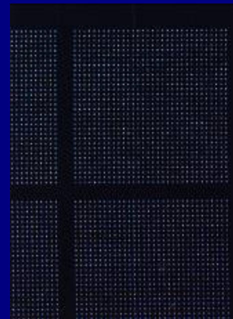
Experiment #2

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

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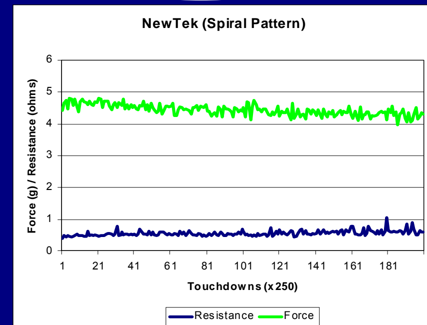
Experiment #2

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

CRes
Force

NewTek™



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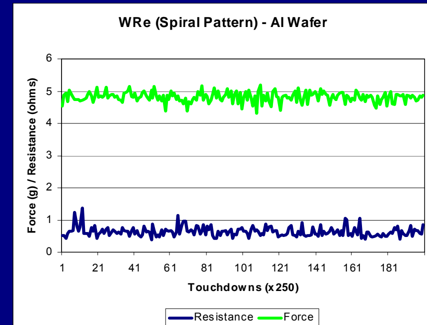

NewTek™: Lower Stable CRes & Lower Force

MORE ANALYSIS UNDERWAY

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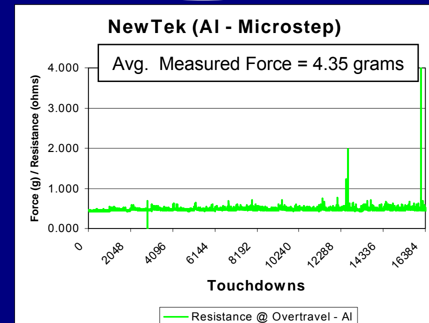
Experiment #2

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

CRes
Force

NewTek™



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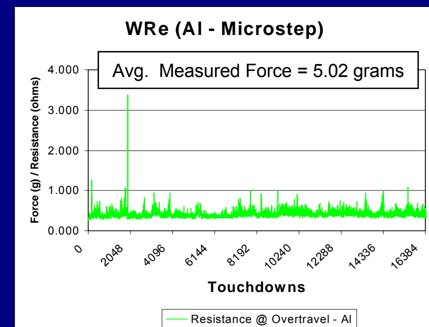

NewTek™: Lower Stable CRes & Lower Force

MORE ANALYSIS UNDERWAY

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Experiment #2

CRes
Force

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

Example:

NewTek™ Characteristic Curve Al @ 0K TD's

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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

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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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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
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- “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