Post-STI Buff Polish to Reduce Defects

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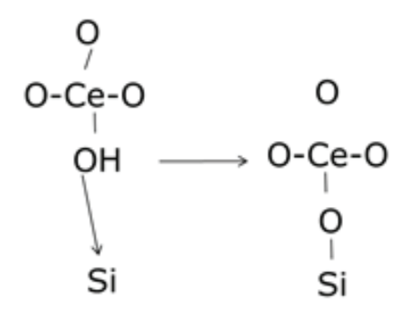
Post-STI Buff Polish to Reduce Defects

- An integrated approach has been developed to greatly reduce post-STI CMP defectivity via the use of:
  - An advanced ceria slurry on P2 specially formulated for low defectivity
  - A simple chemical buff on P2 or a separate buff pad (P3)
    - Chemical buff is called “DP1036”
- The novel chemical buff approach with DP1036 enables defectivity of post-STI polish surfaces to be dramatically improved with no loss of oxide/nitride thickness

Challenges in Ceria Particle Cleaning

- STI and oxide slurries commonly use ceria particles to enable high oxide removal rates.
- The Ce-O-Si bonds that are responsible for high oxide removal rates also create strong adhesion forces, making the particles difficult to remove:



Chemical Tooth Model for Oxide Removal by Ceria Slurry L. Cook, *J. Non-Crystalline Solids,* 120, 152 (1990)

- Any drying between process steps would greatly increase the adhesion of particles to the oxide surfaces.
- Ceria-based slurries tend to have a wide distribution of particles. Cleaning of very fine ceria particles is especially challenging since the particle diameter can be comparable to the fluid boundary layer width.

Traditional Approach for Defect Reduction

- Two step cleaning:
  - Oxide buff on P3 to remove scratches and some residues
  - Post-CMP brush box cleaning
- This approach may not be acceptable as device geometries shrink below 14nm, because it:
  - Leads to loss of oxide and nitride thickness
  - Increases non-uniformity of thickness
  - May introduce additional modes of defectivity

P1 Polish High Rate Silica Slurry → P2 Polish Selective Ceria Slurry → P3 Buff Silica Slurry → Post-CMP Cleaning

Our Integrated Approach for Defect Reduction

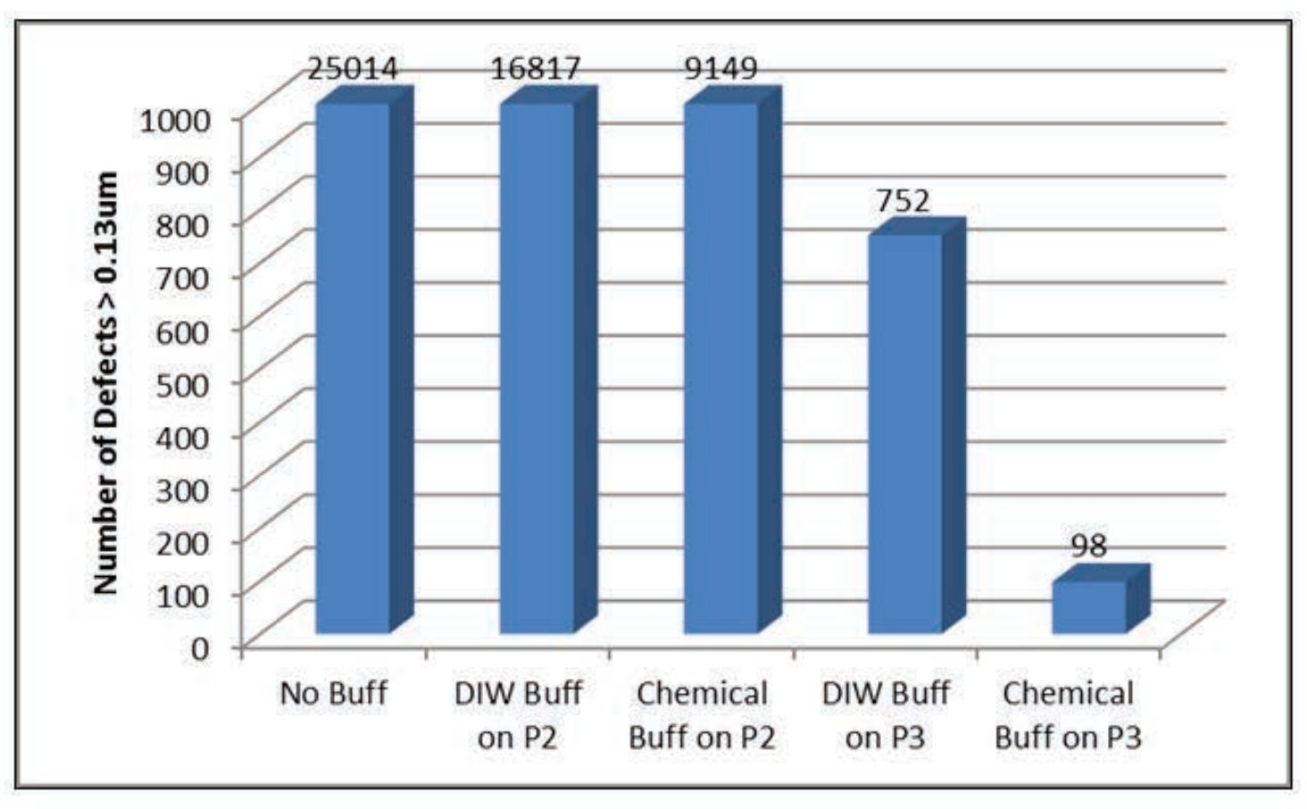
- P2: Use of an advanced ceria slurry specifically formulated for low defectivity (please see P1.24 poster, H. Zhou, et.al.)
  - Advanced manufacturing techniques to tailor particle size distribution
  - Eliminates large particles that are responsible for scratch defects
  - Reduces hard-to-clean fine particles
- Chemical buff on P3 soft pad:
  - Cleans most of the ceria particles and other residues in the buff step
  - No loss of film thickness
  - Chemically compatible with P2 slurry

P1 Polish High Rate Silica Slurry → P2 Polish Advanced Ceria Slurry → P3 Buff Chemistry Only → Post-CMP Cleaning

Initial Proof of Concept
Experimental Process Details

- AMAT Mirra
- TEOS and SiN blanket wafers
- 60-second polish using STI 2100F RA13 slurry
- Buff process:
  - 10 sec buff using DP1036 at 300 ml/min
  - 10 sec high pressure DIW rinse
  - Both P2 and P3 buffs evaluated:
    - P2=Hard pad (IC1010)
    - P3=Soft pad (Fujibo)
- The same cleaning module process was used in all cases

Initial Proof of Concept
Results



- Chemical buff on P3 (soft pad) shows a dramatic 250x reduction in defect levels
- Chemical buff on P2 (hard pad) also shows 2.75x improvement in defect reduction

Comparison with Standard Oxide Buff
Experimental Process Details

- Polishing and cleaning performed on Reflexion-LK
- 4-polish processes were evaluated:
  - See details on next slide
- A standard cleaning process was used:
  - SC1 in Meg
  - DIW and NH_4OH in brush boxes
- Wafers analyzed with SP1 and AIT-XP
- SEM defect review was performed with AMAT G3 SEM on one wafer per experimental condition

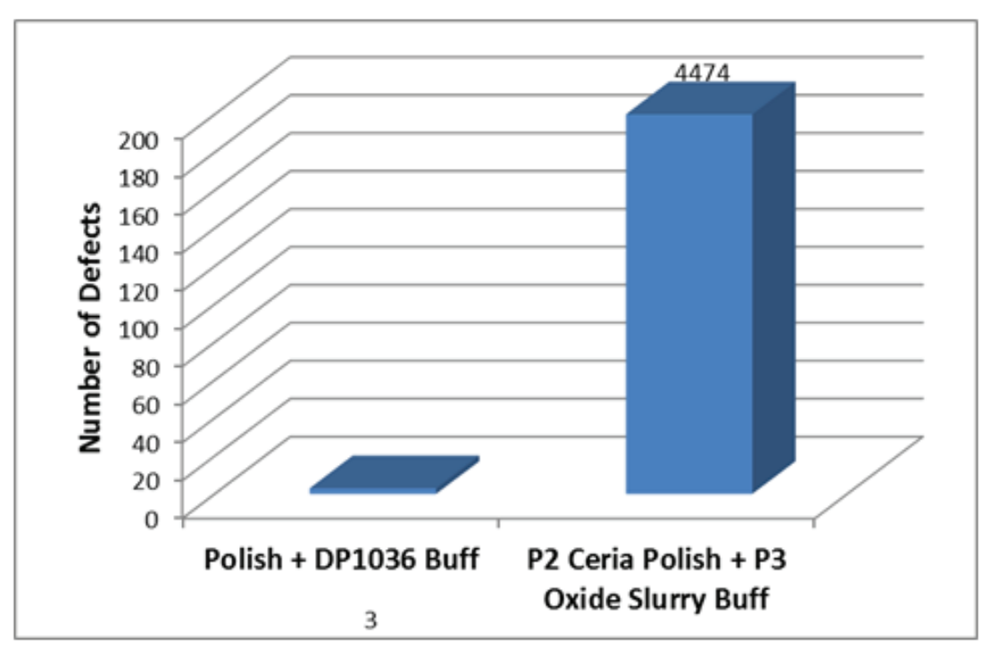
Comparison with Standard Oxide Buff
Polishing Process

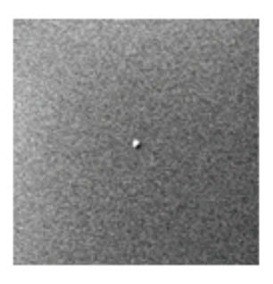
Platen	Slurry	Slurry Flow Rate (ml/min)	Pad	Disk	Speed (rpm) Head	Speed (rpm) Platten	DF (psi)	Polish Time (sec)
1	STI 2100F RA13	250	Dow IC1010	Saesol AF38	50	48	3.5	60
2	Commerical oxide buff slurry	250	Dow IC1010	Saesol 80C1	50	58	1.0	10
3	DP1036 (5x dilution)	250	Fujibo H7000	n/a	50	48	1.0	20

Split	Process
1	STI2100F RA13 polish + DIW rinse
2	STI2100F RA13 polish + DP1036 buff + DIW rinse
2a	DP1036 buff + DIW rinse (*to measure HDP and SiN removal rates only*)
3	STI2100F RA13 polish + commercial oxide buff slurry + DIW rinse
3a	Commercial oxide buff slurry + DIW rinse (*to measure HDP and SiN removal rates only*)
4	STI2100F RA13 polish + commercial oxide buff slurry + DP1036 buff + DIW rinse

Defectivity Results
Particle and Organic Residues

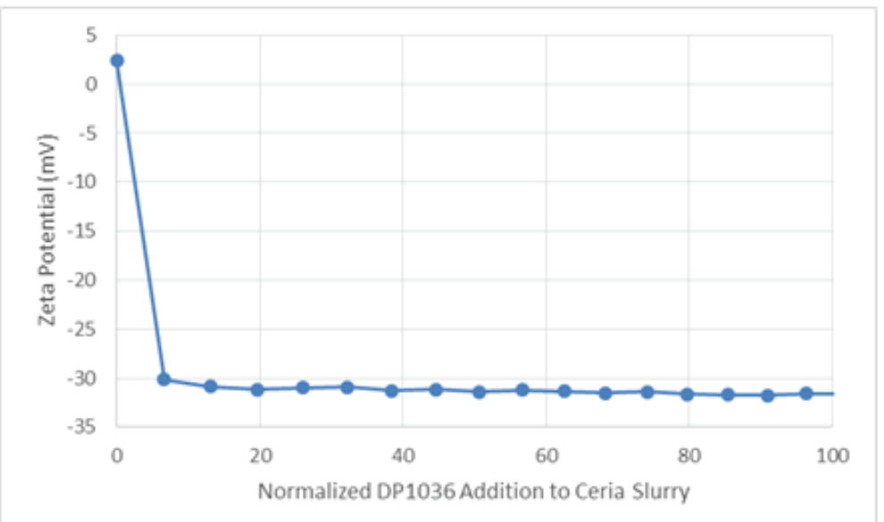
- For each wafer, 100 defects or the total number of defects (whichever is smaller) were reviewed by AMAT G3 SEM
- The number of defects classified as particle and organic residues are shown below:





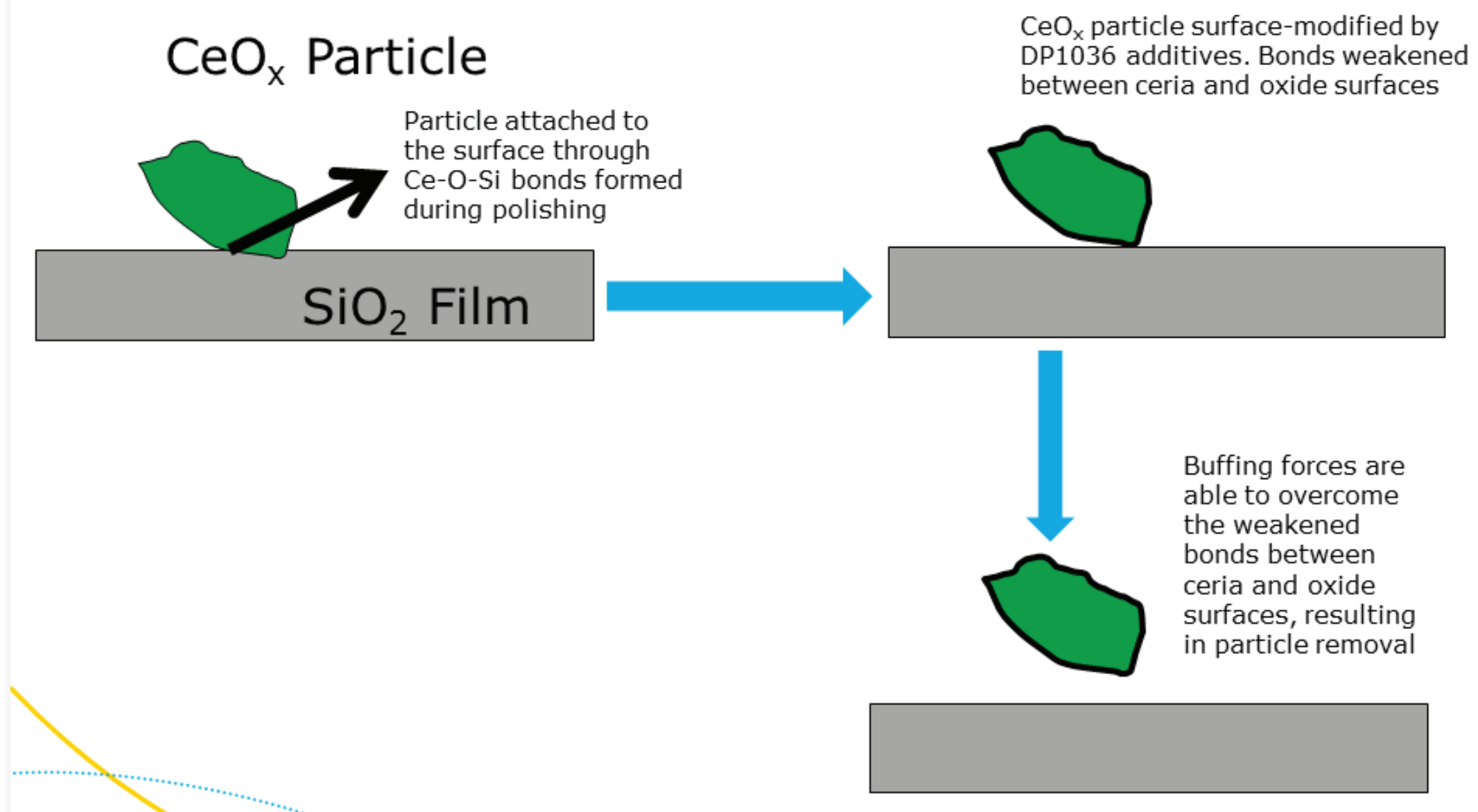
- Extremely low defectivity with DP1036 chemical buff
- Additional defects were generated by silica buff slurry

Ceria Surface Modification



- Strong adsorption of DP1036 additives on the ceria surface result in strongly negative zeta potentials
- The additive layer on ceria surface weakens the Ce-O-Si bonds formed between the particles and the oxide surface during polishing
- Mechanical forces during buffing are easily able to remove these surface-modified ceria particles, resulting in low defectivity
- Surface modification of ceria by DP1036 additives also greatly improves dispersion of the removed ceria particles and prevents re-deposition

Mechanism



Particle attached to the surface through Ce-O-Si bonds formed during polishing

CeO_x particle surface-modified by DP1036 additives. Bonds weakened between ceria and oxide surfaces

Buffing forces are able to overcome the weakened bonds between ceria and oxide surfaces, resulting in particle removal

Conclusions

- Using a novel chemical buff approach with DP1036, defectivity of post-STI polish surfaces is dramatically improved with no loss of oxide/nitride thickness
- Results are even better when compared to standard oxide slurry buff process, which relies on material removal to provide improved defectivity
- Lower particle defectivity on wafers coming into cleaning module are likely to improve the stability of post-CMP cleaning process by reducing the possibility of brush loading, thereby extending the brush life and reducing maintenance requirements

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