Closed-Loop Metrology

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Closed-Loop Metrology

Overview

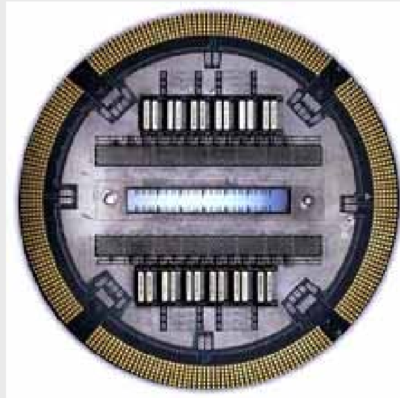
- **Probing Process Evolution**
- **Theory: Closing the Loop**
- **Applications**
- **Implementation**
- **Works in Progress**
- **Conclude**

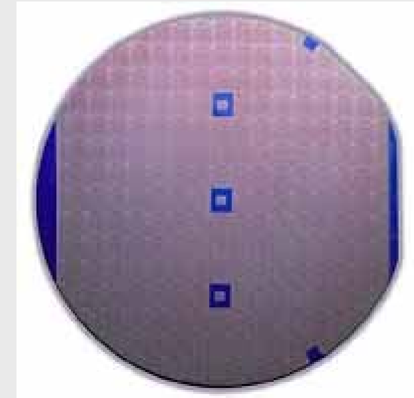
Process Without Metrology

Probe Card

Test Cell

Probed Wafer

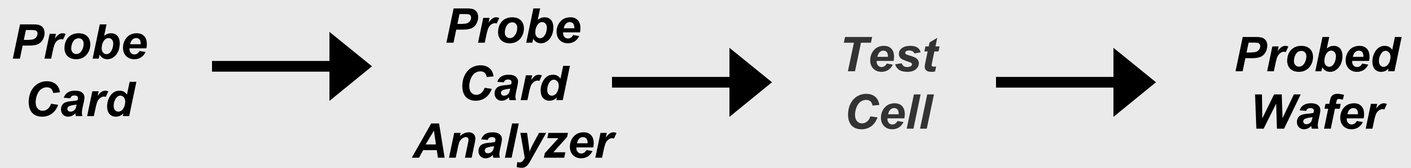


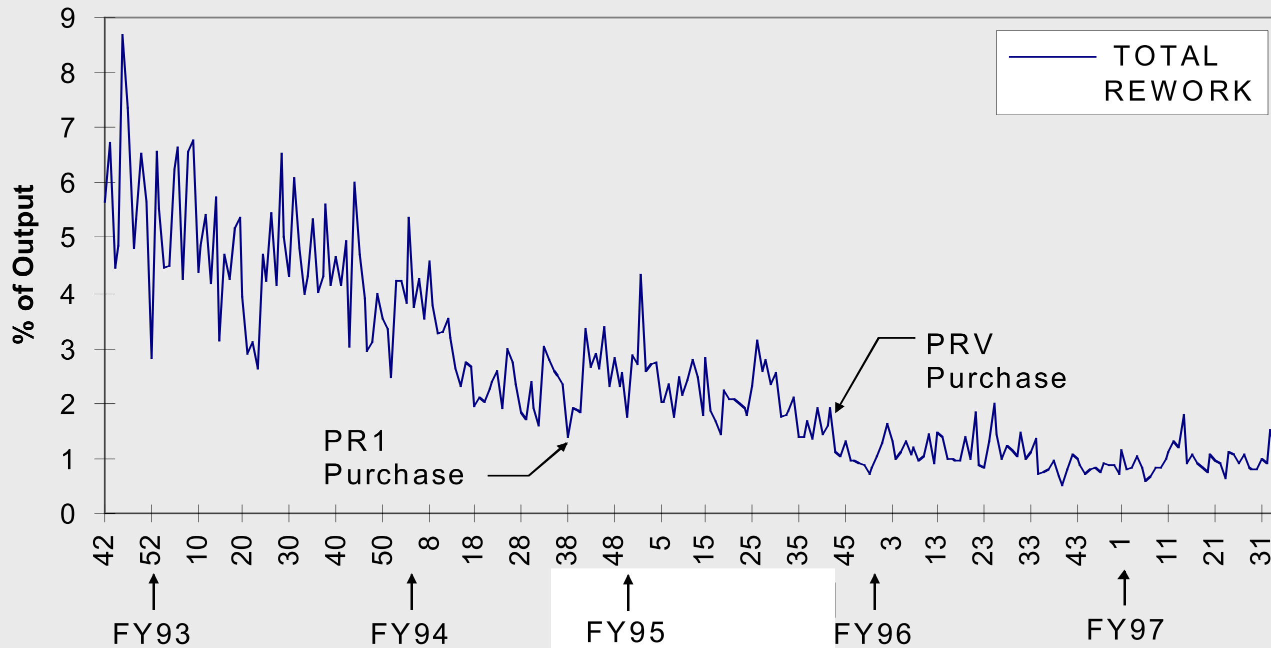


Serial Probing Process

Open-Loop Metrology

Improved Open-Loop Serial Probing Process



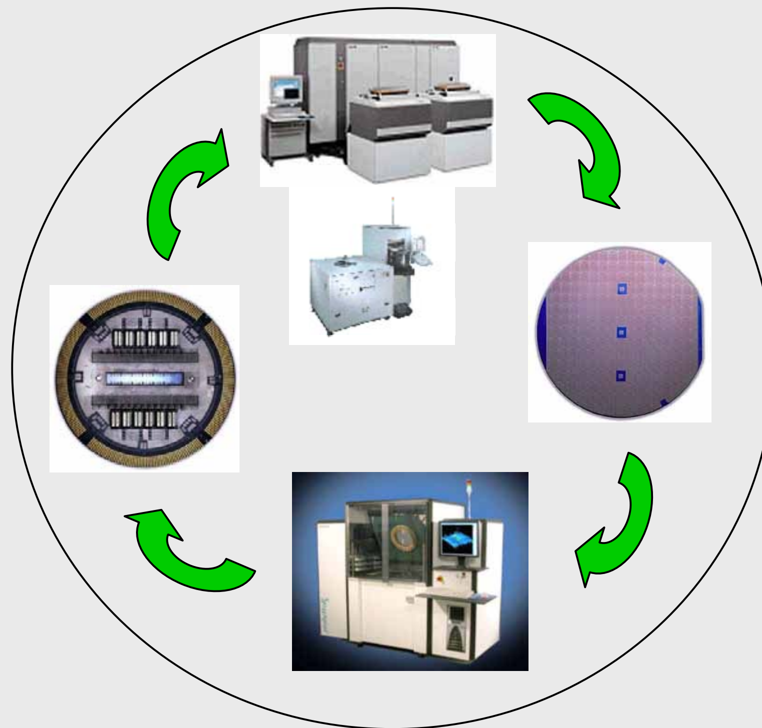


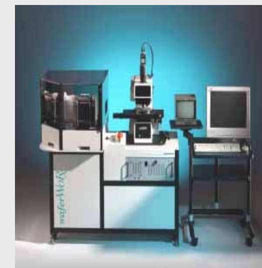
Data Source: ATMEL Memory Group

ITC Economics Workshop

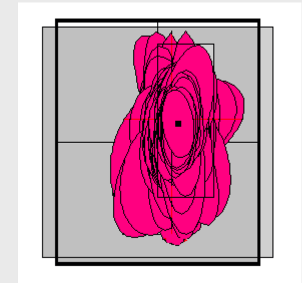
Starting a Closed-Loop Metrology Process

- Today's process's are complex
- Understanding the process as a whole is critical
- Utilize the advanced tools available
- Use data to identify & stay within the "sweet spot"





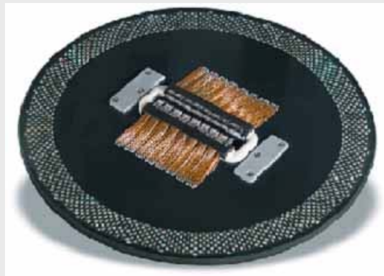
Process Analysis System



Process Precision

Probing Process w/Process Analysis

Closed-Loop Theory



PROCESS PRECISION
(Process Width, Process Length)

Prober Precision
(Prober Setup, Prober Stage)

Probe Card Precision
(Probe Card Width, Probe Card Length)

Setup Parameters

Stage Parameters

Fixturing

- *Card Pitch*
- *Card Roll*

Probe-to-Pad Alignment

- *X Setup*
- *Y Setup*
- *Card Yaw*

Stage Parameters:

- *Wafer Alignment*
- *Orthogonality*
- *X Wafer Scale*
- *Y Wafer Scale*
- *Overtravel Variation*
- *X Deflection*
- *Y Deflection*
- *X Residual*
- *Y Residual*
- *Yaw Variation*
- *Hysteresis*

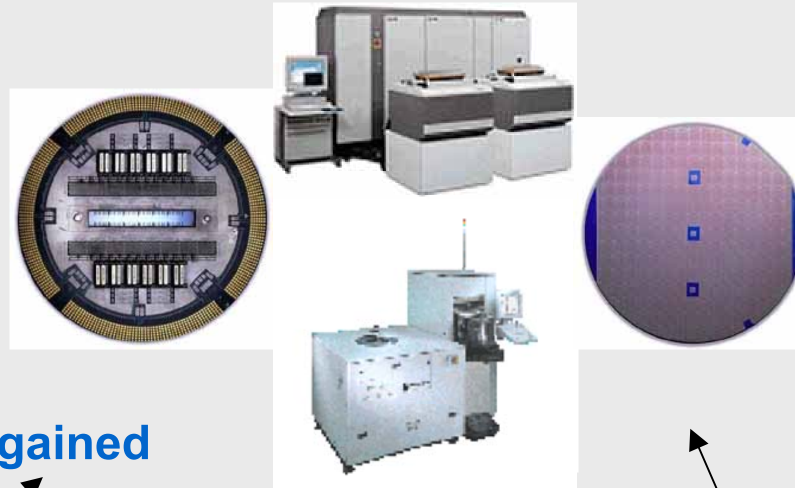
Probe Card Precision:

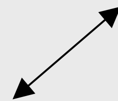
- *X Card Accuracy*
- *Y Card Accuracy*
- *X Card Repeatability*
- *Y Card Repeatability*
- *X Scrub Size*
- *Y Scrub Size*
- *X Card Scale*
- *Y Card Scale*
- *Overtravel Scaling*

Correlation Parameters (X Card Scale, Y Card Scale, Overtravel Scaling)

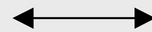
Closed-Loop Metrology

- Collect the data
- Centralize the data
- Analyze the data
- Understand the data
- Correlate the data
- Apply the knowledge gained

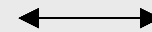




Probe Card Analyzer



Central Database



Process Analysis System

Closed-Loop Metrology enables…

- **Process component analysis**
  - Test cell related
  - Probe card related
- **Correlation between PCA and Test Cell**
  - Scrub Correlation
  - Test at Temperature affects
  - PCA fixturing vs. Prober fixturing/set-up
  - Loads/deflections of the *systems* involved
- **Trend analysis**
  - Optimization/evaluation of cleaning processes
  - Determining prober maintenance schedules
  - Probe card life/maintenance
    - *Reducing inventories and rush charges*
- **New card technology evaluation**
  - Tip shapes/materials/wear
- **Capitol equipment procurement matched to product roadmaps**
  - Knowledge of process latitude is imperative

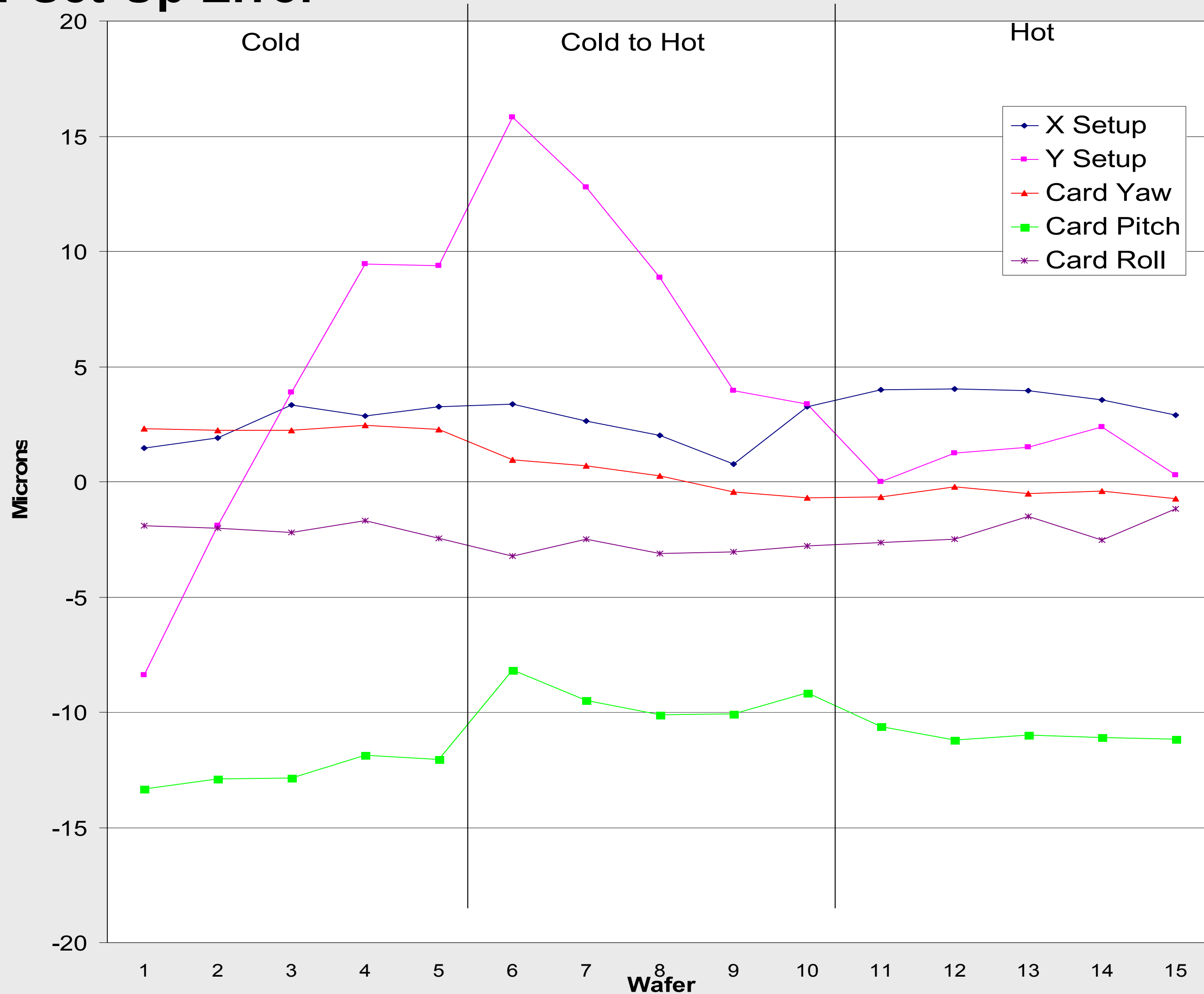
Closed-Loop Metrology Data

Data Analysis

- What parameters are affected by temperature?
  - Prober Set-Up
  - Prober Stage
  - Probe Card
- Probe card
  - Microspring Card
    - 2000+ probes
    - 8x8 - multi-DUT
- Wafers
  - 200mm
    - 15 Wafers
    - 36K+ scrub marks measured per wafer
    - Probed at –30ºC up to 90ºC

Closed-Loop Metrology Data

Prober Set-Up Error

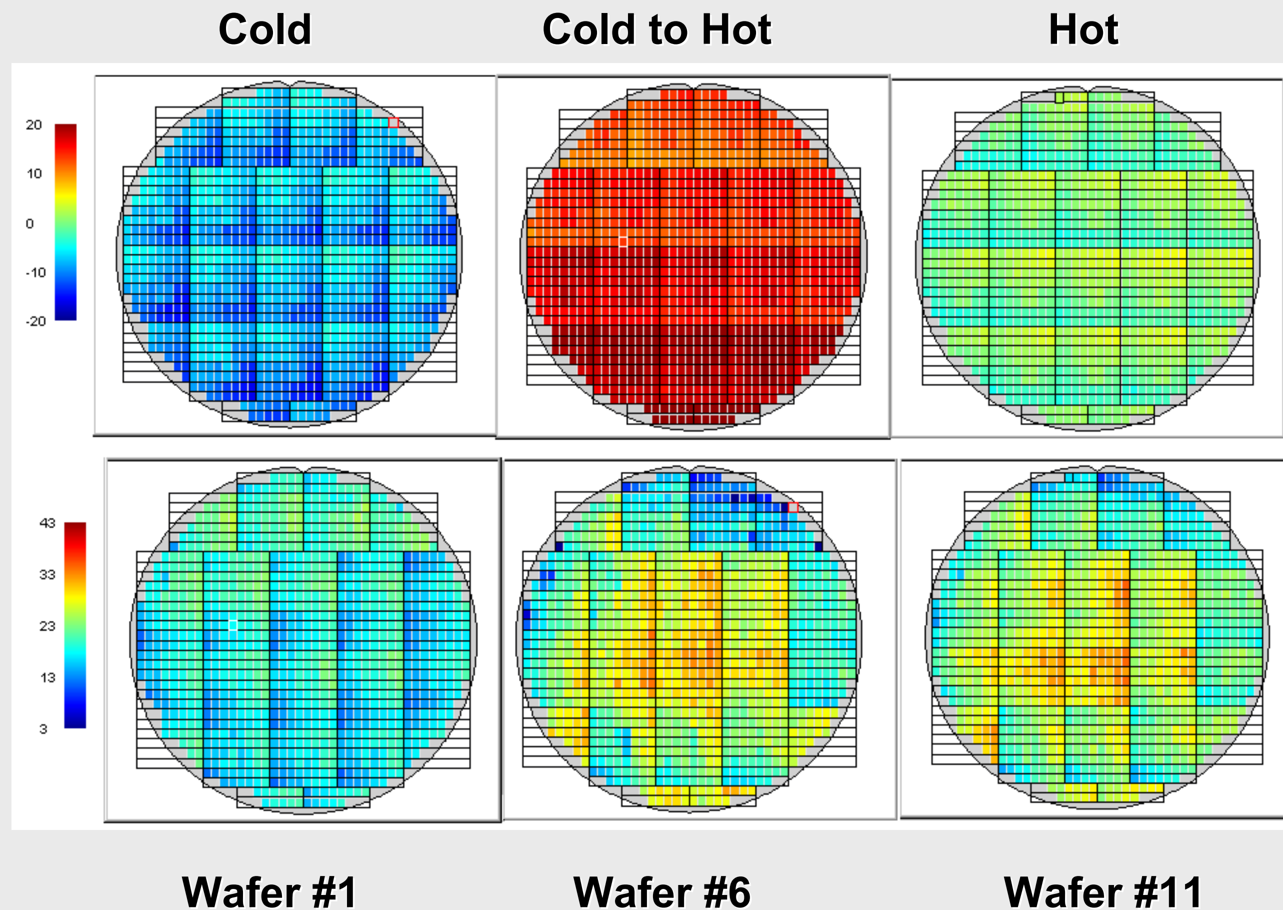


Closed-Loop Metrology Data

Prober Set-Up Error

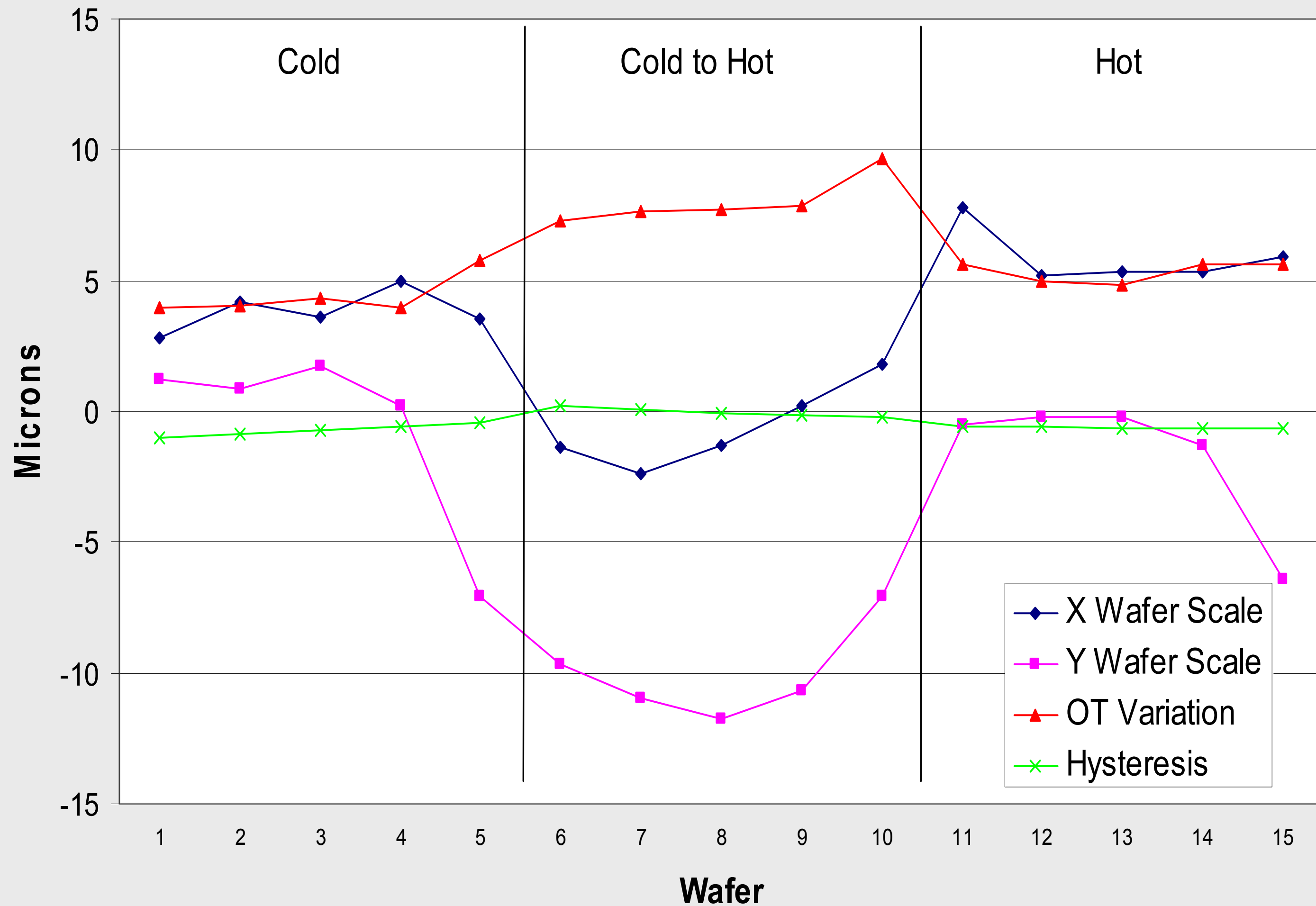
“Y” Scrub Position

Normalized Scrub Length



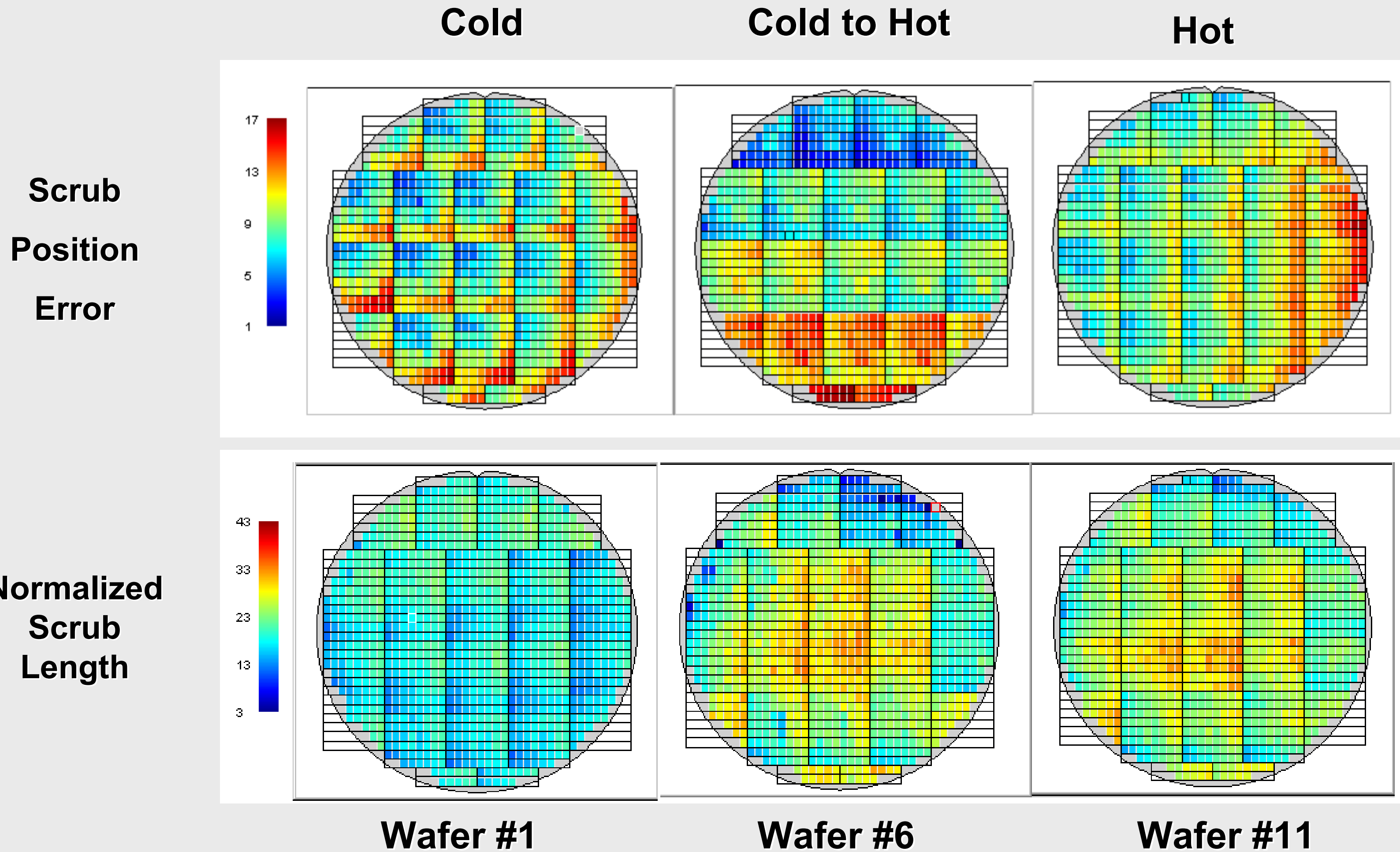
Closed-Loop Metrology Data

Prober Stage Error



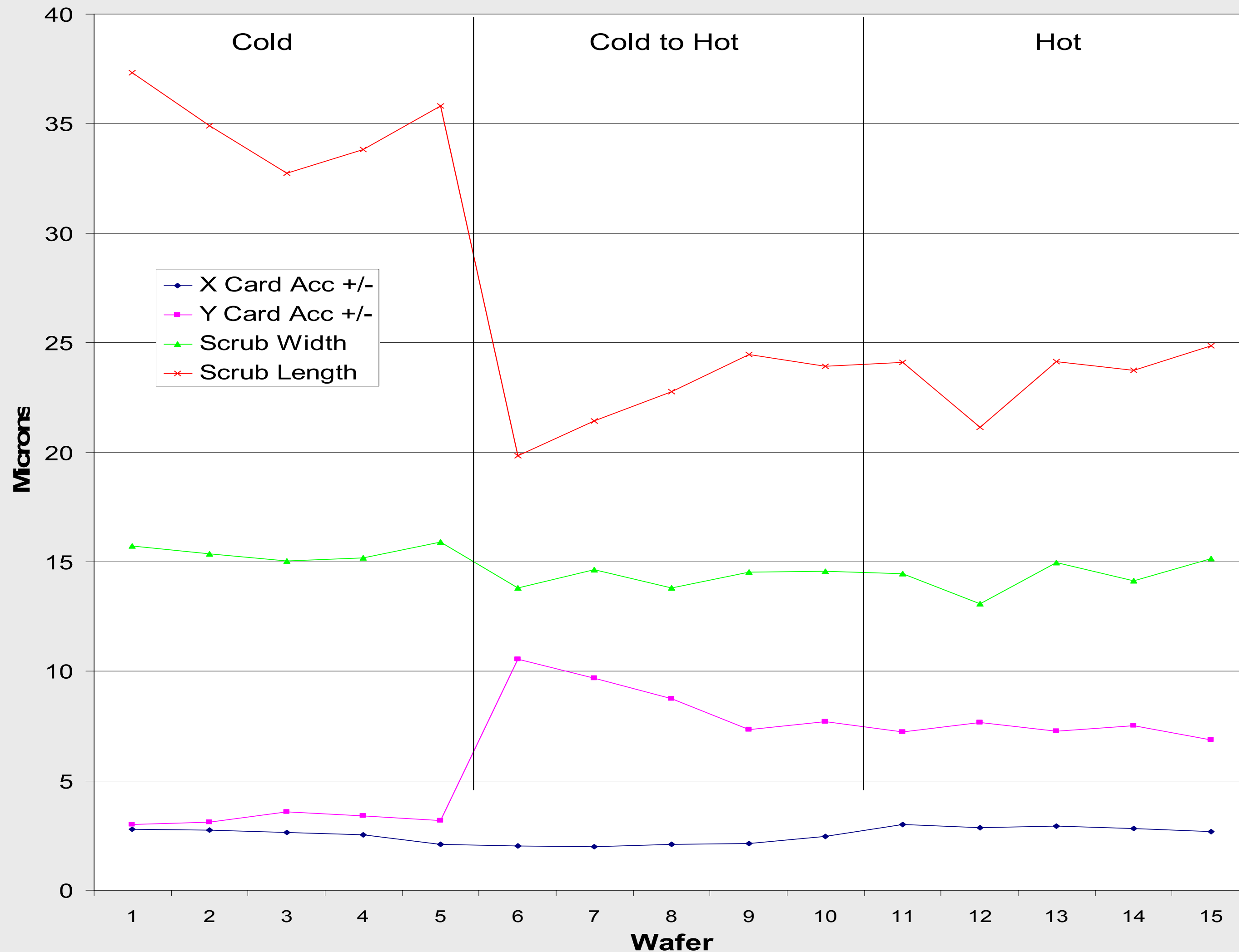
Closed-Loop Metrology Data

Prober Stage Error



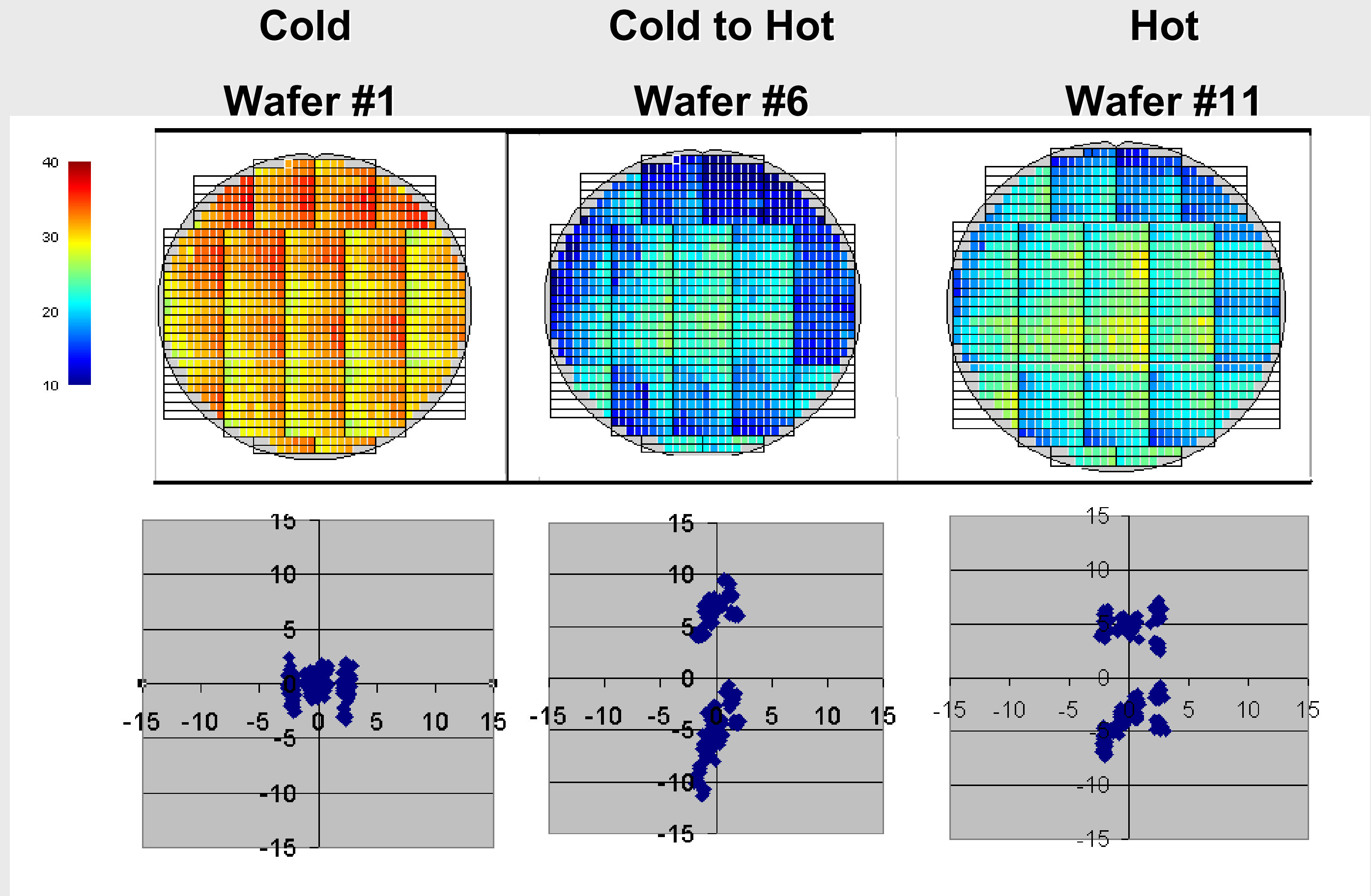
Closed-Loop Metrology Data

Probe Card Error



Closed-Loop Metrology Data

Probe Card Error



Scrub Length

Probe Position

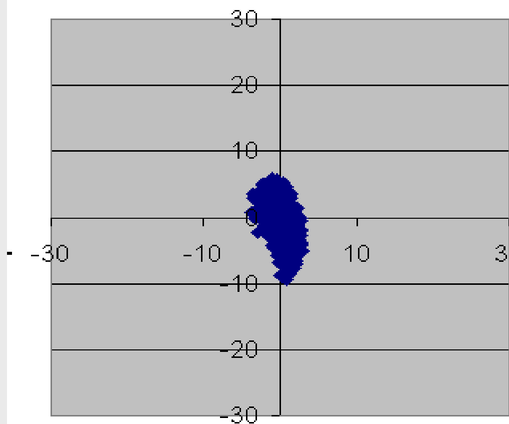
Closed-Loop Metrology Data

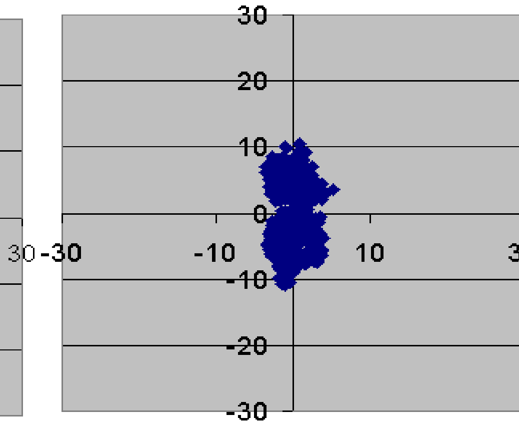
Correlation

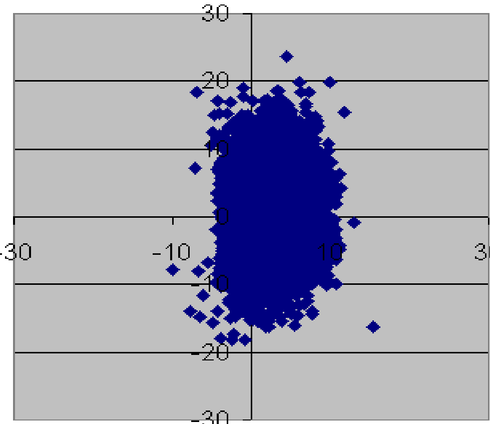
PCA – Tip position

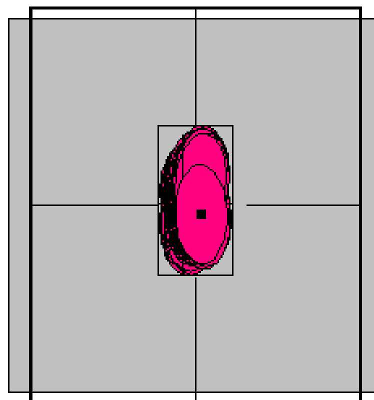
Scrub position – Card only

Scrub position – Raw









Requirements for Closed-Loop Metrology

Implementation needs…

- –Champions for Improvement
- –Infrastructure
- –Equipment to Provide Data
- –Centralized Data Storage
- –Data Analysis Tools
- –Must Adjust Process Based on Data

Closed-Loop Metrology Status

Applied Precision Works-in-Progress:

– Additional Capability for waferWoRx
  - 300mm wafer analysis capability
  - Wafer lot analysis

– 3-D analysis on waferWoRx
  - Punch through identification
  - Probe tip to scrub mark correlation
  - Multiple Probe (re-probe) pad damage analysis

– Additional PCA capability (using the new probeWoRx product)
  - Deflection Analysis/Quantification
    - Probe card deflection analysis
    - Fixture deflection analysis
    - Probe scrub correlation

Closed Loop Metrology

Conclusion

"If you measure it, it will improve!"