Advancements For Sub 45nm Fixed Abrasive STI CMP

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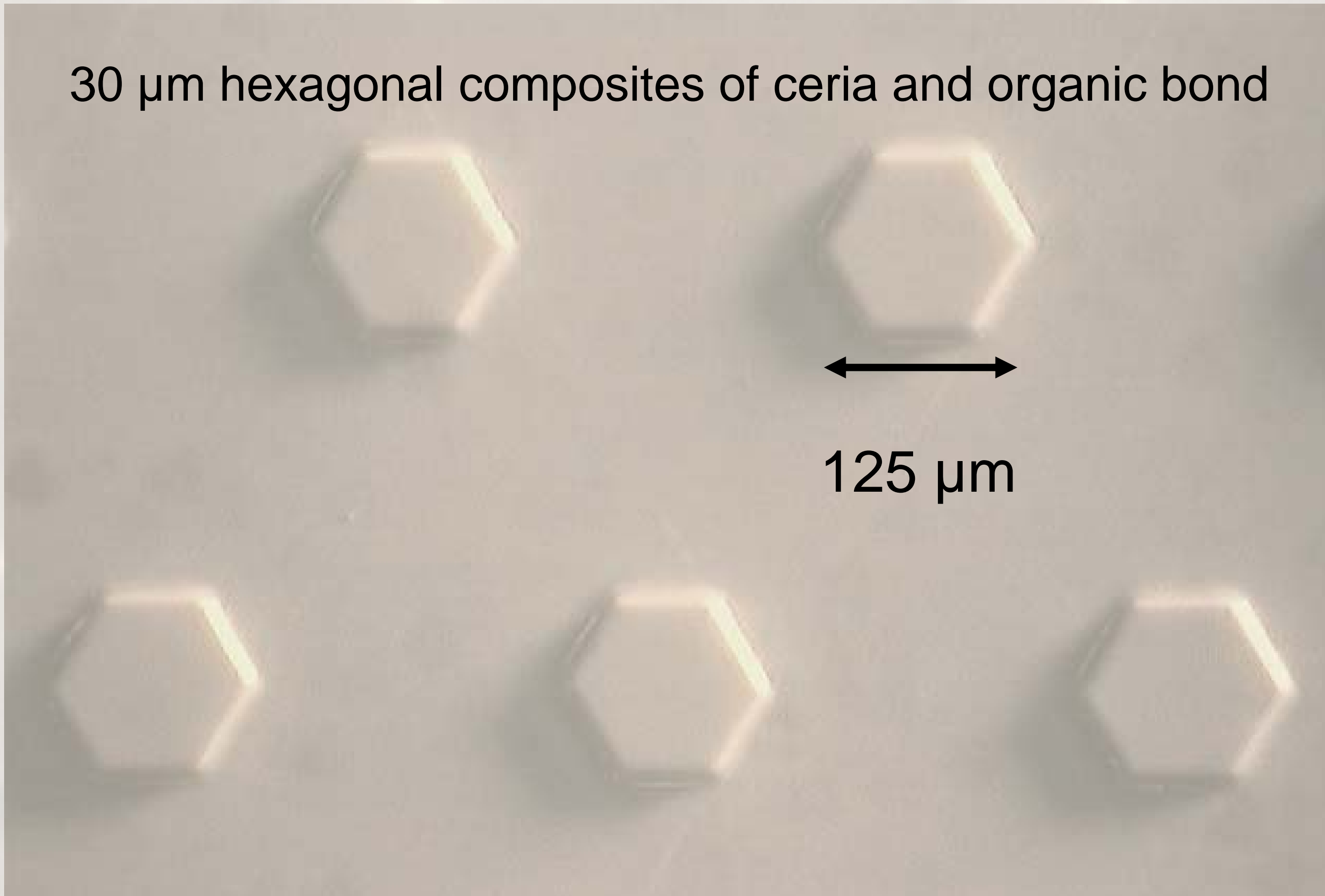
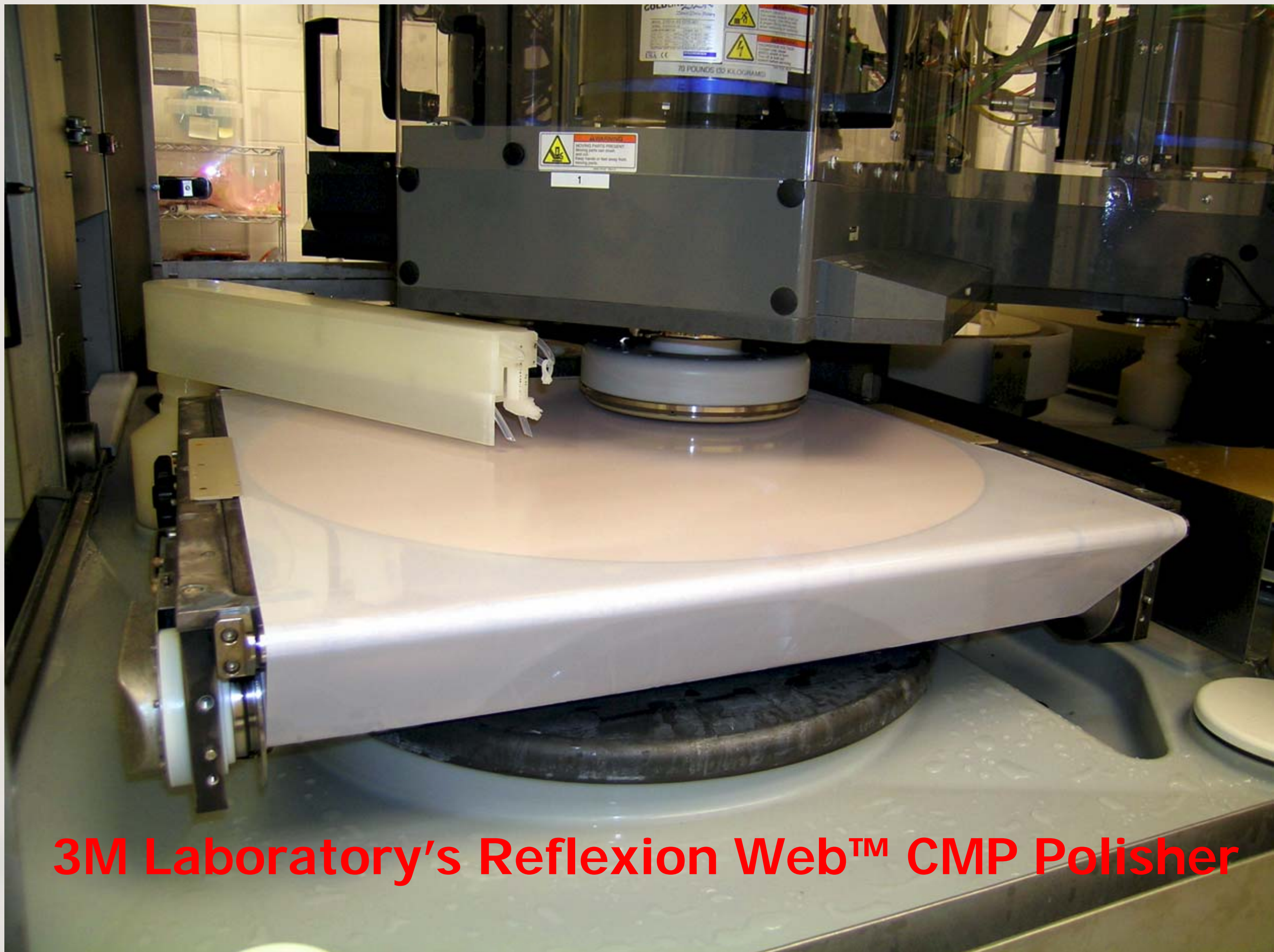
Outline

- Background
  - Timeline of developments leading to Advancements for Sub 45 nm FA STI CMP
  - The FA Process and Outstanding Planarization
- Current FA STI CMP Roadmap
  - 65 nm, 45 nm and Sub 45 nm
- Advancements for 45 nm and sub 45 nm
  - Chemistry
  - Abrasive
  - CMP process and performance
- Summary and Conclusion

Microreplicated Fixed Abrasive





3M Laboratory's Reflexion Web™ CMP Polisher

Development Timelines

Leading to advancements for sub 45 nm

2001 – Third Generation of FA Development was completed

- Close collaboration with tool builder and semiconductor fabs

2002 - AMAT's Reflexion™ Web Ready

- FA production tool available to Industry
- 2-Step process developed
- Selective Chemistry with FA

2003 – FA In Production

- 3 Fabs take FA into production

2004/2005 – Expanding Production

- IBM and UMC publish prominent technical papers

2006 – Sub 45nm FA STI CMP Development begins

- New abrasives, chemistry and subpads
- Low pressure surfactant process taken into production at 45nm

Numerous Technical papers published by industry leaders: UMC, Infineon, IBM, Cypress, Hyundai, AMD, 3M, AMAT, SEMI Europa, Hyundai, VIT and others

Process Approach to attain superior planarization

DI Water Buff
Politex Pad

Buff

P3

3M SWR550 FA
Selective Chemistry
No Conditioning
5k-10k wafer Life

Pre-Planarization

P1

Fixed Abrasive Web

P2

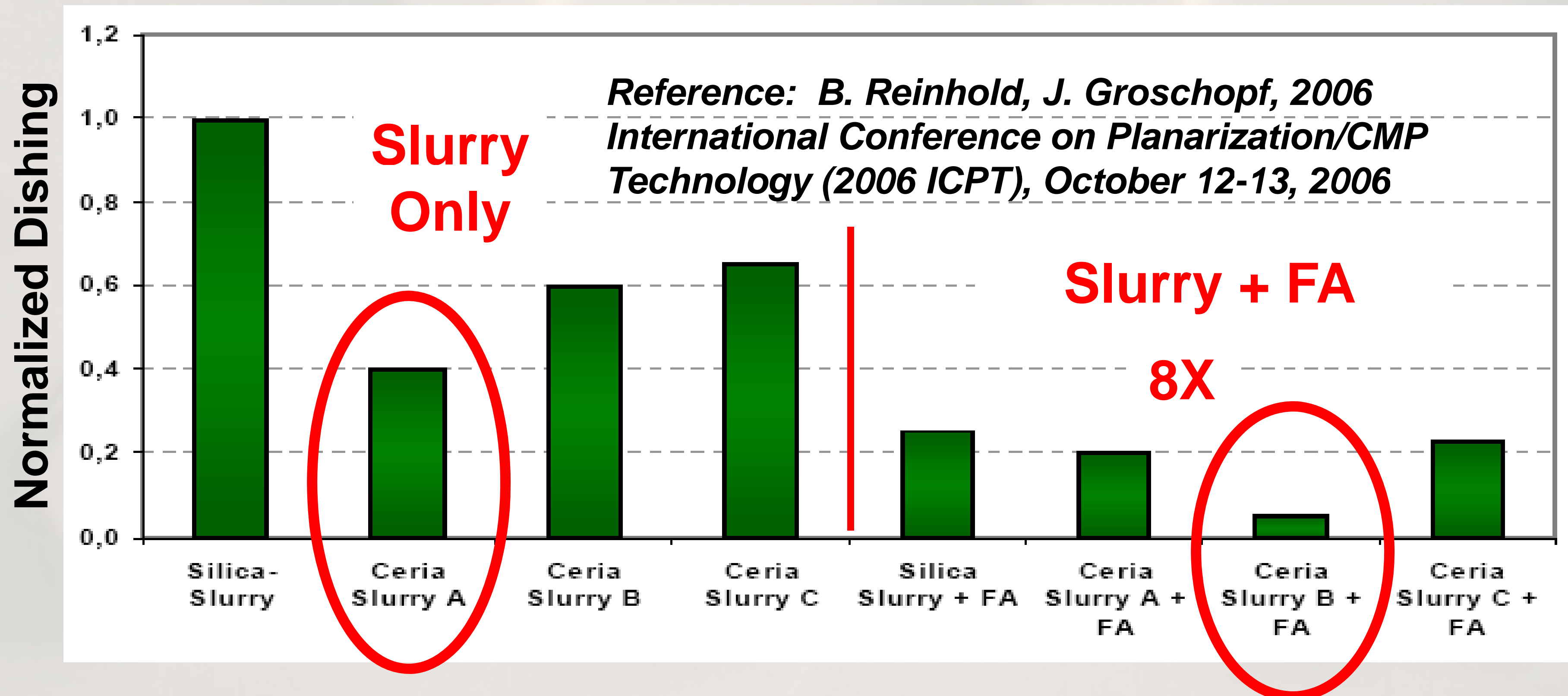
Conventional Pre-Planarization
3M Diamond Conditioner

FA Process

P1 Pre-Planarize
P2 Clear and Stop
P3 Remove Ceria

Planarization Comparison

- **Outstanding Planarization**
  - Low trench oxide dishing/range; low nitride erosion/range



NU and Process Stability

- **Exceptional WIWNU**

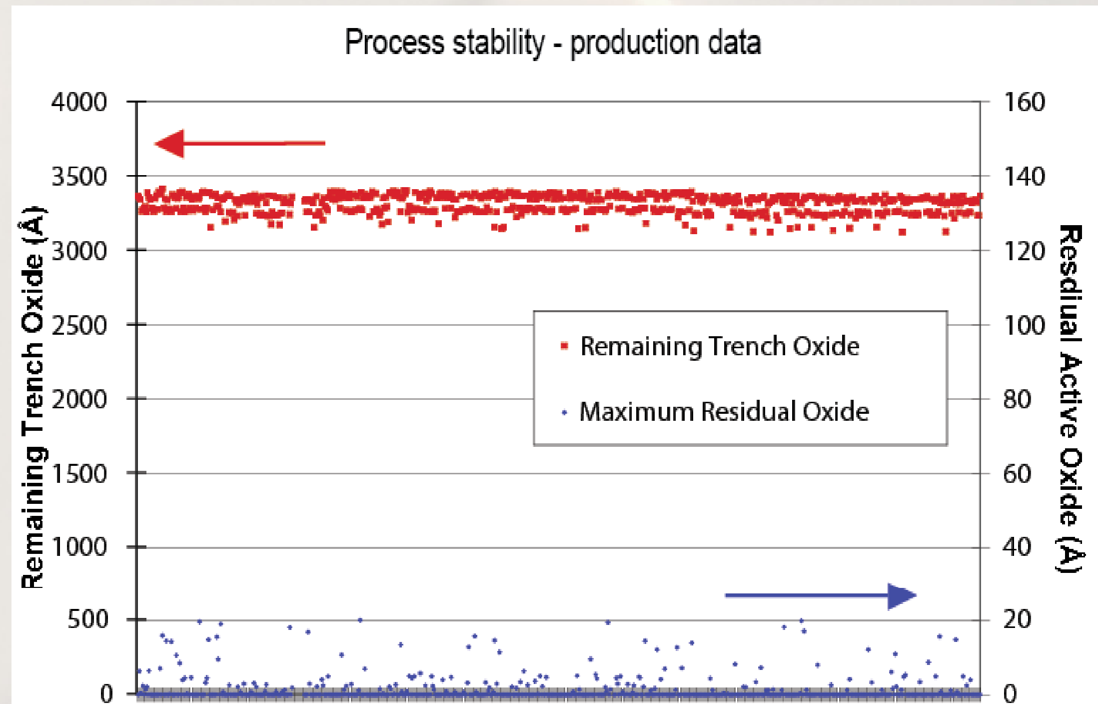
  50-150 Å nitride range (<5% on 3mm EE), depends mostly upon incoming nitride ranges.
- **Planarization Efficiency**

  3-10x greater than conventional pad/slurry processes; maximizes efficient removal of surface "peaks" and minimizes loss on surface "valleys."
- **Process Stability**

  Quick start-up from tool idle

  Long consumable life

  5k-10k Wafers



Reference: J. Gagliardi, 2006 International Conference on Planarization/CMP Technology (2006 ICPT), October 12-13, 2006

Electrical Field Oxide Thickness

Traditional Slurry vs Fixed Abrasive STI CMP

Ref: "Using Fixed Abrasives in a Production Process for 200 mm STI Polishing," Huang, C. K., Gagliardi, J. J., Gleason, E., 16th CMP User's Mtg. Proc., Munich, Apr. 7, 2006,

Traditional Slurry

Fixed Abrasive

Normalized Electrical Field Oxide

1.2
1.1
1
0.9
0.8
0.7

1 2 3 4 5 6 7 1 2 3 4 5 6 7 8 9 10 11 12 13

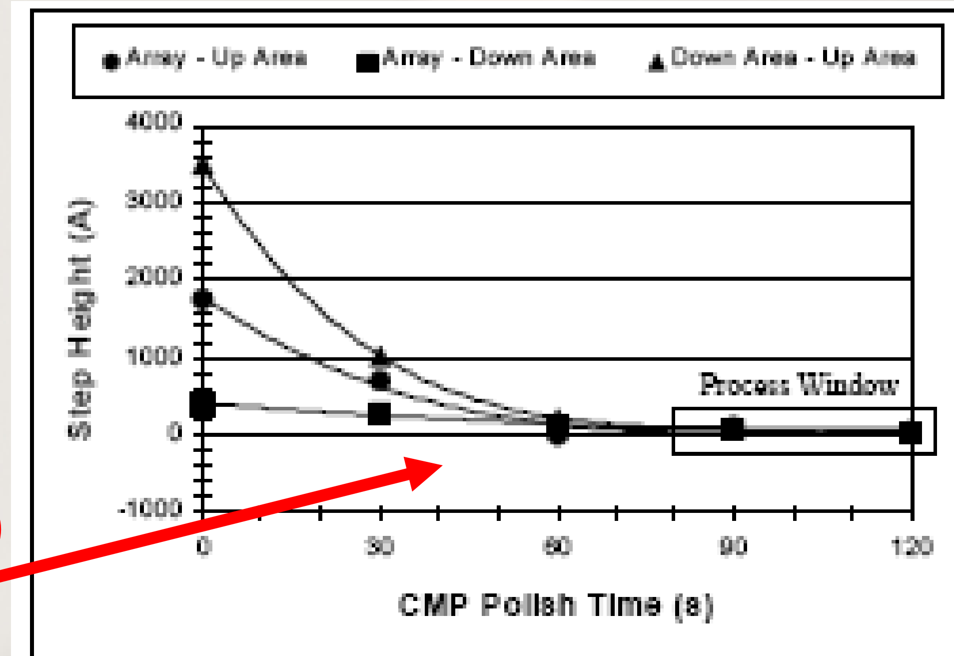
WAFER

0 200 400 600 800 1000

Data Point

Additional Characteristics

- **Selectivity**
  - ~ 200:1 (topography vs. planarized film)
  - ~ 1.2:1.0 (oxide to nitride.)
- **Self-Stopping**
  - High insensitivity to overpolish yields a wide process window.
- **Product Performance**
  - Production-Proven within-roll and roll-to-roll consistency.



Reference: Y. Moon, A. Kapur, R. Venigalla, L. Economikos, 2006 International Conference on Planarization/CMP Technology (2006 ICPT), October 12-13, 2006

FA STI CMP Roadmap
65nm, 45nm and Sub 45nm

300 mm

2006	2007	2008	2009	2010	2011	2012

- 65 nm Manufacturing
- 45 nm Process Dev.
- 45 nm Manufacturing
- 32 nm Development
- 32 nm Process Development
- SWR 521 & 542
- Chemistry
- SWR 548 & 550
- Subpad Improvements
- Nanoceria Abrasives
- Advanced FEOL Applications

200 mm

- Sub 250 nm Manufacturing
- R14 FA Rotary Pad

2006	2007	2008	2009	2010	2011	2012

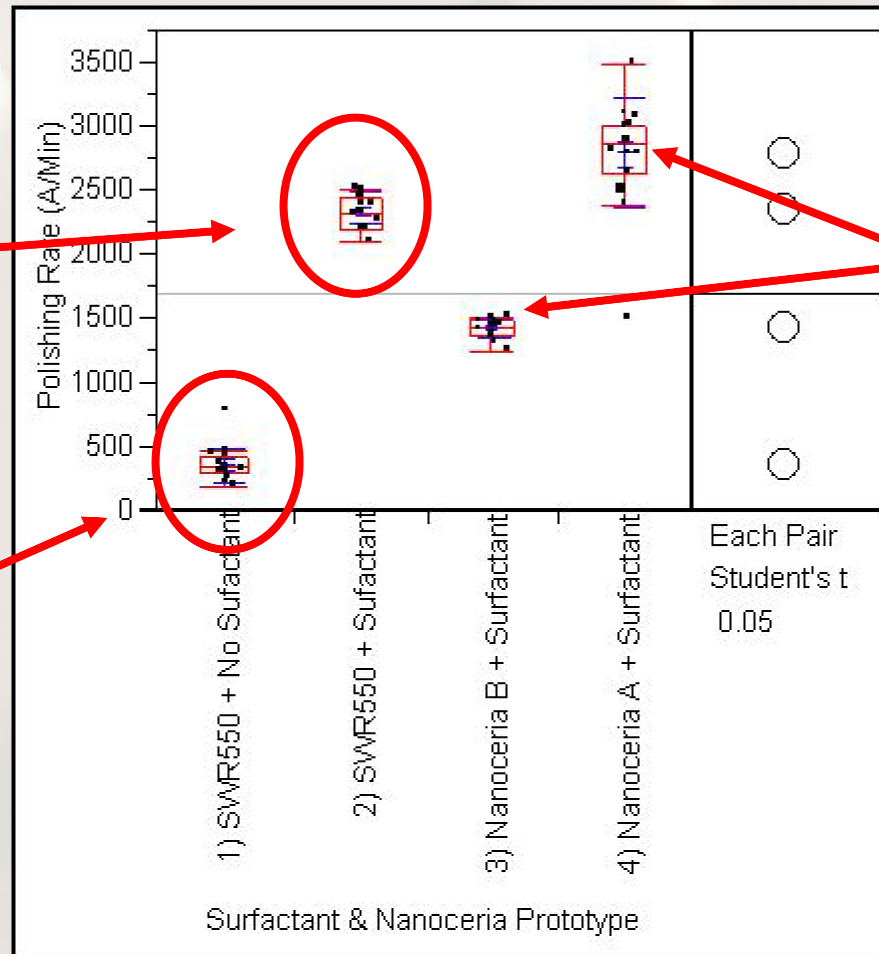
Advancements for 45nm and sub 45nm

- **Chemistry**
  - Surfactant introduced to polishing chemistry
- **Abrasive**
  - Current work with nano-ceria
    - Size, Shape, Loading
  - Fixed Abrasive Topography
    - Shape, Density, Size
- **Process Improvements**
  - Reduced Pressure Polishing
  - Higher throughput
  - Lower Increments

Advancements for 45nm and sub 45nm

Chemistry

Abrasive



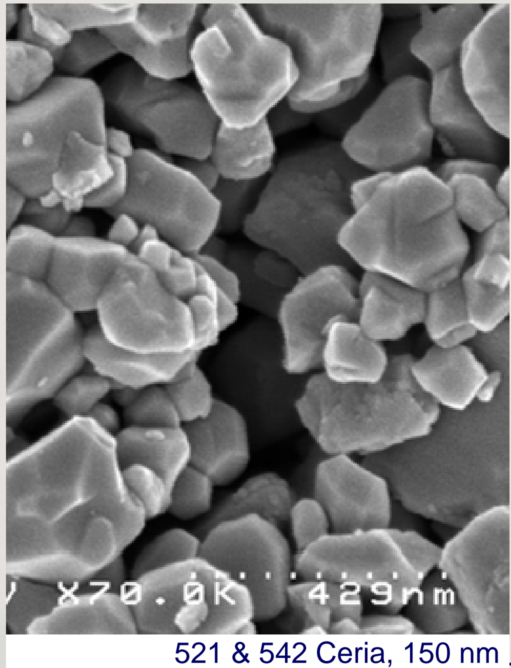
Surfactant Added

Nano Ceria

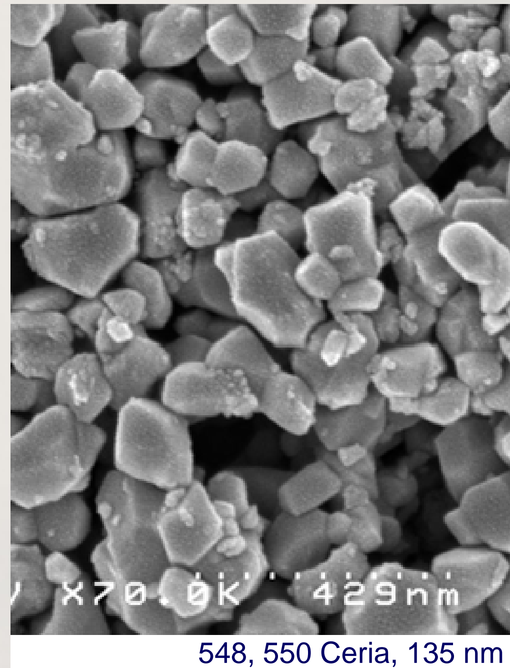
Standard Polish

Advancements for 45nm and sub 45nm Abrasive

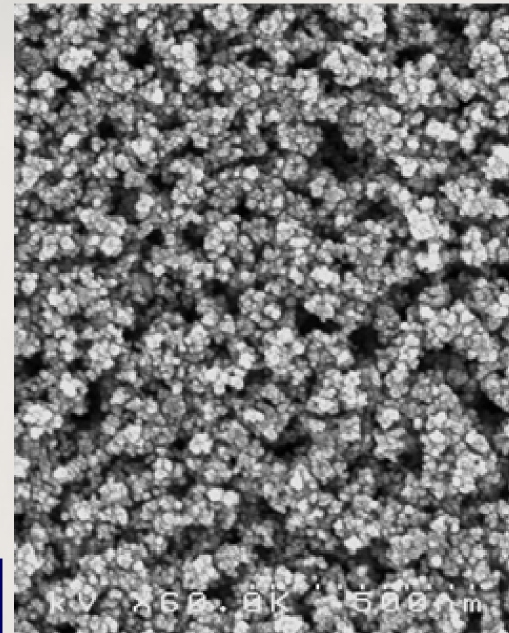
Current work with nano-ceria - Size, Shape, Loading
Fixed Abrasive Topography - Shape, Density, Size



521 & 542 Ceria, 150 nm



548, 550 Ceria, 135 nm



Multiple samples show acceptable rate

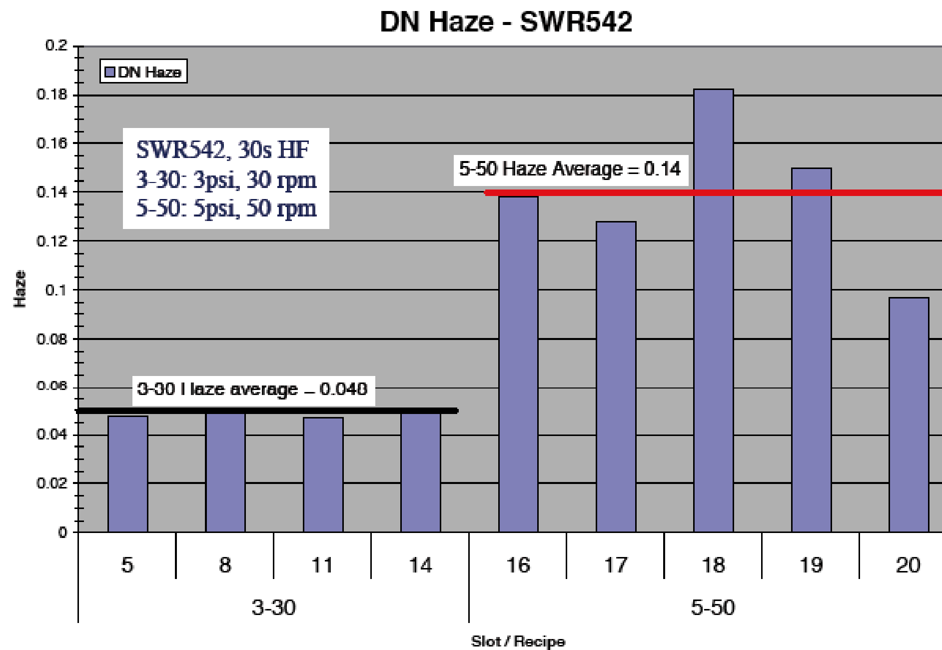
Advancements for 45nm and sub 45nm Process

- **CMP process and performance improvement**

Surfactant Chemistry allows much lower downforce

- Lower downforce
  - reduces defects 50-80% – **Yield**
  - allows FA to run at lower increments – **Cost**

Advancements for 45nm and sub 45nm
Low Pressure Reduces Defects



From a

KLA-Tencor SP2

Advancements for 45nm and sub 45nm Low Pressure Reduces Defects Generally to levels equal to HSS slurry

FAB	
A	12 months in production, HARP STI, 45 nm
B	Tested at 65 nm HDP STI and found 65% reduction in defects on product wafers Reduction of Increment Higher Rate (throughput)
C	Tested at 45 nm HARP STI and found 80% reduction in defects on product wafers Reduction of Increment Higher Rate (throughput)
D	Tested at 65 nm HDP STI and found "significant" reduction in defects on product wafers
E	Tested at 65 nm HDP STI and found 80% reduction in defects on product wafers

Advancements for 45nm and sub 45nm Process

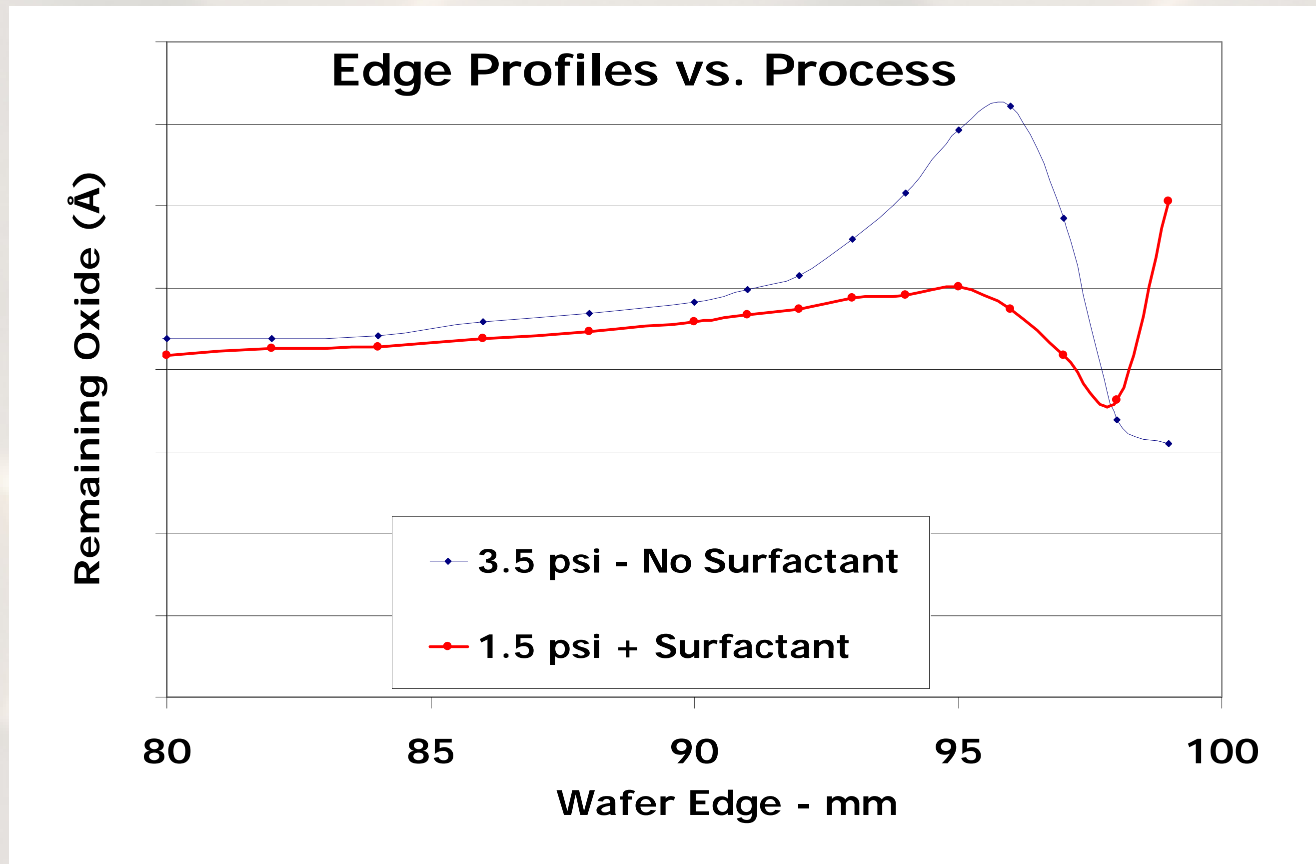
- **CMP process and performance improvement**

Lower pressures reduce subpad deflection

- Some fabs experience a fast-band near wafer edge known to be the result of the subpad deflection

Reference: Fixed Abrasive Direct STI CMP Allows Elimination of the Conventional Subpad Compromise for WIW and WID Ranges, J. J. Gagliardi, Abs. 915, 204th Elec. Chem. Soc., Oct. 12-17, 2003

Advancements for 45nm and sub 45nm Process



Advancements for 45nm and sub 45nm

Process Summary

Benefit	Impact
Higher Rates	Throughput
Lower Defects	Yield
Improved Fastband	Yield
Lower Increment	CoC

Summary and Conclusion

- Advances in Chemistry and Abrasive have improved the performance of the FA approach to STI CMP, enabling 45 nm.

- A path to achieve key performance needs – lower defects – for sub-45 nm process has been identified.

Outline

- ✓ Background
  - ✓ Timeline of developments leading to Advancements for Sub 45nm FA STI CMP
  - ✓ Two Step "hybrid" FA Process and Outstanding Planarization
- ✓ Current FA STI CMP Roadmap
  - ✓ 65nm, 45nm and Sub 45nm
- ✓ Advancements for 45nm and sub 45nm
  - ✓ Chemistry
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Future Venues for 3M CMP Updates

- **August 2007, Clarkson University CAMP CMP Conference**
  1. “ADVANCEMENTS IN PAD CONDITIONING FOR TUNGSTEN CHEMICAL MECHANICAL PLANARIZATION”
  2. “RECENT ADVANCEMENTS IN FIXED ABRASIVE STI CMP”

- **September 2007, Semicon Taiwan, Taipei, Taiwan**
  1. “Mineral, Chemistry and Process Advancements to take Fixed Abrasive STI CMP to sub 45 nm”

- **October 2007, ICPT Conference, Dresden, Germany**
  1. “Defectivity Improvement for Fixed Abrasive Based STI CMP in Advanced Logic Technology ”
  2. “Laser Scattering Technique for Characterizing Defects and Surface Morphology in the Fixed Abrasive CMP ”

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