

2018 CMPUG Meeting

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04/12/2018

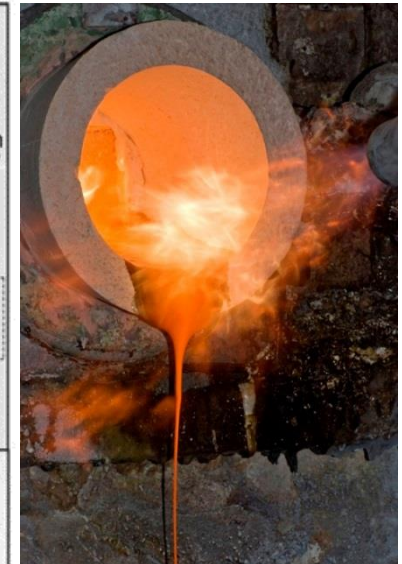
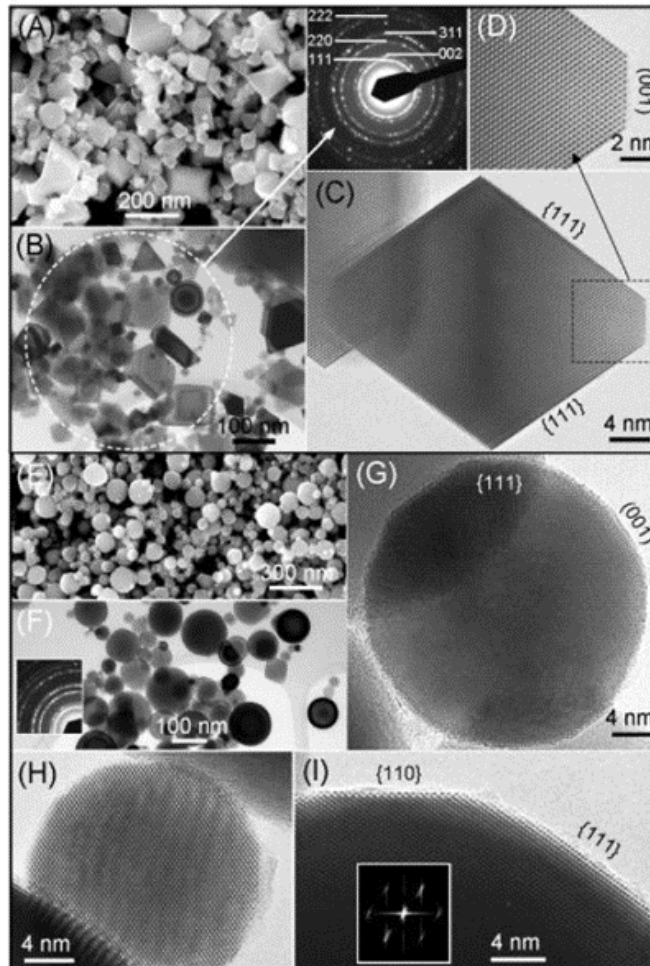
“Particle Developments as an Enabler
of Next Generation Ceria Slurries”

Outline

- Ferro's core technologies
- Calcined ceria for fast oxide CMP
- Precipitated ceria for STI CMP
- Summary

Ferro's Core Technologies

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



Fast Oxide CMP

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



Source: www.memx.com

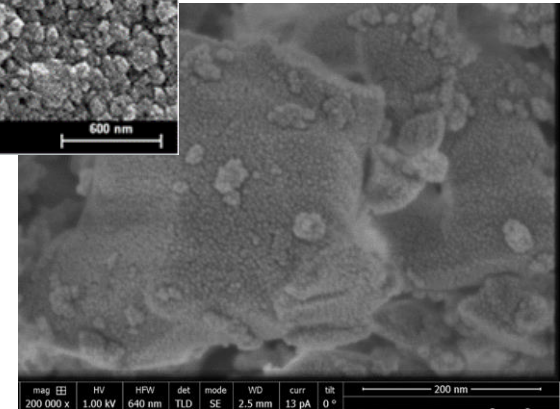
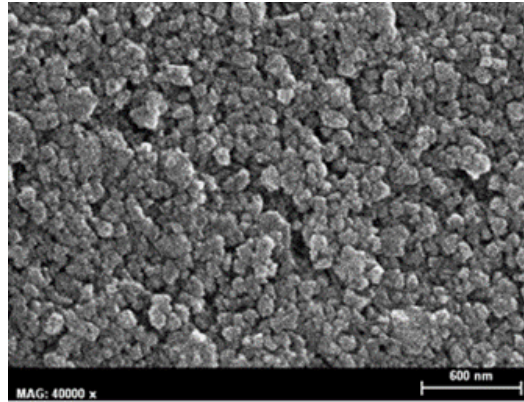
Polish oxide films as fast as possible while
maintaining high planarization efficiency

Ferro's Manufacturing Process Flow

**Heat
Treatment**

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

Milling



**Formulate /
Filter**

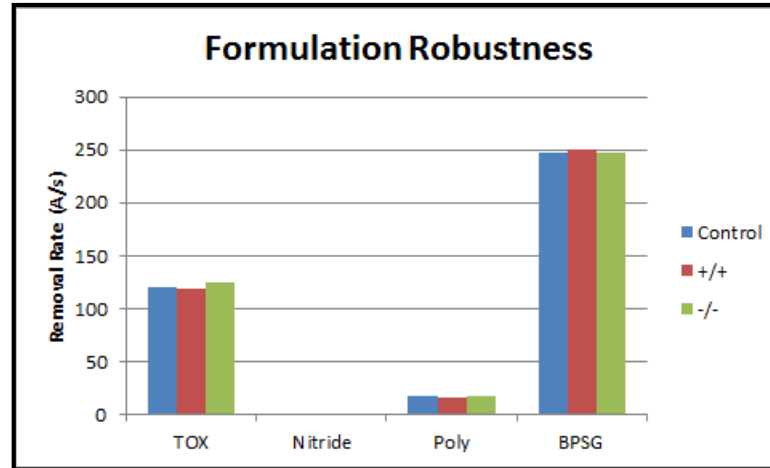
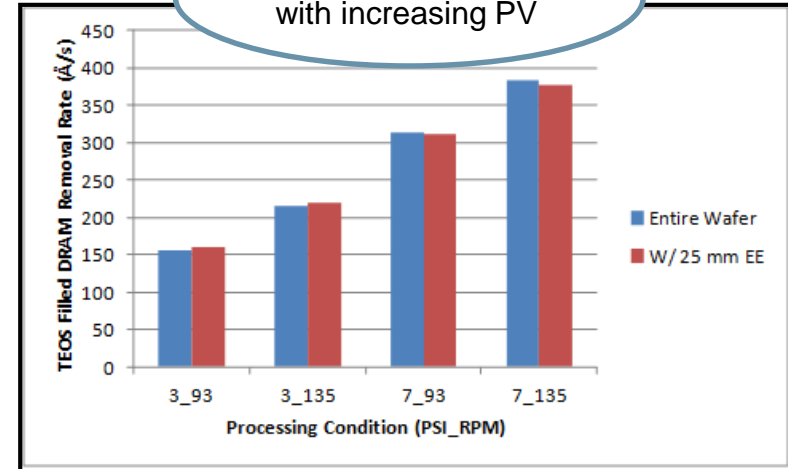
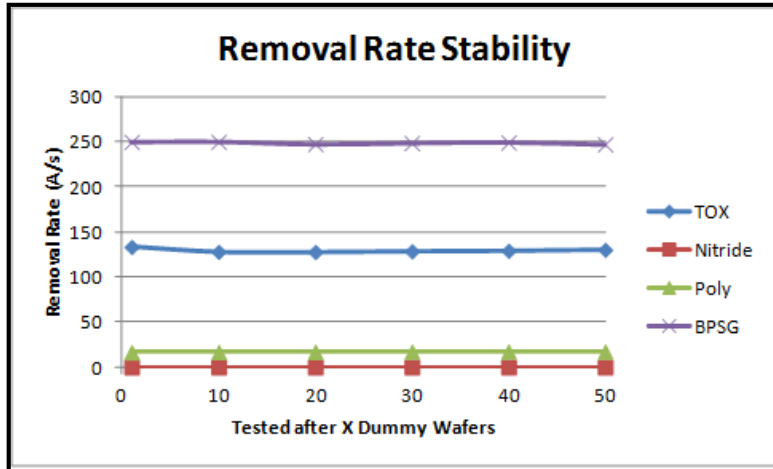
The formulation is then
customized for the specific
particle and application to
accelerate removal rates,
enhance uniformity, extend
shelf-life, etc.

Pack



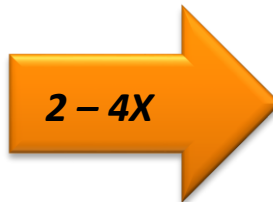
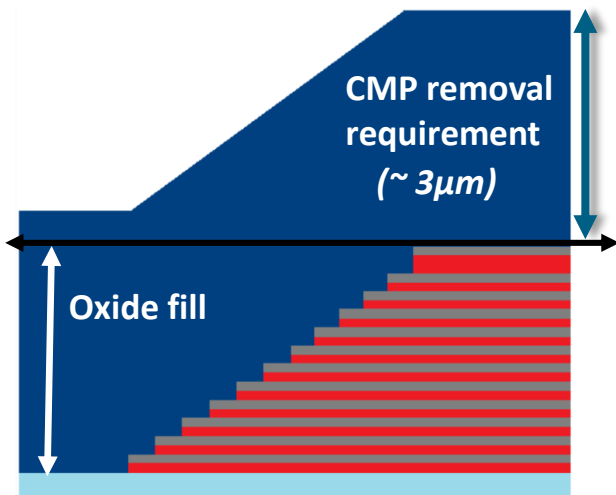
1631: HVM Fast Oxide Slurry

Prestonian Behavior
with increasing PV



- A few of the parameters studied during the development of the 1631 are shown above
 - A robust slurry is key to having a capable process

Looking Ahead

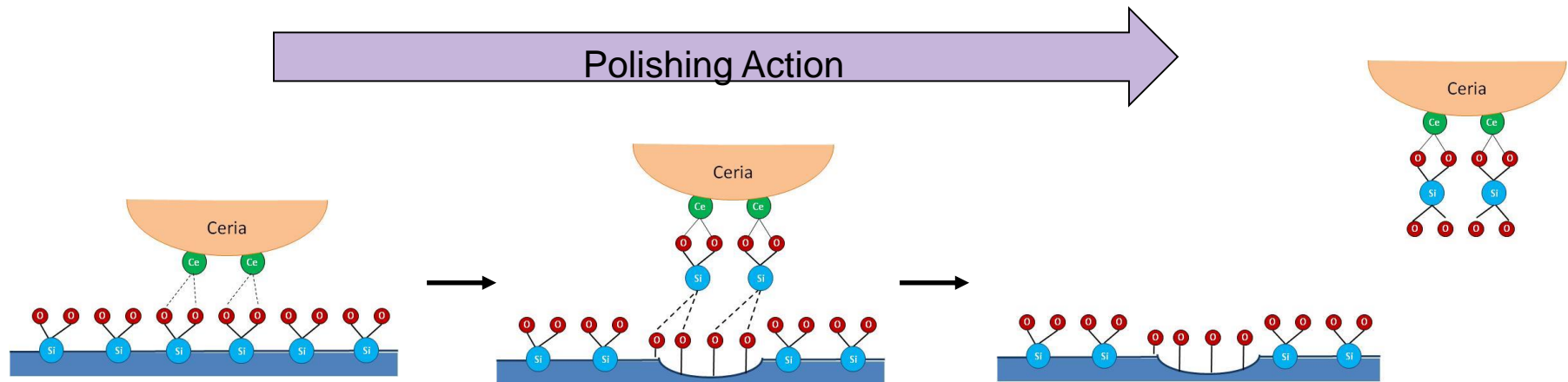


CMP removal requirement

- Oxide removal requirements will continue to grow
- Faster removal rates are needed
- Developing a new ceria particle + complementary formulation is key!

Ceria Polishing Mechanism

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

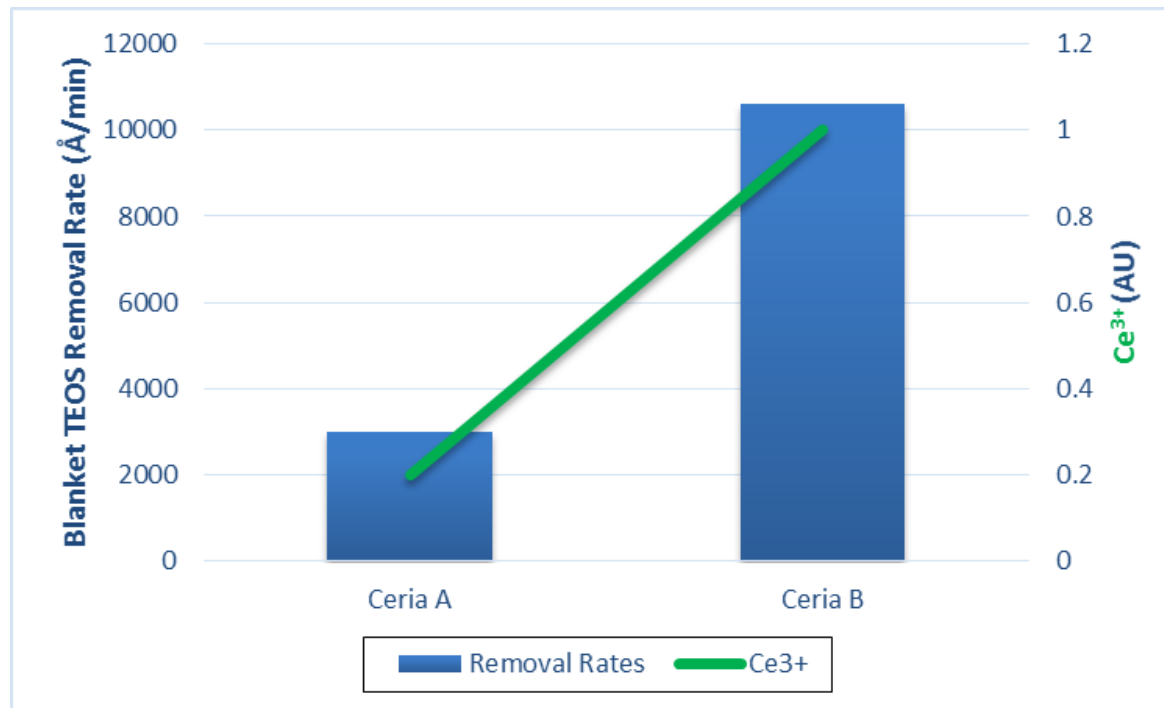


• Lee Cook, *Journal of Non-Crystalline Solids* 120 (1990), p. 152-171

- 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

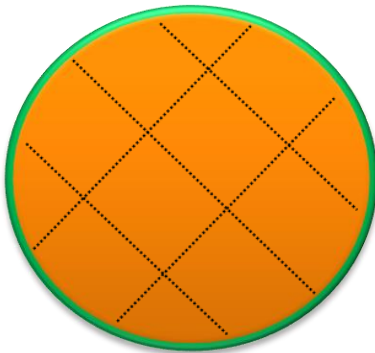
- Particle processing modified to optimize Ce^{3+} stabilization
- Removal rates increase in parallel to Ce^{3+} density*



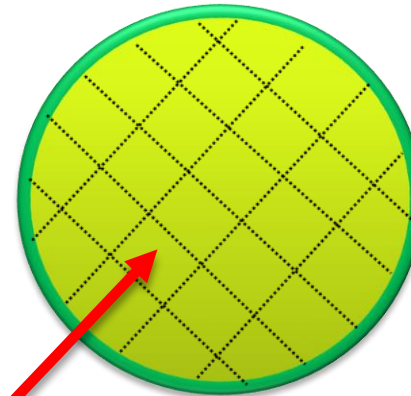
**Unformulated “blank” particle*

Further Particle Optimization

Ceria Particle A



Ceria Particle B

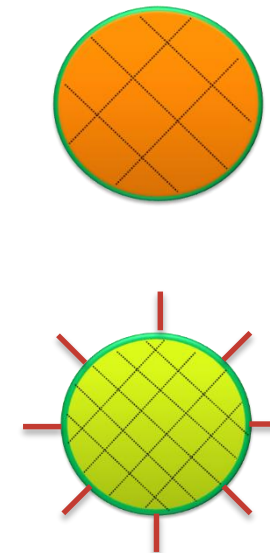
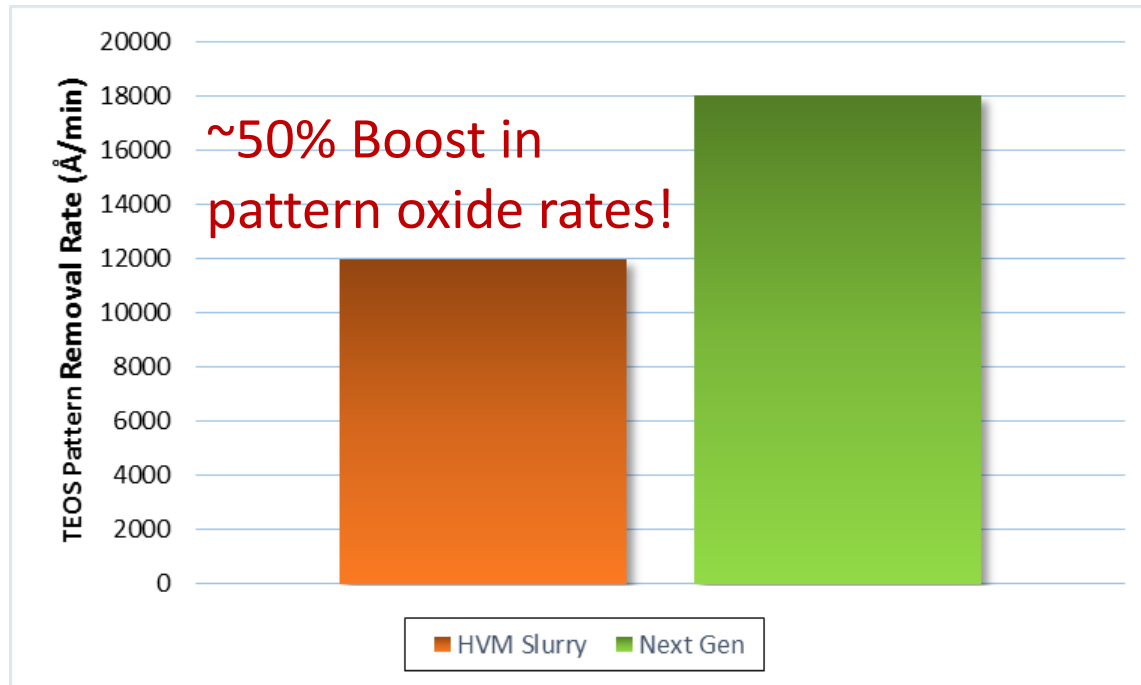


Ce^{3+} Dense surface

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

1731: Ultra Fast Oxide Slurry

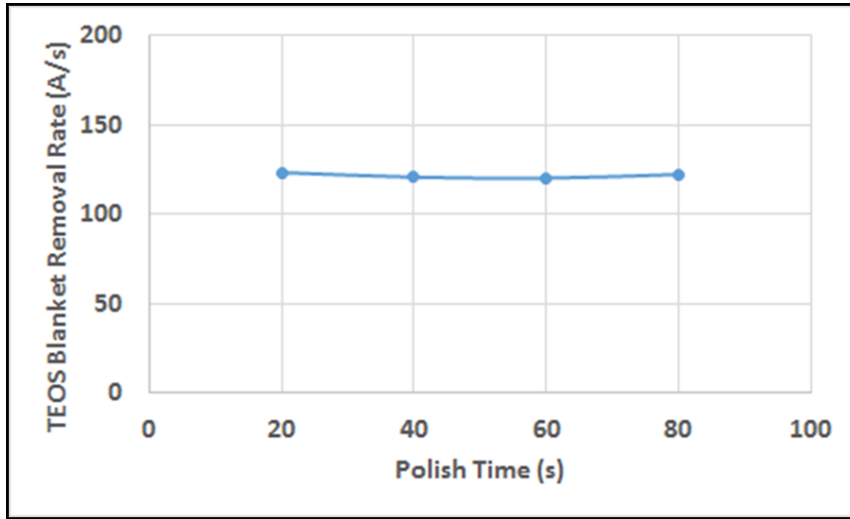
- Pairing the next gen. particle with complementary formulation chemistries yields an ultra fast oxide slurry



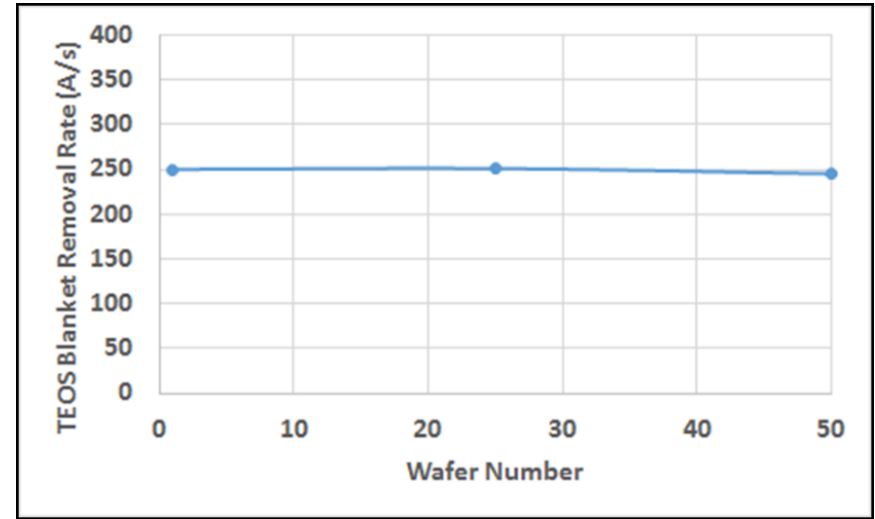
— = Custom formulation

3 PSI
IC1000 Pad
200mm Mirra

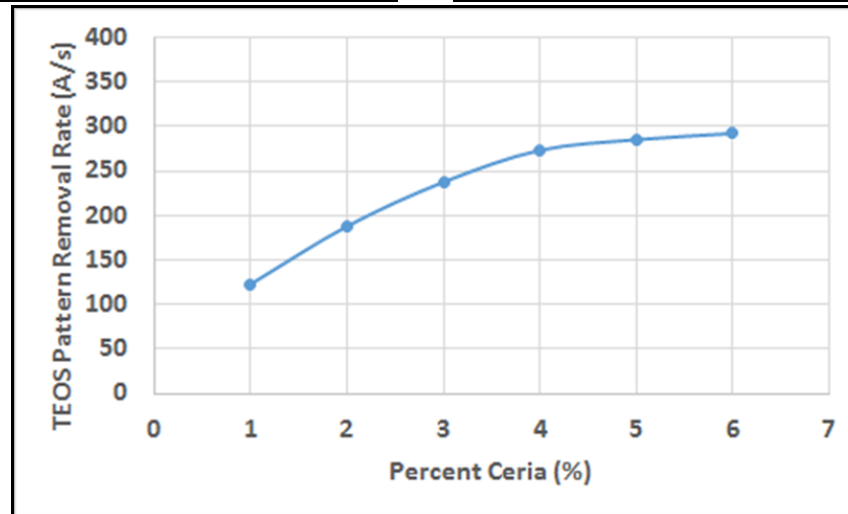
1731 Slurry Performance



1.5 PSI, 100 ml/min



3 PSI, 100 ml/min



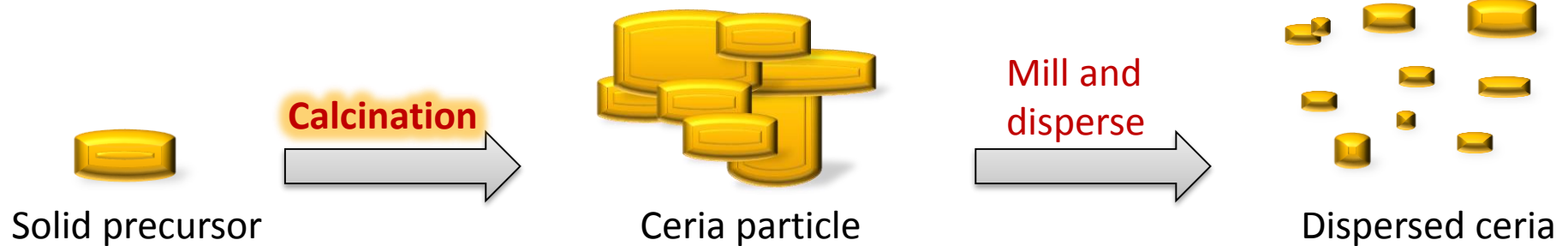
3 PSI, 100 ml/min

- A robust slurry is key to having a capable process

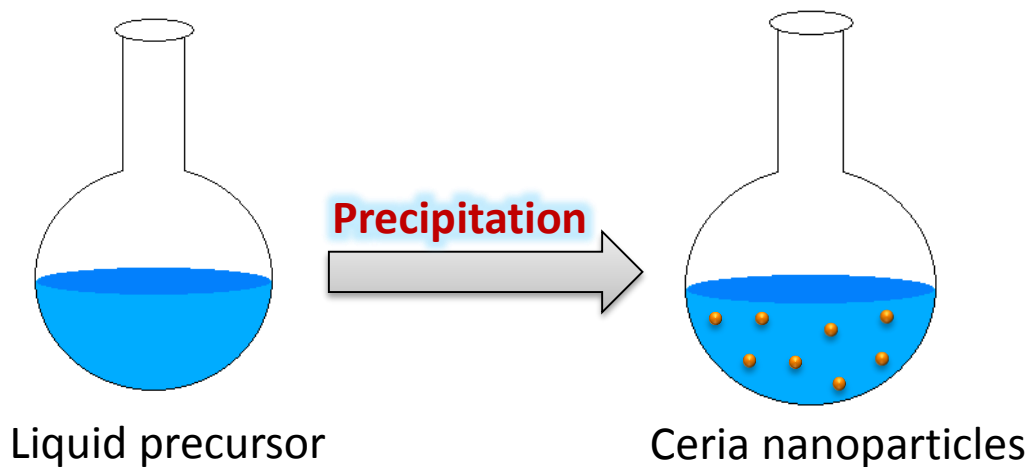
Other CMP Applications

❖ Precipitated ceria for STI CMP

Solid State vs. Precipitated



VS



Advantages

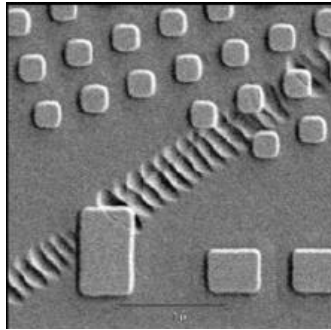
Convenient synthesis of sub-30nm particles

extremely narrow PSD's

No contaminations introduced from milling process

Shrinking Devices

As devices shrink

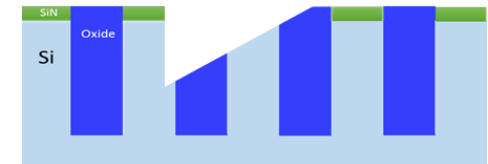
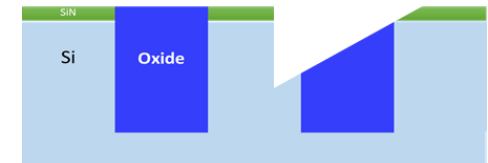
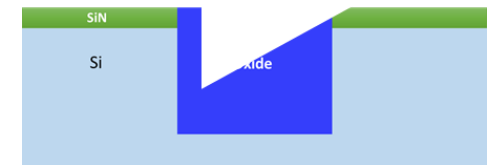


Krishnan M, Nalaskowski J W, Cook L M. *Chem Rev* **110**(1): 178-204 (2010)



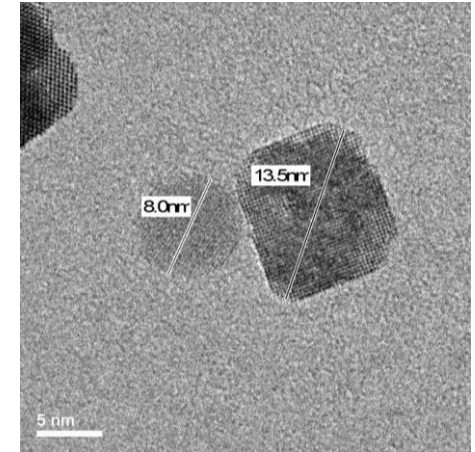
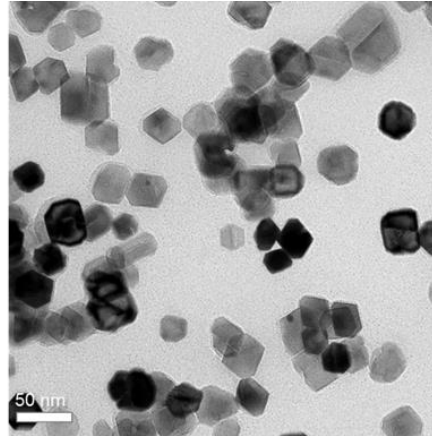
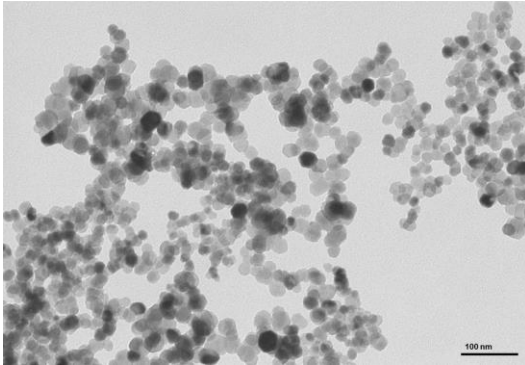
Impact of microscratches
increases

Scratch of equivalent dimensions

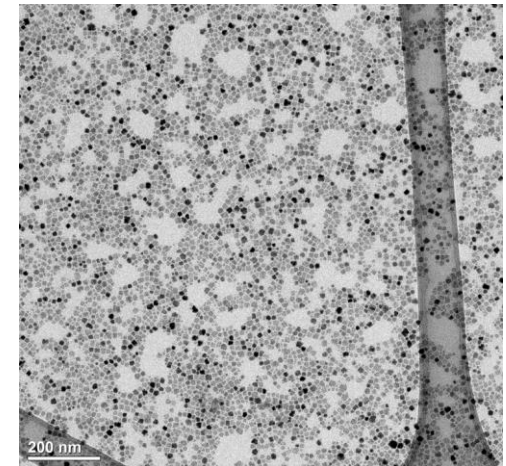
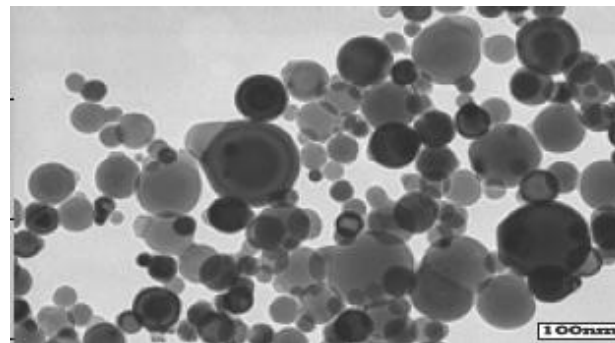
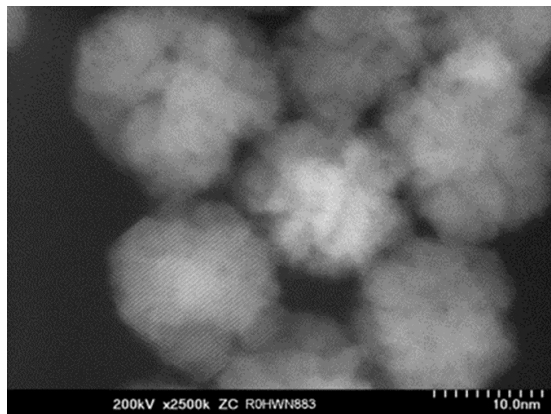


Abrasive particle must also shrink to reduce the occurrence
and impact of microscratches

Ferro Particle Expertise



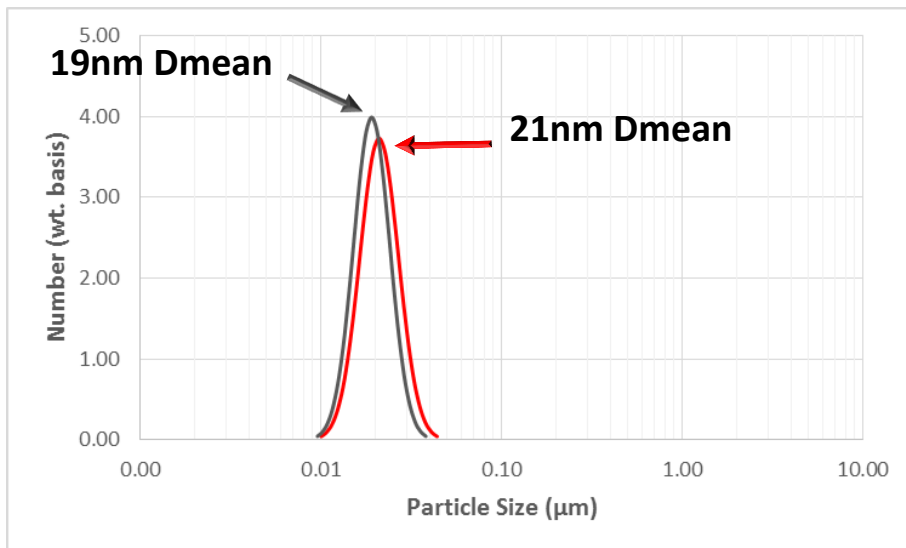
- Ferro has studied and developed precipitated ceria particles for over a decade
 - Countless microstructures and particle sizes are possible with dramatic implications on CMP performance



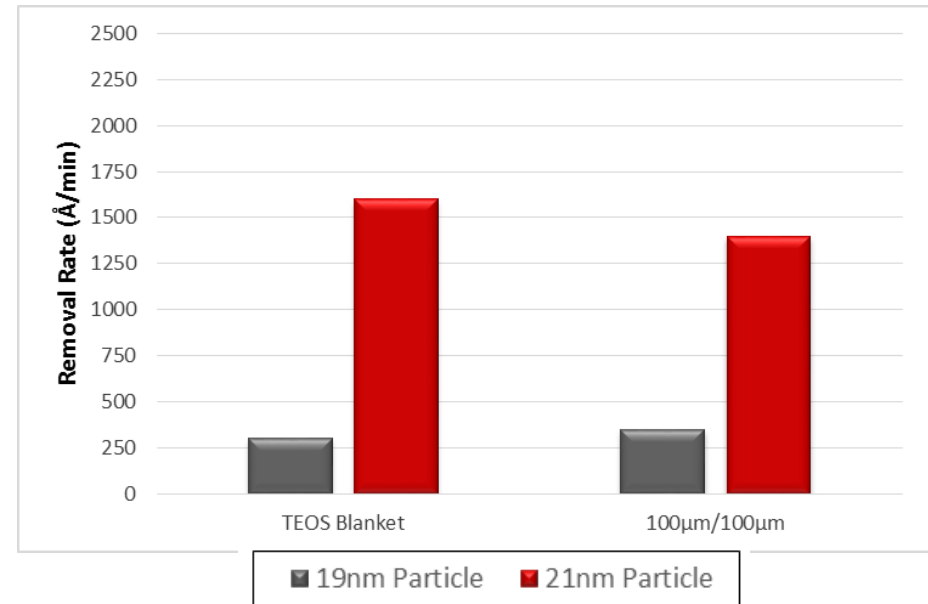
Particle Development Impact

- Two different precipitated ceria particles with similar particle size

PSD



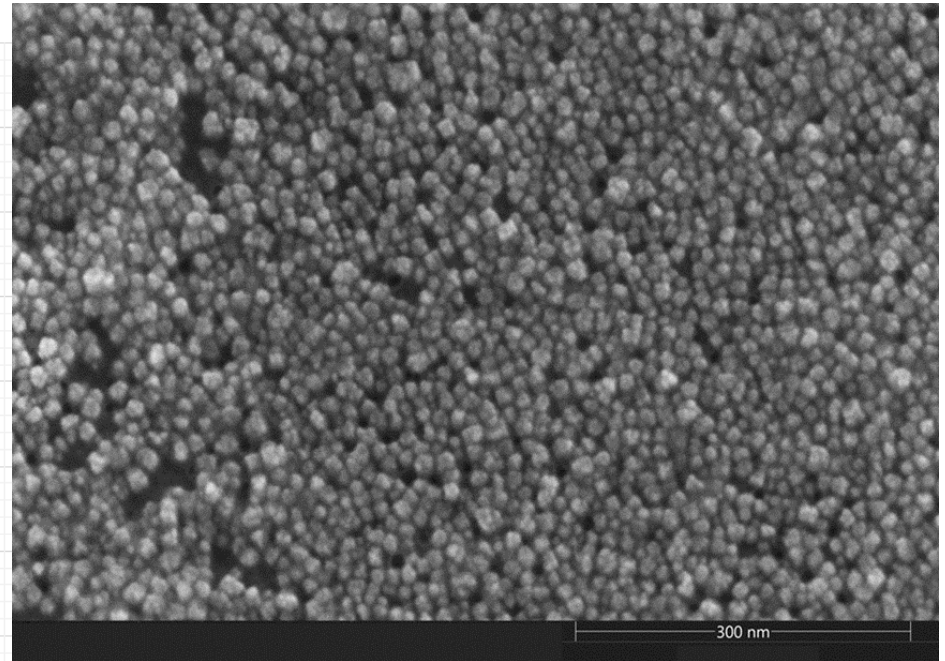
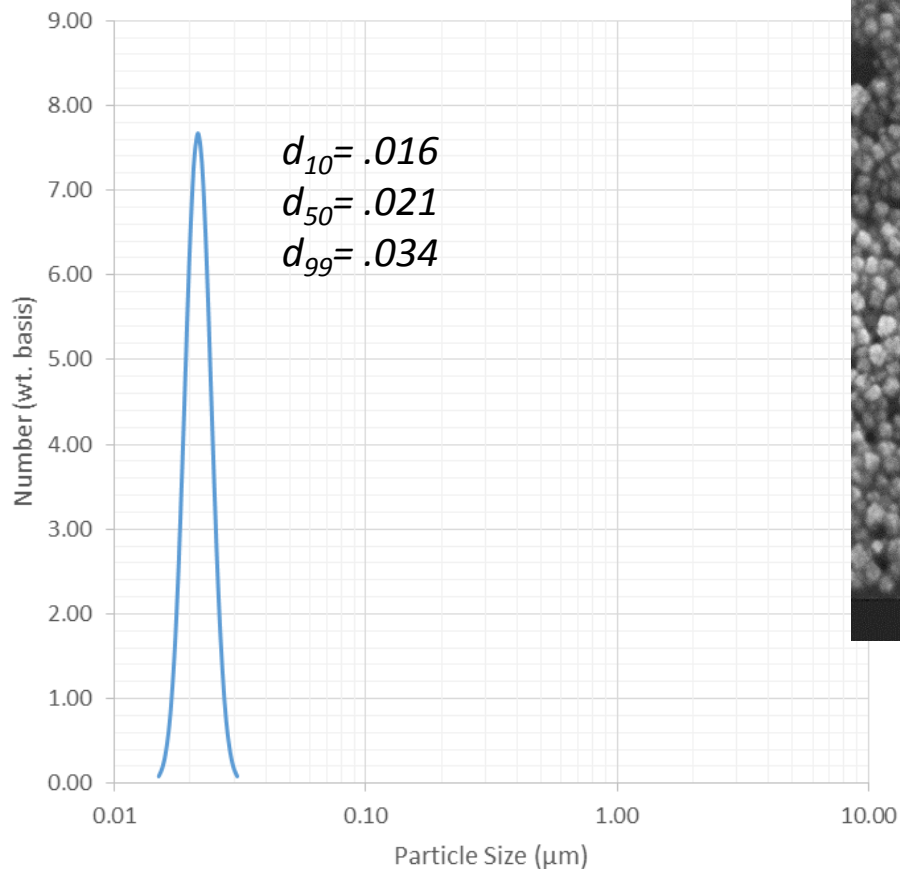
Removal Rates



Particle size is only one factor to consider in developing a high performance colloidal ceria particle

Ferro Colloidal Ceria

- We have developed a highly uniform particle which can meet the requirements for advanced STI applications



- ✓ Low defectivity
- ✓ Predictable removal rates
- ✓ High stability/shelf life

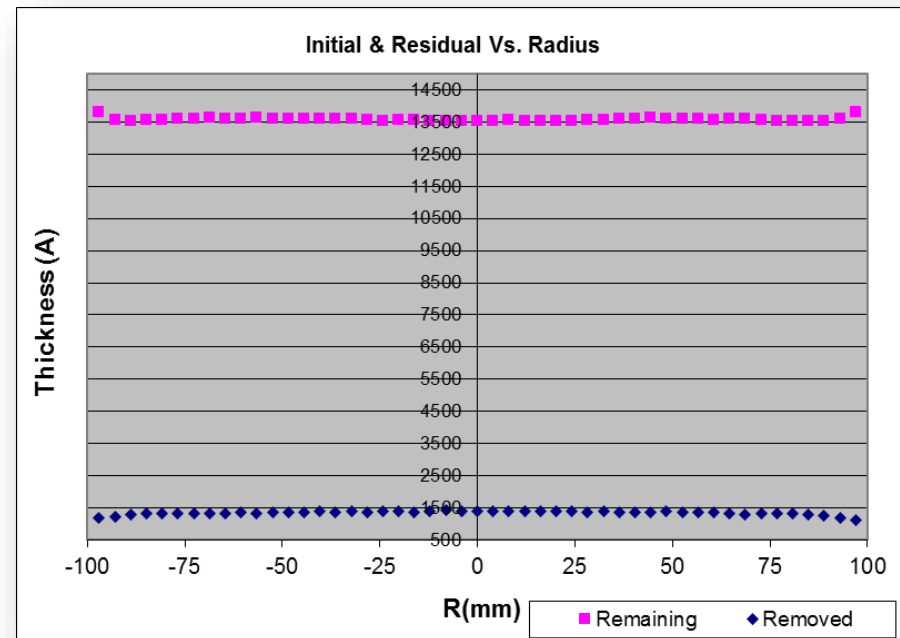
- Ferro's low defect, high selectivity, colloidal STI slurry

Blanket TEOS (A/min.)	Blanket Nitride (A/min.)	Pattern Oxide* (A/min.)	Pattern Nitride* (A/min.)	Pattern Selectivity
1300	< 2	1200	30	40:1

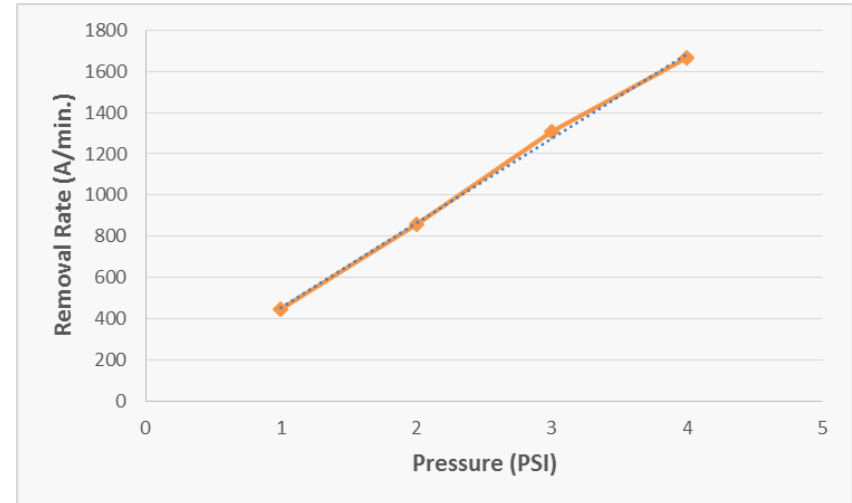
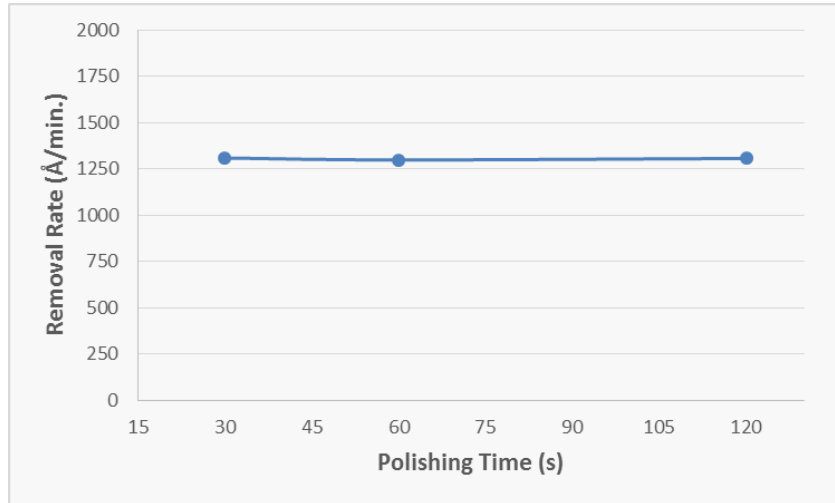
*100 μ m/100 μ m feature

3 PSI, 93 RPM

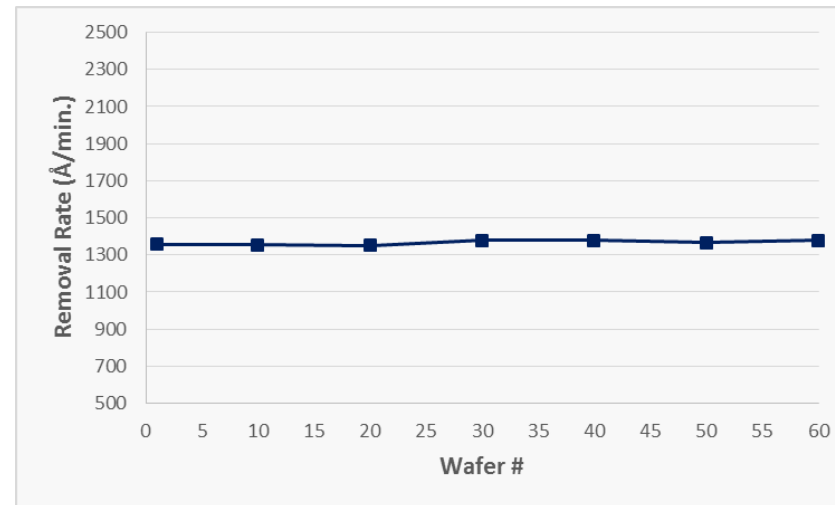
200mm Mirra



2296 Slurry Performance



*3 PSI, 93 RPM
200mm Mirra*



- Predictable and stable removal rates yield a robust slurry

Summary

- Ceria particle synthesis has a significant impact on polishing performance and is a crucial part of the slurry development process
- Ferro's particle and formulation expertise enables new ceria slurries that can meet the challenges of current and future integration schemes

Acknowledgements

- Levern Burm
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