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# 2019 CMPUG Meeting

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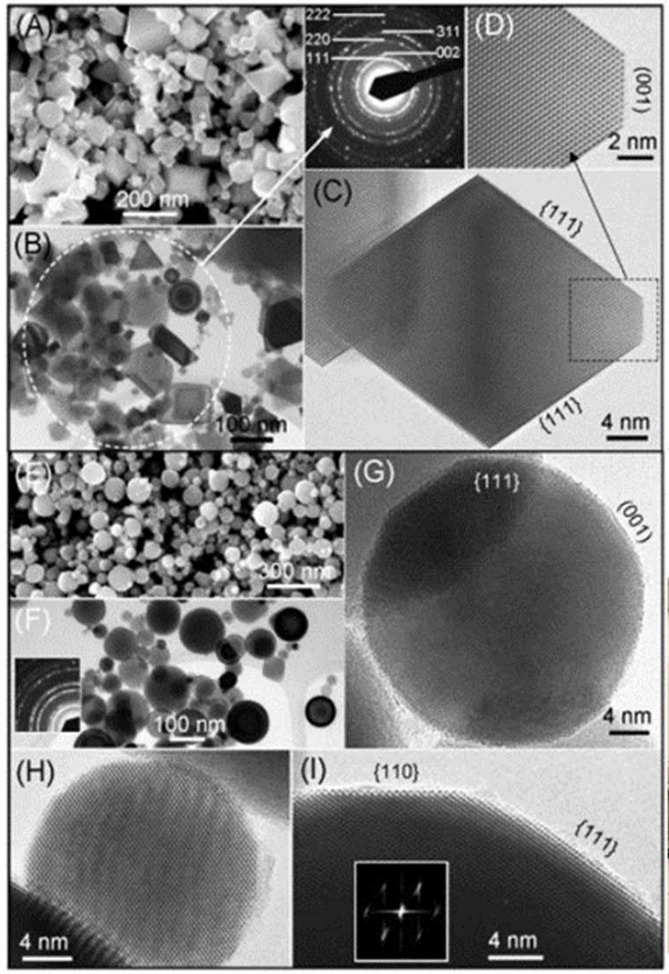
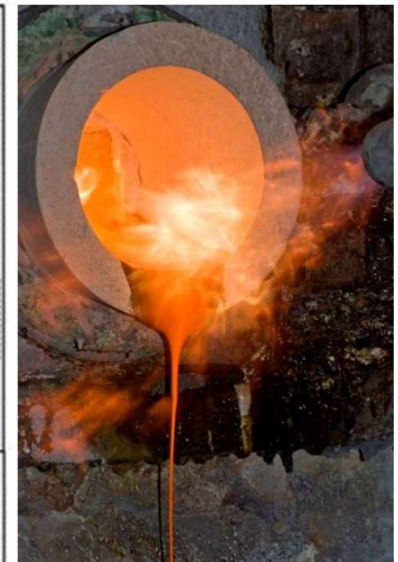
**04/11/2019**

## "Low Particle Size Ceria STI Slurry Designed for High Performance Dishing and Nitride Loss"

# Ferro’s Core Technologies

- Particle engineering
- Particle surface science and modification
- Materials characterization
- Formulation chemistry



# Fast Oxide CMP

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- Staircase CMP
- MEMS
- Inter-layer dielectric (ILD)

Source: www.memx.com

Polish oxide films as fast as possible while maintaining high planarization efficiency

# Ferro's Manufacturing Process Flow

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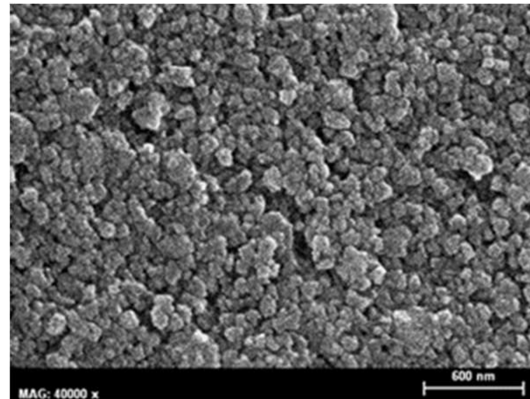
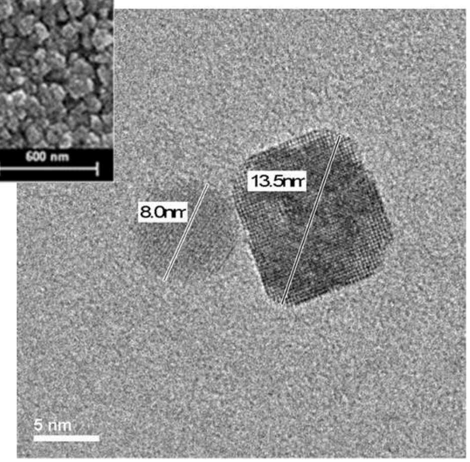
***Heat Treatment***

We make our own particle to optimize size, shape, phase, and reactivity

***Milling***



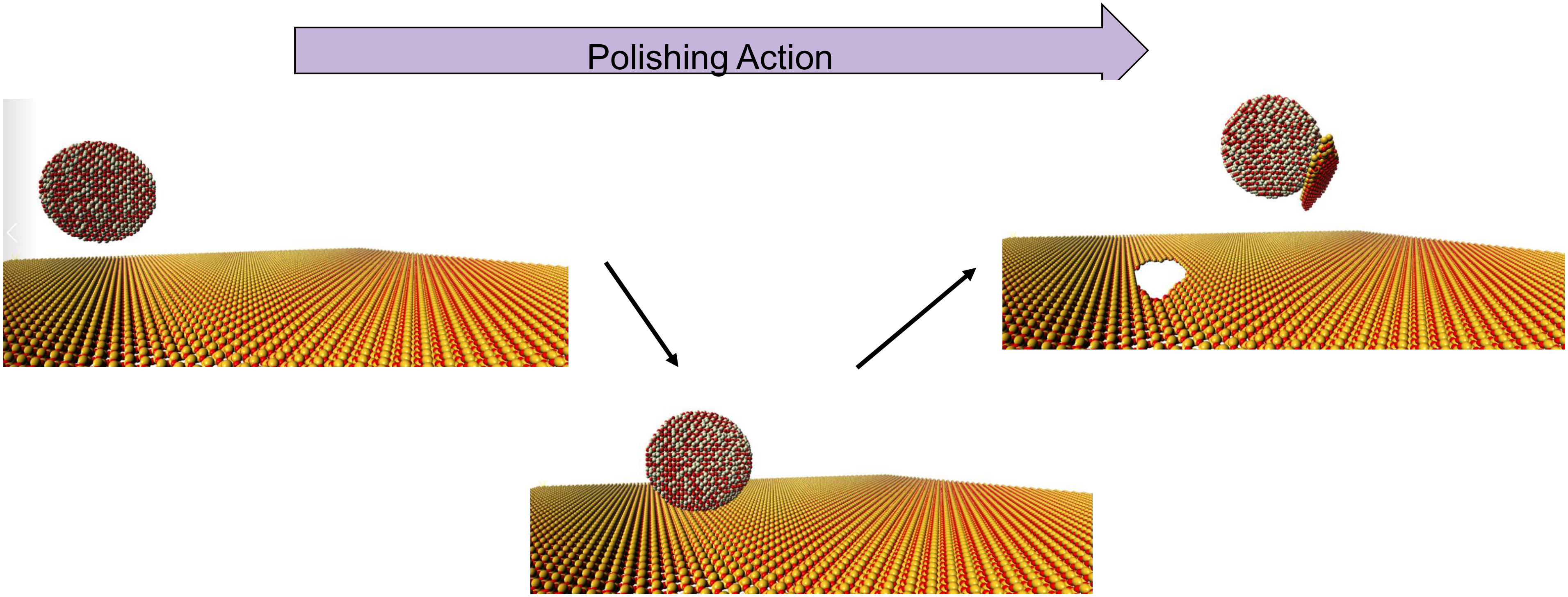

***Formulate / Filter***

The formulation is then customized for the specific particle and application to accelerate removal rates, enhance uniformity, extend shelf-life, etc.

***Pack***

# Ceria Polishing Mechanism

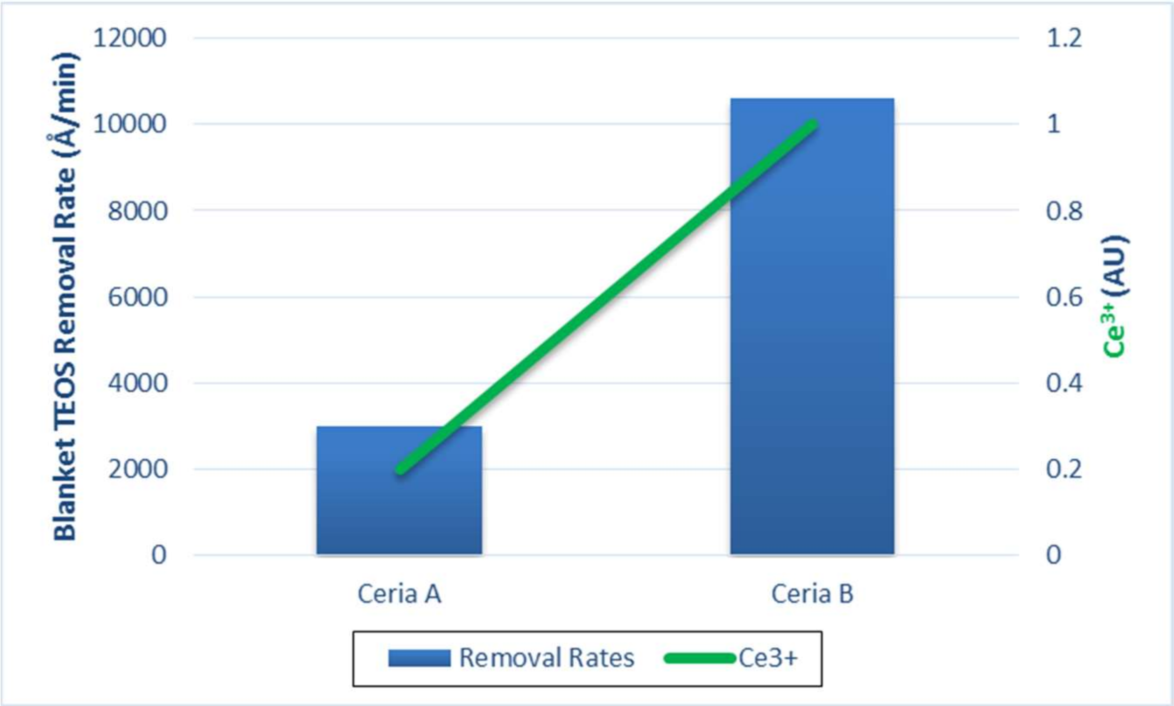
- As opposed to other abrasive types, ceria has a large surface chemical action during oxide polishing




- Studies have shown that **$Ce^{3+}$** sites on the surface of ceria particles are critical for $SiO_2$ removal rate
  - Veera Dandu (Clarkson thesis, also presented at 17th Annual International Symposium on Chemical Mechanical Planarization, August 12th-15th, 2012, Lake Placid, NY)

# Next Generation Ceria Particle

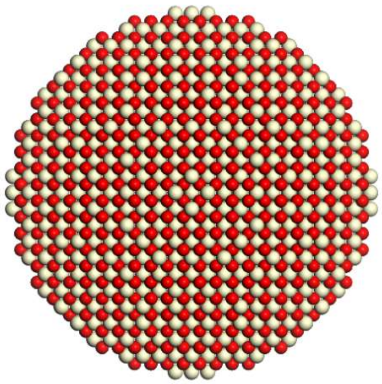
- Particle processing modified to optimize $Ce^{3+}$ stabilization
- Removal rates increase in parallel to $Ce^{3+}$ density*



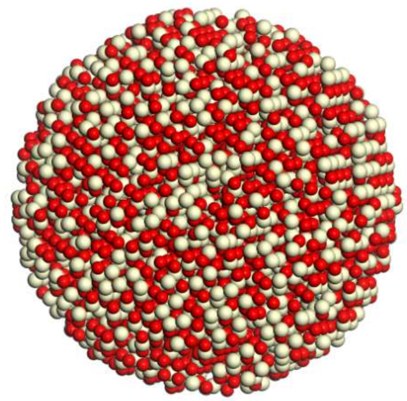

**Unformulated "blank" particle*

# Further Particle Optimization

Ceria Particle A



Ceria Particle B

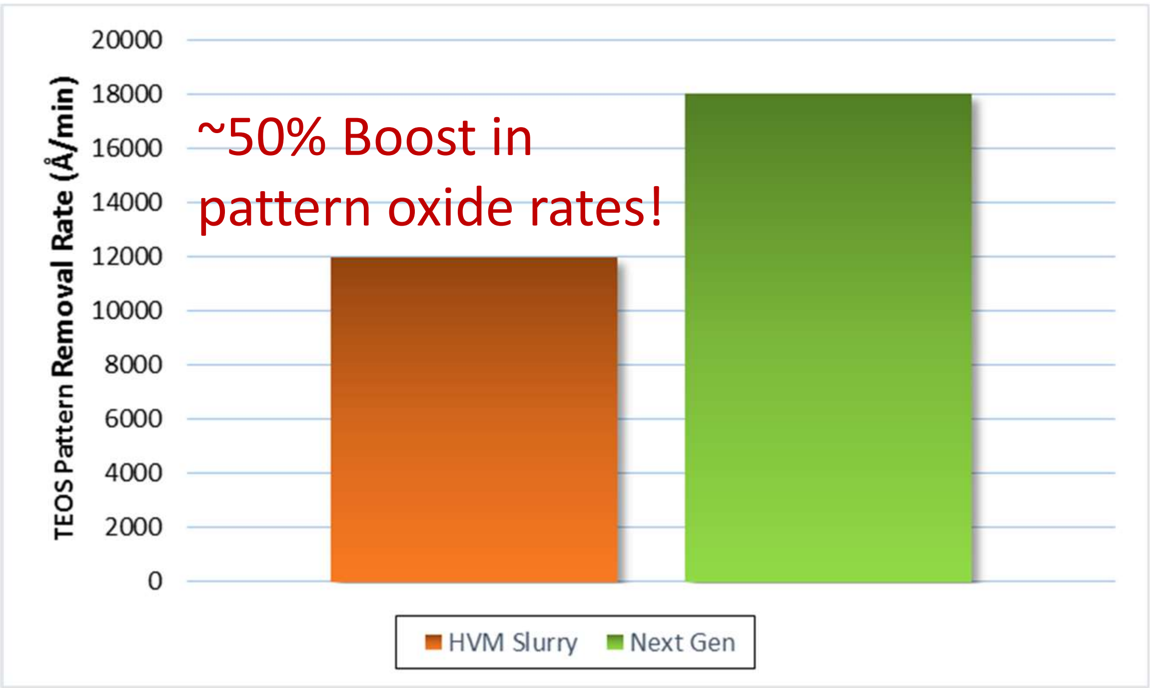


**$Ce^{3+}$ Dense surface, more O vacancies on surface**

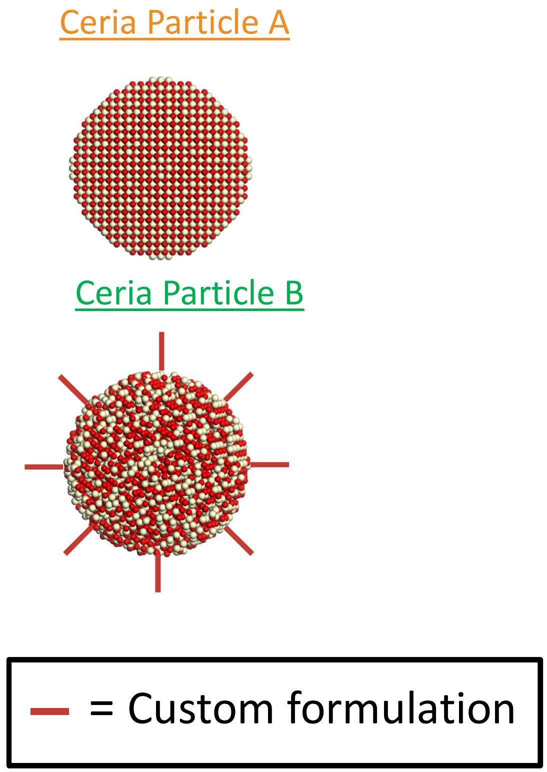
**Particle modified further to have more active surfaces to make contact with oxide substrate**

# 1731: Ultra Fast Oxide Slurry

- Pairing the next gen. particle with complementary formulation chemistries yields an ultra fast oxide slurry

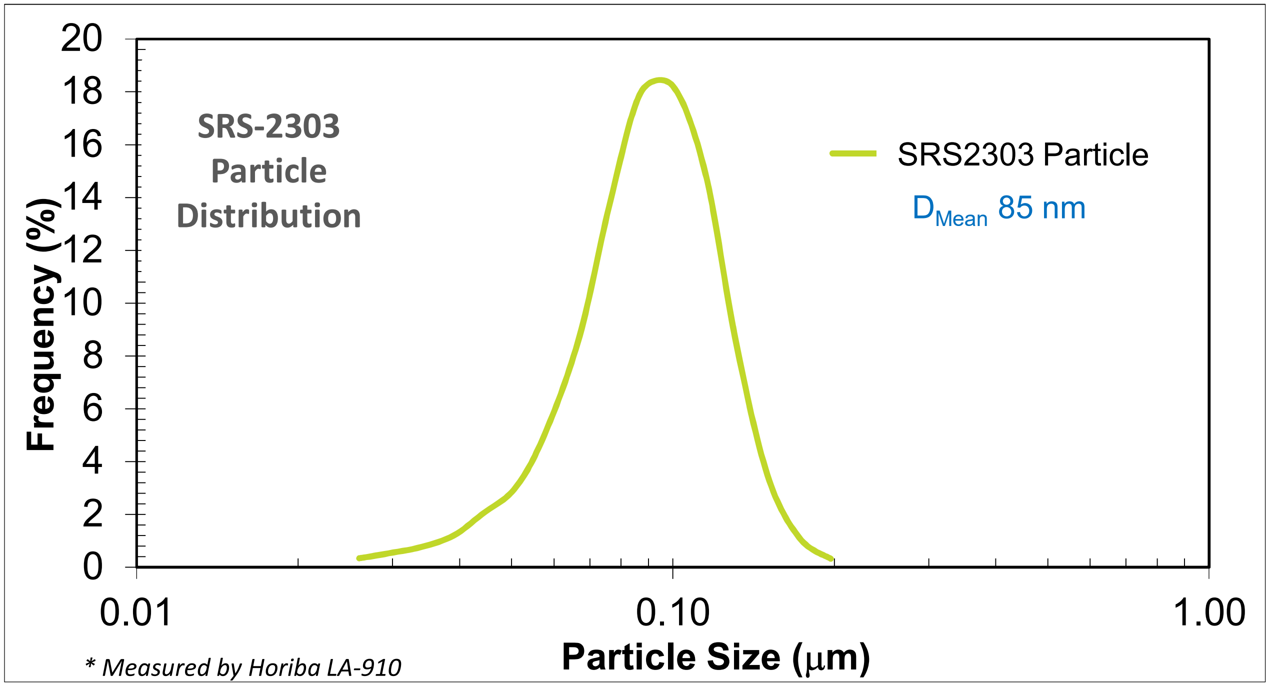



*3 PSI*
*IC1000 Pad*
*200mm Mirra*



# Ferro Calcinated Ceria STI Slurry

- Our Custom made low $D_{mean}$ solid state ceria particle is intended to minimize defects
- Employing know how for ceria particle engineering and formulations(accelerants, inhibitors…etc), we have developed a STI slurry with low $D_{mean}$, and is still able to maintain high RR and good selectivity in low abrasive concentrations



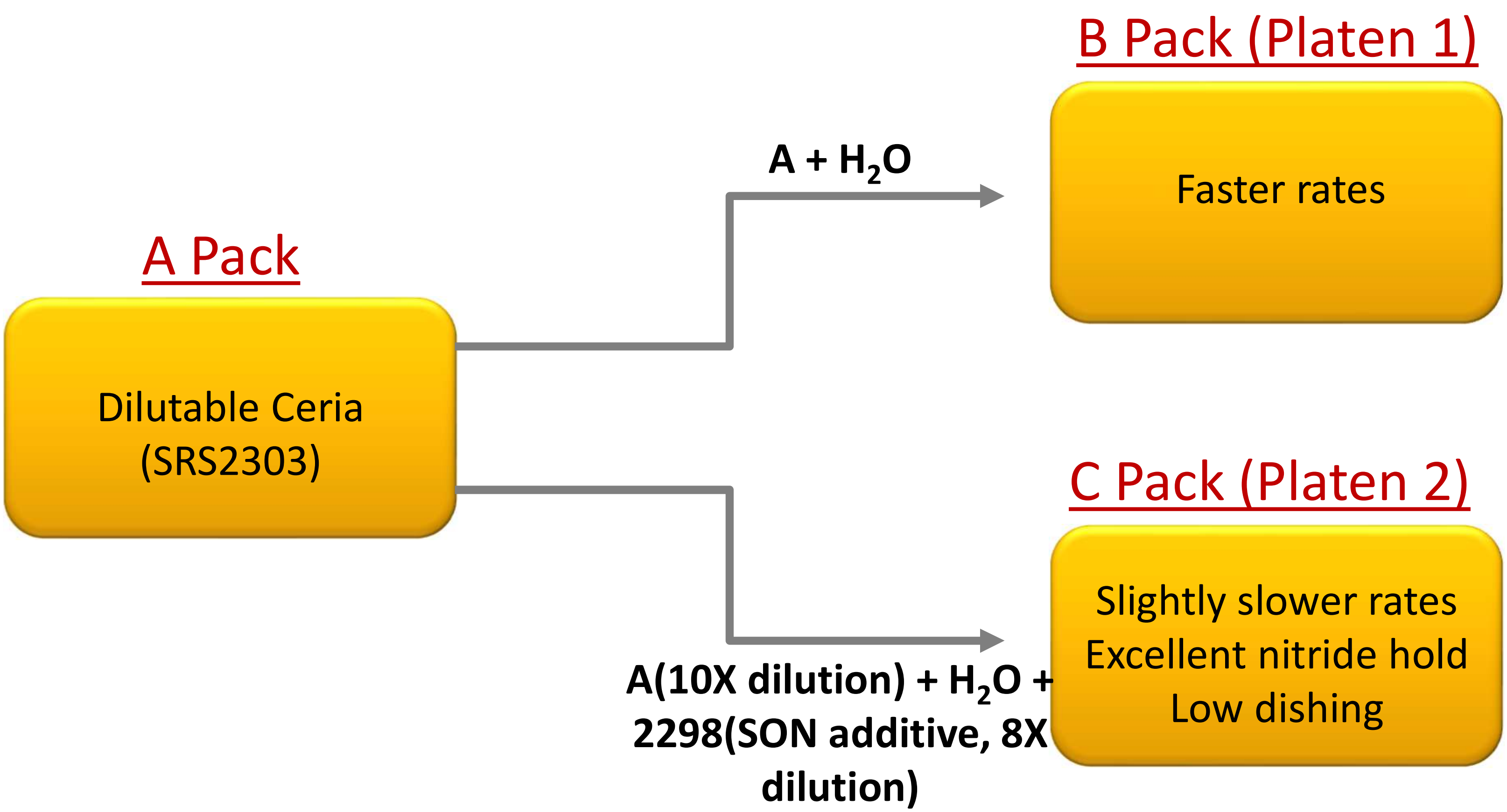
# SRS-2303 VS Competitor A
# Brief Summary

| | SRS-2303 | Competitor A |
|---|---|---|
| Solids | 3% | 4% |
| Solids at POU | 0.3% | 1-4% |
| pH | 3.5-3.8 | ~5 |
| Dilution Ratio | 10X | 3X~4X |
| $D_{mean}$* | 85nm | 150nm |
| D0* | 197nm | 584nm |
| TEOS RR(A/min)** | 3200 | 950 |
| SiN RR(A/min)** | 2 | 15 |
| Selectivity | 1600:1 | 60:1 |

*Measured on Horiba 910
**Mirra 200mm, IC1000 2psi for SRS-2303 3psi for Competitor A Platen 77 rpm Head 73 rpm, SRS-2303 Combined with 8X diluted 2298

# Multi-Component STI Platform

- Ferro has developed a multi-component STI platform for our solid state ceria designed to be a mix-on-tool, either 1 or 2-Platen, STI solution



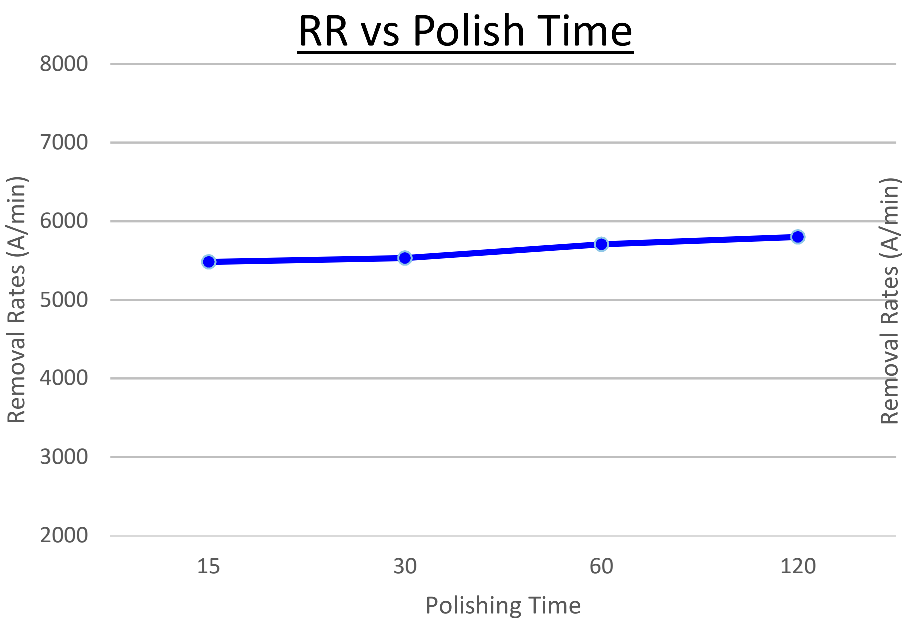
# SRS-2303 & SRS2303+2298

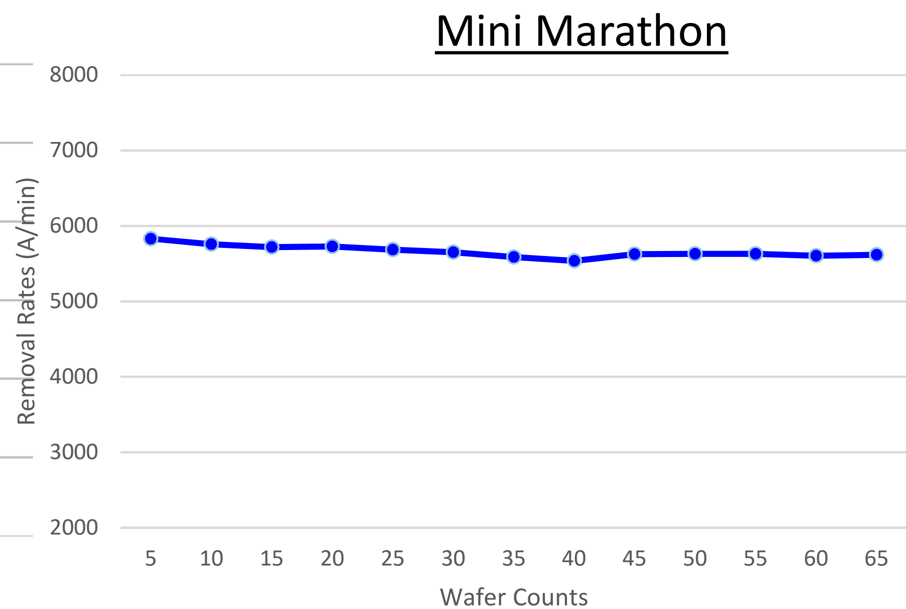
| | Blanket TEOS (A/min.) | Oxide RR* (A/min.) | Nitride RR* (A/min.) | Selectivity |
|---|---|---|---|---|
| SRS-2303 | 5400 | 6000 | NA | NA |
| SRS-2303+2298 | 3200 | 3600 | 2 | 1600:1 |

*50/50µm feature 2 PSI, 93 RPM, IC1000 pad 200mm Mirra

# SRS-2303: Polishing Stability

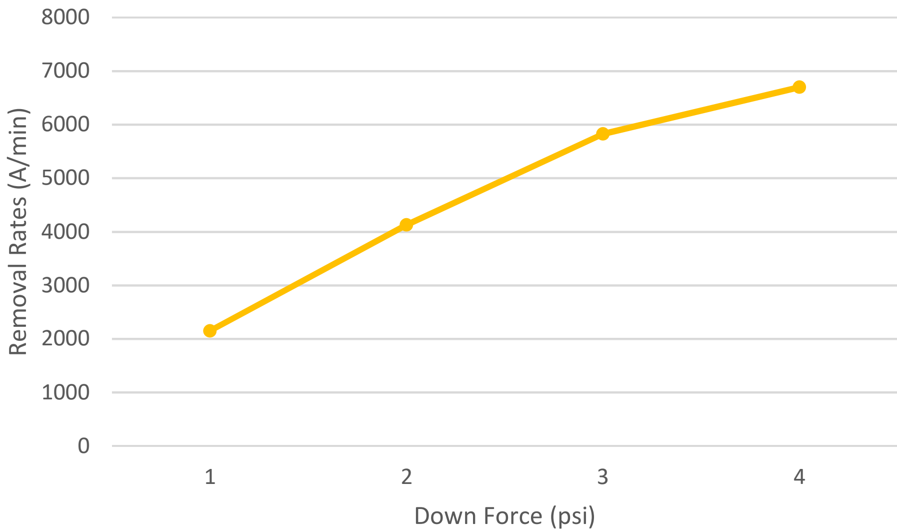
- Stable and predictable removal rates



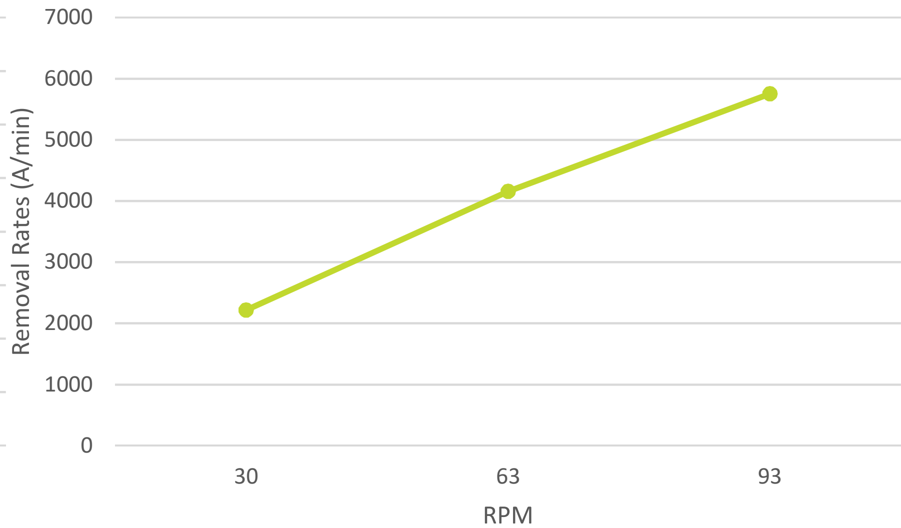



# SRS-2303: PV Response

- Prestonian polishing behavior with a predictable response to PV




*93 RPM, 150 mL/min.*
*200mm Mirra, TEOS Blanket*



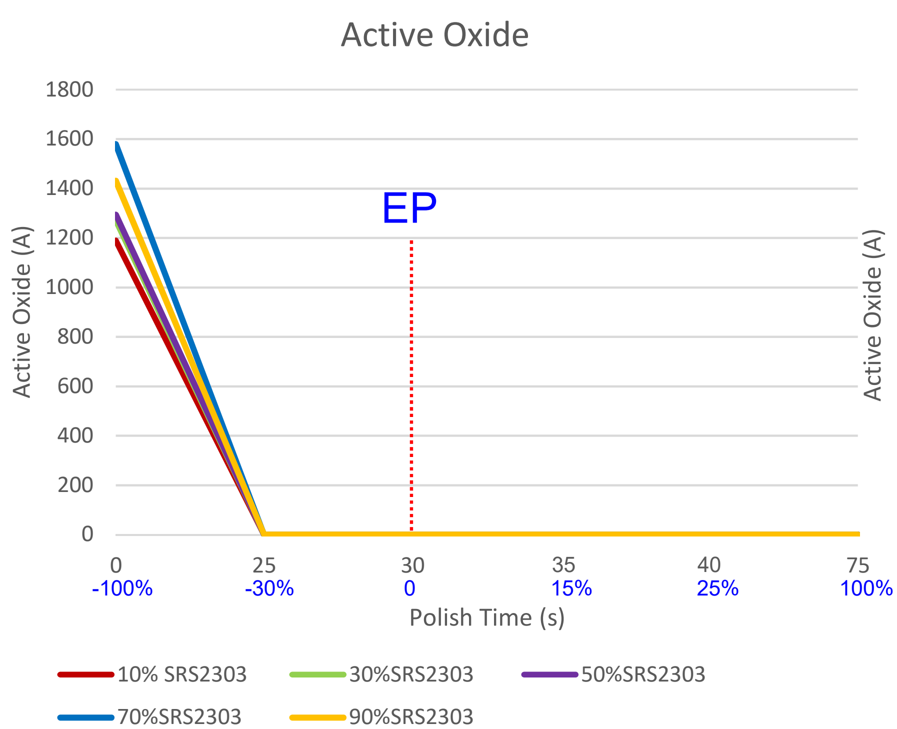

*3 PSI, 150 mL/min.*
*200mm Mirra, TEOS Blanket*

# Experimental Setup

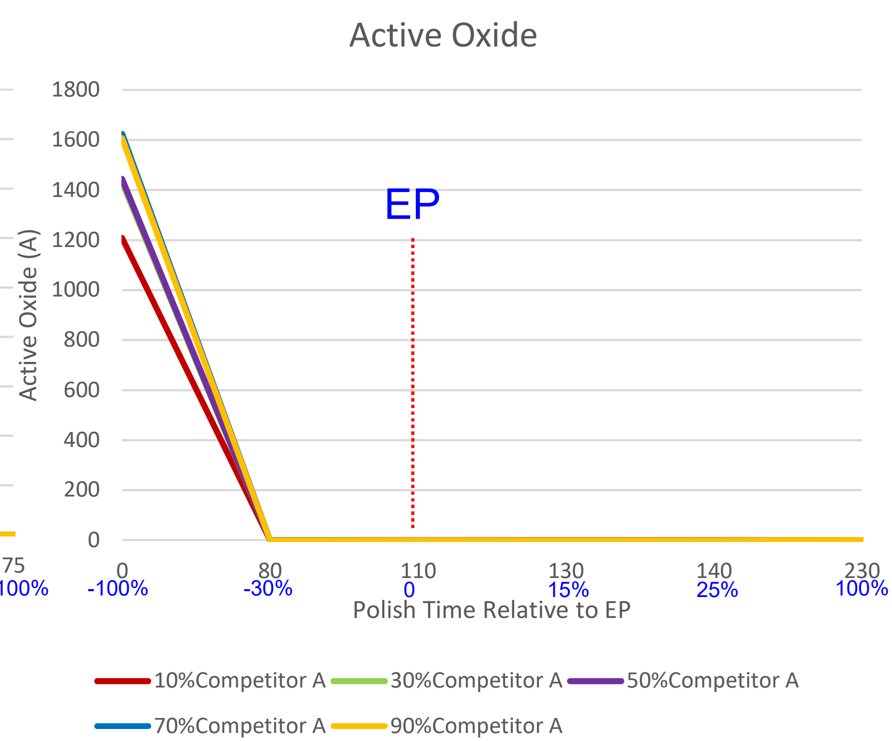
- Pattern wafers (MIT864 mask), 1$^{st}$ step polished to active oxide THK=1150~1250A (10% feature density) is used for comparison
- Polish 2$^{nd}$ step with SRS-2303 and Competitor A slurry
- Polished on AMAT Mirra 200mm polisher, **2 psi** DF, 77 rpm platen, 73 rpm head and 150ml/min slurry flow for SRS-2303, **3 psi** DF, 77 rpm platen, 73 rpm head and 150ml/min slurry flow for Competitor A
- End Point is determined when 500um pitch feature cleared

# SRS-2303+2298(SON additive) VS Competitor A Slurry

- Platen 2 Active Oxide THK (10%-90% features, 100um size)
- SRS-2303 polished at lower DF, but still clears wafer within 30s



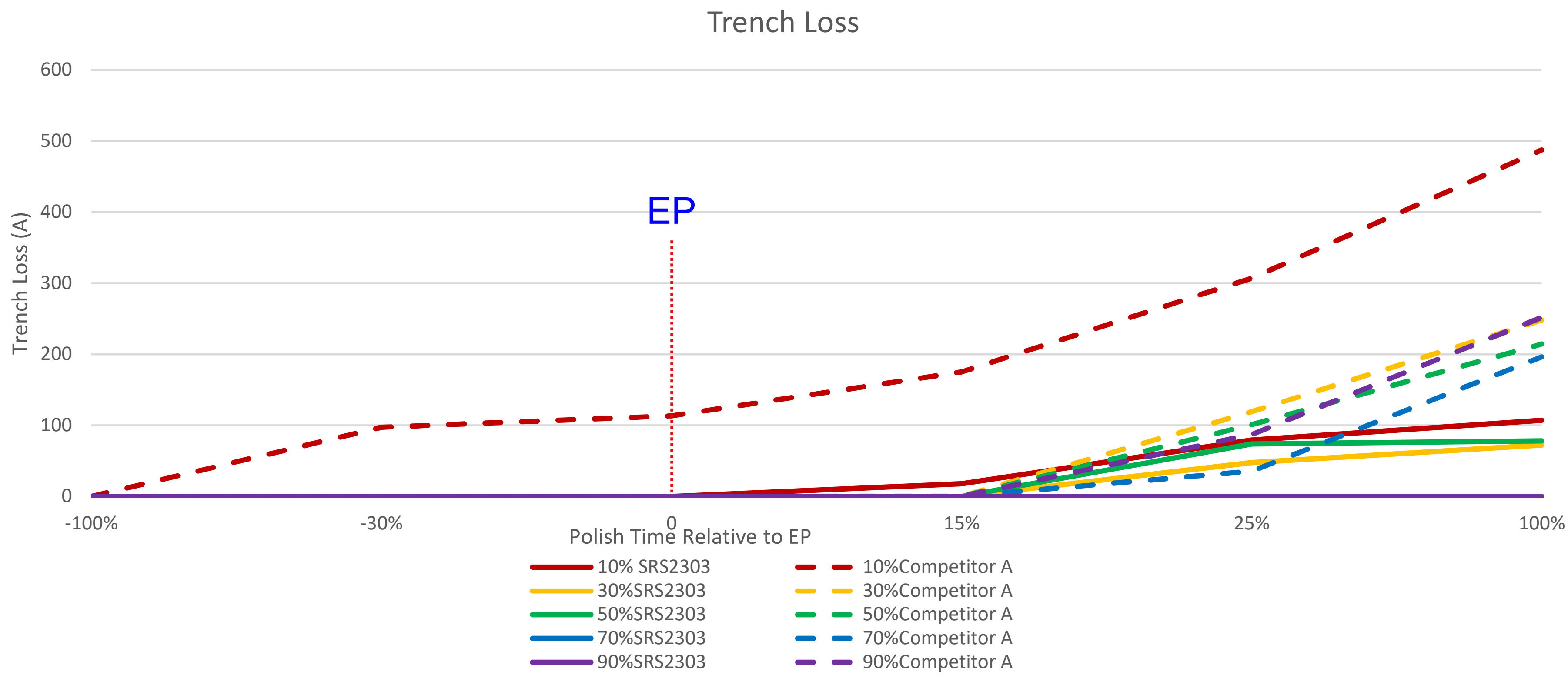

100µm feature size **2 PSI**, 77 RPM, IC1000 pad 200mm Mirra




100µm feature size **3 PSI**, 77 RPM, IC1000 pad 200mm Mirra

# SRS-2303+2298(SON additive) VS Competitor A Slurry

- Platen 2 Trench Loss (10%-90% features, 100um size)
- Lower Trench Loss across all features with SRS-2303

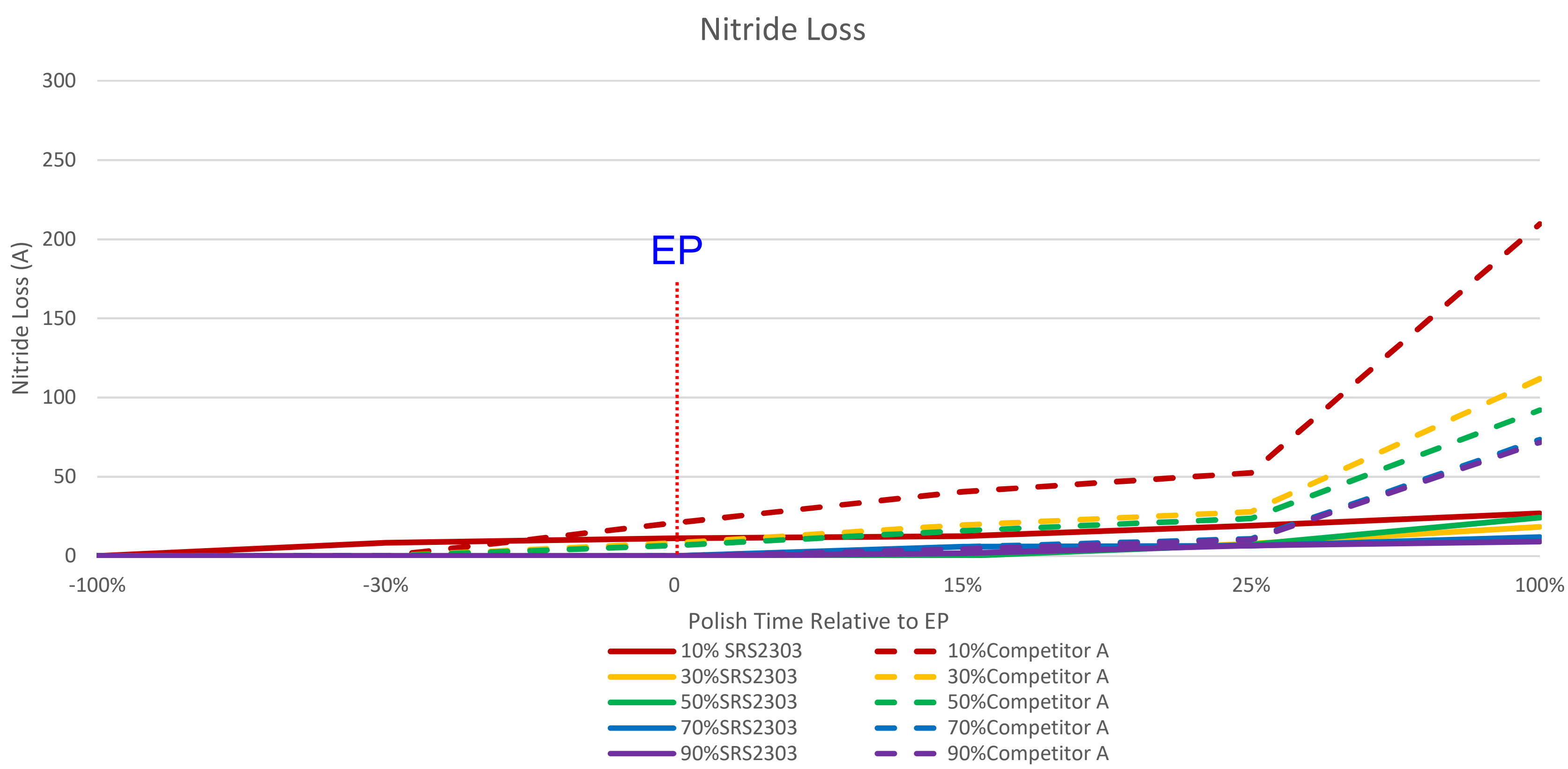



SRS-2303:100um feature size 2 PSI, 77 RPM, IC1000 pad 200mm Mirra

Competitor A:100um feature size 3 PSI, 77 RPM, IC1000 pad 200mm Mirra

# SRS-2303+2298(SON additive) VS Competitor A Slurry

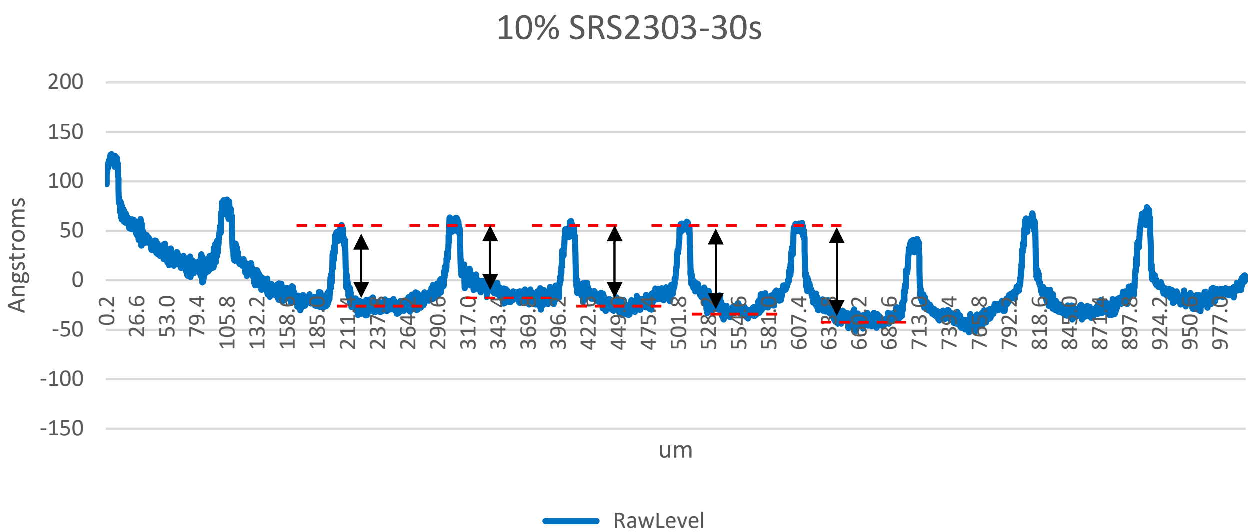
- Platen 2 Nitride Loss (10%-90% features, 100um size)
- Lower Nitride Loss across all features with SRS-2303




SRS-2303:50% feature density 2 PSI, 77 RPM, IC1000 pad 200mm Mirra

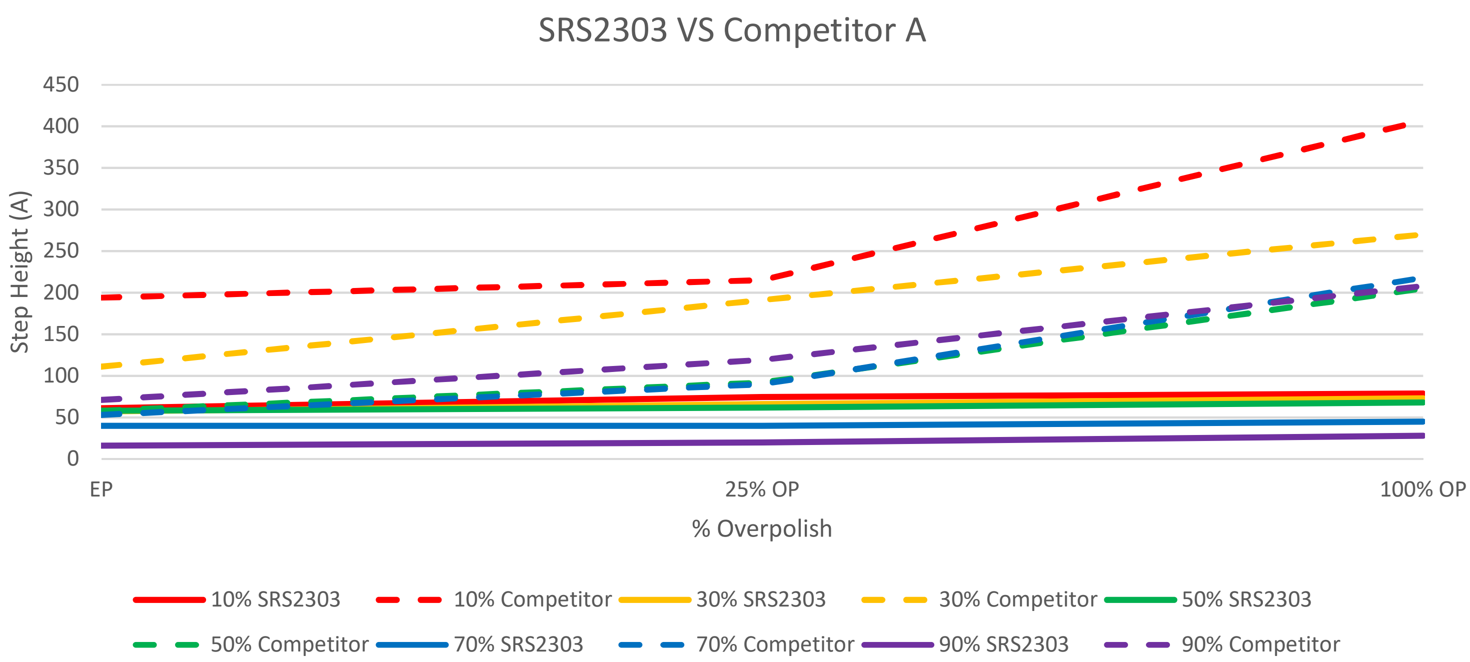
Competitor A:50% feature density 3 PSI, 77 RPM, IC1000 pad 200mm Mirra

# Profilometry Methods



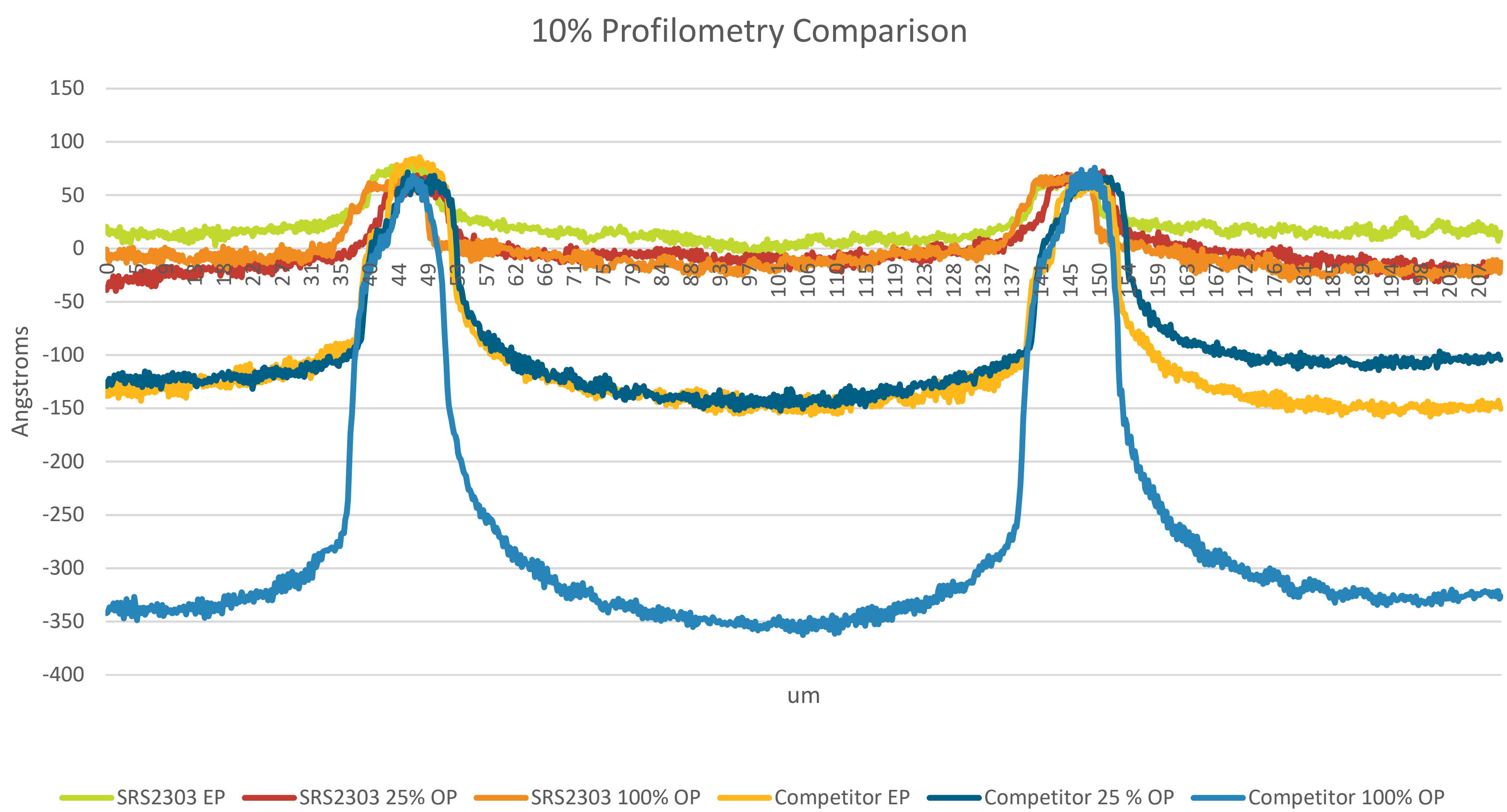

- EndPoint (EP) is defined when 500um-50% feature cleared
- Profilometry done with KLA HRP-220
- We pick 5 peaks/valleys in the middle that is leveled and average

# Step Height Comparison

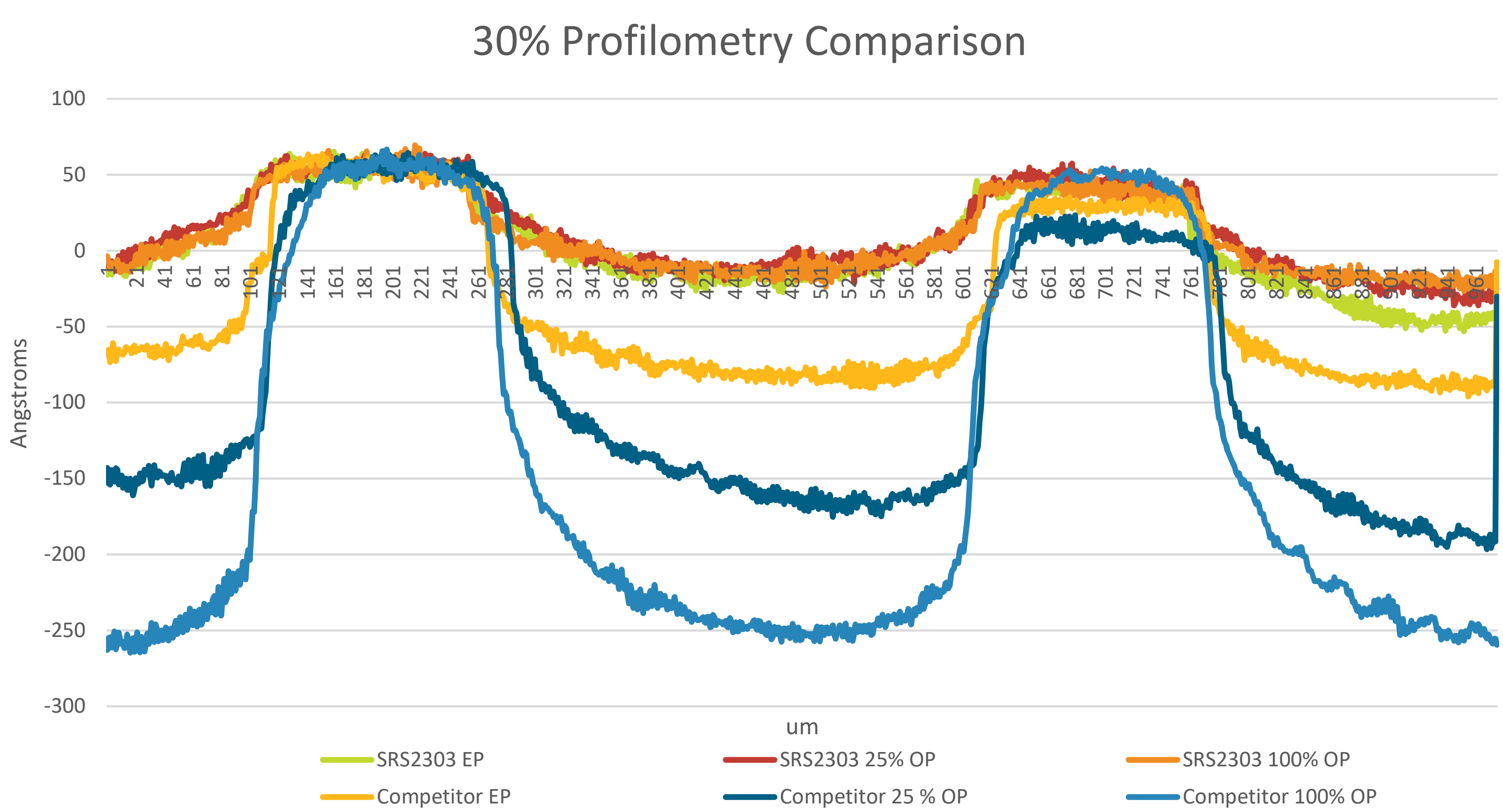



- SRS-2303 shows superior resistance to dishing with extended overpolishing
- SRS-2303 has tighter grouping across all density ranges, better planarity

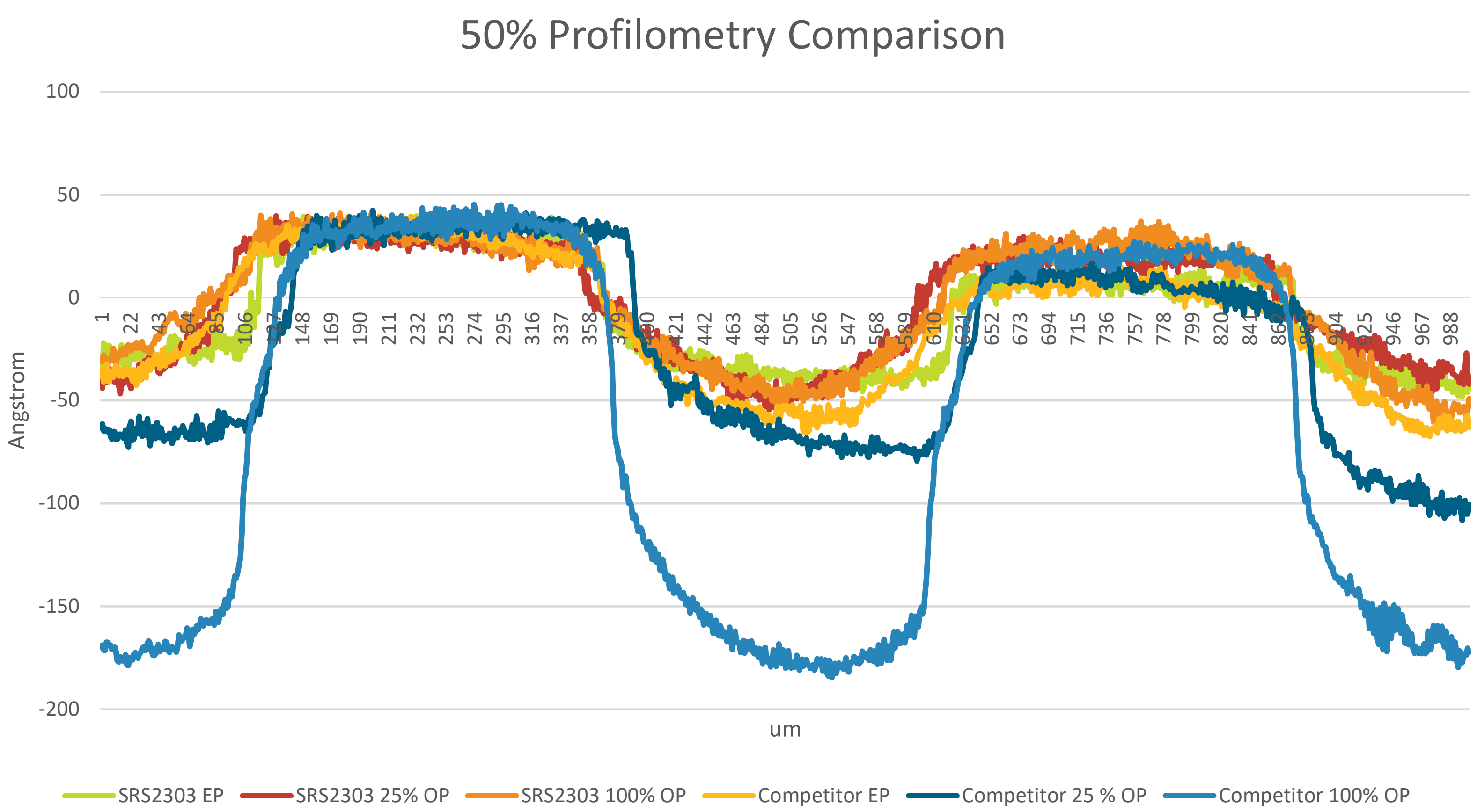
# Profile Comparison



# Profile Comparison



# Profile Comparison



# 864 Pattern wafer with KLA-2139 scan

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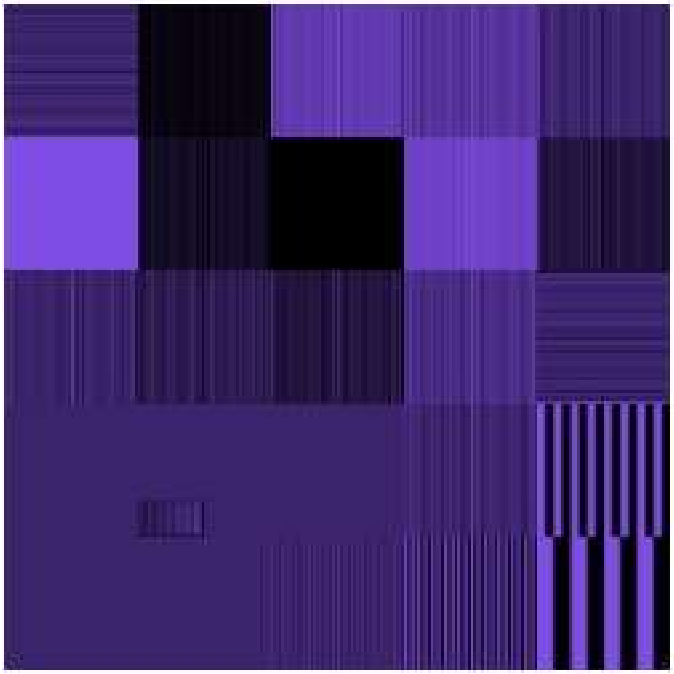
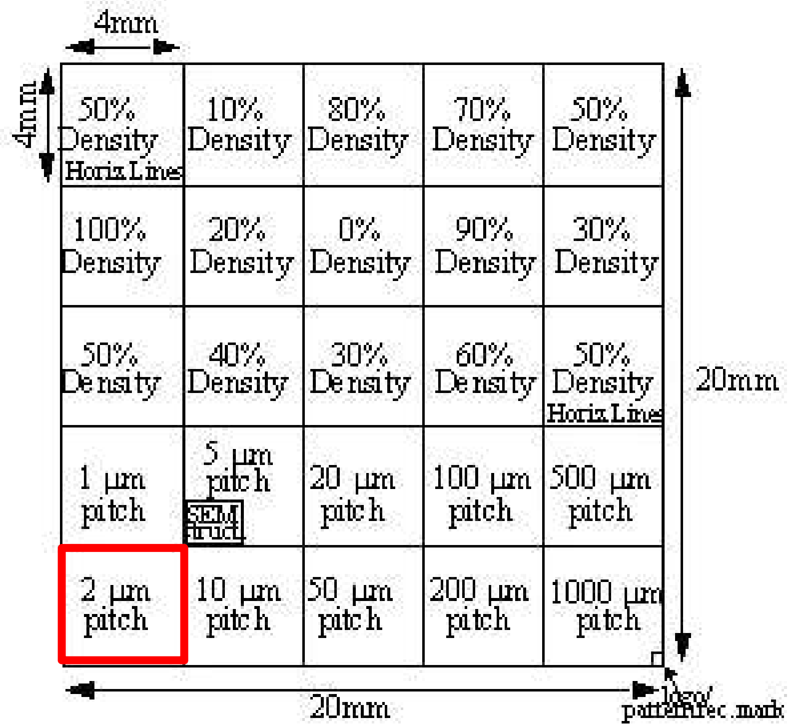




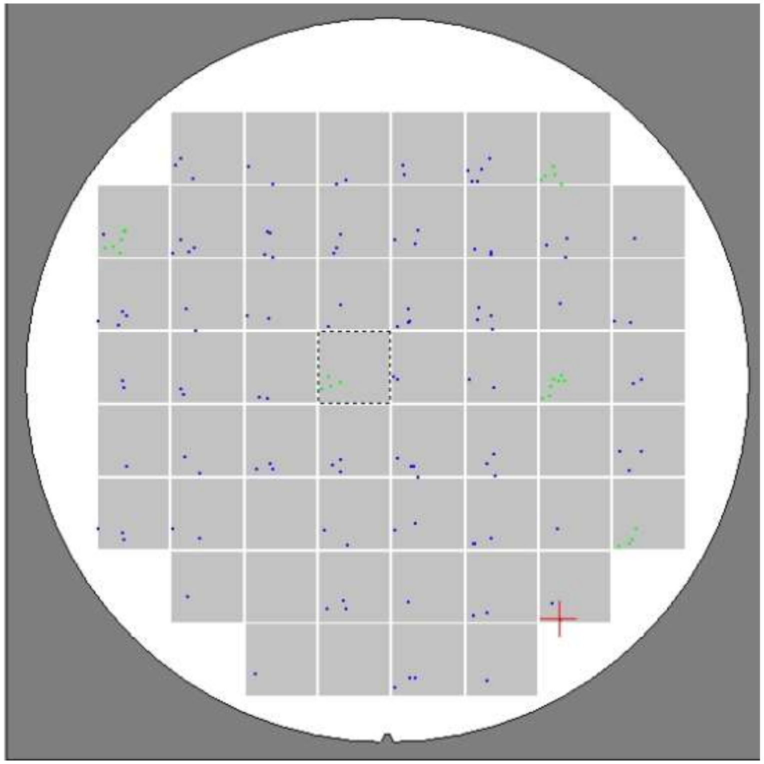
# Defect Comparison

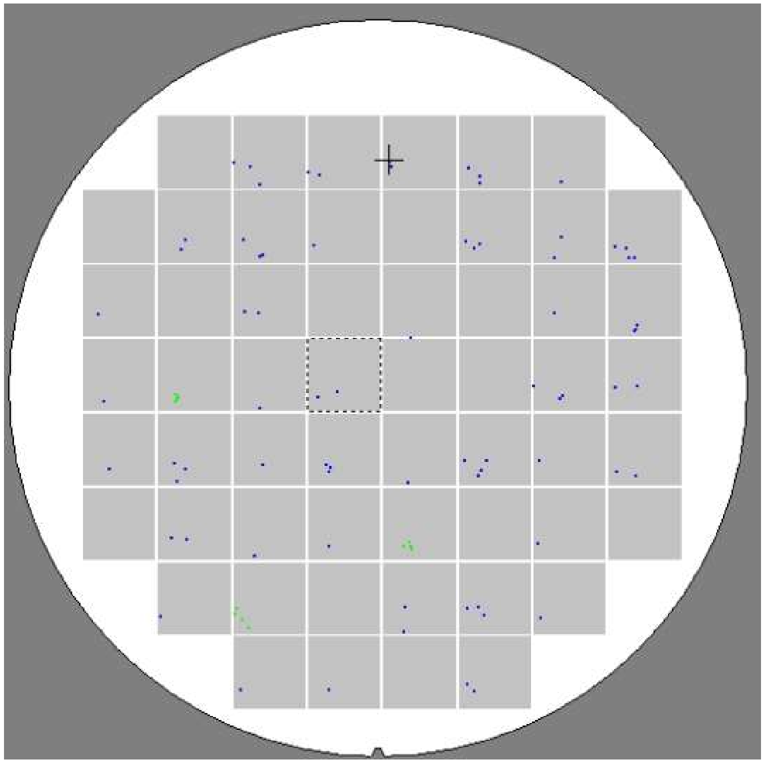
## Competitor

| | Small particle | Big particle | Other | False | Total |
|---|---|---|---|---|---|
| Review count | 87 | 24 | 18 | 12 | 141 |
| Defect count% | 61.7% | 17.0% | 12.8% | 8.5% | |

## SRS2303

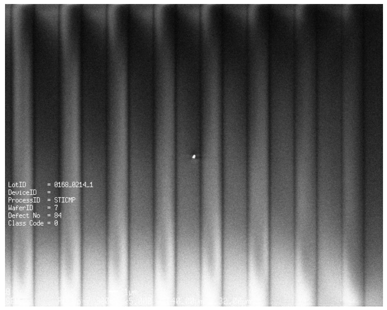
| | Small particle | Big particle | Other | False | Total |
|---|---|---|---|---|---|
| Review count | 69 | 4 | 9 | 12 | 94 |
| Defect count% | 73.4% | 4.3% | 9.6% | 12.8% | |

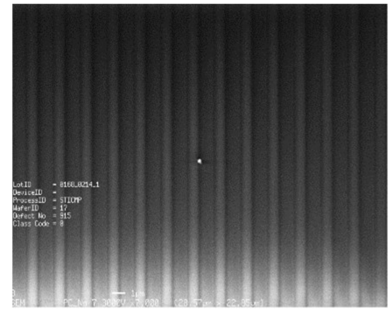




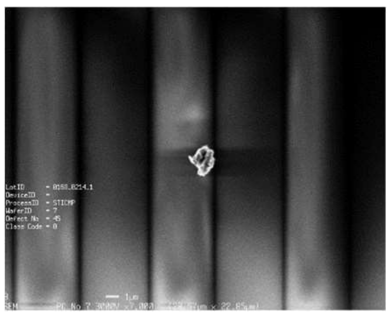
# Defect type

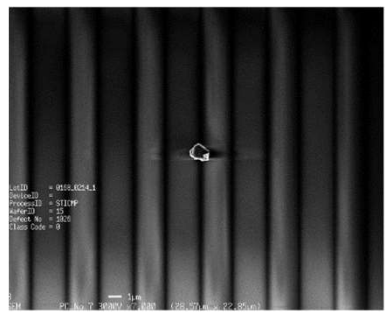
Small particle





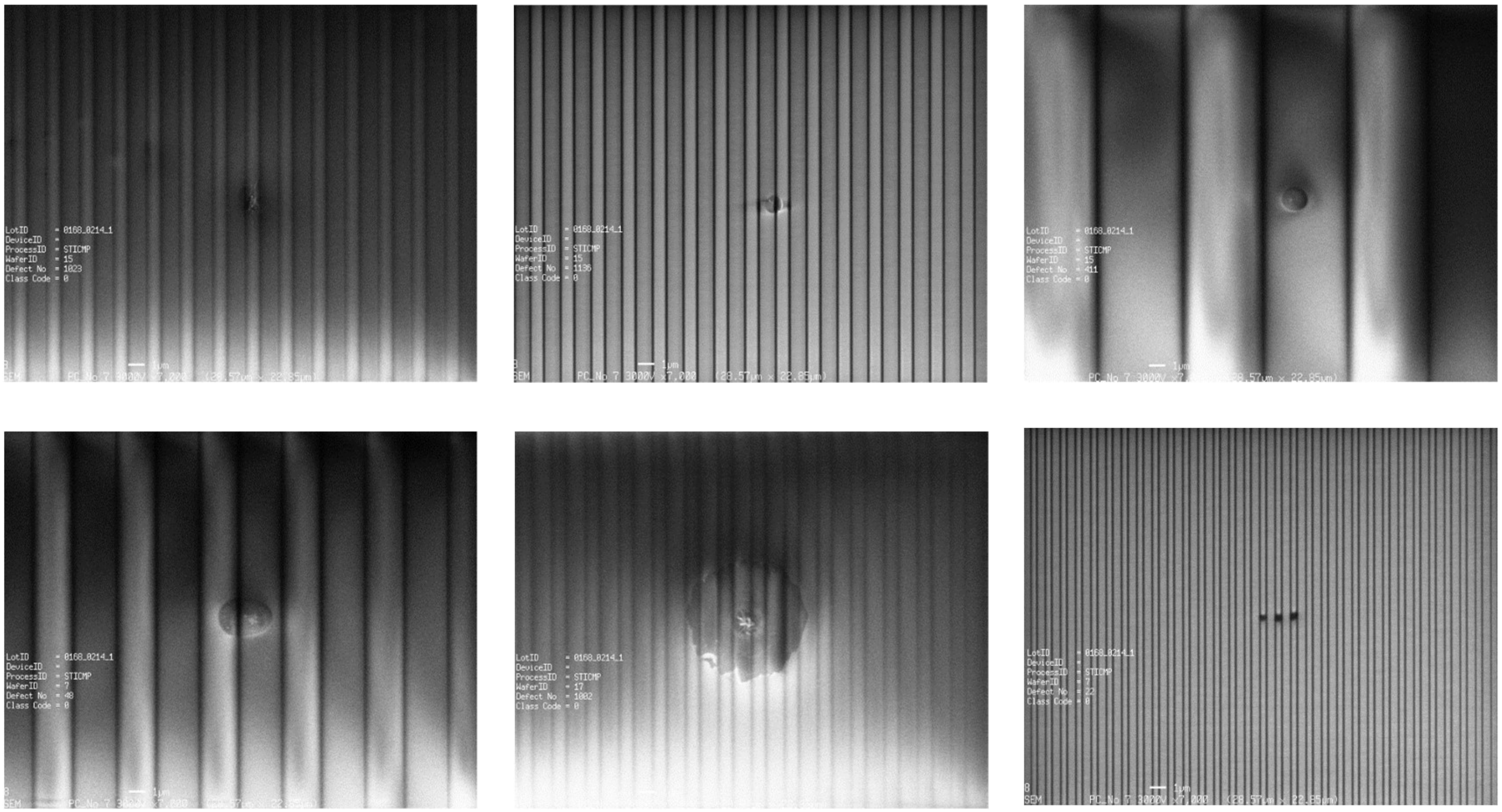
Big particle





# Defect type

Other



# Ferro SRS-2303 Advantage

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- Low $D_{mean}$ particles have been made to minimize defect concerns associated with larger particle size
- Superior defects
- Lower $D_{mean}$ particles, lower polishing down force
- Faster removal rate (3X) to achieve high throughput and lower costs
- High dilution ratio (0.3% ceria POU) lowers cost
- Excellent stop on nitride performance and low trench loss enables customers more processing window
- Custom slurries can be developed upon request