KLA-Tencor

Accelerating Yield

NCCAVS Plasma Applications Group Meeting

EtchTemp Silicon Etch (ET-SE)

SensArray Division

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Executive Summary

- **EtchTemp Silicon Etch (ET-SE) targets Poly/STI Etch application**
- **ET-SE hasY_2O_3 deposited on top of the Si cover of EtchTemp**
- **Metal contamination levels are similar to regular EtchTemp (silicon cover)**
- **Prototype testing in Poly Etch (HBr Chemistry)**
  - **Etch rate of Y_2O_3 film is minimal to none**
  - **Temperature profile during Poly Etch**
    - Delta temperature between ET-SE Prototype and ET
      - No Significant Delta Temp between ET-SE and standard ET
    - Temperature profile in continuous Plasma ON condition
      - ET-SE shows stable temperature up to 10mins Plasma On

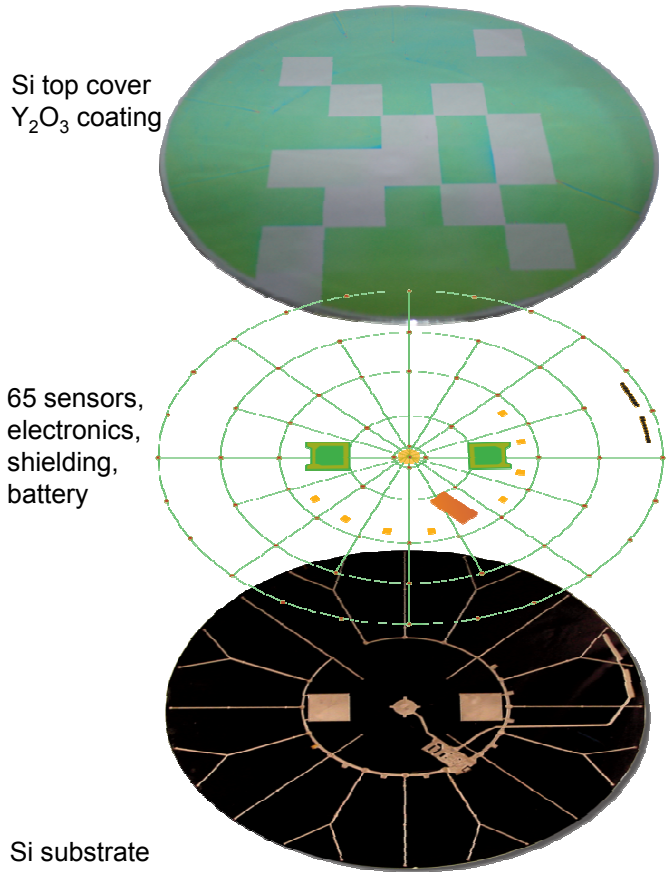
- **Prototype testing in Poly Etch (SF6 Chemistry)**
  - **Etch rate of Y_2O_3 film is minimal to none**

EtchTemp-SE

Plasma ON Temperature Monitoring of Silicon Etch Processes

- Flat, wireless wafer for in-situ silicon etch chamber & process temperature monitoring
- Enhancements over silicon etch alternatives (special coating, wider operating range, improved S:N, greater lifetime, & lower profile)
- Temperature monitoring with silicon etch chemistry & plasma ON in key use cases:
  - Qualify new etch chambers
  - Match etch chambers
  - Post-PM chamber verification
  - Electrostatic chuck qualification

Accuracy: +/- 0.2C, Precision: 0.25C, Range: 15-130C



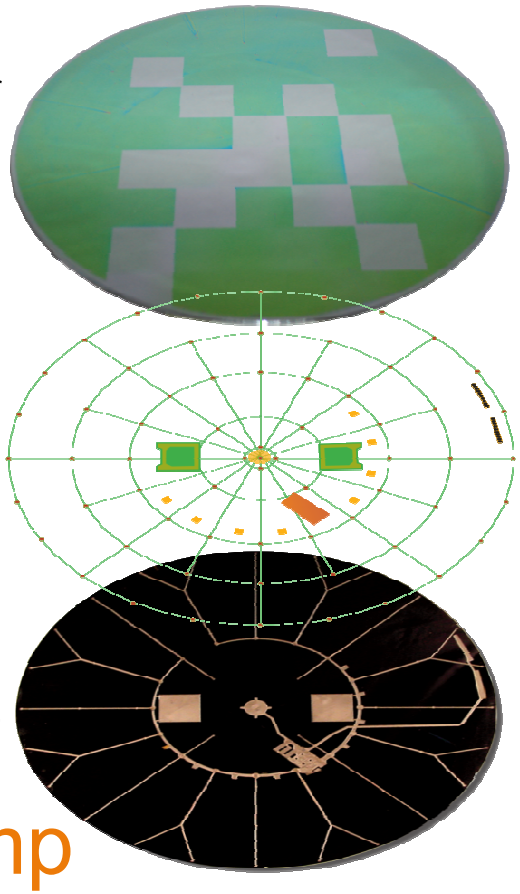
EtchTemp-SE

Enabling Plasma ON Wafer Temperature Monitoring of Silicon Etch Process

Application Landscape

ET for BEOL Oxide Etch, ET-SE for FEOL Si Etch

Accuracy: +/- 0.2C, Precision: 0.25C, Range: 15-130C



EtchTemp

- EtchTemp
  - Ideal for BEOL applications such as.
    - Copper Trench Etch
    - Stack capacitor etch
  - FEOL applications for Etch Temp has some limitations.
    - Must Use a Proxy chemistry to protect Silicon cover.
    - This Proxy chemistry does not provide exact thermal match to production recipe.
- EtchTemp-Silicon Etch
  - For critical FEOL application

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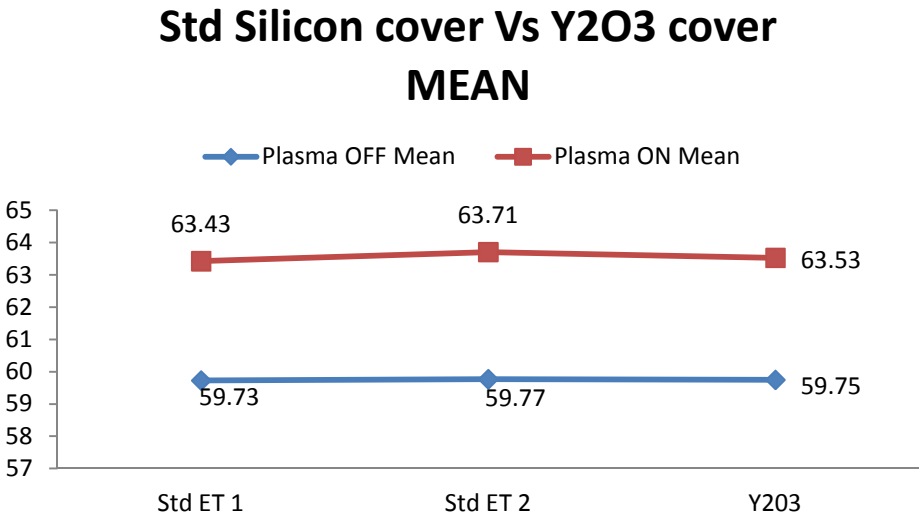
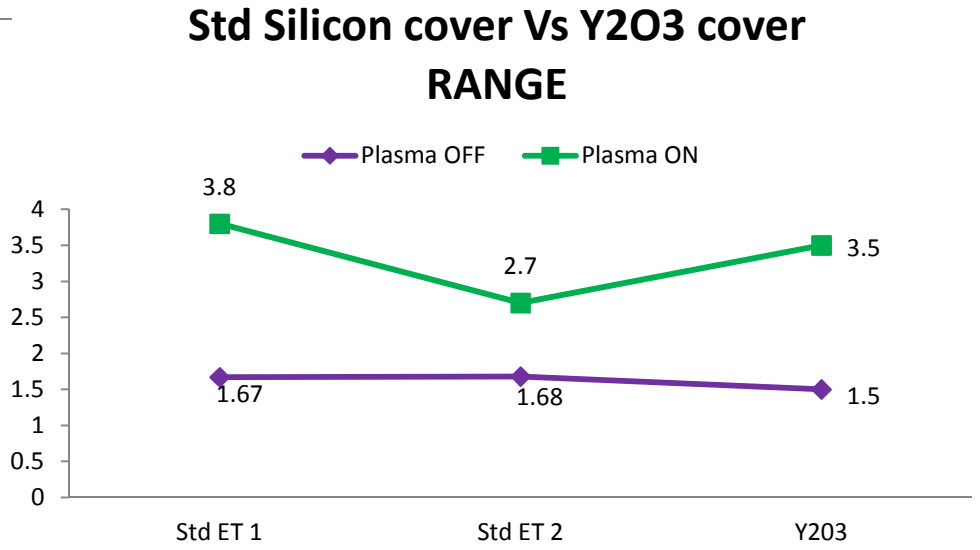
Key Spec Comparison
EtchTemp vs. EtchTemp-SE

Features	EtchTemp	EtchTemp-SE
Etch Application Space	Oxide	Poly, STI
Accuracy (C)	+/-0.2	+/-0.2
Sensor-to-Sensor Precision (<C)	0.25	0.25
Max RF Power (Dual Source, kW)	7	7
Sensor Quantity	65	65
Front Surface Back Surface	Silicon Silicon	Y_2O_3 Silicon
Sampling f(max) (Hz)	4	4
Operating Temperature Range (C)	15-130	15-130
Roadmap	Extendable	Extendable

No Significant Delta Temp Between ET-SE (Y_2O_3) and Std. ET

Poly Etch



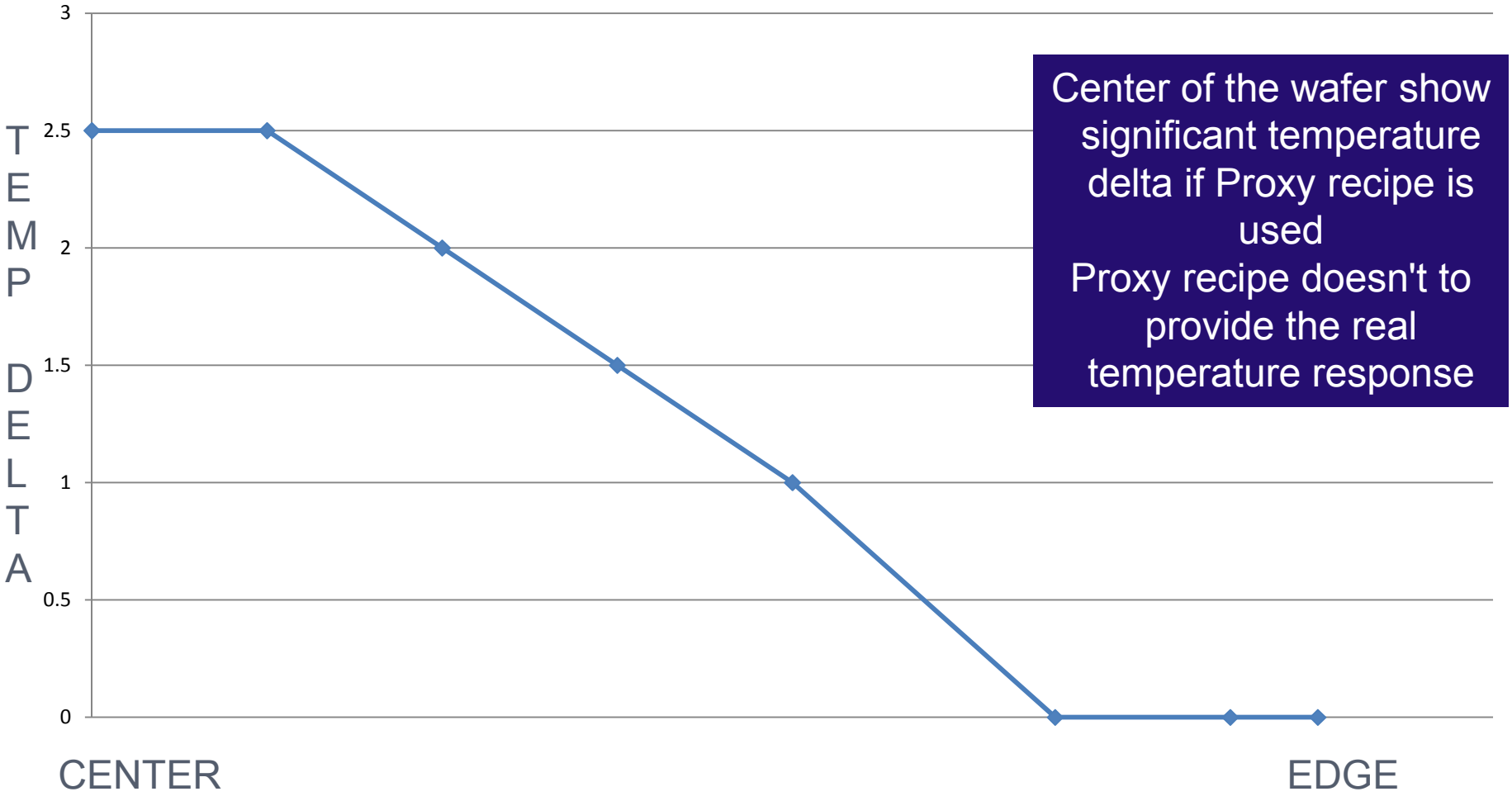


Etchtemp with standard silicon cover vs Etchtemp with Yttrium coating

Test to verify that Y_2O_3 will not affect temperature reading

EtchTemp Silicon Etch (ET-SE) Value

Deep Trench Etch

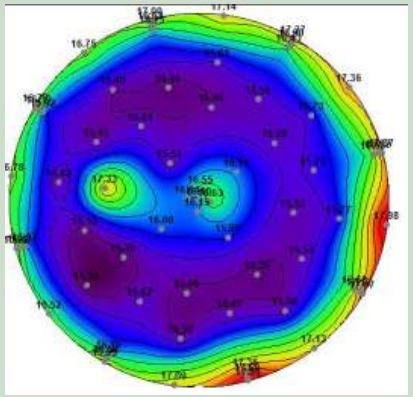
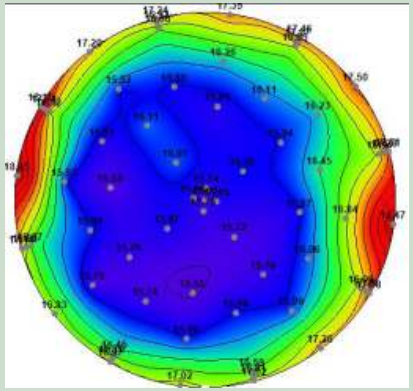
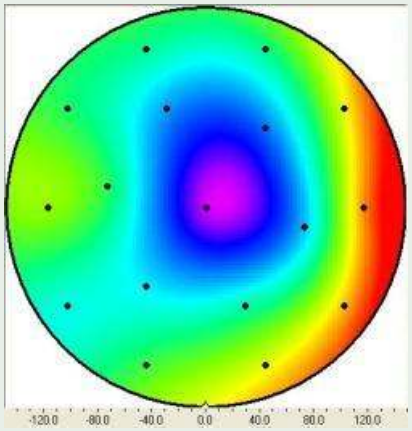
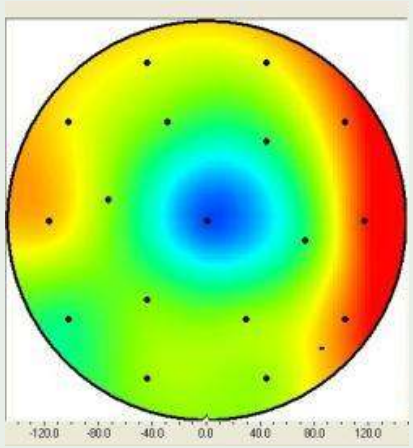


Temperature delta using Production recipe (HBr/NF3/O2) and Proxy Recipe (Ar/O2)

Use Case

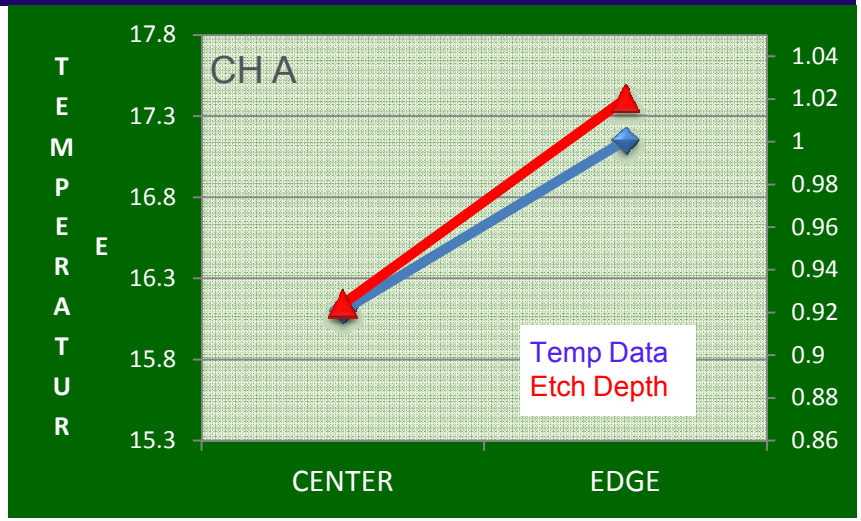
ET-SE identify edge temperature issue correlated to etch depth issue

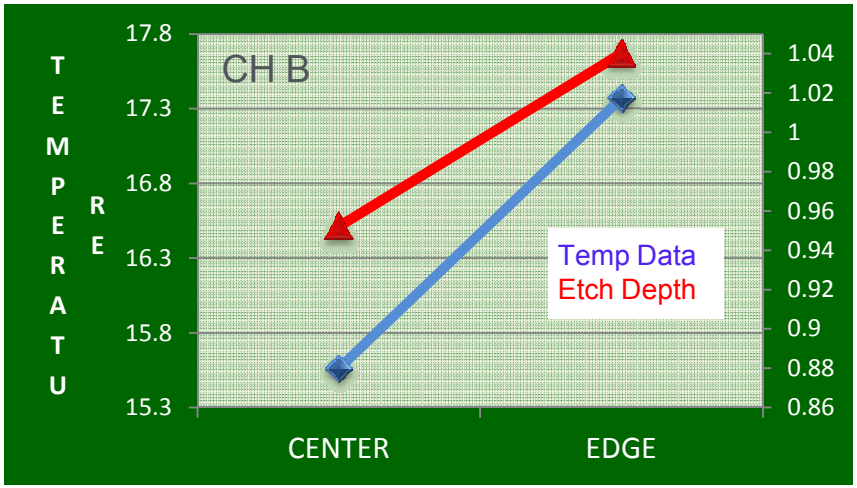
DTI Logic

Chamber A	Chamber B
	
	

ET-SE

Etch Depth

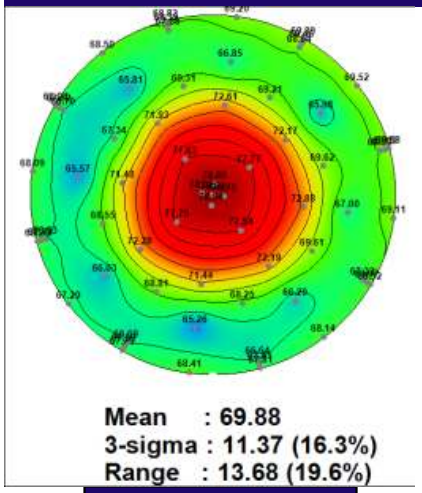




Temperature data correlate to Etch Rate data

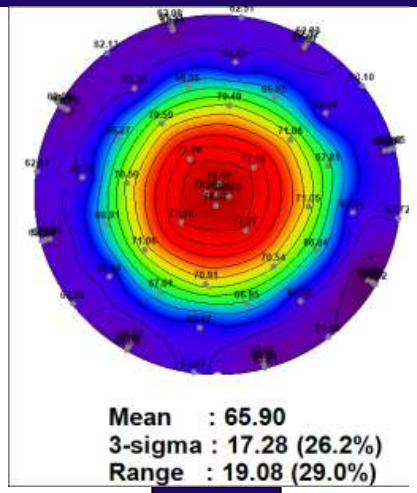
Higher Etch Rate= Higher Temperature

ET-SE identified Yield issue : CH A *production Hold for CDU issues*
STI Etch



Mean : 69.88
3-sigma : 11.37 (16.3%)
Range : 13.68 (19.6%)

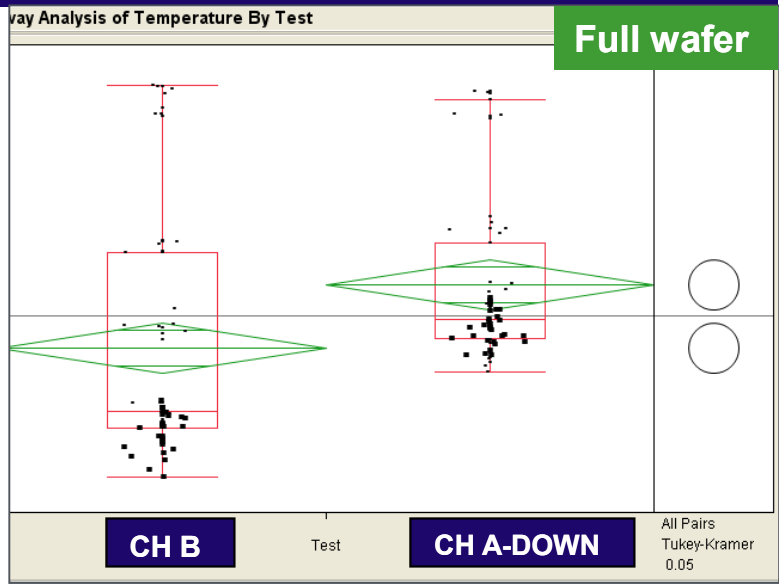
CH A-DOWN



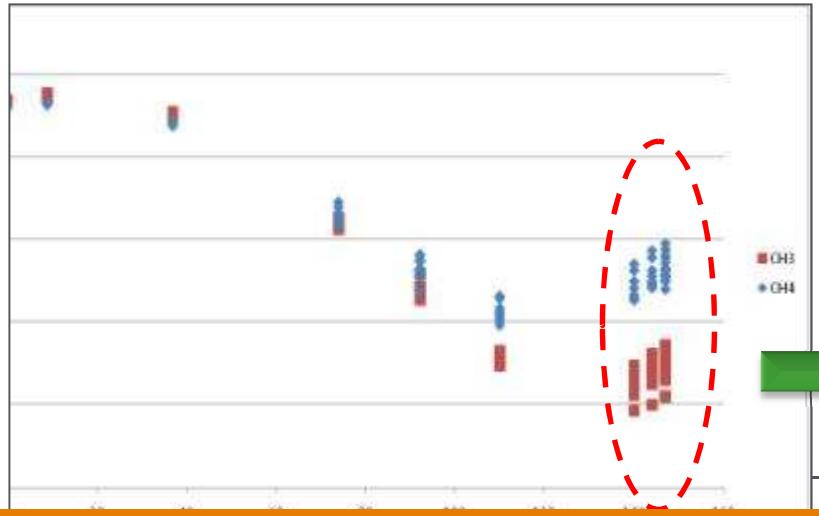
Mean : 65.90
3-sigma : 17.28 (26.2%)
Range : 19.08 (29.0%)

CH B

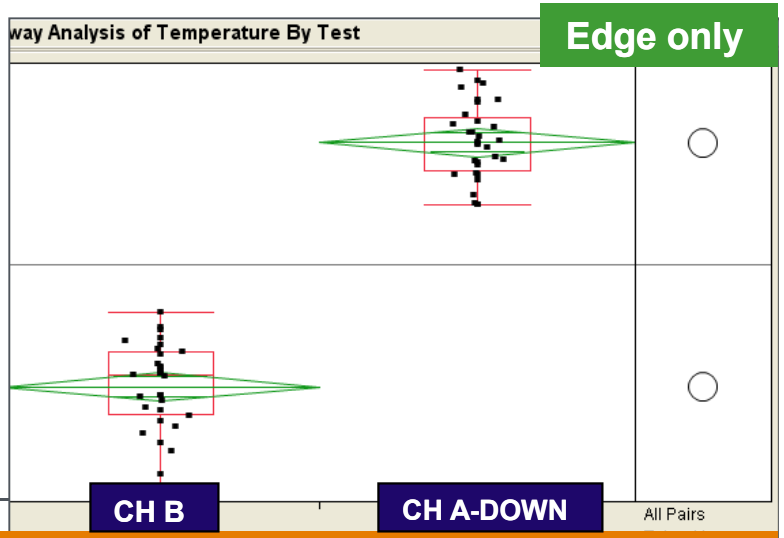
Full wafer



Full wafer Mean DELTA:3.98 degree



Edge only

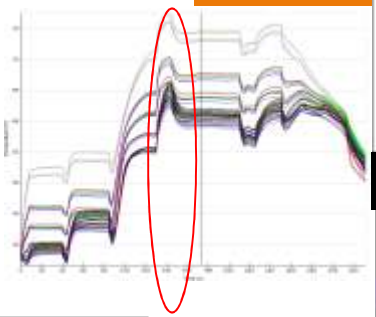


YIELD ISSUE AT THE EDGE SOLVED WITH ESC REPLACEMENT

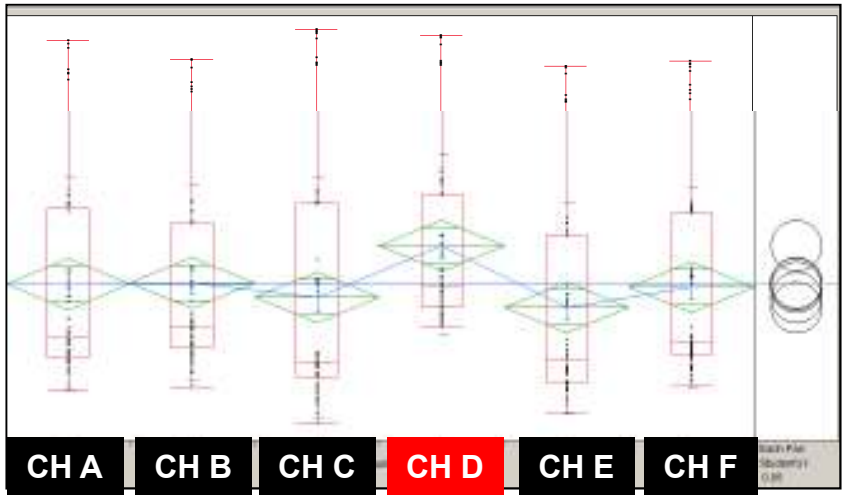
High CD Chamber shows High Wafer Temperature

STI Etch

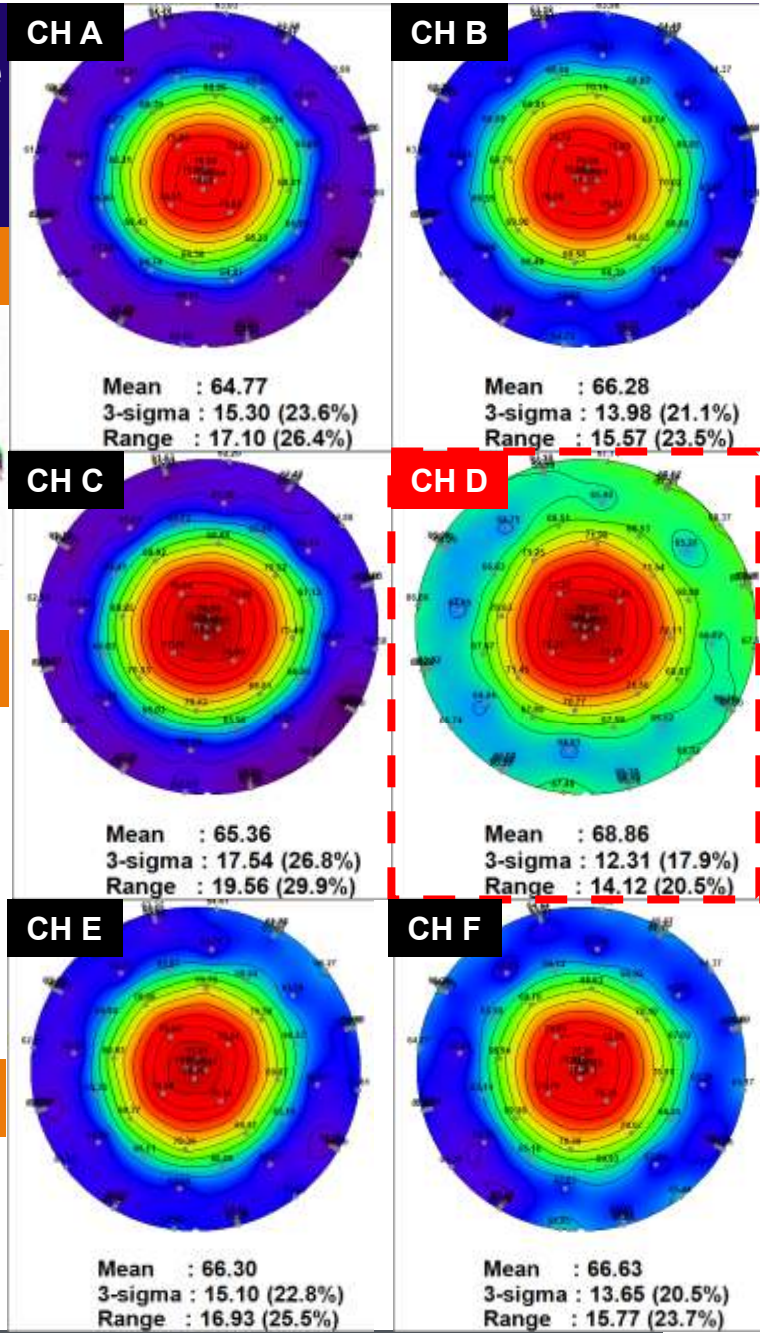
Tool X



Tool Y



Tool Z



ET-SE shows CH D has an outlier , this correlate to High CD

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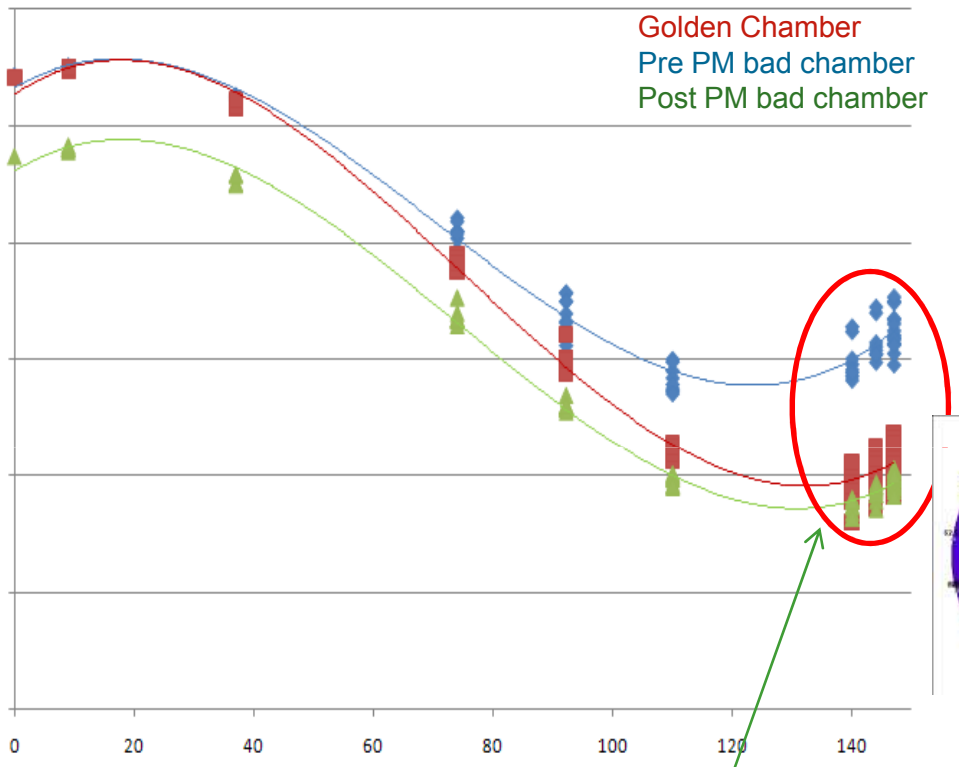
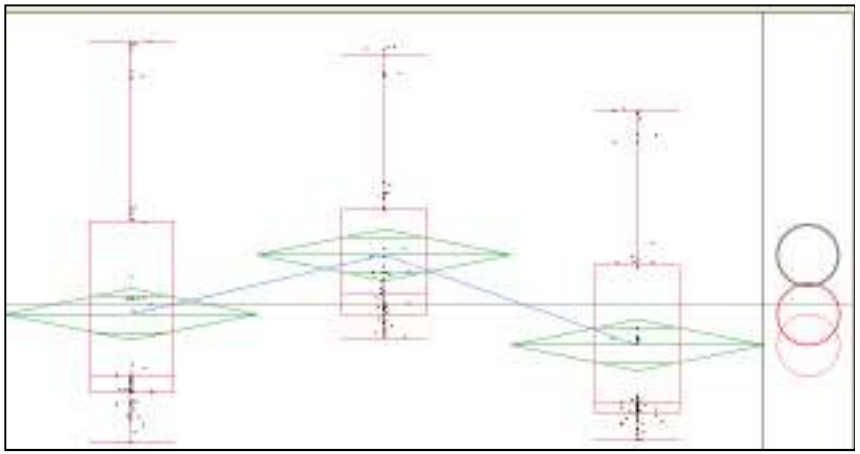
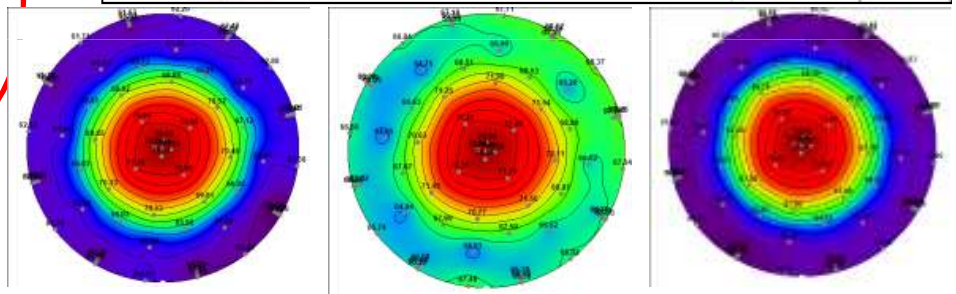
High CD Chamber shows High Wafer Temperature

STI Etch







Golden Chambers

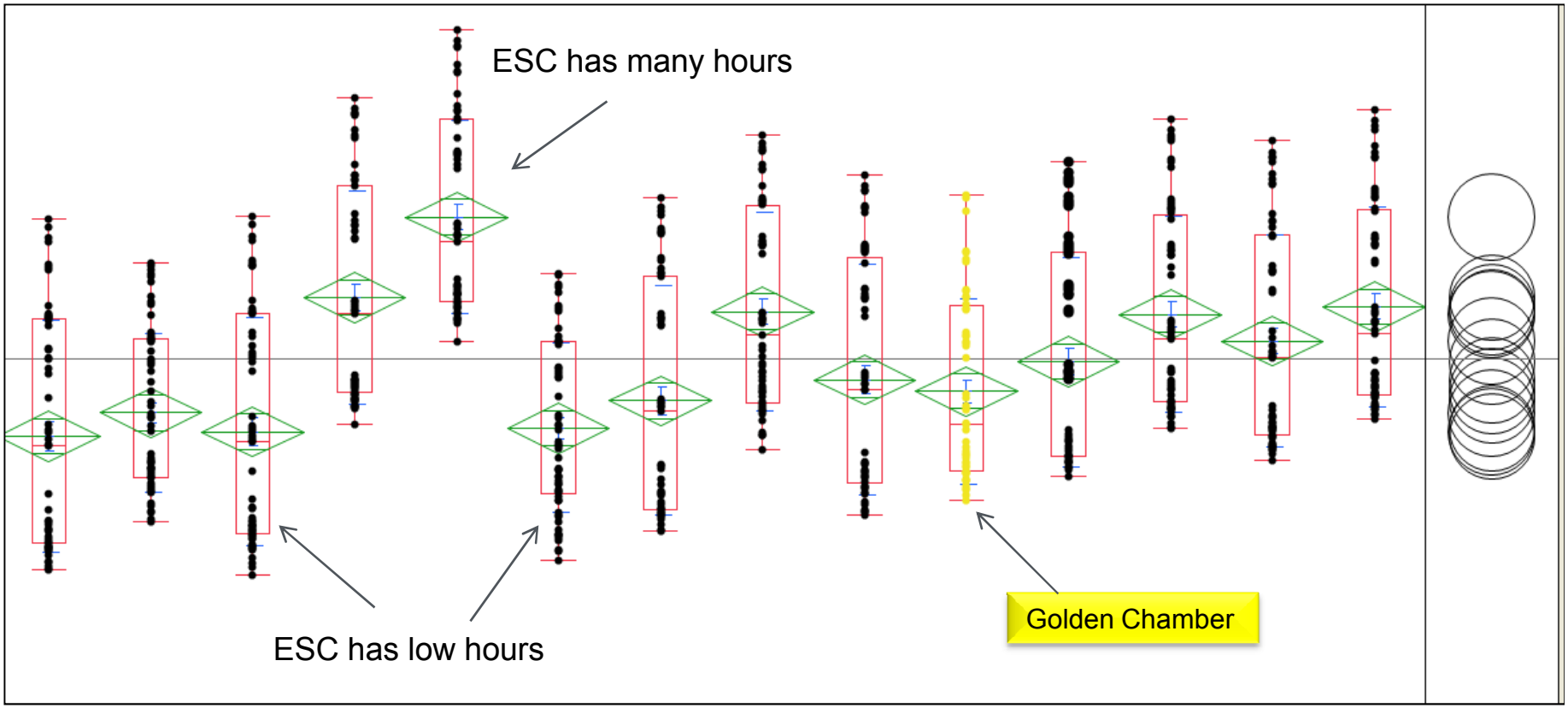
Pre PM Bad Chambers

Post PM Bad Chambers

Post ESC replacement fixed the edge temperature spread with between golden ch and down ch

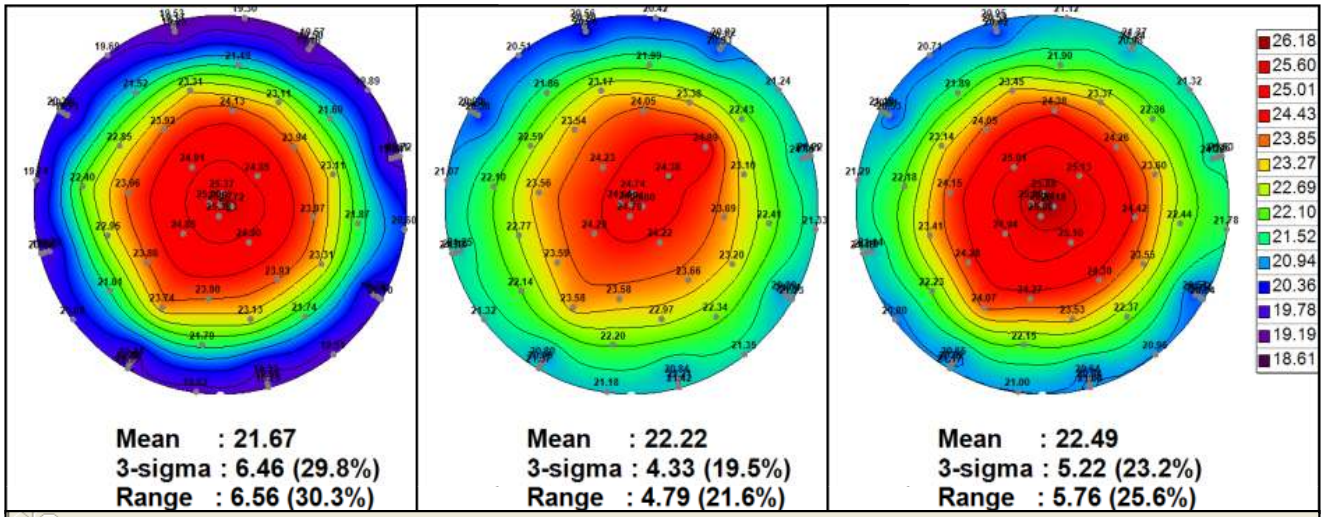
ET-SE identify ESC lifetime impact on Temperature

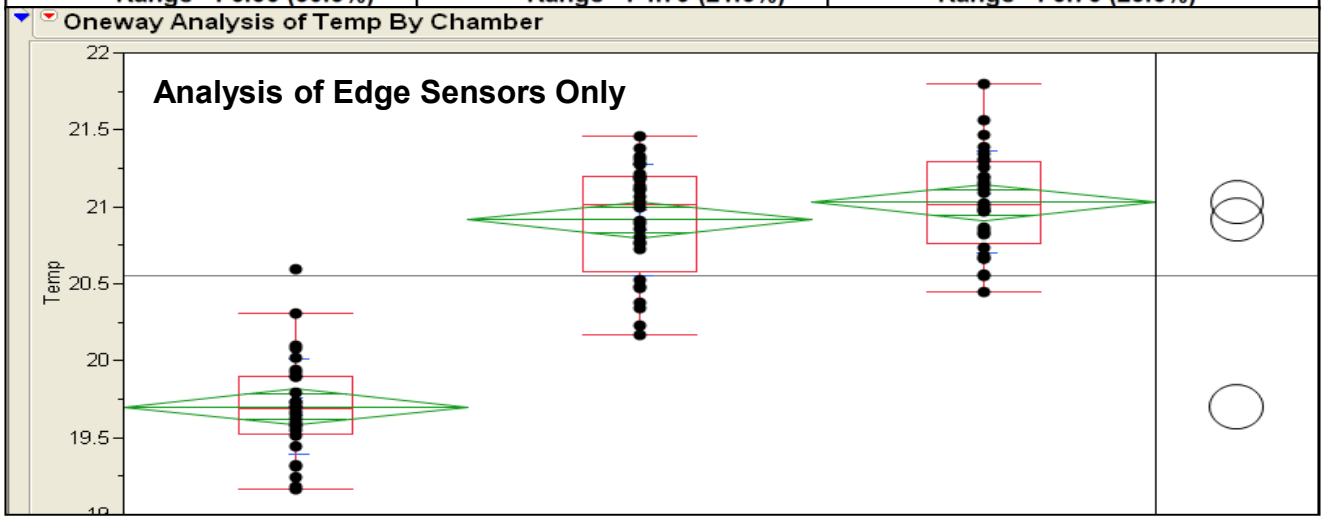
Poly Etch



Example of ESC plasma ON data collection that was able to identify chamber differences due to ESC lifetime

ET-SE
Poly Etch





Down Chamber | Chamber A | Golden Chamber

- Chamber matching issue within different fabs.
- Also, demonstrated process gas trouble shooting capability with ET-SE.
- This excursion event led to a 3-week chamber down time before temperature analysis.

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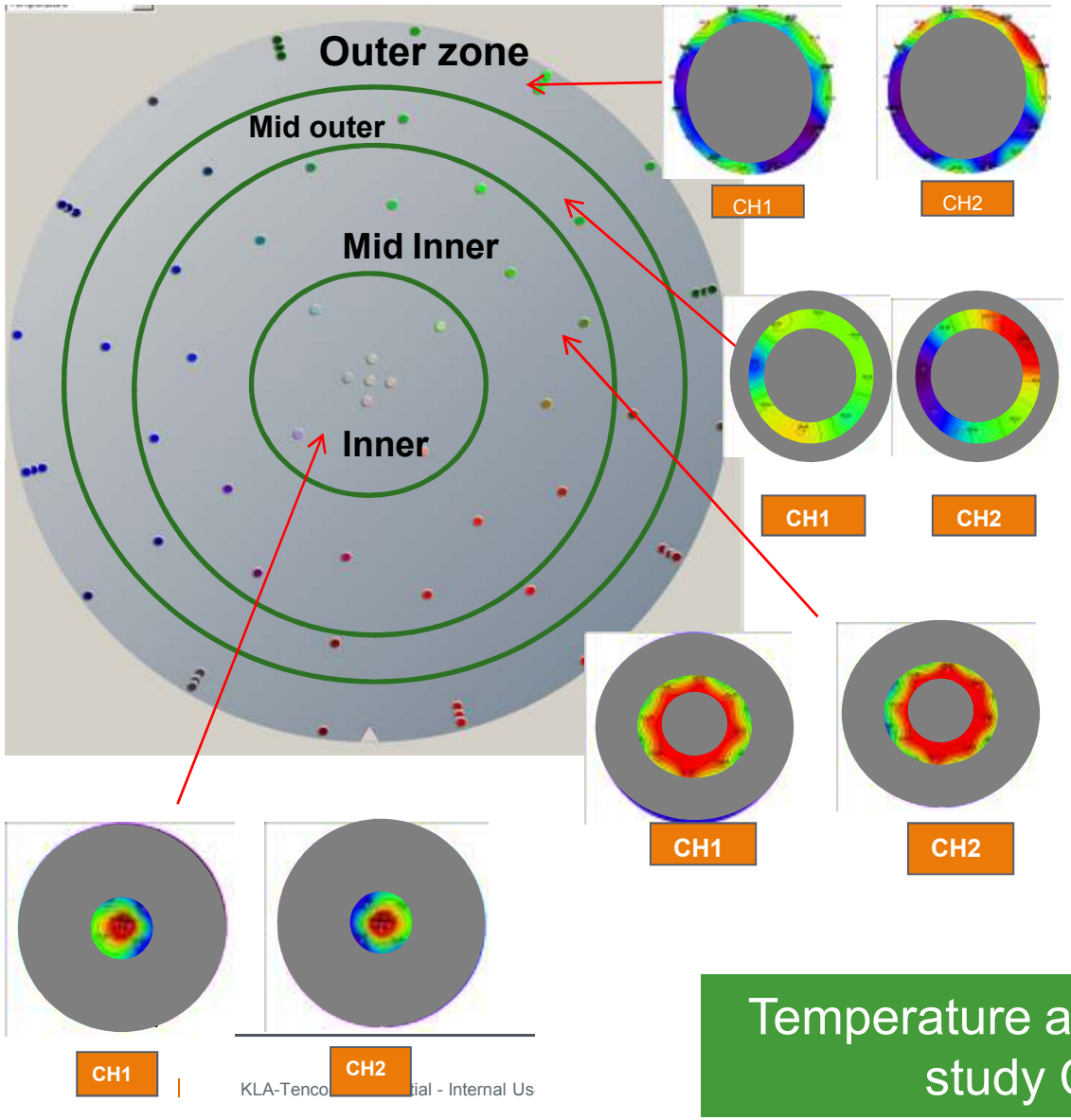
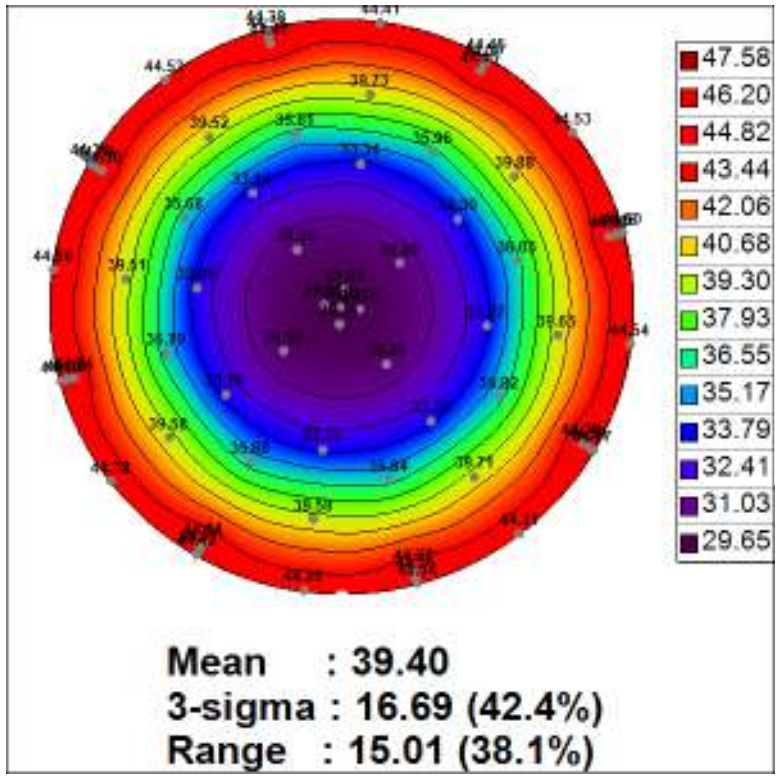
ET-SE Recommended for 4zone ESC Plasma ON Qualification

Poly Etch

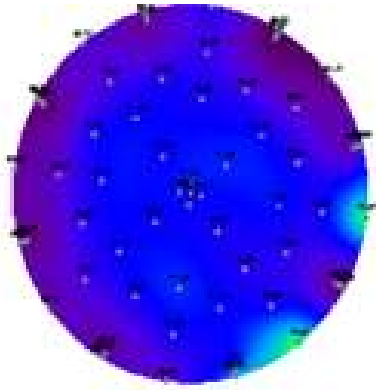




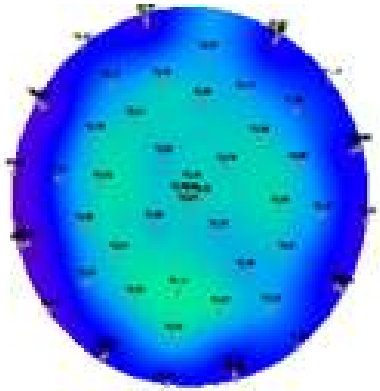
Temperature analysis by ESC zone in order to study CD/Yield localized issue

ET-SE Identifies Hot Spot that Correlates to CD Excursion

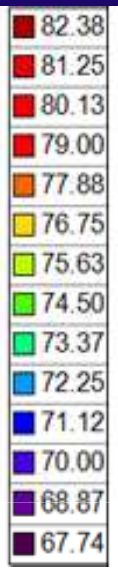
Poly Mask Etch

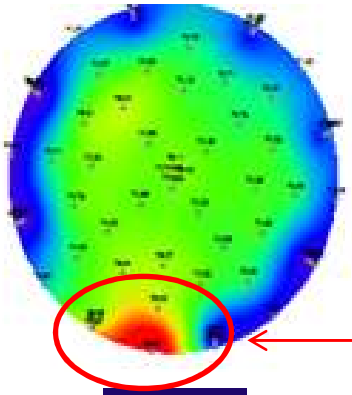


PM6



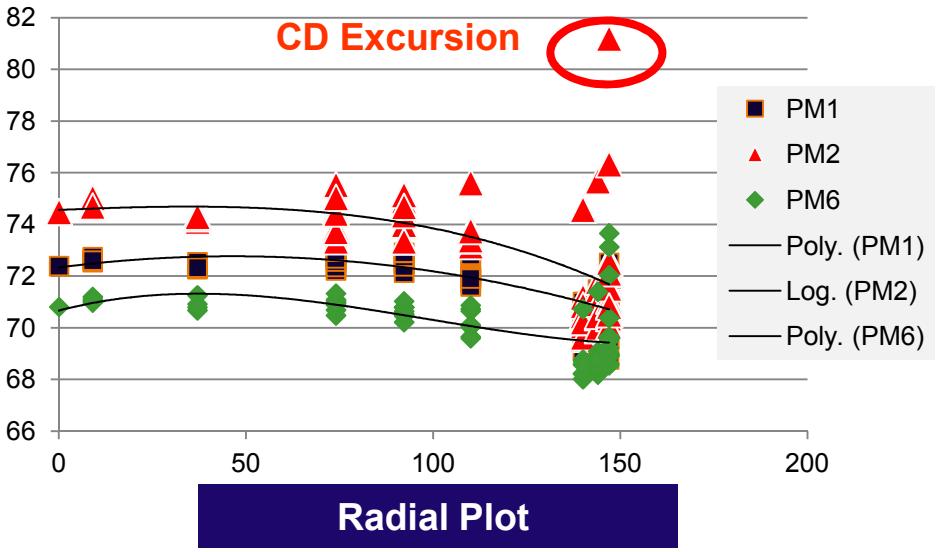
PM1





PM2

High temperature area correlate with CD excursion

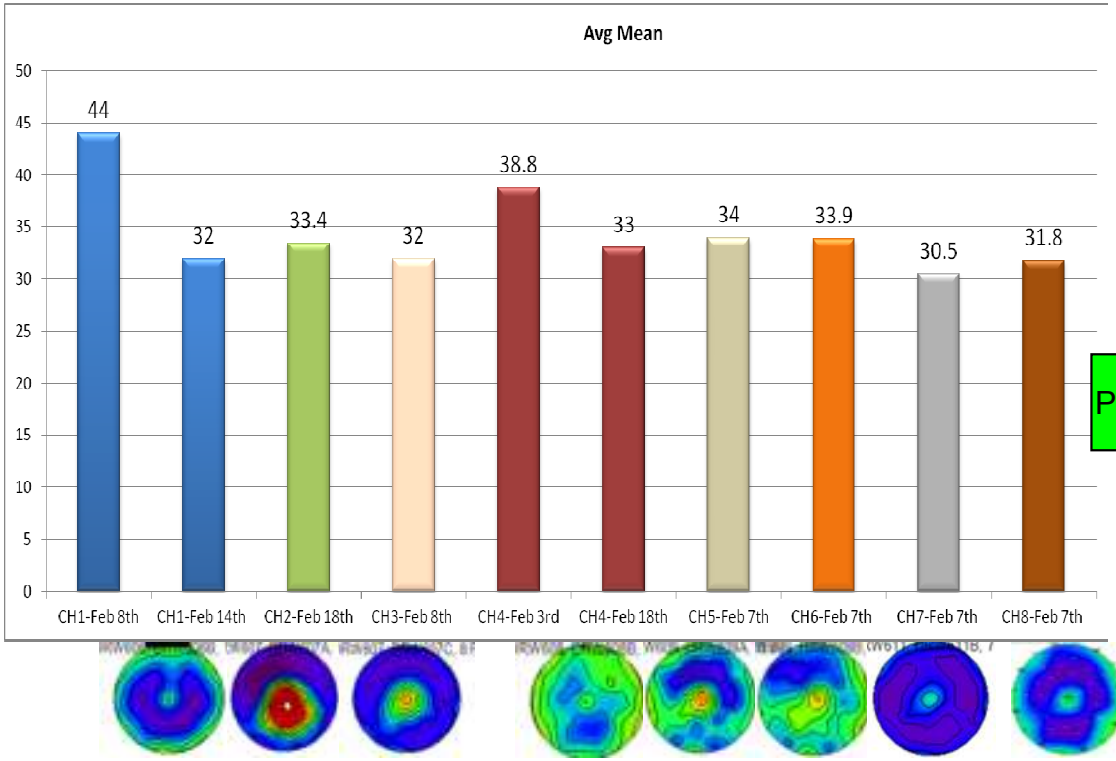


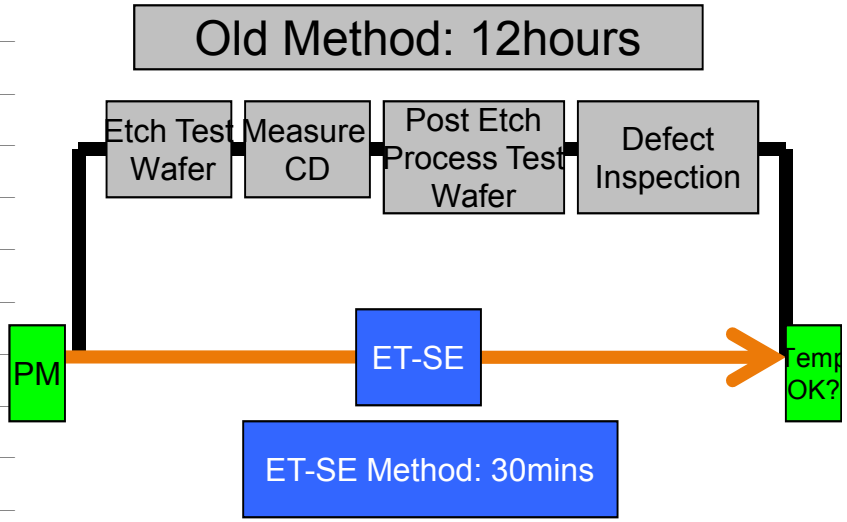
Radial Plot

PM2 shows CD excursion in lower left edge that correlates to hot spot seen on ET-SE

Temperature Variation across Chambers & Shifts Over Time

Cylinder Support Etch





Chamber baseline confirmed shifts over time

New Procedure: Post PM temperature data collection for chamber monitor and faster troubleshooting

Conclusion

- ET-SE demonstrated temperature monitoring capability with silicon etch chemistry & plasma ON in key use cases
- ET-SE is used for :
  - Chamber Matching
  - Troubleshooting
  - Chamber Monitoring
  - Temperature DOE for process optimization
  - ESC replacement
  - Tool Start up
  - Post Pm chamber verification