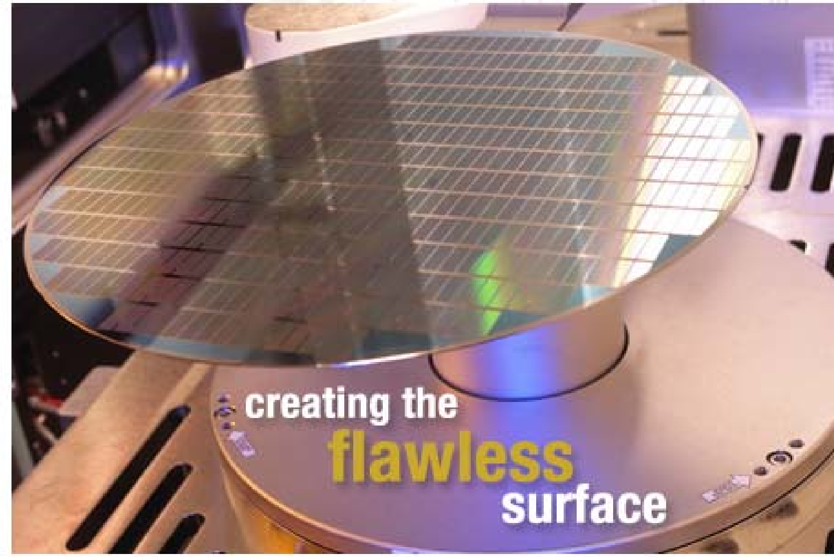
ROHM AND HAAS ELECTRONIC MATERIALS
CMP TECHNOLOGIES



Advances in STI Process and Consumable Design

A. Scott Lawing

June 1, 2005

ROHM HAAS ELECTRONIC MATERIALS
CMP TECHNOLOGIES

Outline

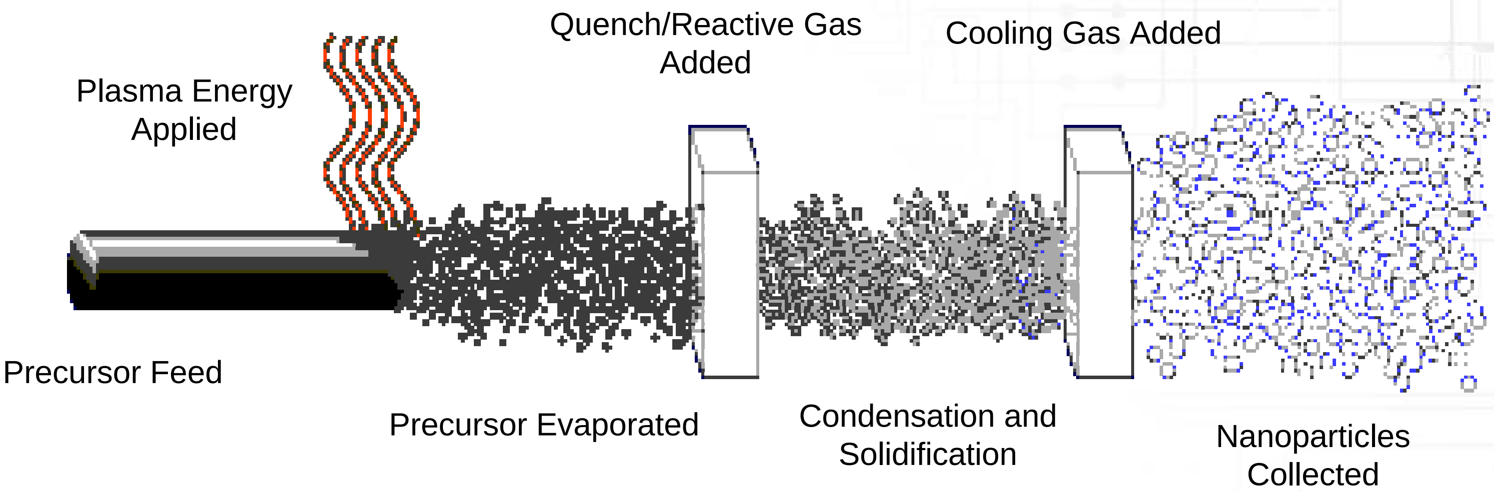
- Nanophase ceria particle technology
  - Consistency
- CMP Technologies slurry technology
  - Celexis™CX94S single component highly selective ceria slurry
  - Colloidal stability
  - Low defectivity
  - Ease of use
- CMP Technologies process technology
  - Robust process design
  - Leverage entire consumable set
- Next Generation performance

Particle Technology

- Celexis™ slurries use a unique ceria particle produced by Nanophase Technologies via a patented gas-phase plasma technology
- NanoArc™ Synthesis (NAS) process creates a unique discrete, single ceria crystal:
  - Stable dispersion due to *in situ* created high particle surface charge
  - Tight particle control to eliminate large, defect causing particles.
  - Non- milling process (eliminates media contamination)
- Other Benefits:
  - Simplified process for consistent and repeatable particle output
  - Enhanced filtration compatibility
    - Final product is filtered to 1.0 µm absolute
    - POU filtration capability

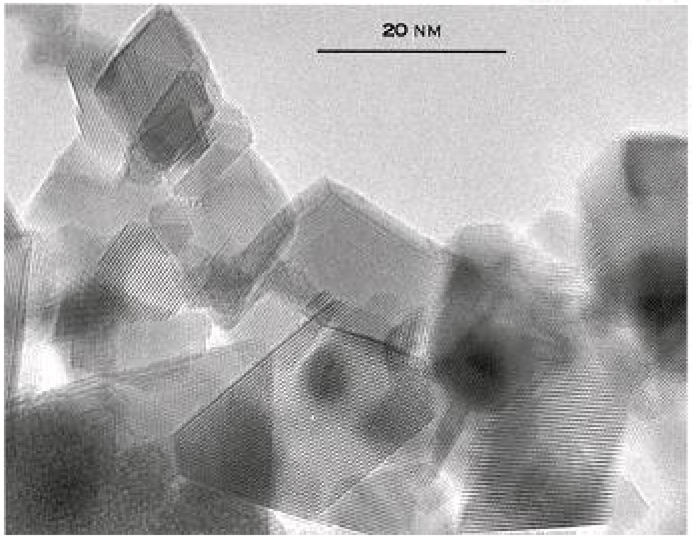
nanophase
Nanoengineered Products

Nanophase NAS Process



NanoArc™ Synthesis (NAS)

- **Patented gas-phase plasma process**
- **Non-porous, discrete single crystals**
- **Mean particle size: 50 nm**
- **High chemical purity**
- **High zeta potential via *in situ* surface treatment**



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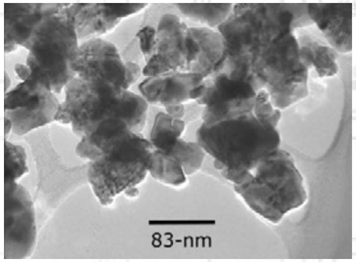
Ceria Dispersion

Typical ceria process

Ceria Raw Stock →

1. Cerium solution
2. Particle precipitation
3. Drying
4. Milling
5. Calcining
6. Wet dispersion (forms agglomerates)
7. Final milling

→ Final ceria dispersion



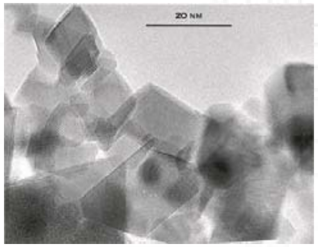
Form Crystals | Dispersion Step | Final Sizing

Nanophase ceria process

Ceria Raw Stock →

1. NAS Process
2. Dispersion to primary particles
3. Truncate particle size distribution

→ Final ceria dispersion



Particle Size/Low Defectivity

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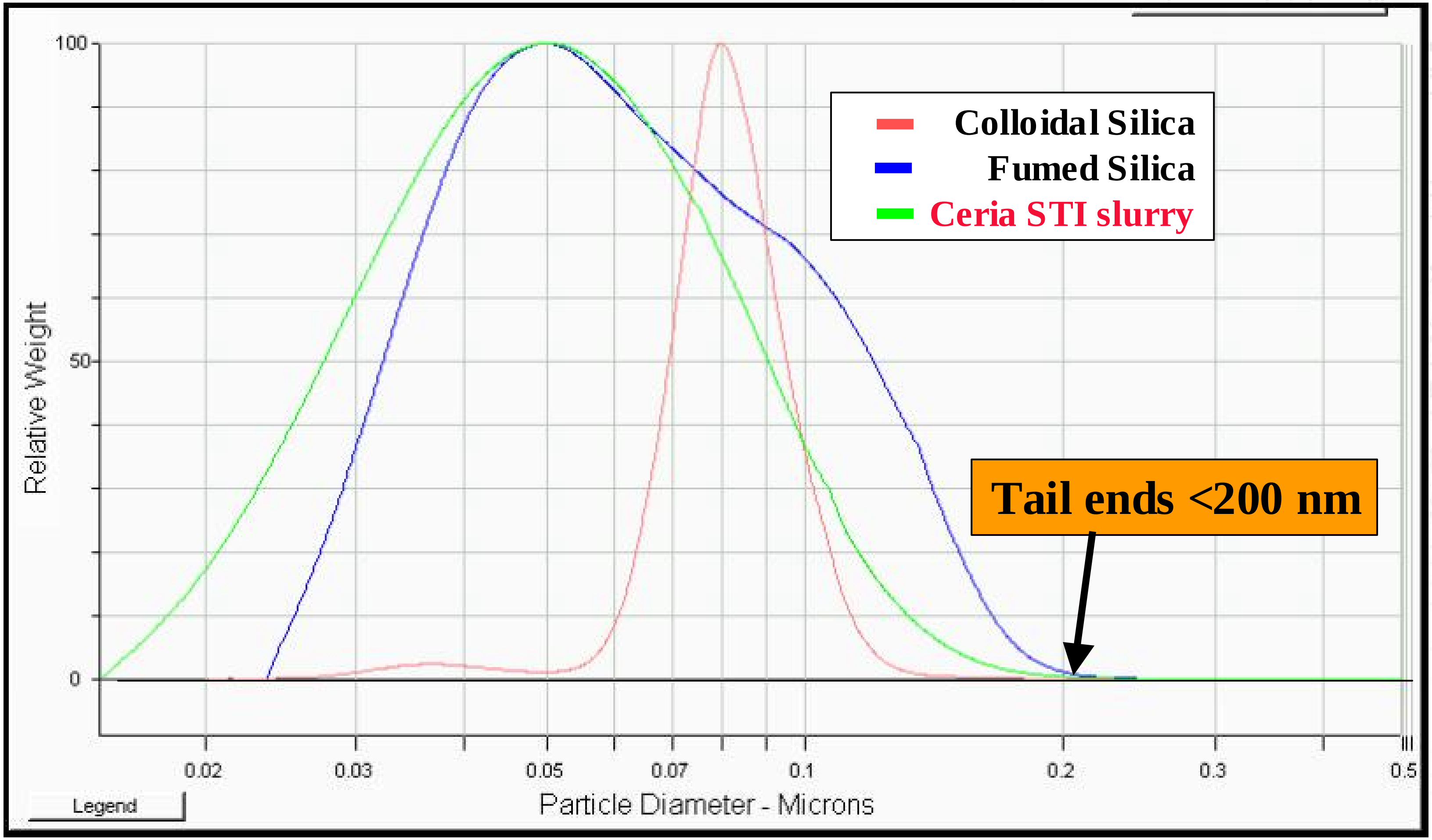
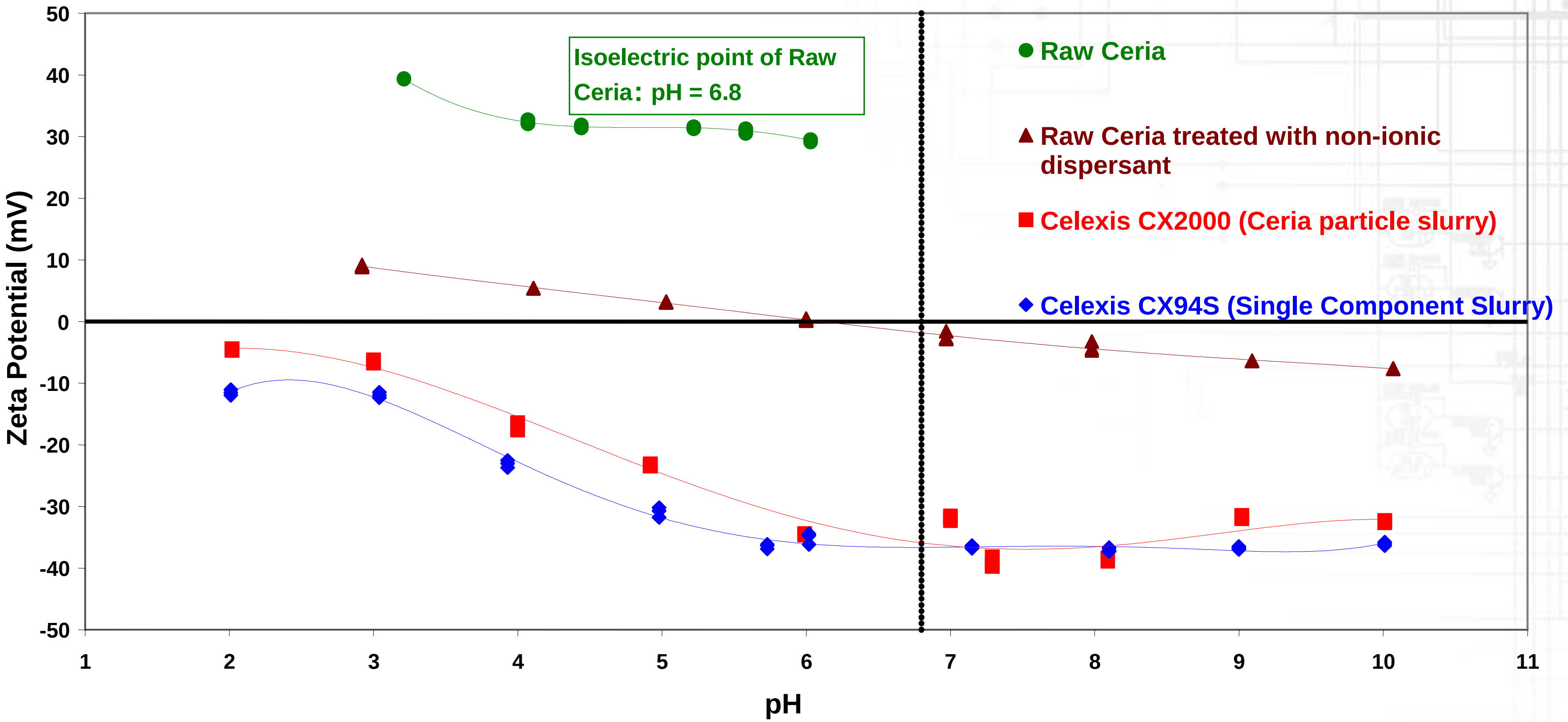


Celexis ceria particle distributions matches state-of-the-art low defectivity silica products.

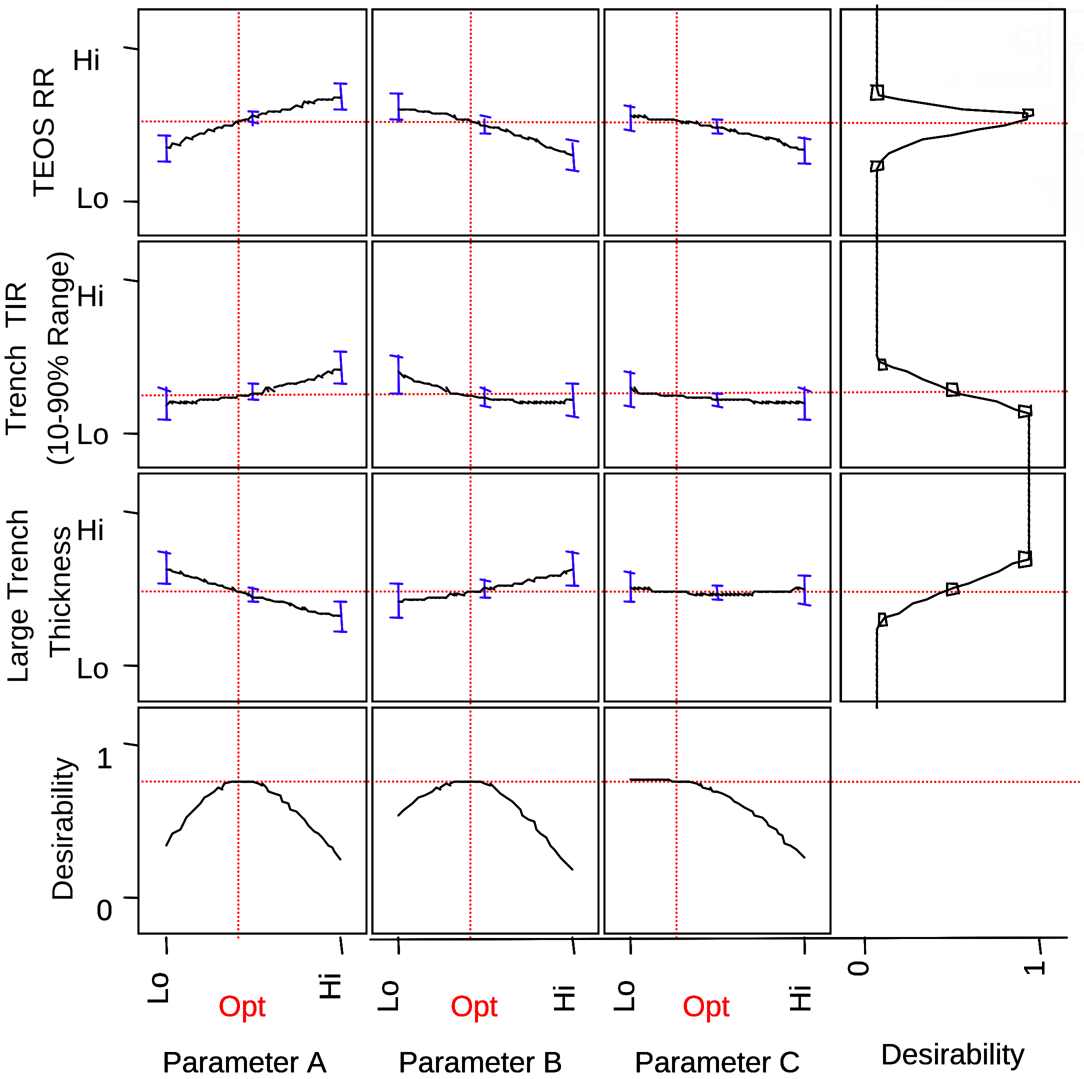
Zeta Potential



Zeta Potential as a Function of pH

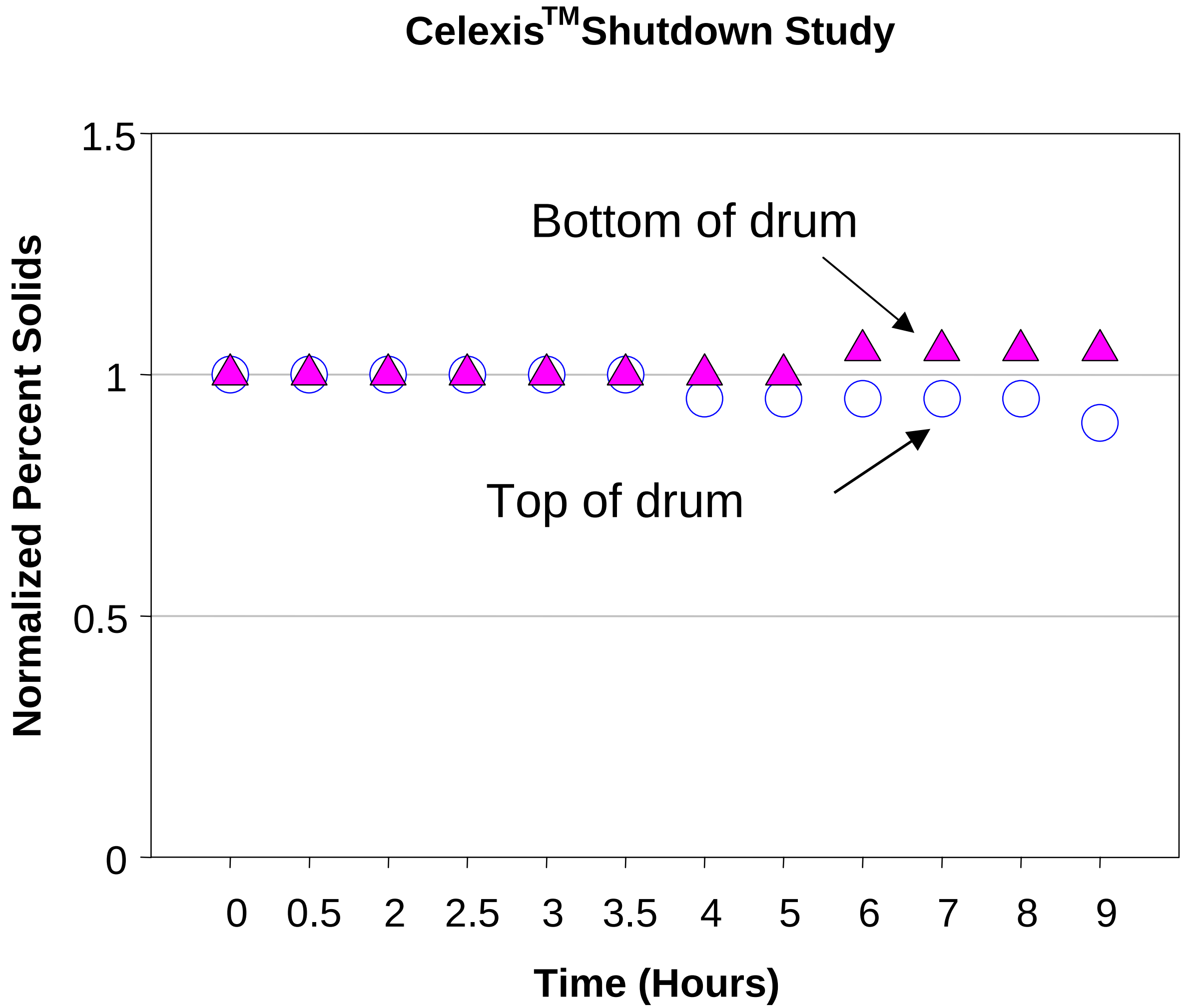
Optimized dispersion of ceria particle provide stable ceria particle slurry and enhanced single component slurry stability

Chemistry Optimization



- Celexis CX94 slurry chemistry has been optimized to hit target polish rate, while minimizing range across active density and maximizing the thickness remaining in the widest trench
- Note that rate and planarization metrics are coupled
  - Planarization metrics are tied to the rate inhibiting nature of the chemistry
- CX94S chemistry does not have significant stop-on-planar or deceleration characteristics

Slurry Stability



Celexis™ CX94S slurry has excellent ceria particle suspension and stability

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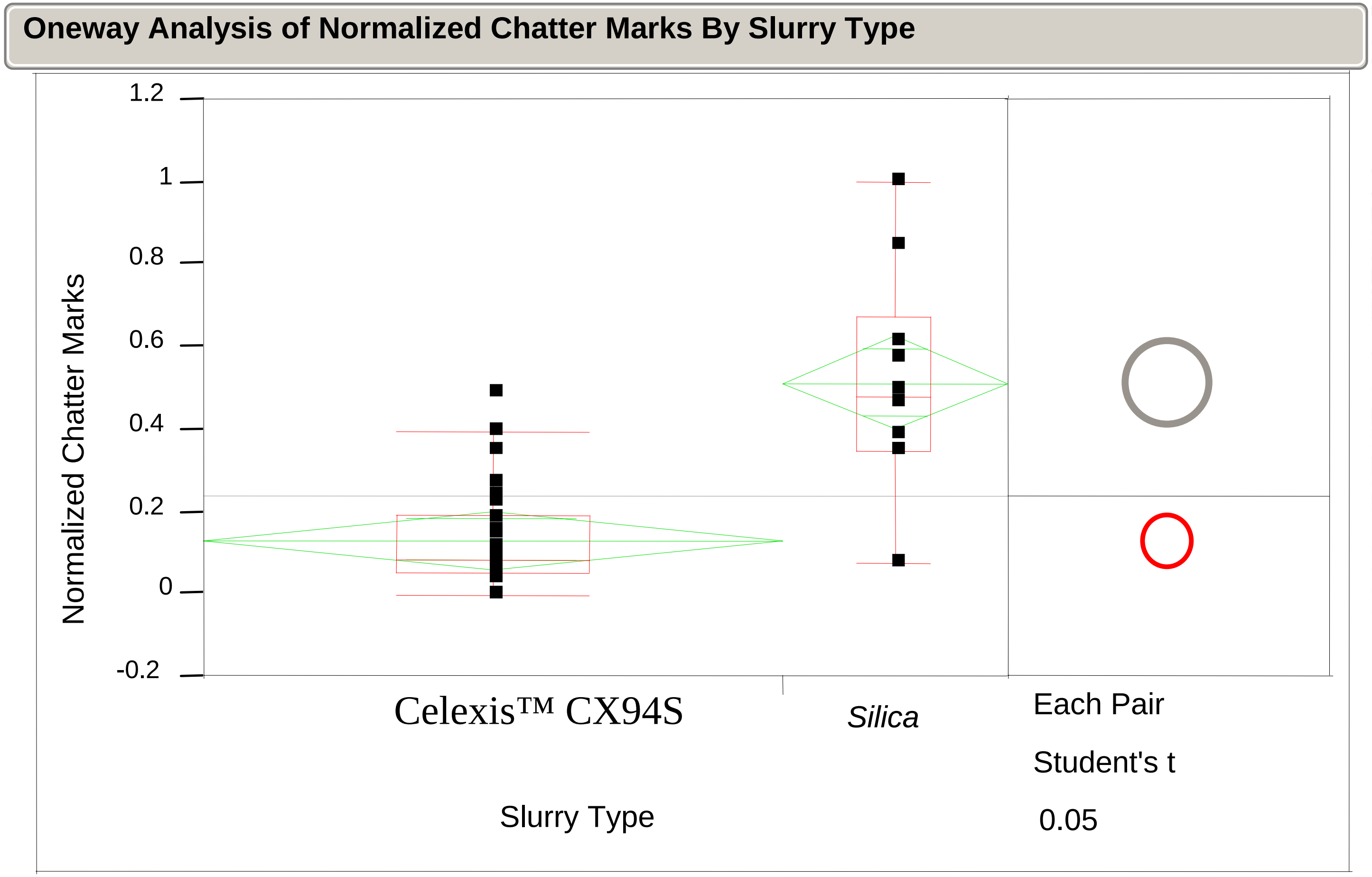
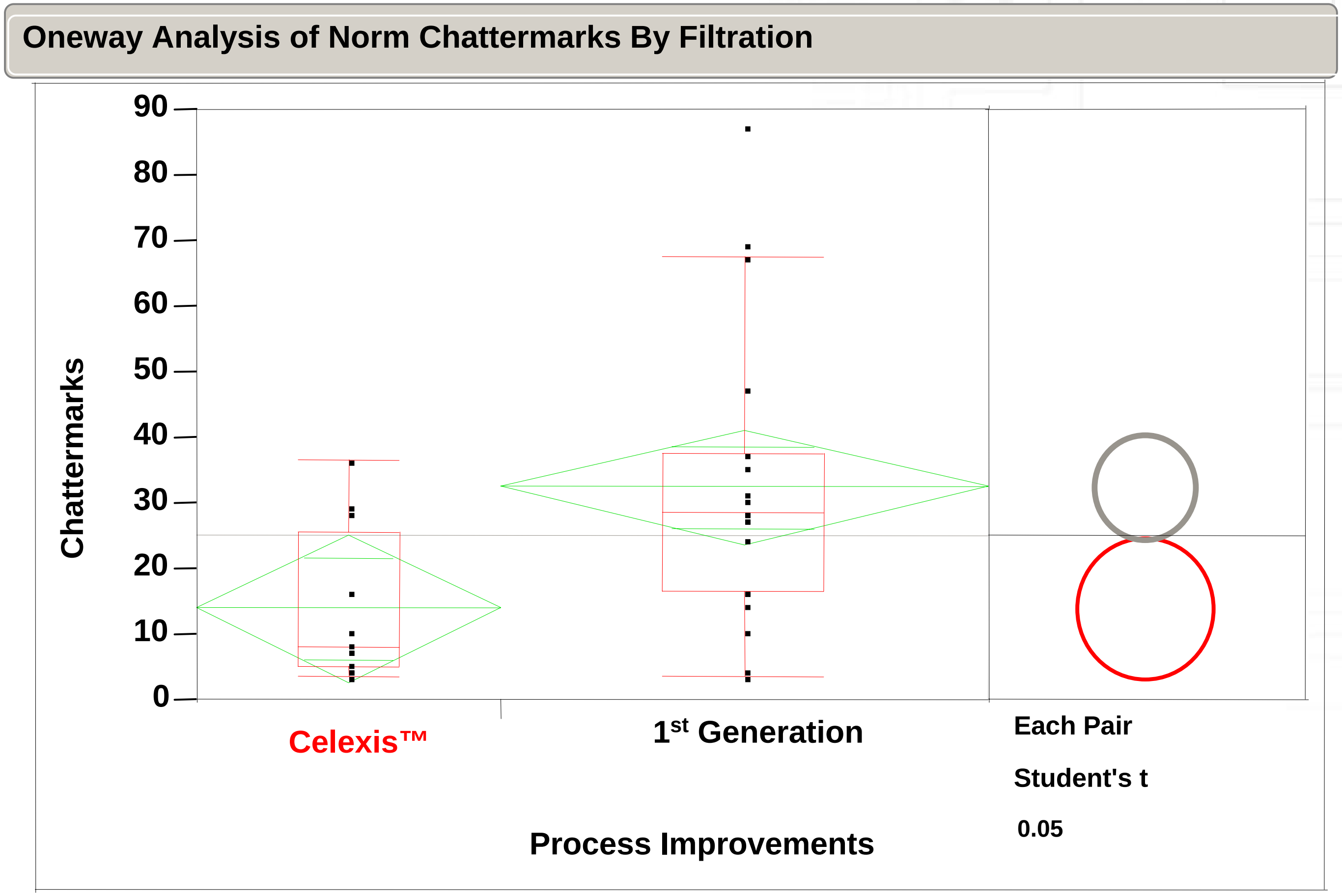
Defectivity Performance



Celexis™ STI slurry outperforms low defectivity ILD slurry for micro-scratch defectivity

Defectivity Performance



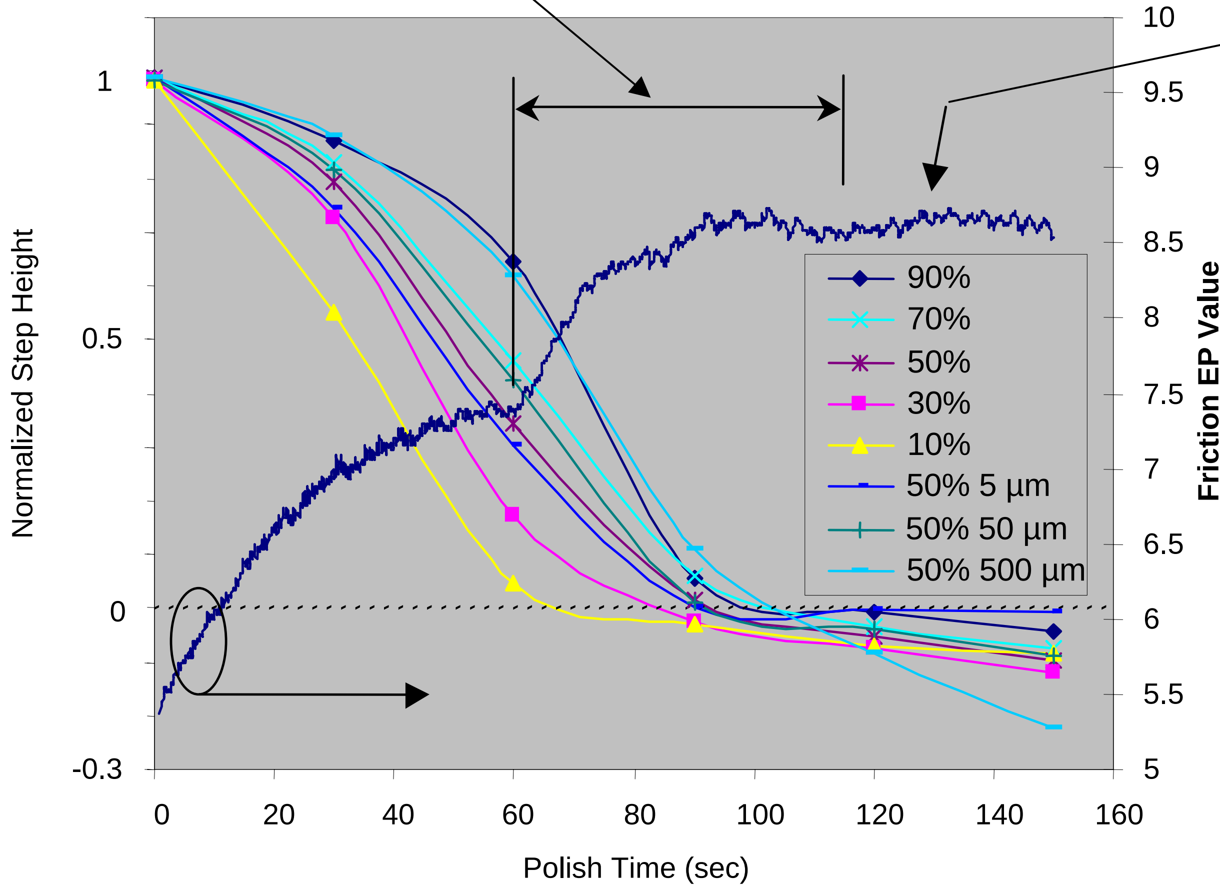
Celexis CX94S slurry Defectivity Improvements

Microscratch count determined by 100% defect review using SEM Vision™.
(after 300 angstrom HF decoration)

Step Height and Motor Current Response

This characteristic "hump" in the friction trace corresponds to planarization across the entire range of pattern density

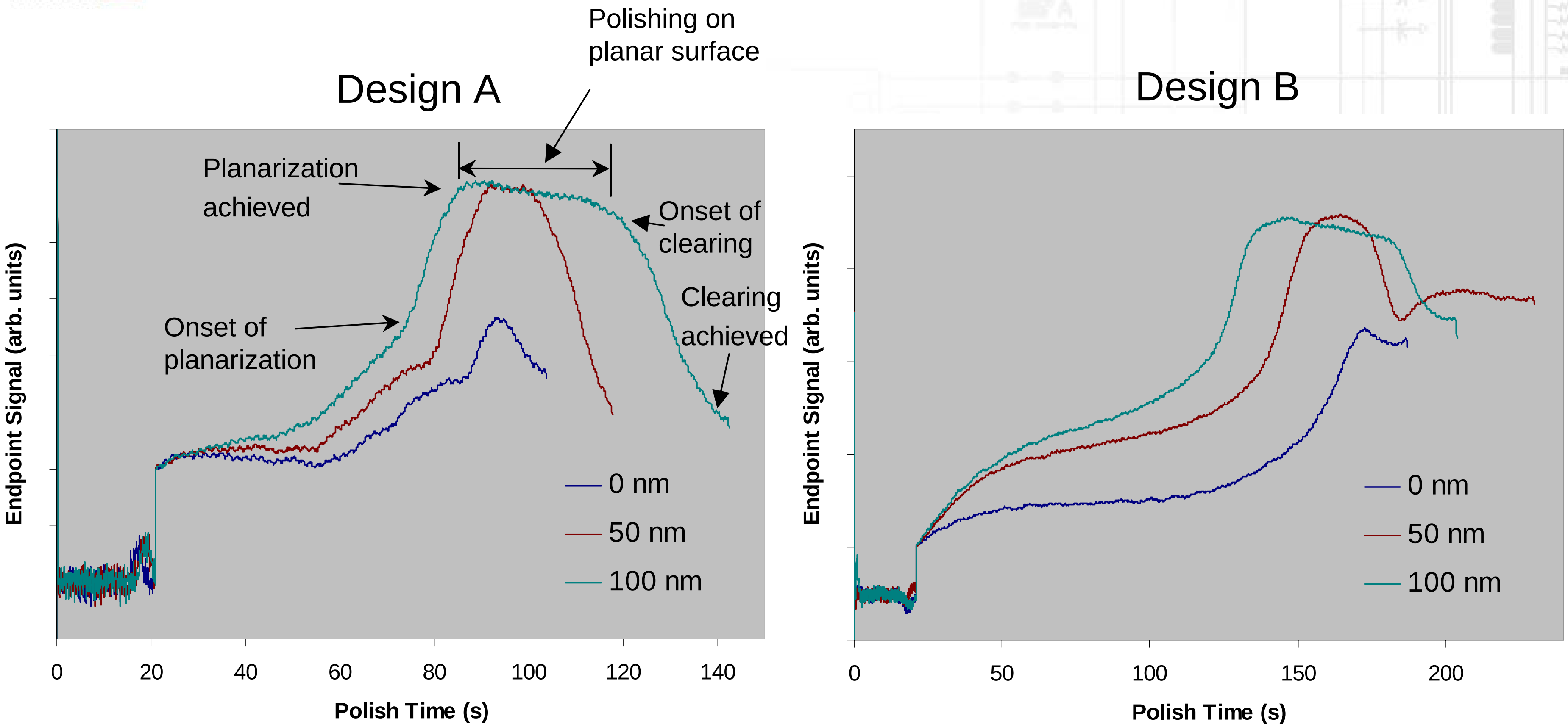
This more subtle feature indicates clearing of the nitride



"MIT" mask:
10-90 % features on 100 µm pitch [i.e. 10 µm line 90 µm space (10 %) – 90 µm line 10 µm space (90 %)]. Sizes on 50% % density structures refer to the trench depth.

- Most significant features of the friction endpoint trace seem to correlate with planarization, not clearing

Effect of Overfill on Motor Current



- Both devices exhibit the same qualitative behavior
- 5 stages of polishing evident:
  - I – pre-planarization, II – planarization, III polishing on planar surface, IV – clearing, V - overpolish

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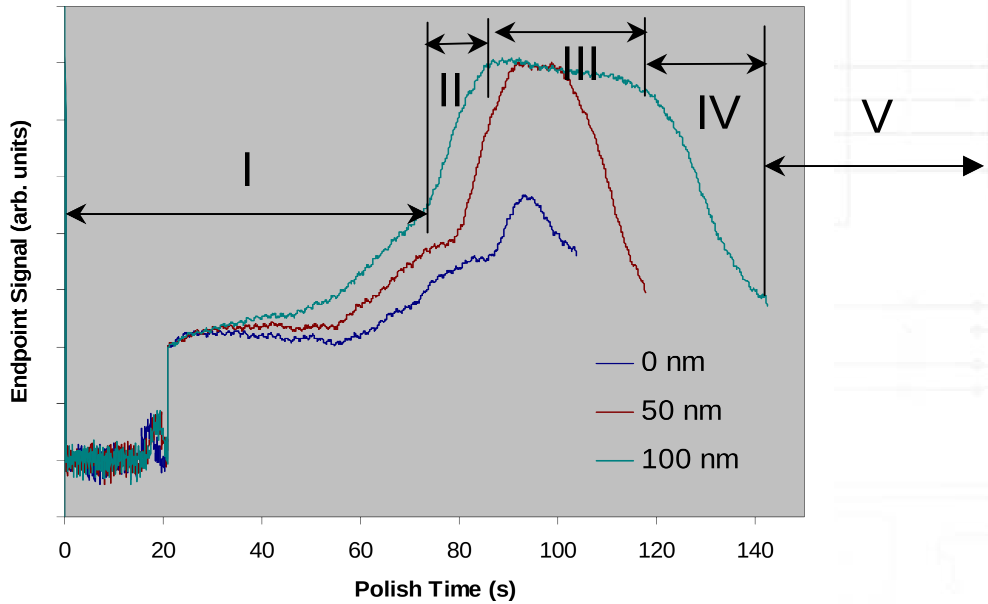
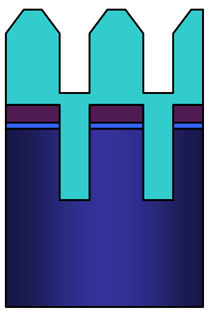
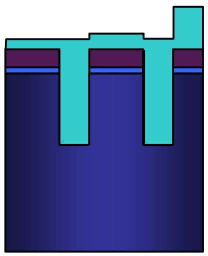
Stages of Polishing & Endpoint Trace





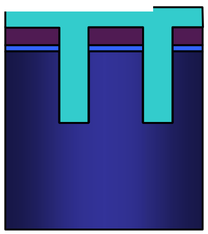
Stage I –

Pre-planarization. Polishing on surface with significant step height



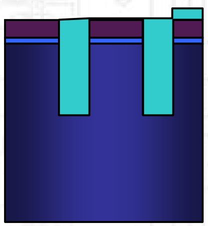
Stage II –

Planarization. Steps removed in some areas. Substantial planarization as stage II proceeds.



Stage III –

Polishing on planar surface. Length of stage III dependent on overfill thickness.



Stage IV –

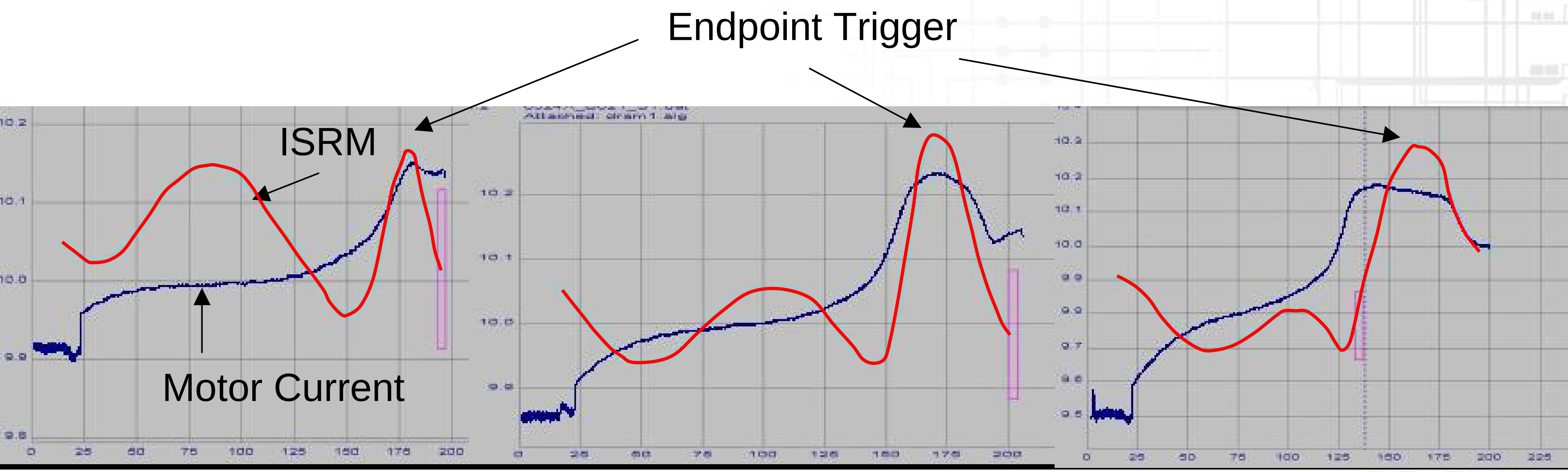
Clearing. Wafer clear at end of stage IV

Stage V –

Wafer clear. Nitride thickness decreases and dishing increases.

- Length of stage III and height of the feature at the end of stage II affected by overfill
  - Height of feature saturated with complete planarization (50 & 100 nm overfill reach same height), 0 nm overfill probably not completely planarized

Motor Current - ISRM Comparison

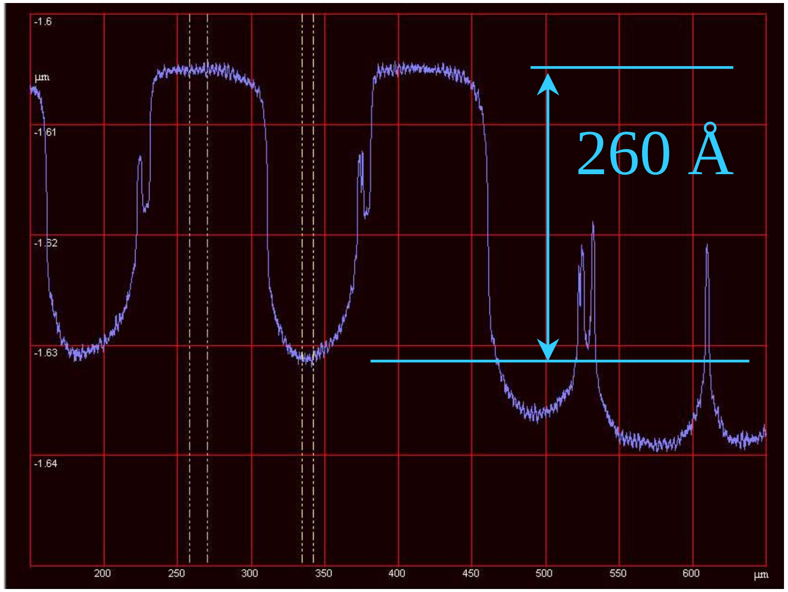


0 nm Overfill | 50 nm Overfill | 100 nm Overfill

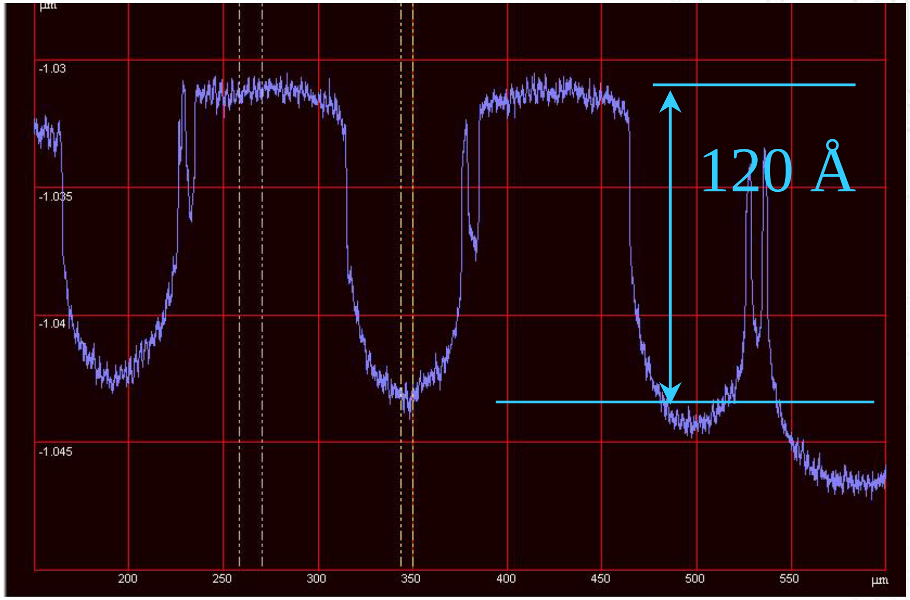
- Both signals show a similar response of the “trigger" feature
  - Peak at 160 - 175 s in ISRM trace increases with increasing overfill
  - Maximum in optical traces does not signal endpoint directly, but can be used as a reliable trigger for the end of the polish step

Effect of Downforce on Dishing

Medium down-force process



Low down-force process



- Dishing performance improved at low down-force

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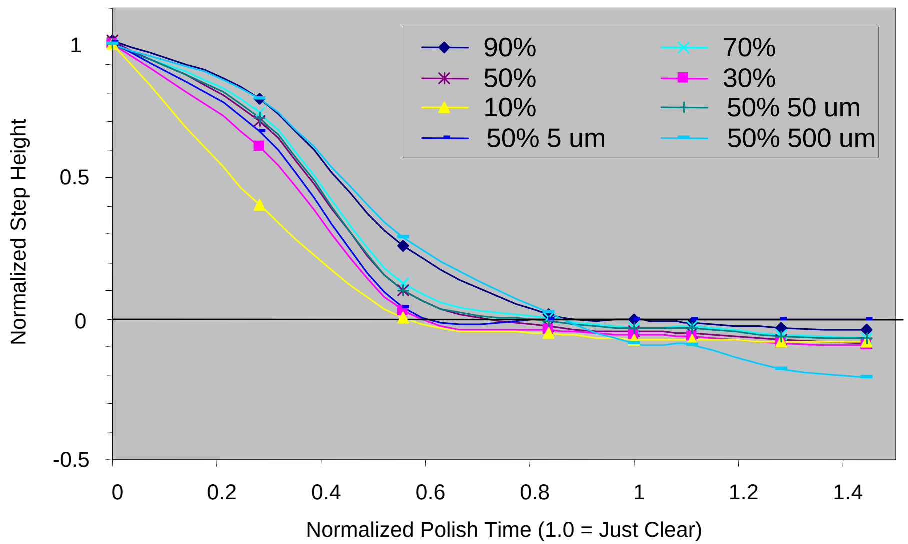
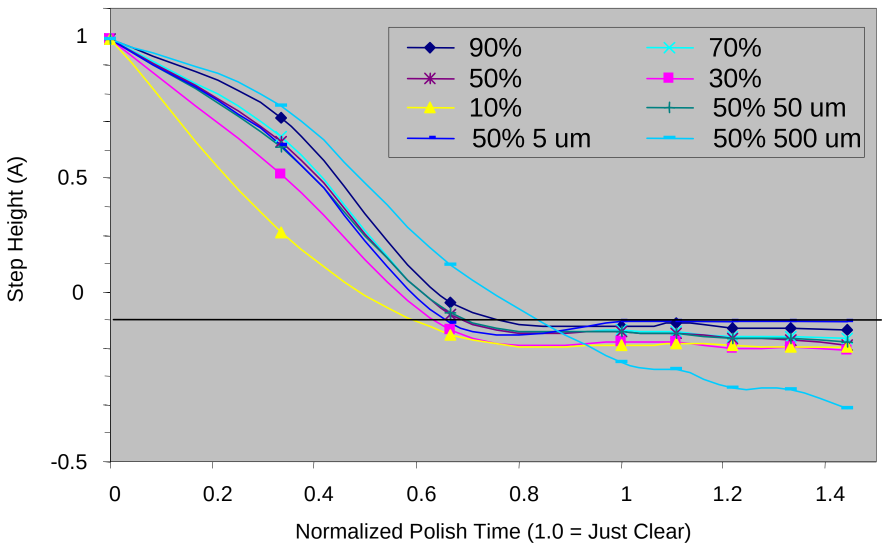
Subpad Type and Dishing

IC1010™/SP2150

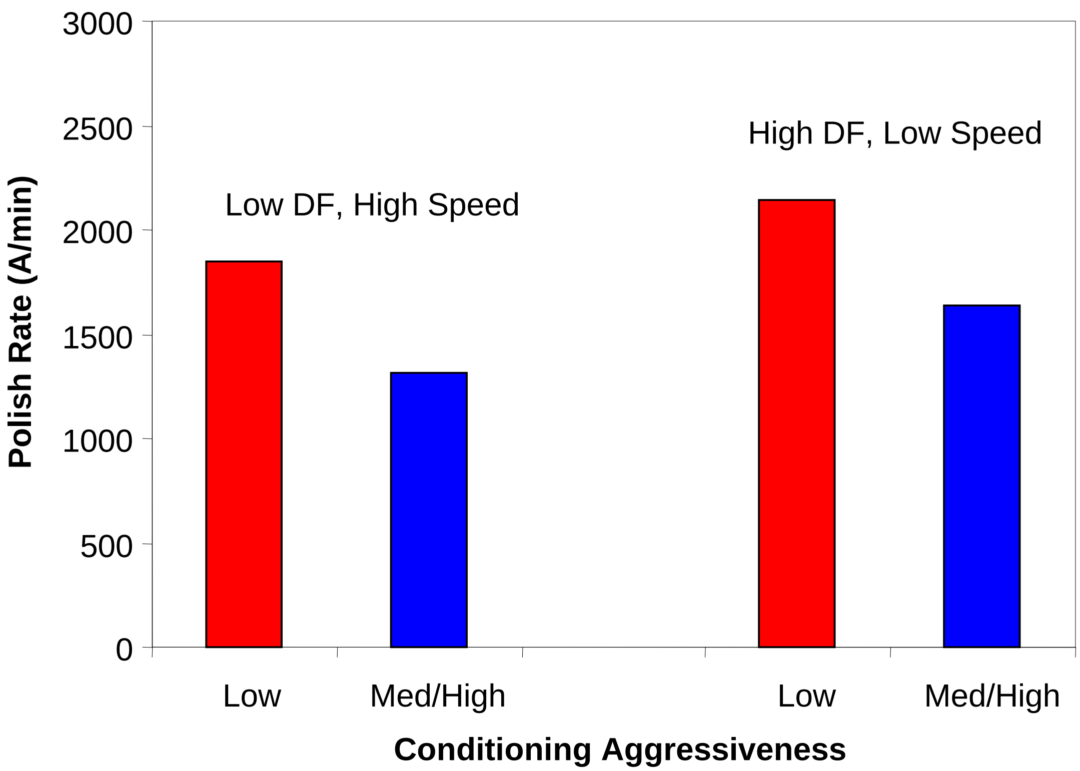


IC1010™/Suba™IV



- Step height is combination of dishing and erosion with overpolish
- Dishing improved with SP2150 subpad vs. Suba™ IV

Effect of Conditioning on Rate



- These data from the AMAT Mirra™ using CX94 slurry formulation, IC1010™/Suba™ IV pad, 100 % *in situ* conditioning
- 30-40% higher polish rate with low aggressive conditioning compared to medium/high

Conditioning and Polish Rate

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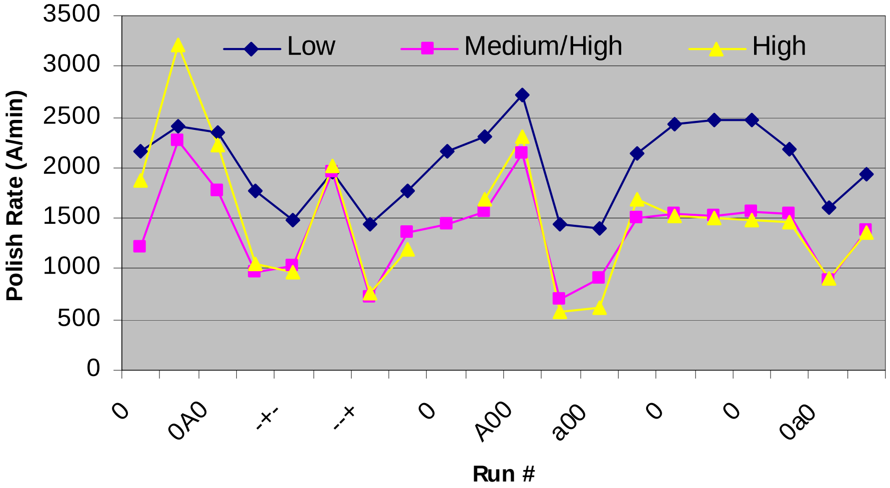
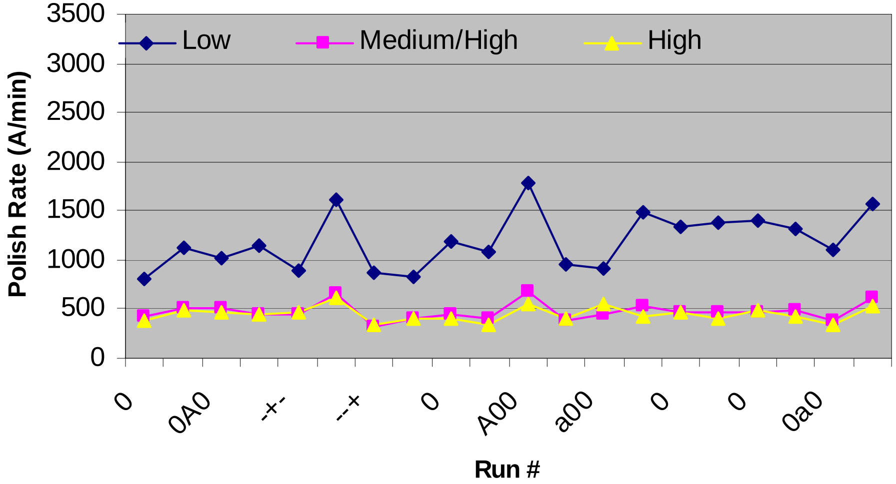
Experimental Solid Pad



IC1000™ k-groove Pad



- Identical DOE's with developmental formulation (not CX94S) and various levels of conditioning aggressiveness on the Ipec472
- Highest polish rates obtained with low aggressive conditioning
  - On IC series pads, higher aggressiveness conditioners exhibit extremely low polish rates

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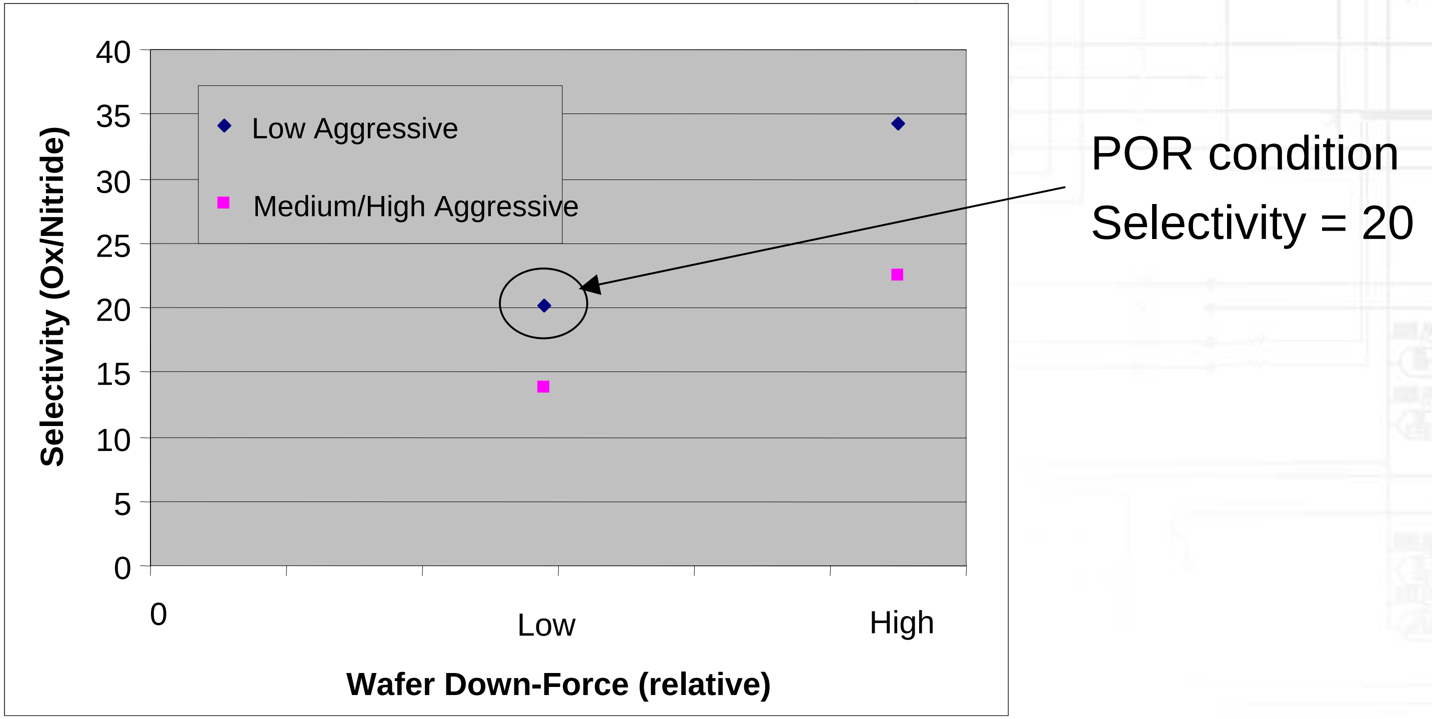
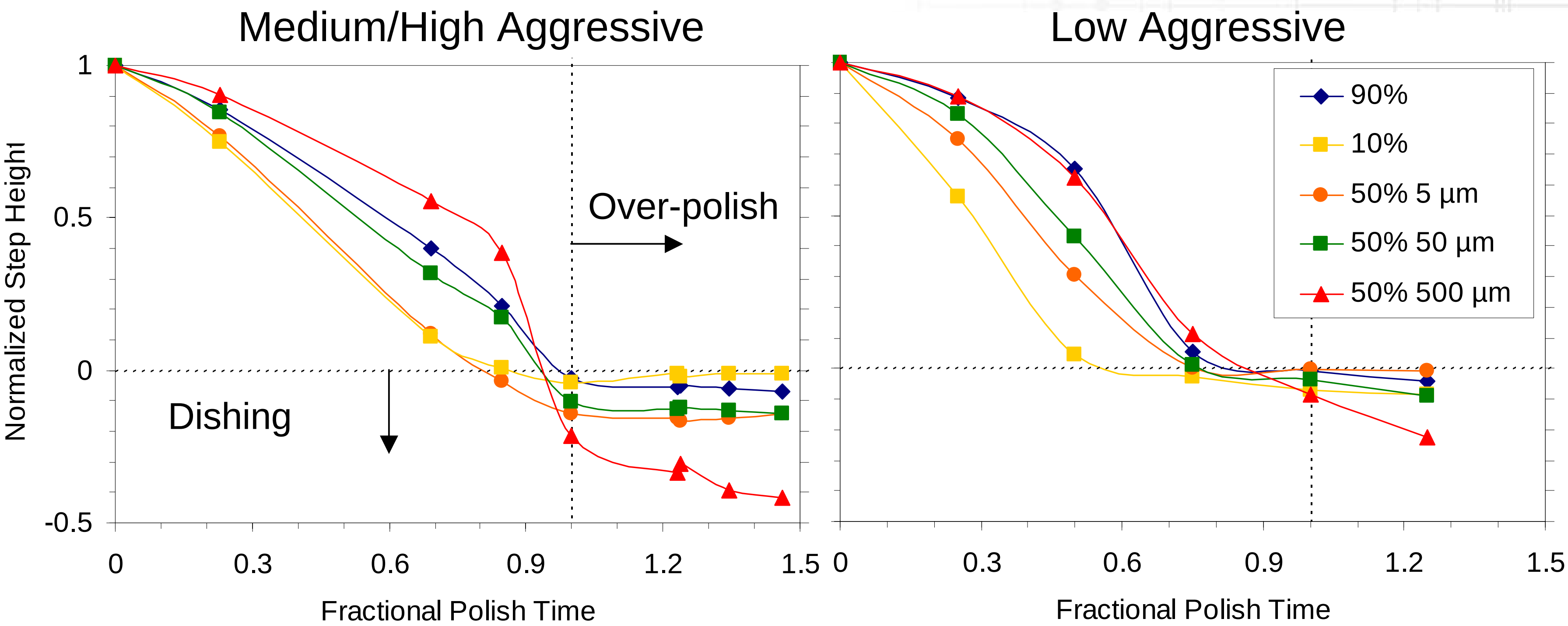
Effect of Conditioning on Selectivity



- Selectivity increases with increasing down force
- Selectivity decreases with increasing conditioning aggressiveness

- Data from Mirra™ tool with 100% *in situ* conditioning

Effect of Conditioning on Dishing



- Low aggressive conditioning results in significantly less dishing
- More truncated asperity structure penetrates less deeply into low lying areas
- Data from EBARA EPO222

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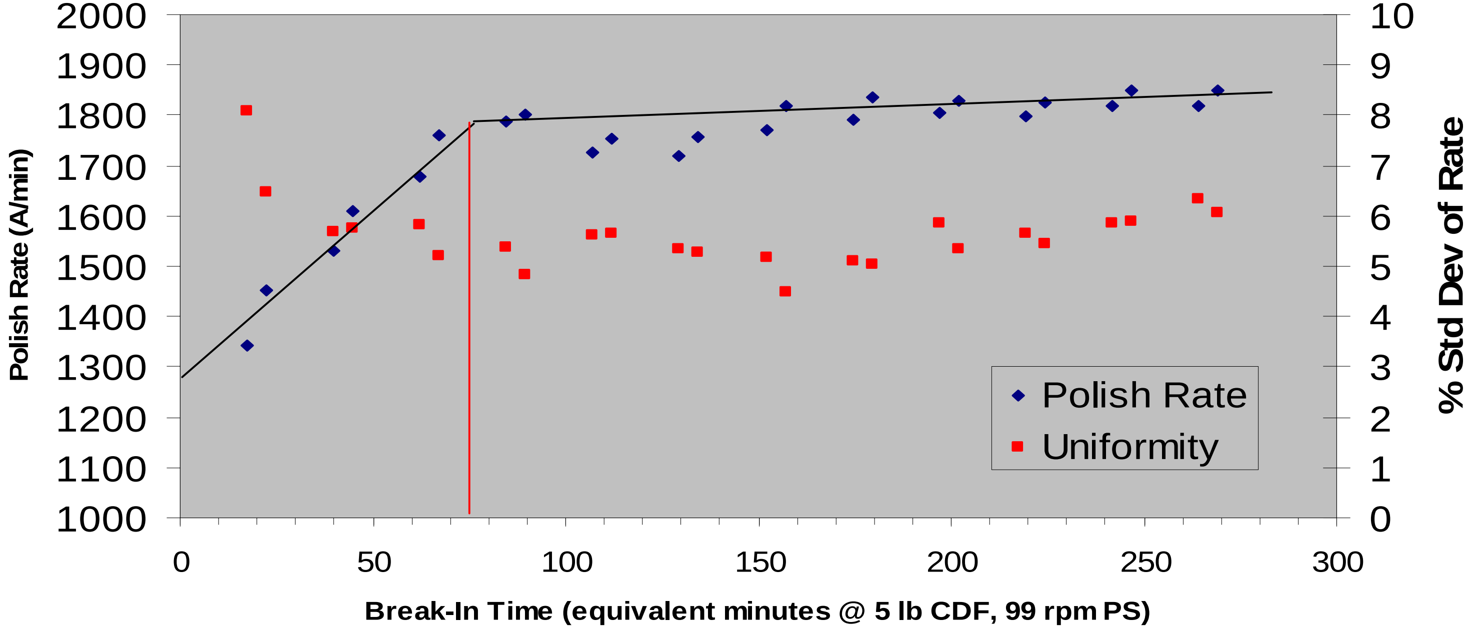
IC1000 Pad Break-in Characteristics



- Medium cut-rate conditioner
- ~75 minutes equivalent break-in time @ 5 lbs CDF, 99 rpm PS
- Rate is unstable until pad is sufficiently broken-in
  - Ceria-based STI is particularly sensitive to break-in effects
- Break-in can be reduced to 30 minutes with process adjustments

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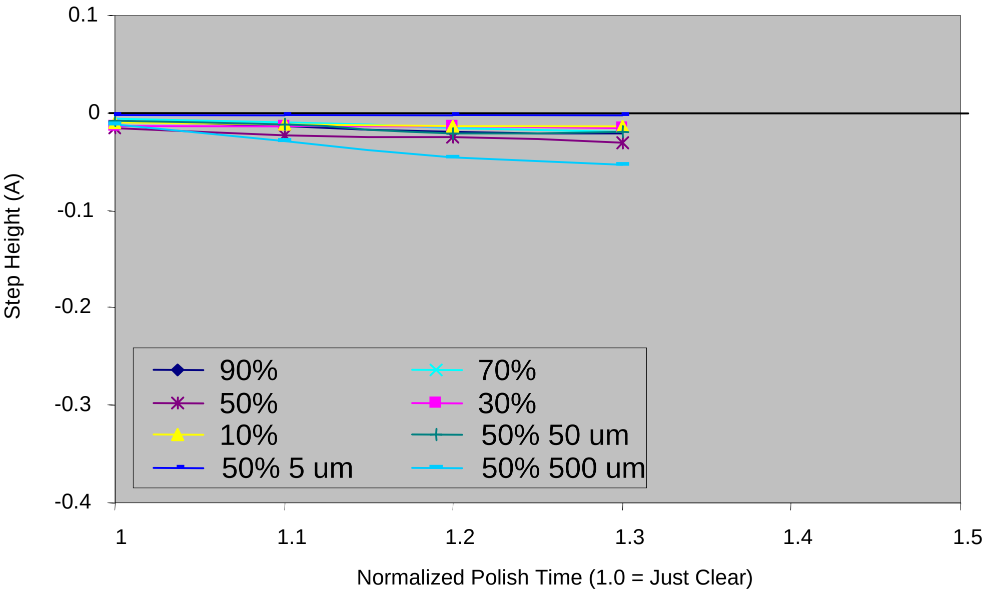
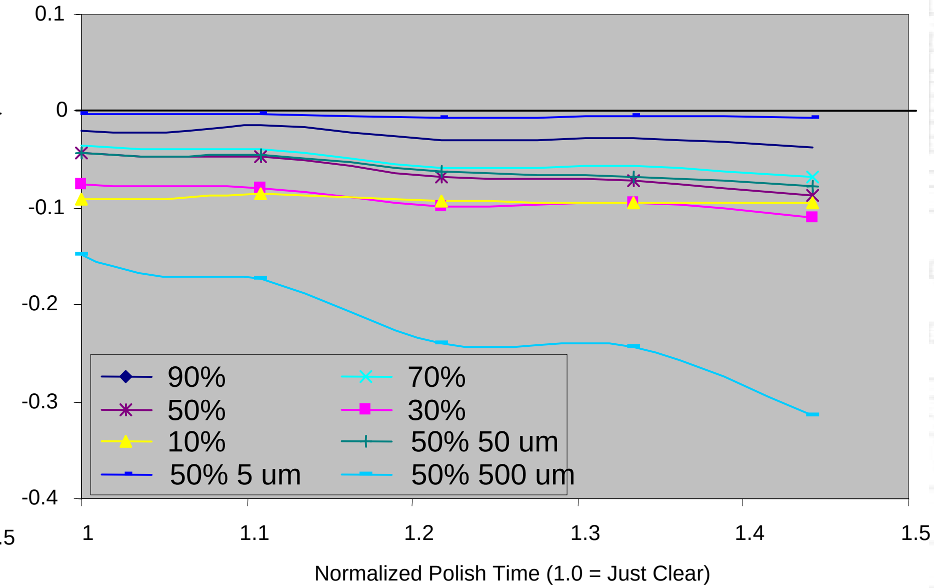
Performance Comparison - MIT Wafers

Nex Gen Process



Celexis™ CX94S Process



Endpoint   30% Overpolish   Endpoint   30% Overpolish

- Next generation process incorporates stop-on-planar chemistry
- Planarization performance rivals fixed abrasive
- Robust clearing with excellent planarization and wide overpolish window

Conclusions

- Rohm and Haas Electronic Materials CMP Technologies has developed the Celexis™ series of STI slurries
  - Nanophase ceria particle technology forms the backbone of the slurry line
  - CMP Technologies slurry design and manufacturing expertise ensure consistent, repeatable performance
  - CMP Technologies process expertise provides solid process and consumable design guidance and support in the field
  - Celexis™ CX94S slurry provides consistent, predictable performance with excellent defectivity, robust clearing behavior and high planarization efficiency in a single component package
  - Next generation polish performance rivals fixed abrasive planarization levels

Acknowledgements

- Rohm and Haas Electronic Materials CMP Technologies
  - Kerry Lindemann, Asa Yamada, Brian Mueller, Pat Flanagan, Charlie Yu, Sarah Lane, Mike Collins, Josh Ruple, Nichole Bishop
- Nanophase
- Kinik