Motivation

- **Experienced the challenges of building advanced memory probe cards**
- **How do you ensure your probe card works in production?**
  - Cards in production deflect differently than PCAs
  - Testing at multiple temperatures is required
  - Intermittent connections can not be detected
  - Life testing with relays does not work
- **Test solutions get expensive**
  - Probe counts - 60K+, embedded ICs, card sizes - >480 mm
  - Need convoluted test flow with custom developed tools
- **Need real time and comprehensive diagnostic tools**
- **There has to be a simpler solution**

Challenges

- **Probe cards can generate >200Kg force & every test cell can deflect differently**
  - Deflection contributors
    - Prober chuck and head plate
    - Probe cards and their attachment to head plates
    - ATE test head weight
    - Temperature distortion (-45 to +200°C)
- **Significantly reduce the cost of test**
- **How do you test for Cres and electrical planarity with ICs in the way?**

Objectives / Implementation

- **Minimize deflection differences of test cells**
  - Mount switch electronics on probe card in target prober
  - Use ATE suppliers interface kits to attach to head plate
  - Use manipulator to support electronics & replicate load
  - Perform tests at all required temperatures
  - Measure tip positions using scrub marks on blank wafer

- **Reduce cost of test**
  - Faster parallel bussed pin testing
  - Streamline the test flow – keep on one tool
  - Minimal cabling and connectors
  - Scrub mark damage to replace force measurement

- **Test through embedded ICS**
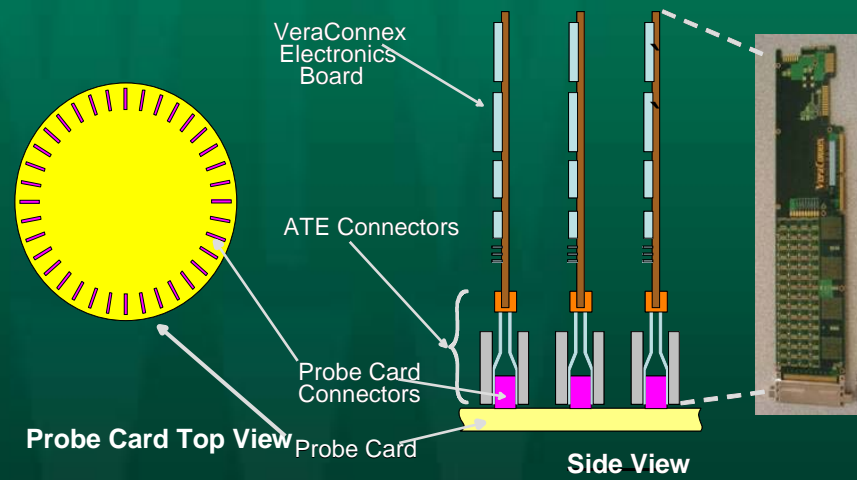 - Any channel can be a logic control channel

Approach

- **First target: ATE with large installed base**
  - Advantest T5375: 96 ZIF connectors, 440 mm
- **Criteria**
  - True 4 - point measurements
  - Control digital ICs
  - High performance: intermittent & life time testing
    - Hot switching & stable $\Rightarrow$ solid state switches
  - Measure passives and relays
  - Scalable architecture: start at 65,536 channels
  - Thorough self-test: configuration and communication
  - Confocal microscope: location & damage = force

Electronics Hardware

- **Manipulator to support pin electronics and match load**

- **Prototype: Shown directly mounted on head plate of EG prober**

VeraConnex Electronics Board

ATE Connectors

Probe Card Connectors

Probe Card Top View Probe Card

Side View

Prototype on EG Prober

Cres Testing: Signal Probes

- **4-wire resistance measurement of each probe using probe card**
  - Use prober to raise blank metalized wafer in contact with all probes
  - Connect force F+ and sense S+ rails from measurement unit to selected probe
  - Connect force F- and sense S- from measurement unit to several near by probes
  - Voltage across F+ to F- limited to < 50mv to not burn through interface layers
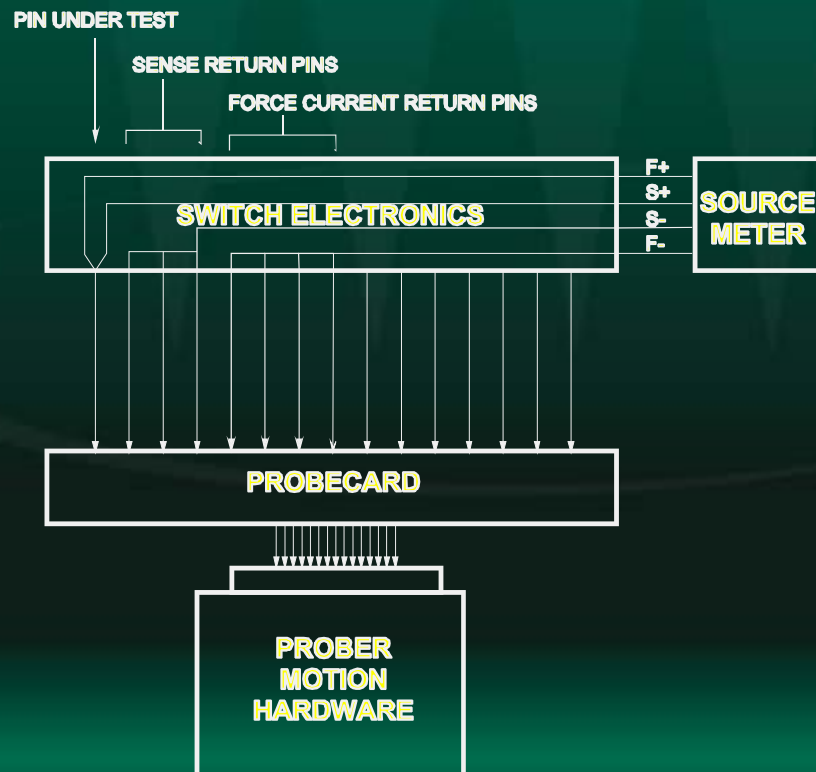
Performance Verification

- **Use system to analyze a 64 site LM4 probe card to evaluate tool effectiveness in diagnosing problems**

  – Electrical Planarity (on Au and Al wafers)

  – Cres on 100 touchdowns to Au and Al wafer

  – Leakage

- **Verify measurement speed**

  – More than 300 Cres tests per second
     (Data+Reports for presentation in minutes)

  – Immediate data analysis and capture of images from electrical results
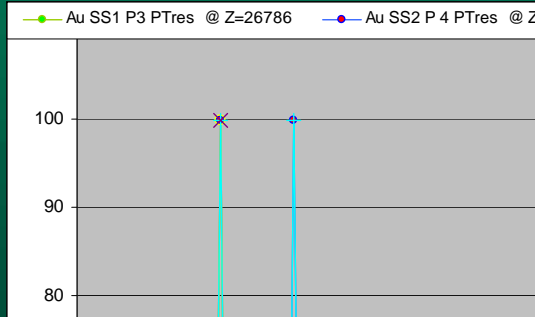
Resistance Repeatability

- **Pin Card Measurements with shorting board**
  - 100 Measurements are consistent to within 16 mohms
  - Values include: Shorting resistance +Traces + Connector
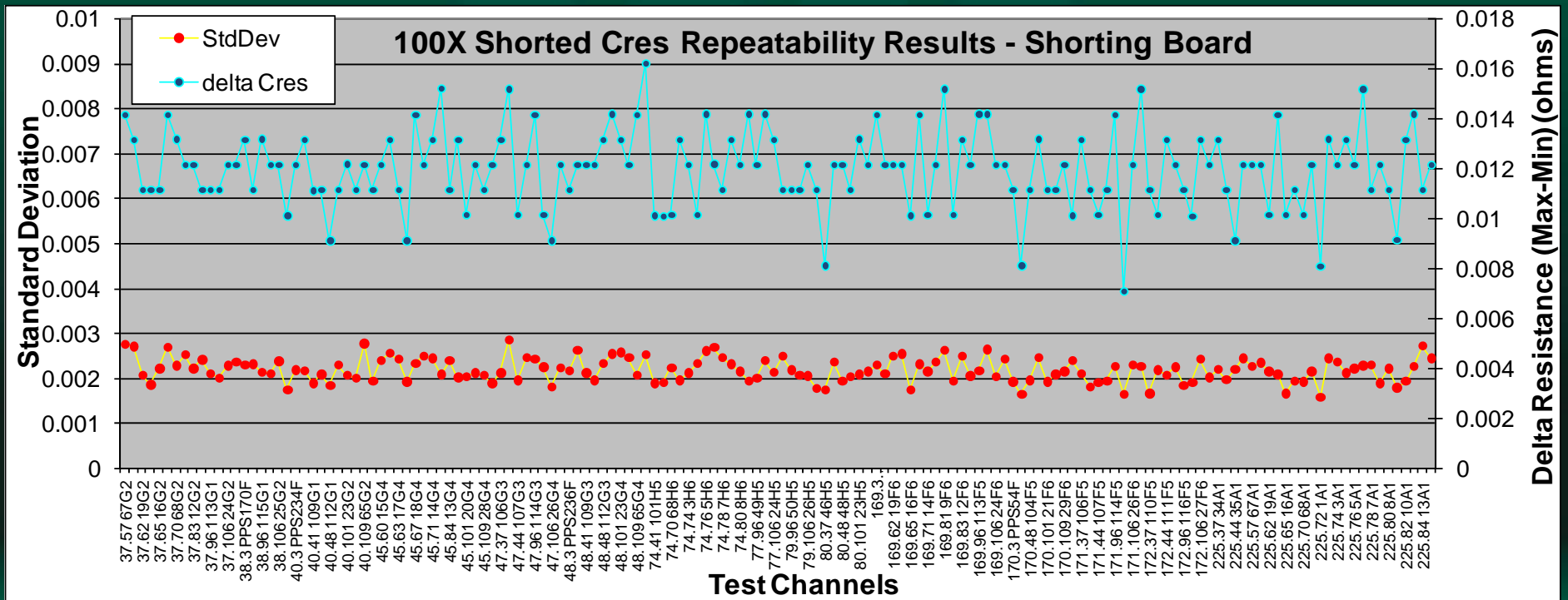
3X Planarity Results on Au Wafer
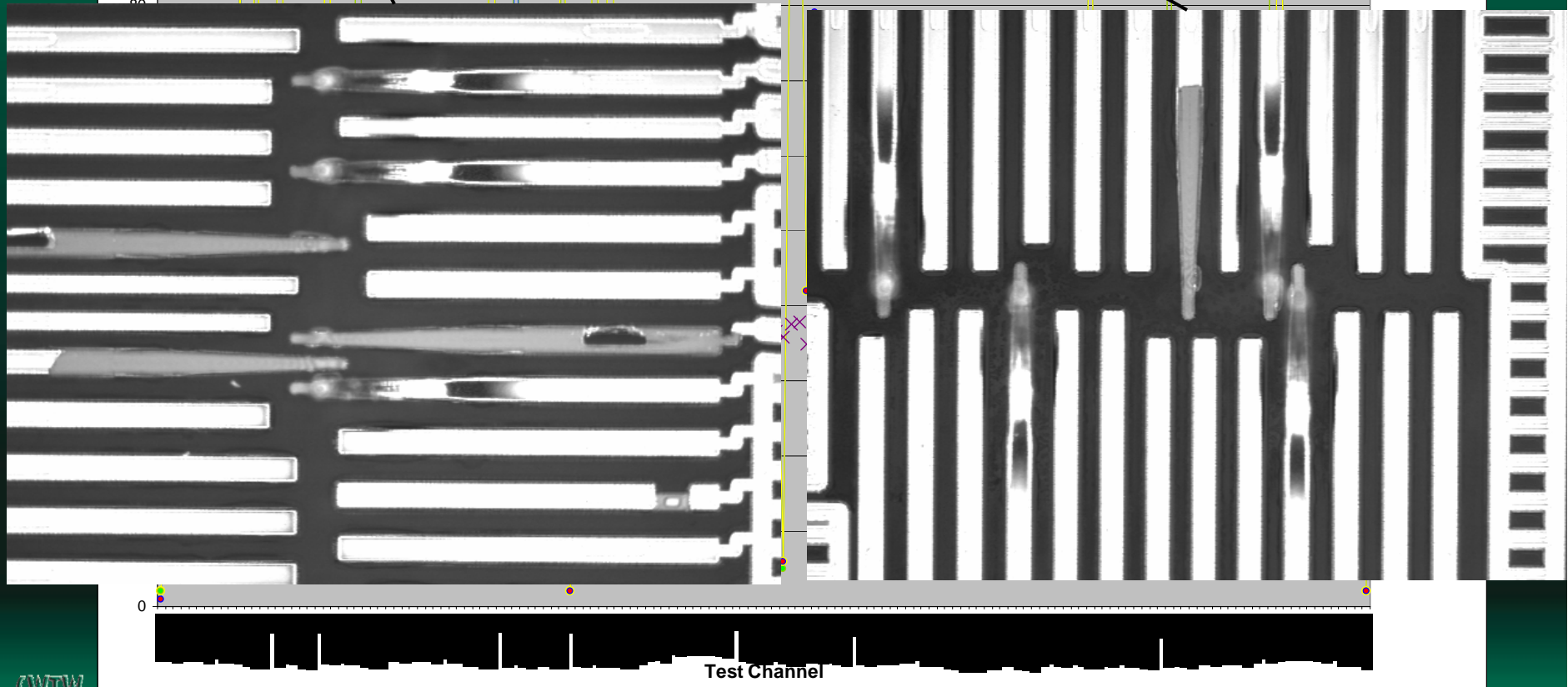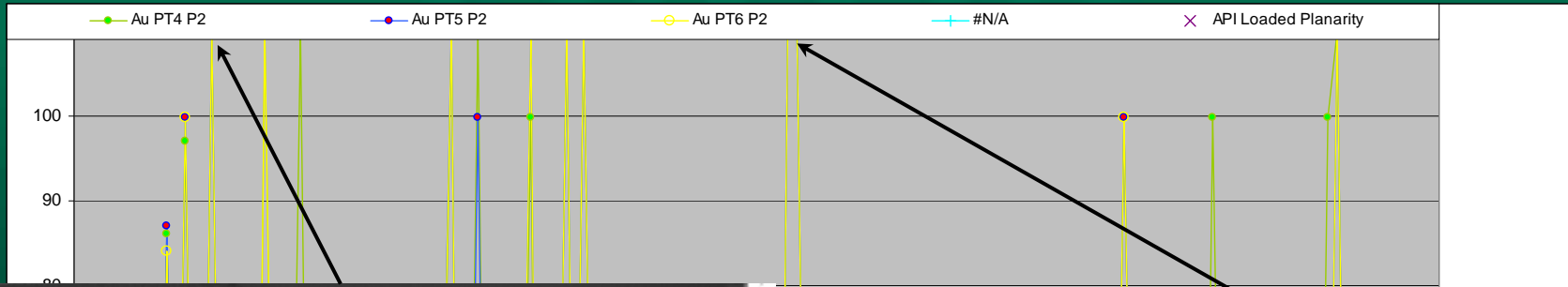
Stepping Cres on Au Wafer (100um OD from 1st touch)

Corresponding Scrub Marks
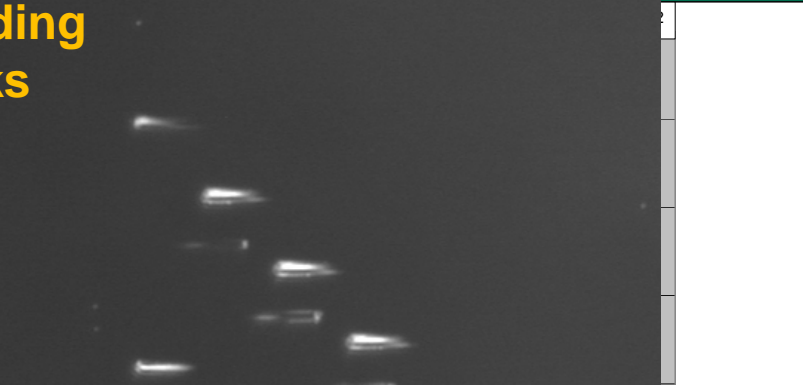
Positions with Fluctuating Cres
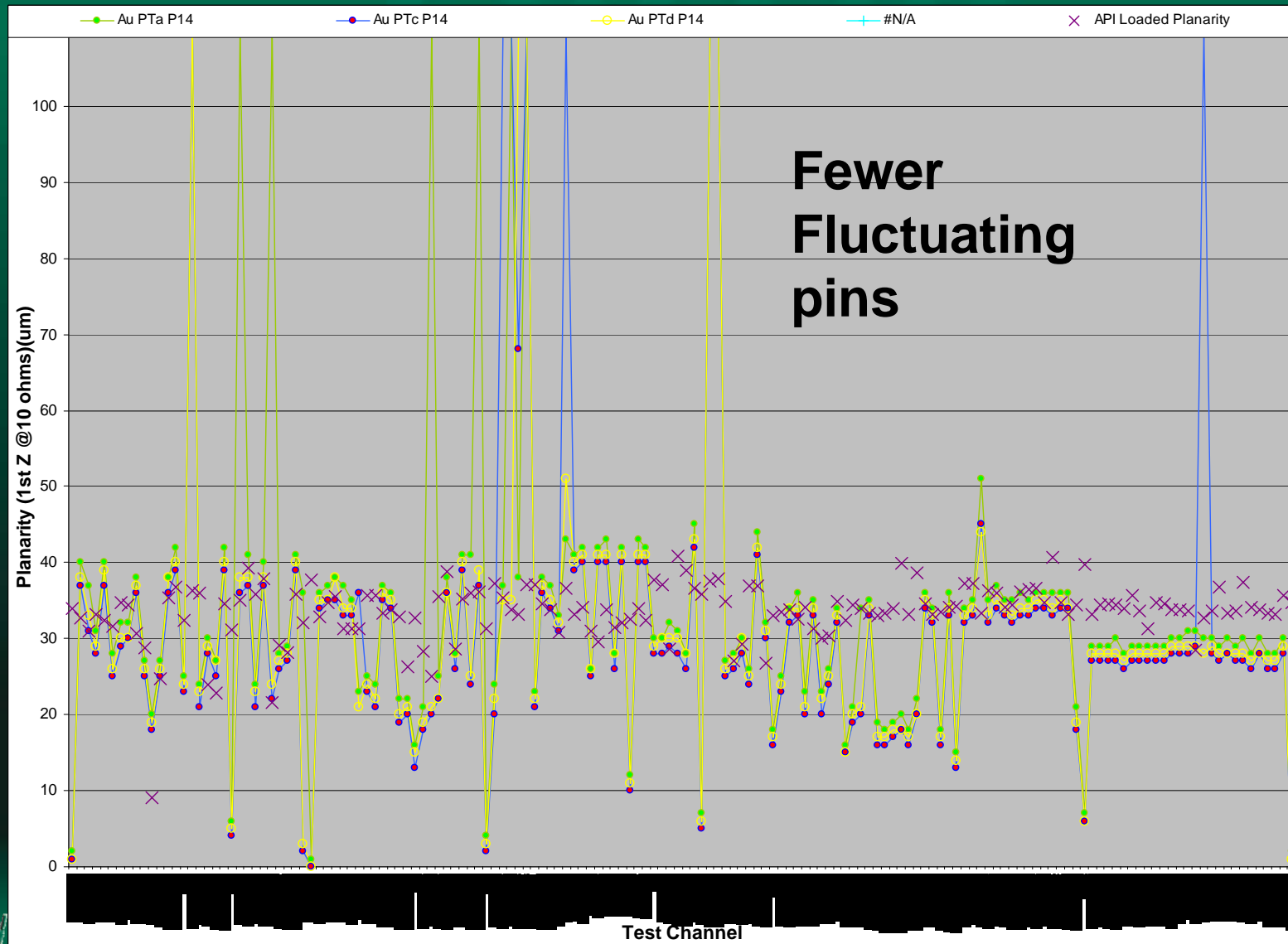
After 50 steps on Probe Clean™ @ 50um OD

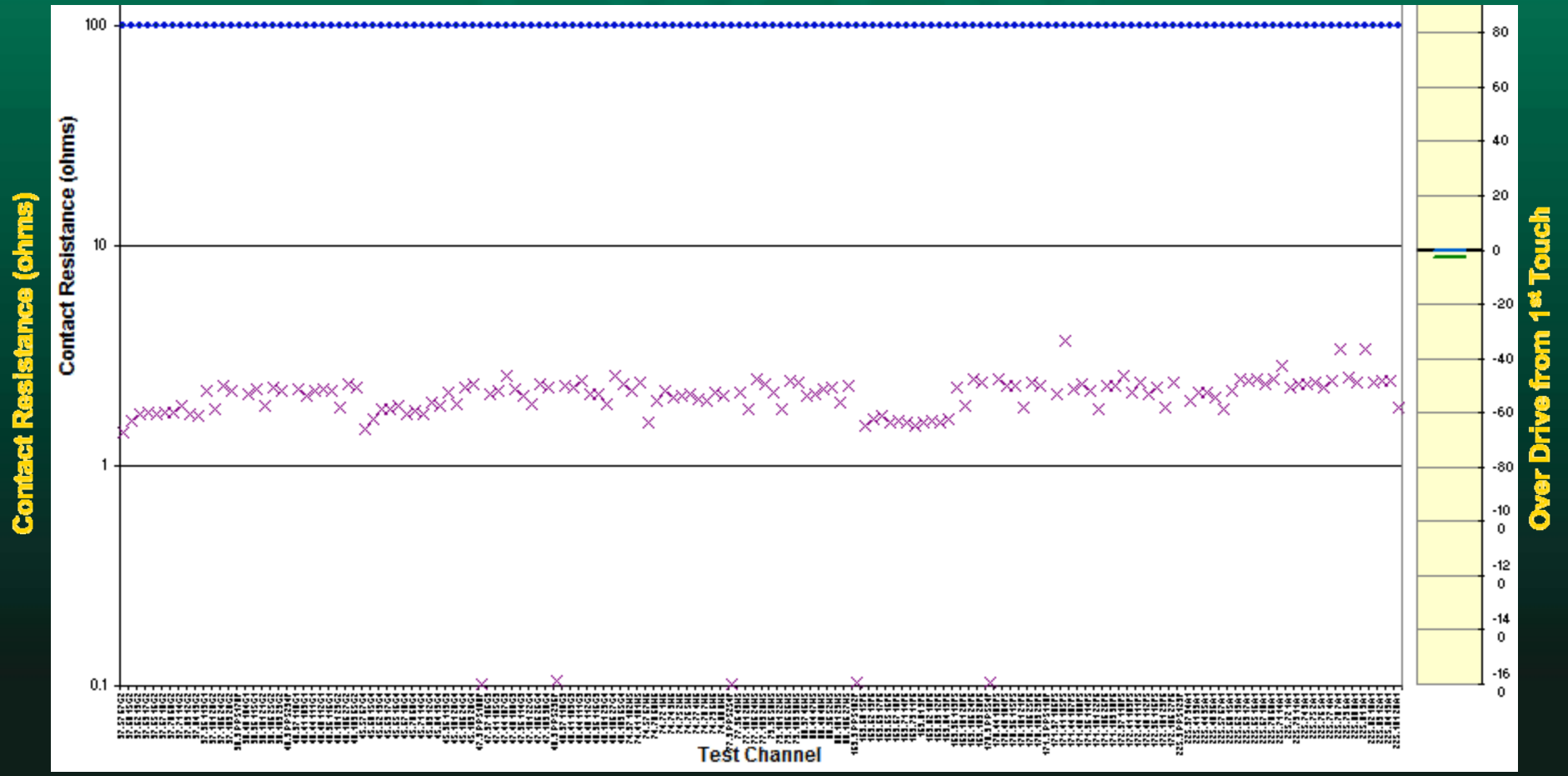**After Probe Clean™ + 50 Steps on WC + Probe Clean™**
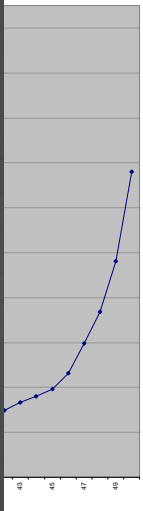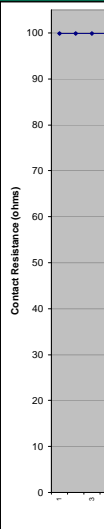
3X Planarity on Au Wafer after clean
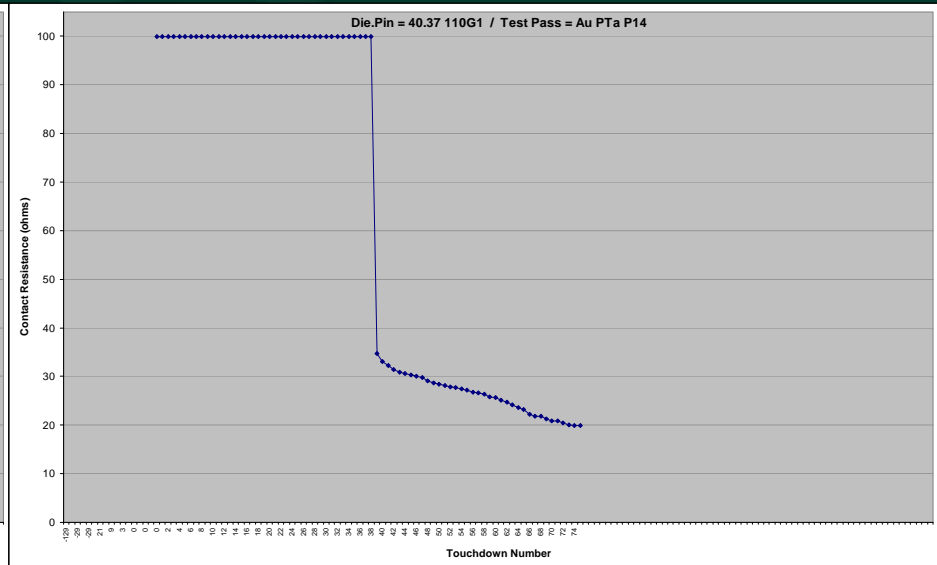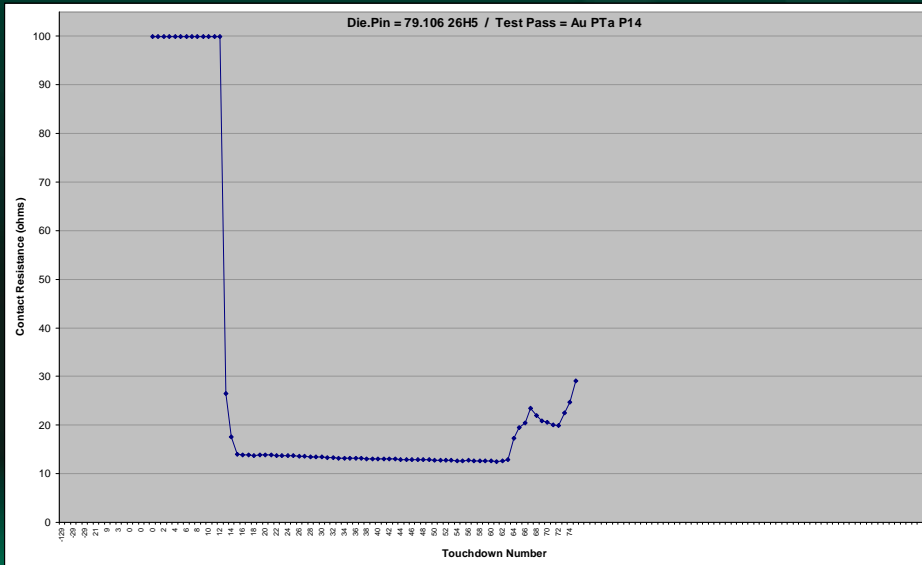
Animation of Contact Resistance During Planarity Test
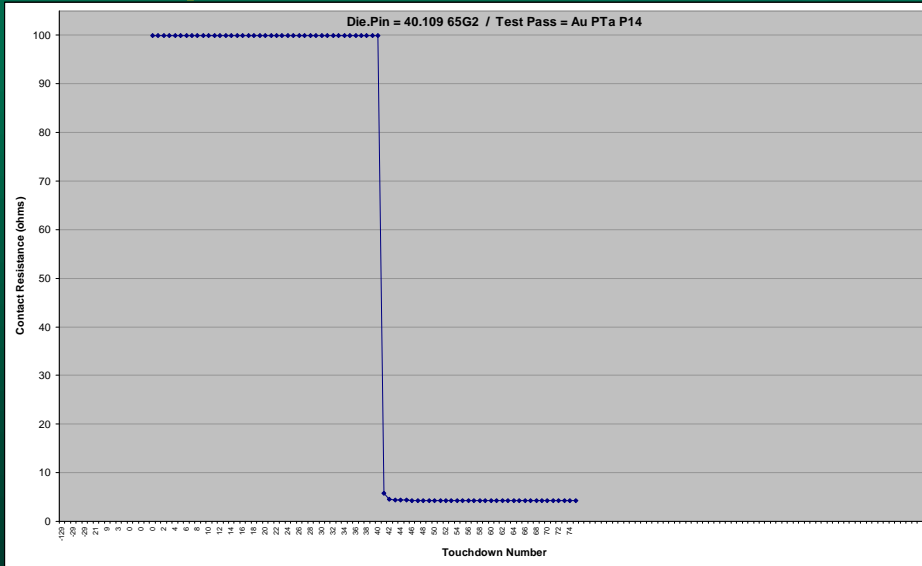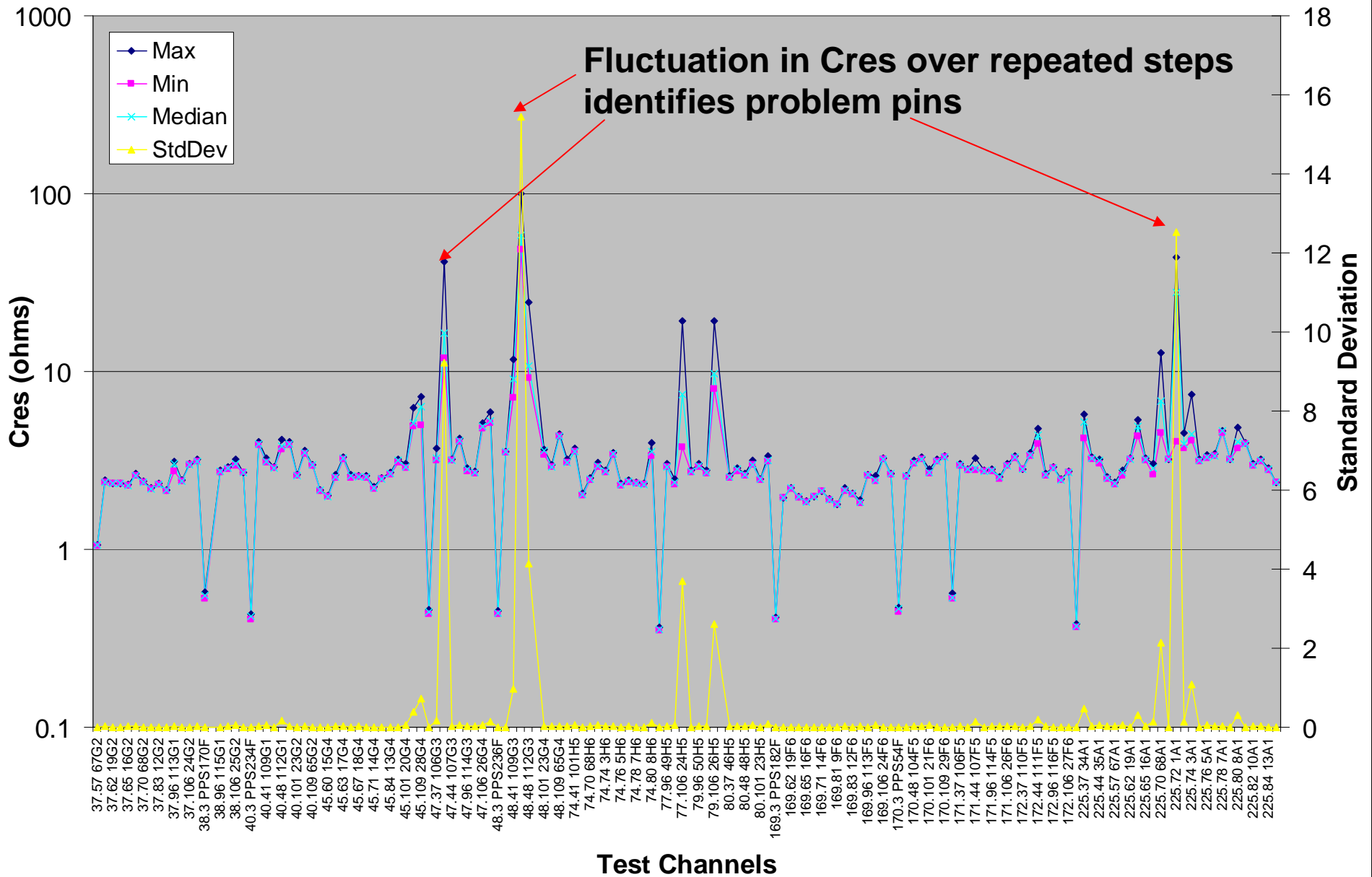
Individual Pin Cres During Planarity Test
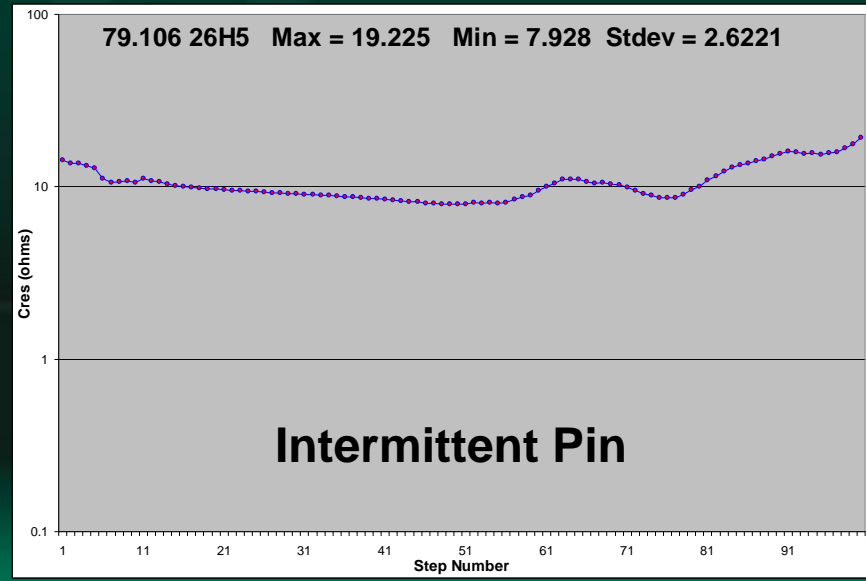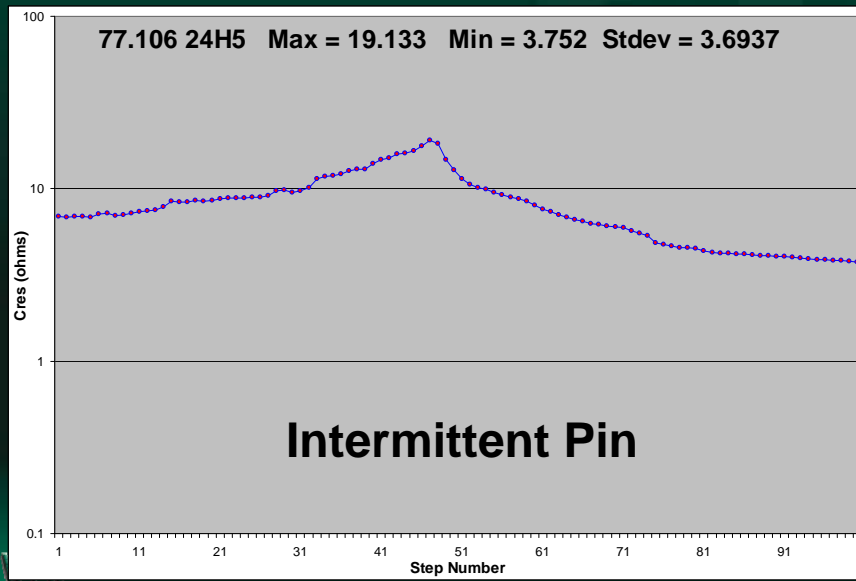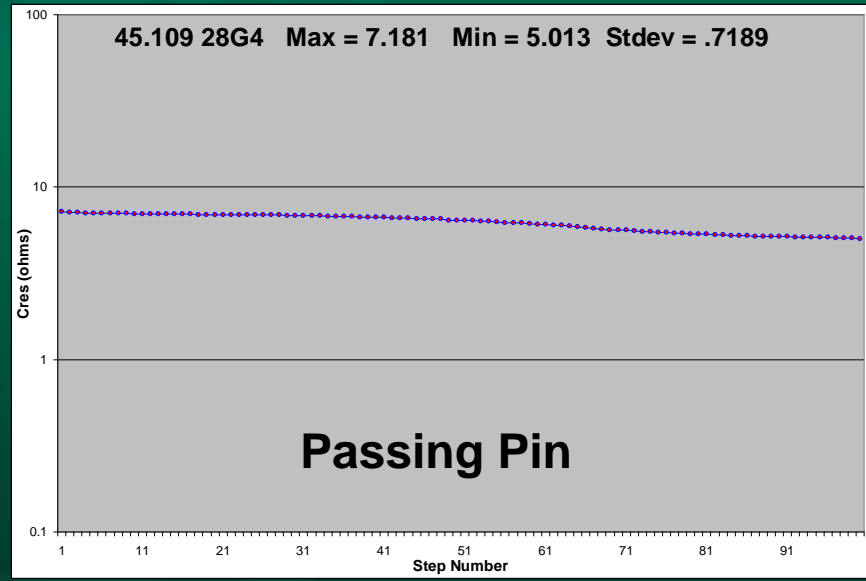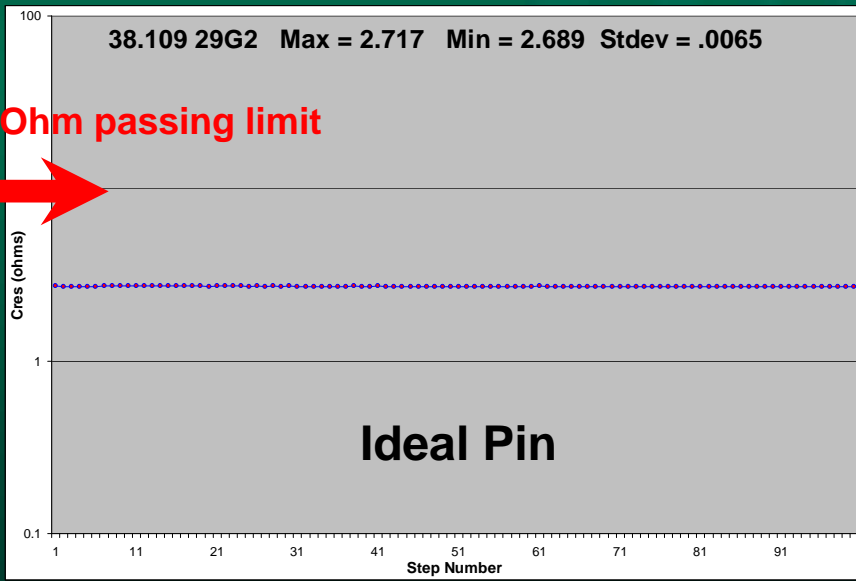## (Au Wafer @ 75um OD after 1st touch) (Post clean)
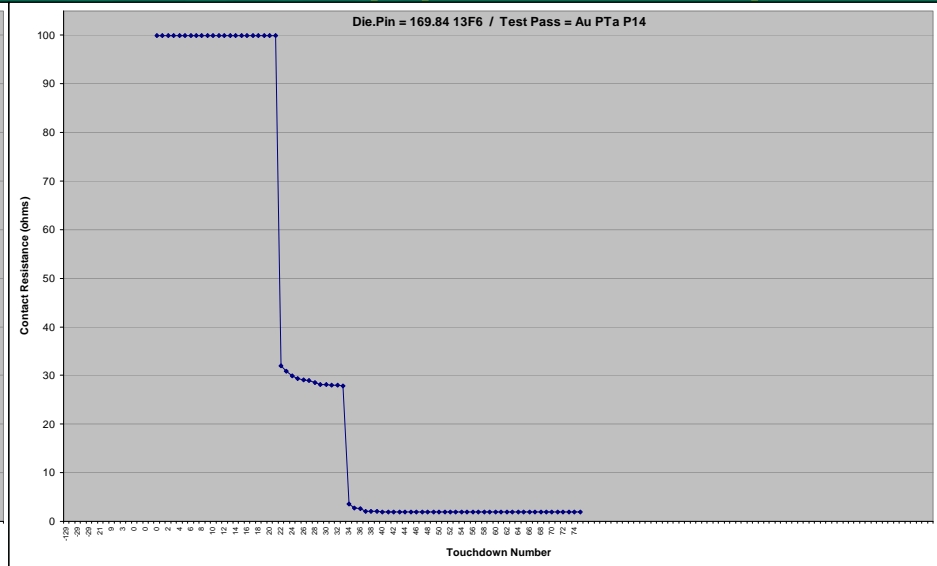
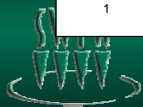**100 Step Repeatability Results - No stepping (Pos 1) (50um OD on Au6)**

Fluctuation in Cres over repeated steps identifies problem pins

Legend: Max, Min, Median, StdDev

Y-axis (left): Cres (ohms)
Y-axis (right): Standard Deviation
X-axis: Test Channels

Per Pin Cres Signature over 100 Steps on Au

38.109 29G2   Max = 2.717   Min = 2.689 Stdev = .0065

10 Ohm passing limit

Cres (ohms)

Ideal Pin

Step Number

45.109 28G4   Max = 7.181   Min = 5.013 Stdev = .7189

Cres (ohms)

Passing Pin

Step Number

77.106 24H5   Max = 19.133   Min = 3.752 Stdev = 3.6937

Cres (ohms)

Intermittent Pin

Step Number

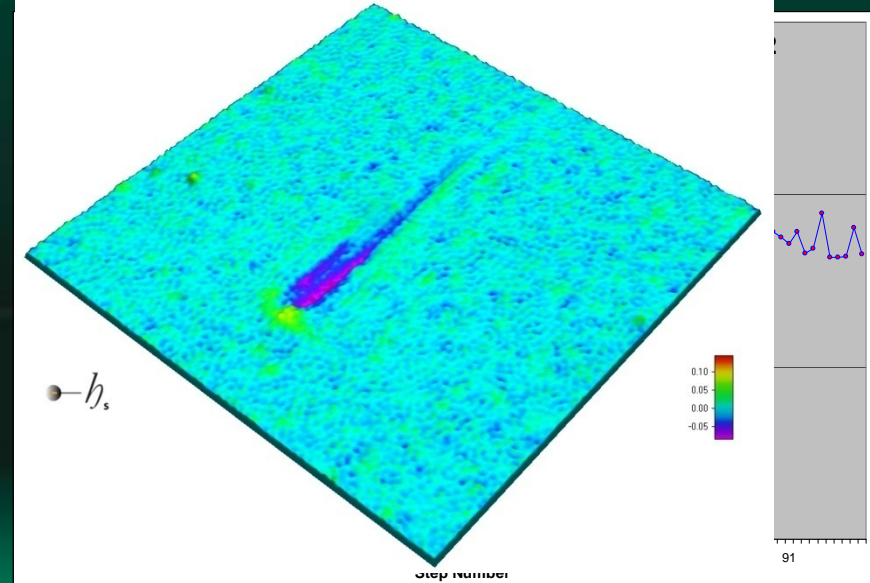79.106 26H5   Max = 19.225   Min = 7.928 Stdev = 2.6221

Cres (ohms)

Intermittent Pin

Step Number

Per Pin Cres signature over 100 Steps on Al

First Touch Z Sampled During 1 hr Soak

Initial Probe card temp = 25°C
Chuck temp = 85°C

Legend:
- Soaking with chuck tracking at 0 um OD
- Soaking with chuck tracking at 50um OD
- Soaking at 200um below tip median plane(@25°C)
- Reference with Chuck and Probe card @25°C

Y-axis: Delta Z from Room temp Position (um)
X-axis: Time (secs)
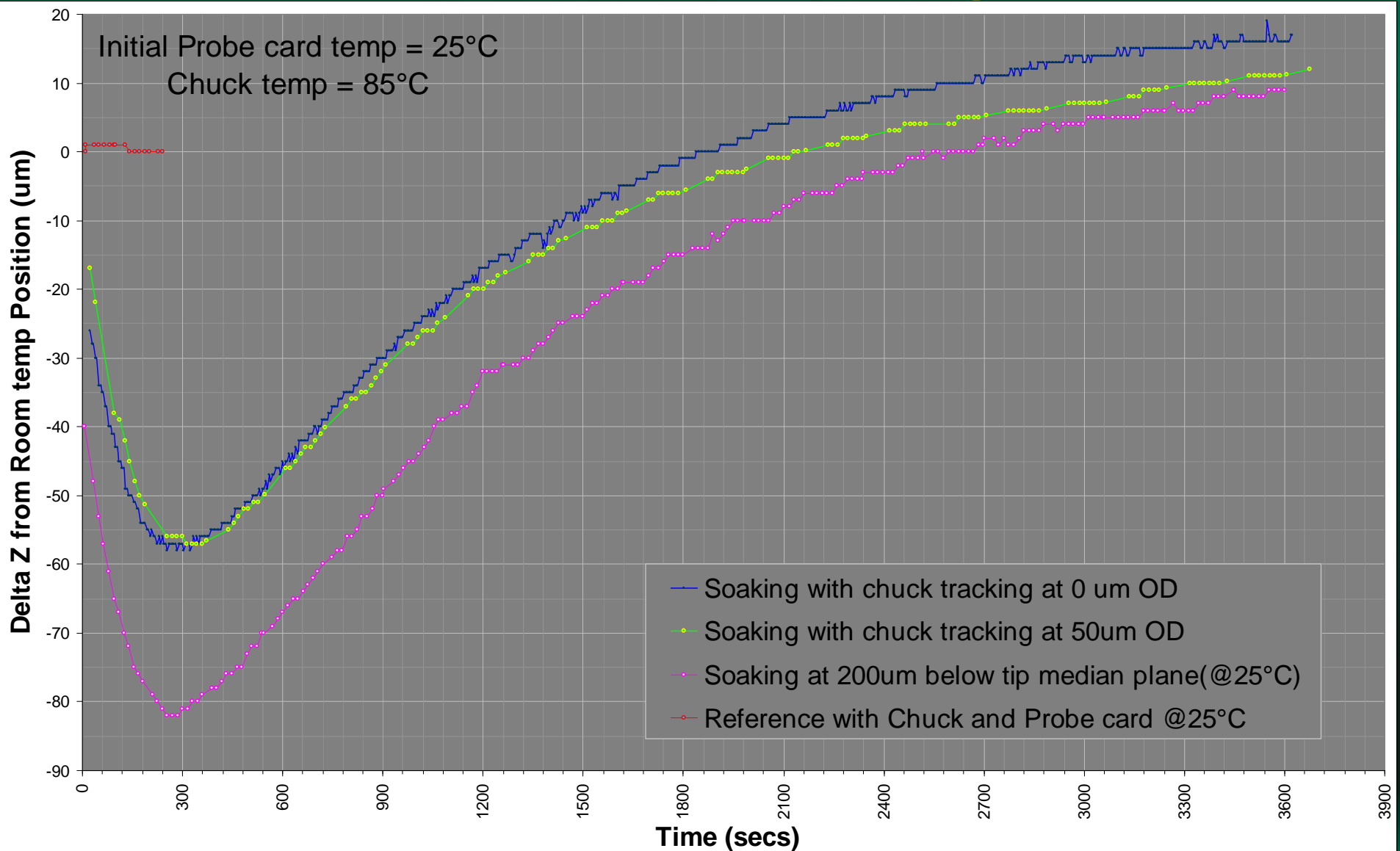
Dynamic First-Touch Z Profiling
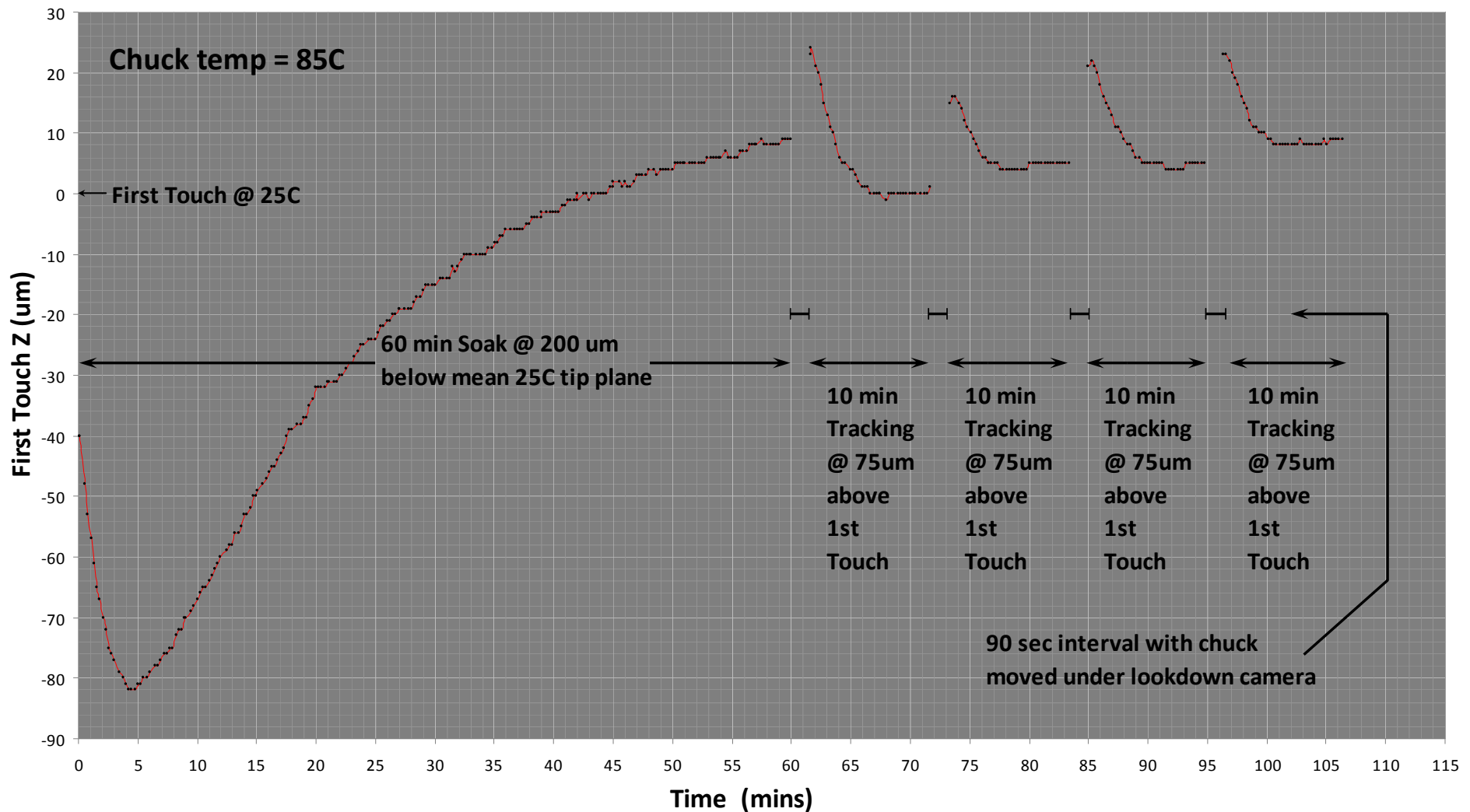
Results

- **Demonstrated that the system can collect data in minutes and provide immediate analysis**
- **Fast electronics integrated into prober opens up new methods in diagnosing problems**
  - Fast Cres measurements enable collection of individual pin signatures
    - Can identify unique problems despite passing Cres
    - Intermittent Cres can be identified
  - Dynamic planarity behavior of probe card can be observed
  - Integrated real time data analysis help correlate measurements to problem pins

Follow-On Work

- **Investigate other signatures**
  - Scrub

- **Correlation of pin signature to**
  - Probe card life
  - Product die test yield

Acknowledgements

- **Co-Authors: VeraConnex, LLC**
  - Frank Swiatowiec
  - Fariborz Agahdel
  - Bruce Pettyjohn
- **Hyphenated Systems, LLC**
  - Edward Robinson
- **Electroglas, Inc.**
  - Steve Martinez
  - Jonathan Halderman
- **Aehr Test**
  - Chris Buckholtz