Wafer Based Temperature Metrology

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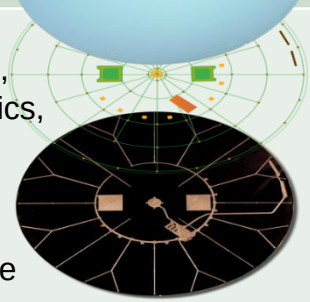
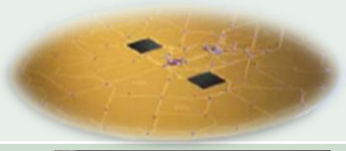
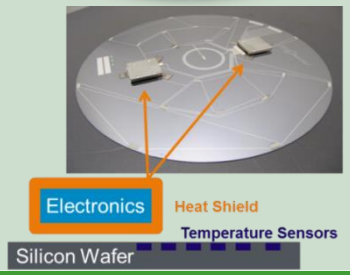
Agenda

- Introduction
  - SA Wireless Wafer Products
- Wafer based metrology
  - Accuracy & Stability
- Key use cases for Etch, Thin Film processes
  - Characterize thermal stability of process tool
  - Correlation between wafer temperature and critical process parameters, CDs
  - Matching of wafer temperature and thermal budget
  - Diagnosis of process and process tools
- Summary

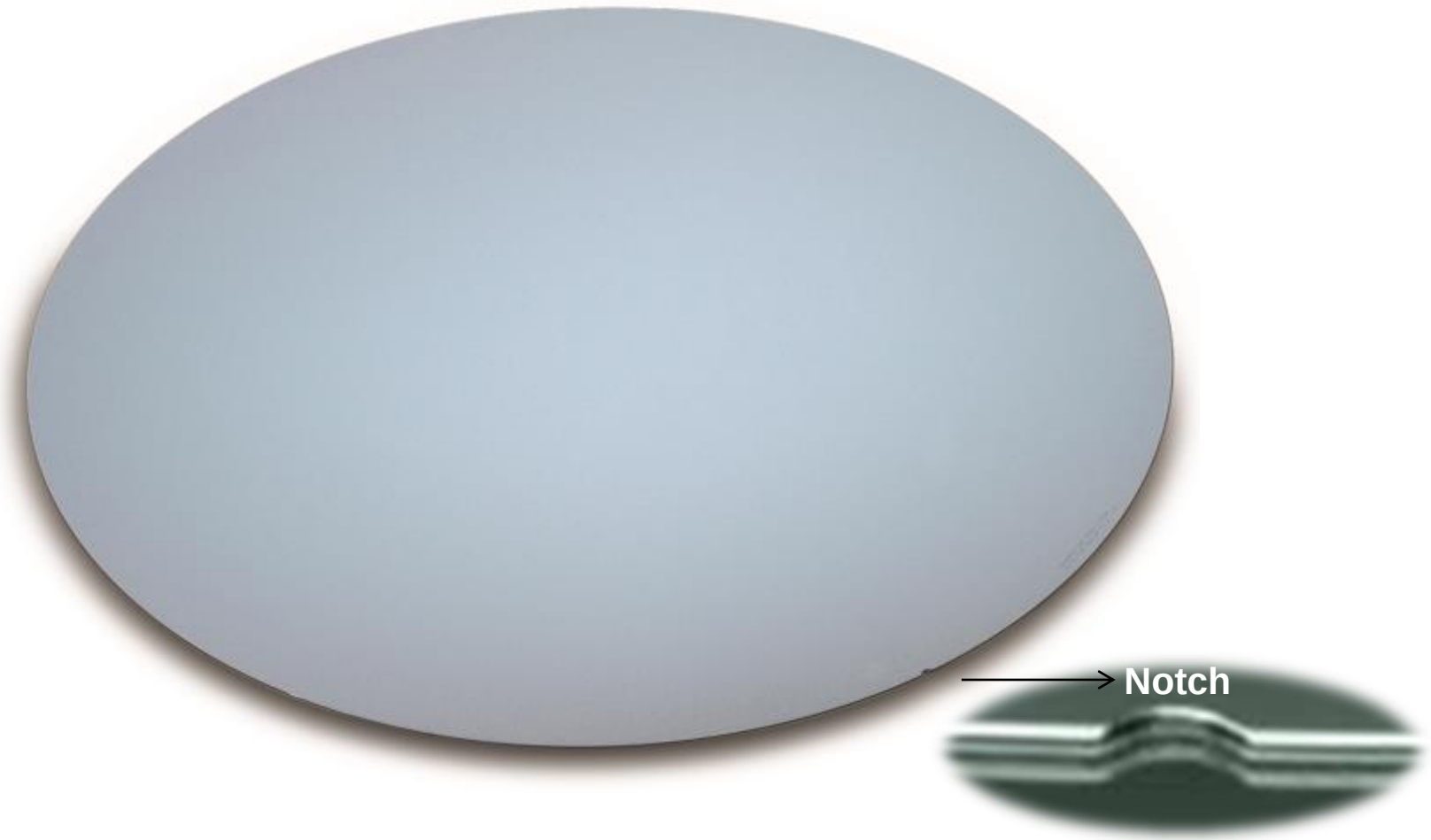
Key Wireless Temperature Wafers

Wireless Wafers		Spec.	Process
ST	Si cover 	20~24ºC ±0.05ºC; 0.03ºC 65 Sensors; 775um	Scanner
ET ET-SE	Sensors, electronics, battery Si substrate 	20~140ºC ±0.2ºC; 0.25ºC 65 Sensors (Edge Dense); 1.2mm	Dry Etch Implantation
WT-LP		15~140ºC ±0.5ºC; 0.5ºC 65 Sensors, 775um	Wet Etch Clean
Integrated Wafer		20-145°C ±0.1°C; 0.1°C 65 Sensors; 1.3mm	Clean Track Room Atmosphere
HT-350 XP		25~350ºC 21 Sensors ±1.0ºC; ≤0.6ºC Plasma Off <6mm	Thin Film Strip

Metrology Tools
An enabler, and/or part of a Process Solution

SensArray Integral Wafer Technology

Proprietary Sensor Solutions >160 Patents

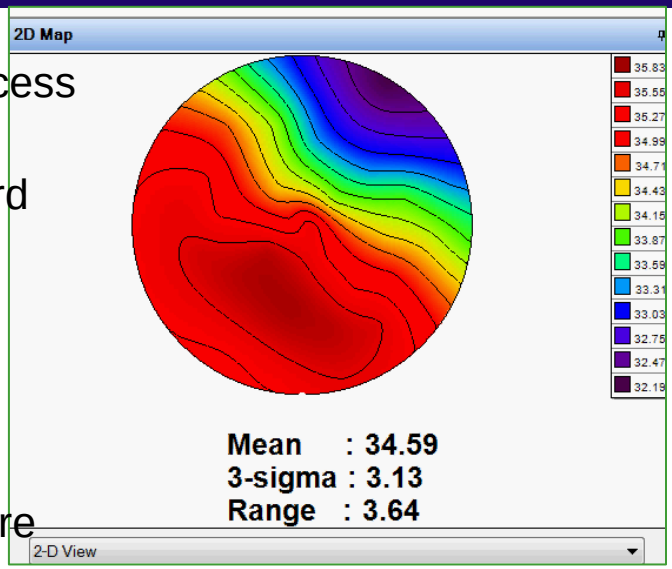


SensArray Wireless in-situ SensorWafer System

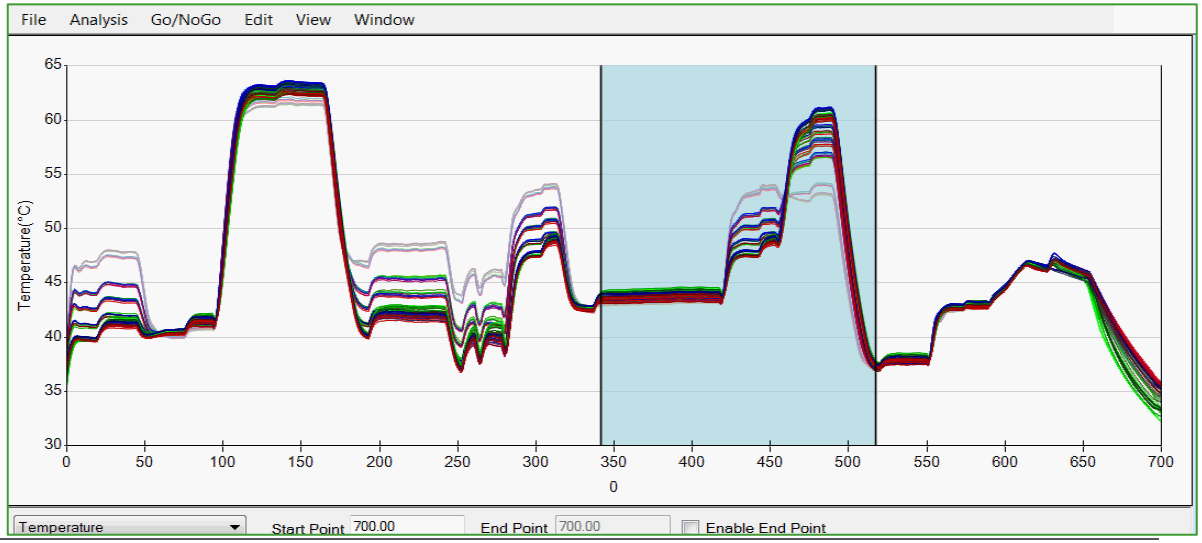
Measure and record in-situ wafer temperature up to 4Hz

SAT Control and Analysis Software Version 2.6

- Create Mission using process recipe
- Launch Mission and record temperature on the wafer while in a chamber
- Download data from the BaseStation
- Analyze data using the SensArray system software



BaseStation 300Z Communication & Charging

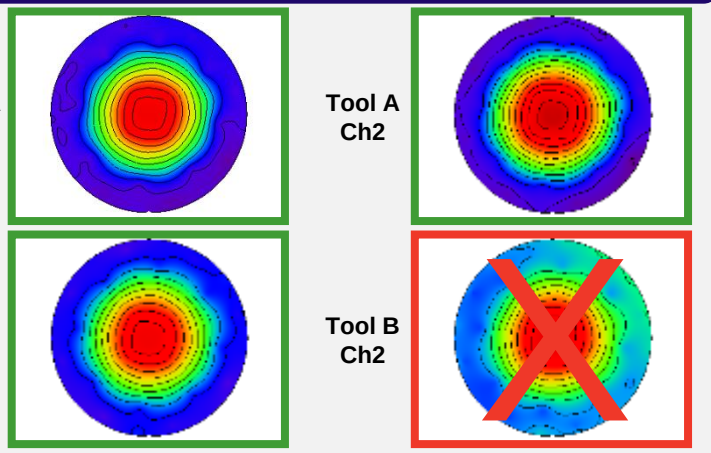


SensArray Core Value Proposition

Enhancing Process Equipment ROI Across the Fab

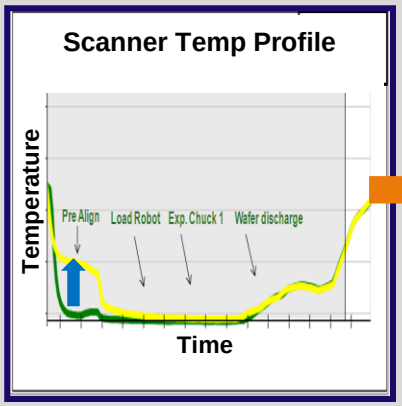
Tool Matching

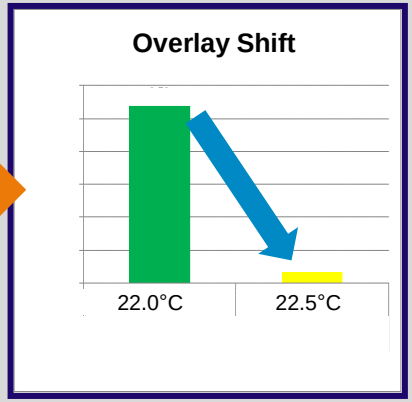
EtchTemp-SE



Troubleshooting

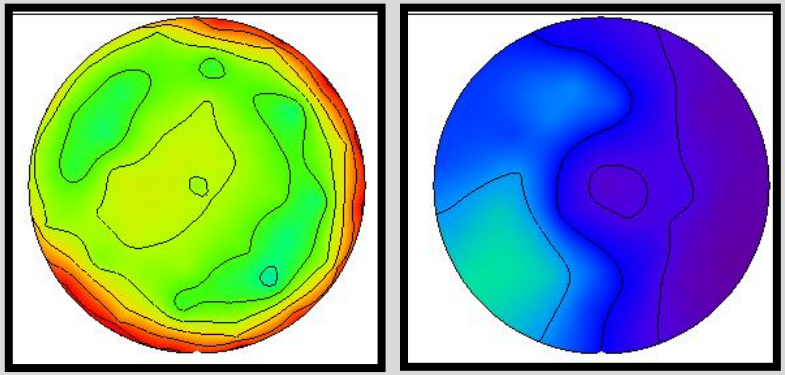
ScannerTemp





Process Characterization

WetTemp-LP

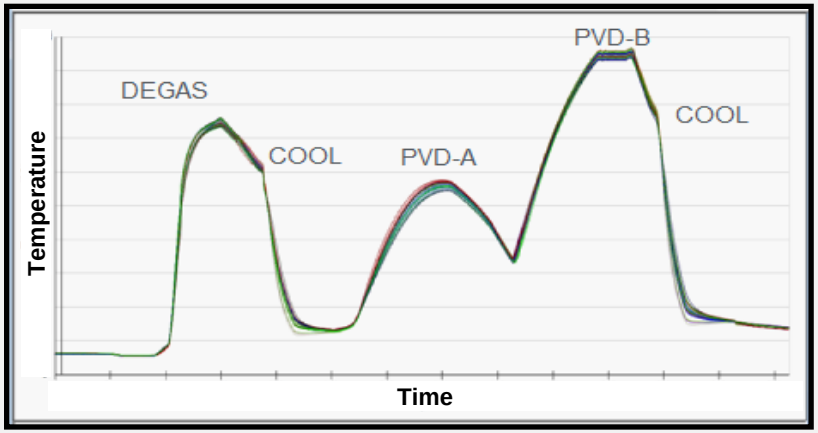


Process Condition A

Process Condition B

Multi Temp/Chamber Optimization

HighTemp-350

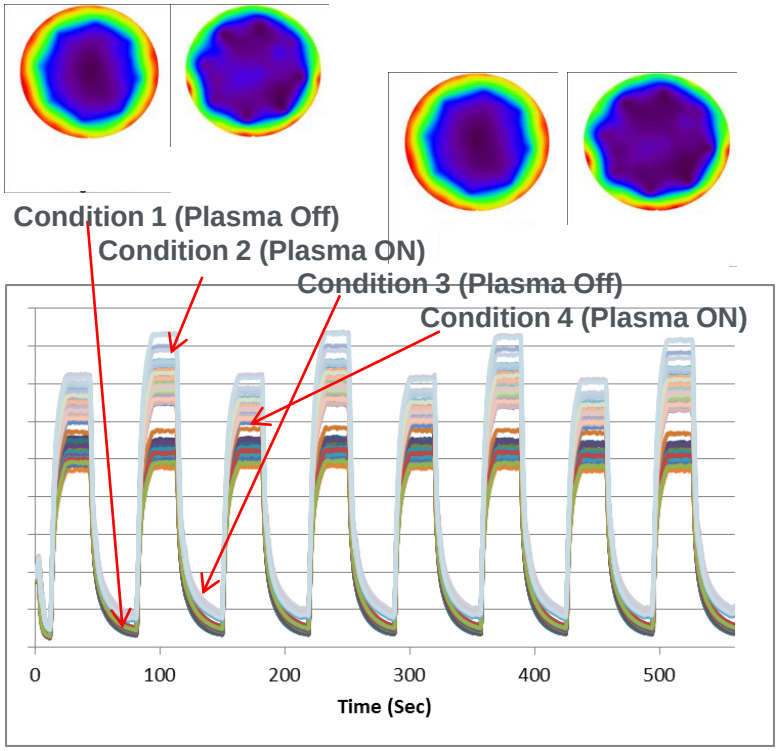


Key Use Cases

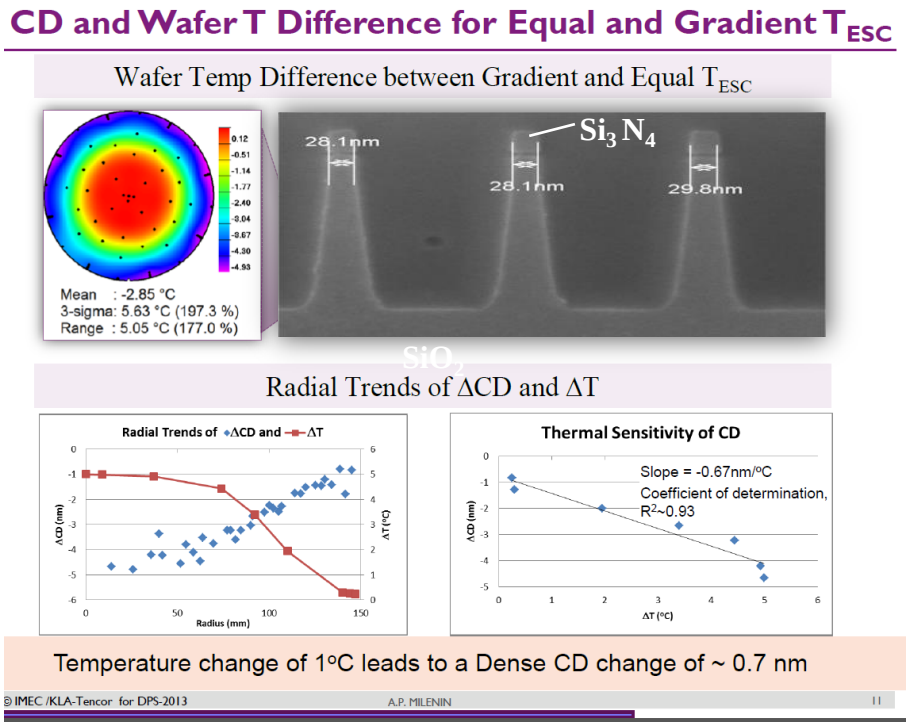
- Equipment Engineers
  - Calibration/Qualification — How accurate is ?
  - Thermal Stability — How stable is ?
  - Thermal Transient (Ramping) — How fast is ?
  - WiW uniformity — How uniform is ?
  - C2C and T2T Matching — How much variation is?
- Process Engineers
  - Process Development — How sensitive is?
    - Effect of process knobs, i.e. temperature, power, chemistry, etc.
    - Allowable process window, i.e. range of temperature vs. process parametrics
  - Process Optimization & Integration — How optimal Temp & Duration are?
    - Duration between process steps
    - Thermal history

Etch Temp Use Cases in additional to ESC Cal

- Thermal Stability & Uniformity of Process Tool



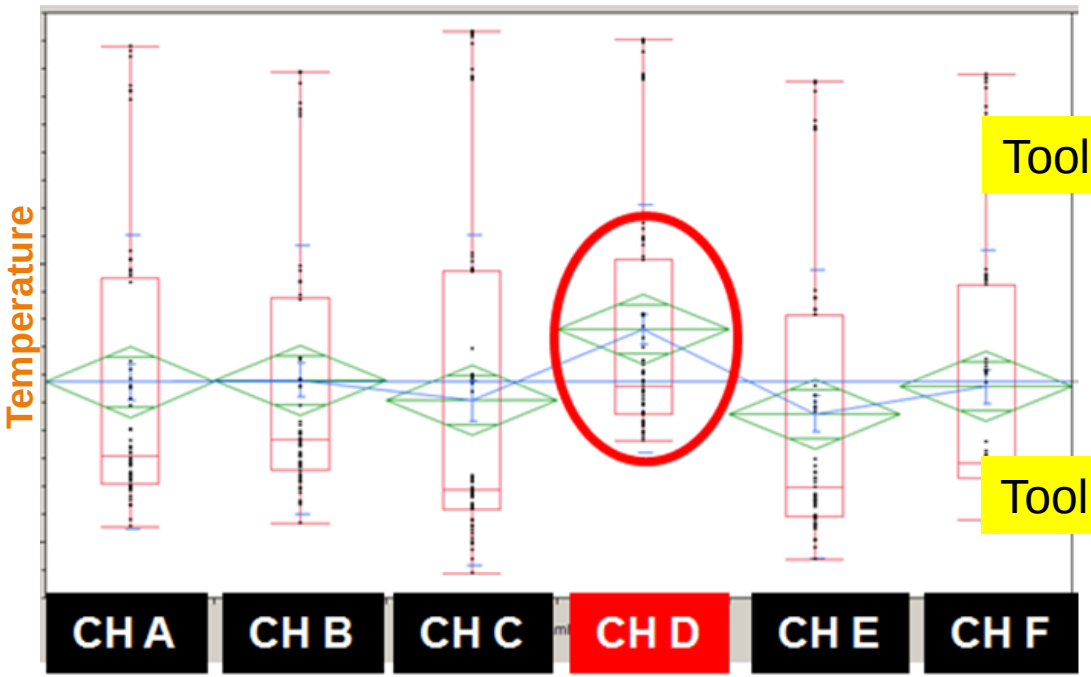
- Thermal Sensitivity of Process



Wafer Based Temperature Metrology for Development & Optimization of Equipment & Process

Chamber Matching

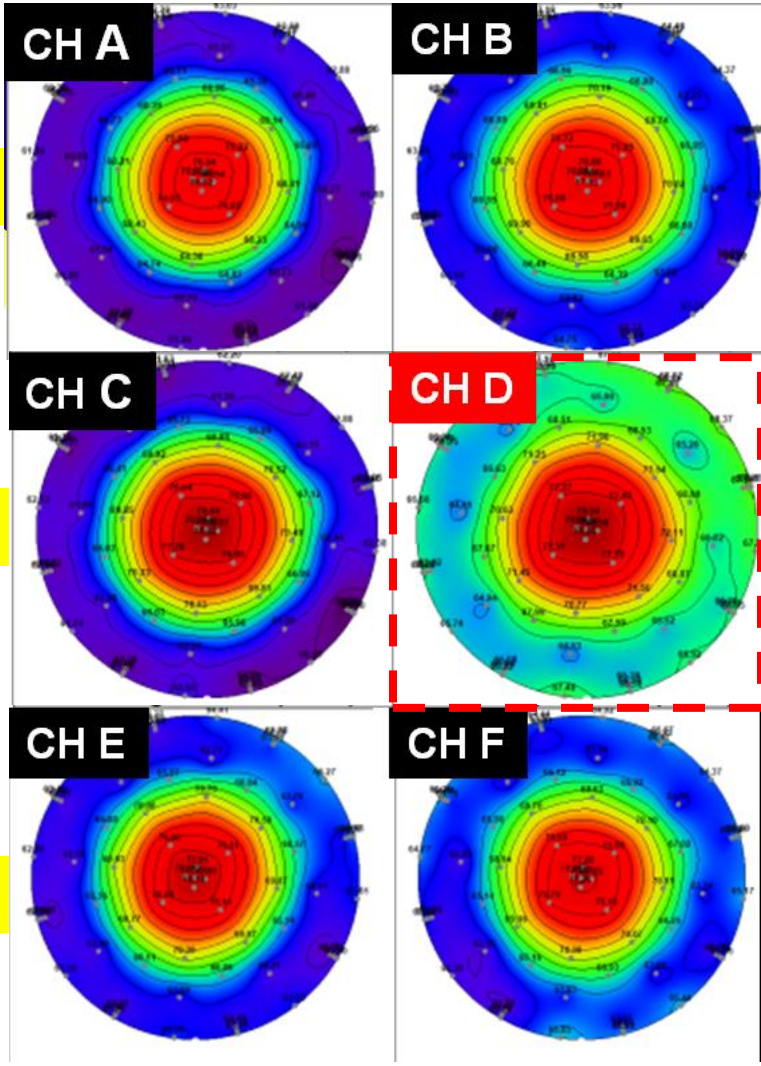
STI Etch – High CD correlates to higher temp



Tool X

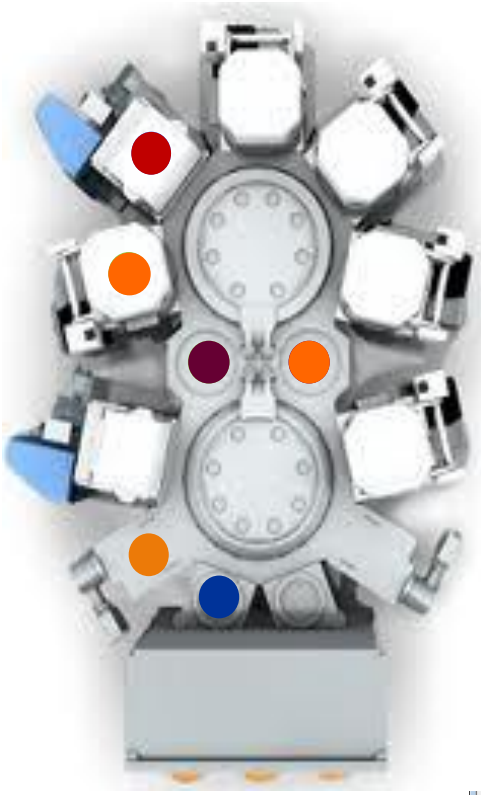
Tool Y

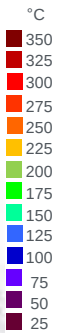
Tool Z



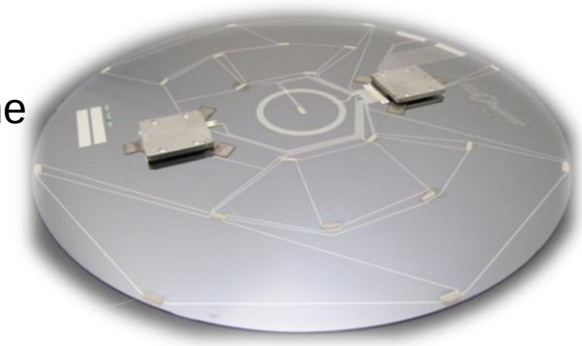
CH D shows higher temperature resulting in higher CD

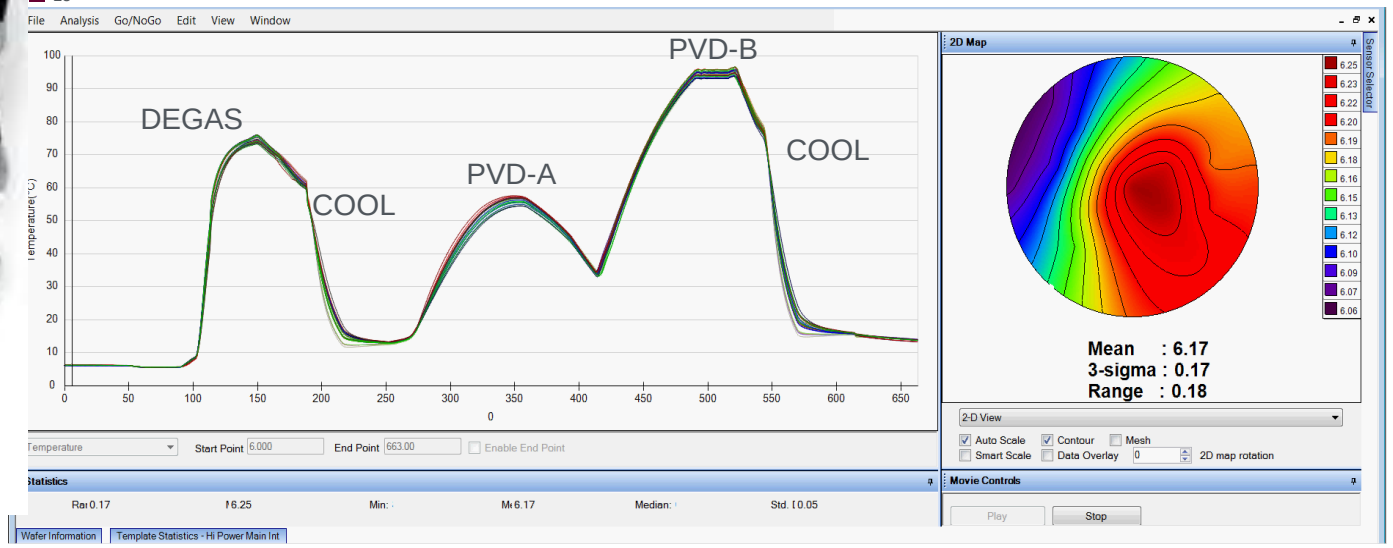
HighTemp-350 Multi-Chamber Thermal Profiling





- Provide temporal & spatial temperature information beyond the current 140°C limitation
- Insulate temperature-sensitive components from extreme heat during time-limited missions

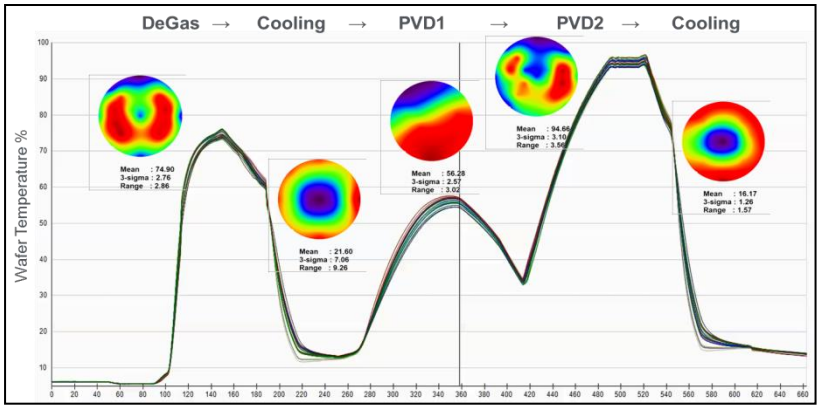




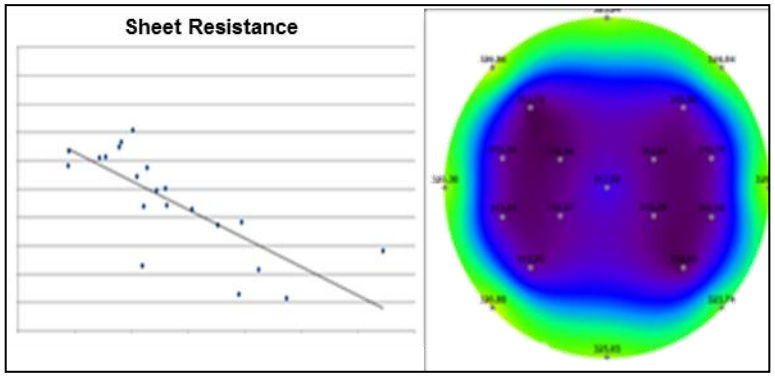
Cluster-tool thermal characterization not available by any other means

High Temp 350XP for Thin Film

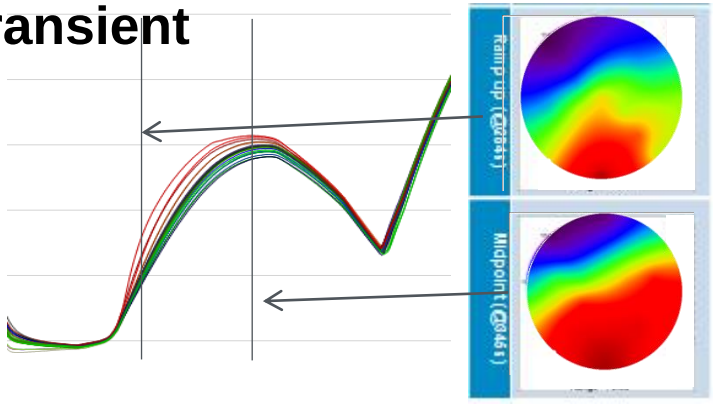
Integration



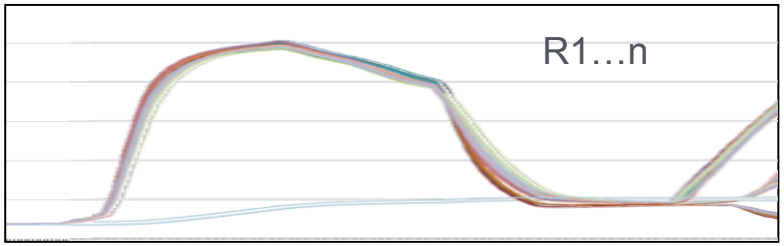
Thermal Sensitivity



Transient

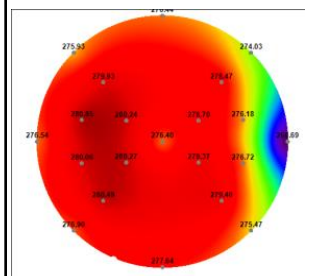
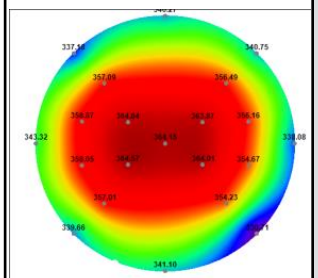
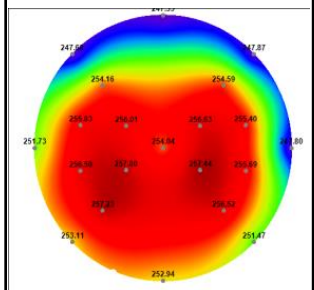
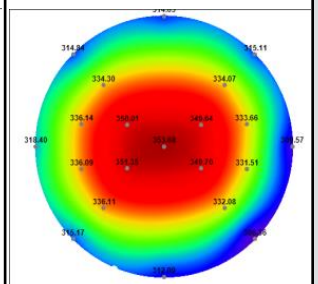


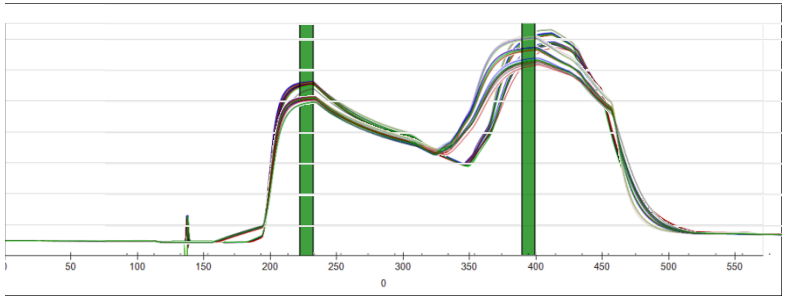
Thermal Stability



High Temp-350 enables process tuning based on wafer temperature

For Tool – Tool (chamber-chamber) Matching

Tools	A	B	Δ
Degas			
Mean			13.8
Range	14.2	10.1	
PVD			
Mean			21.4
Range	33.9	47.3	



- Both Chambers in Tool B are cooler than of Tool A
- Different cold spots between two degas chambers
- Larger temperature range in the PVD chamber of tool B than that of tool A
- ***Longer duration in PVD of tool B over tool A***
  - ***Different thermal budget***

Summary

- A metrology solution for characterizing and/or monitoring process tools
  - Thermal stability, uniformity, accuracy, matching, and throughput of all ≤350^{o}C
- A metrology tool for process development & optimization
  - Effect of process knobs.
  - Thermal Sensitivity
  - Allowable process window
  - Duration of each and between process steps
  - Thermal budget