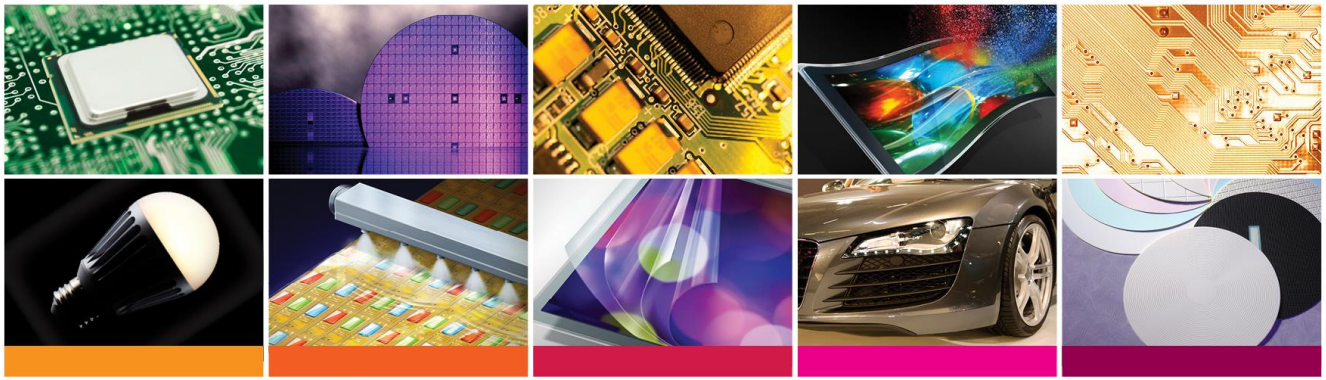
Electronic Materials



Cationic Silica Particles in Acidic CMP Slurries for Performance Enhancement

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Dow Electronic Materials
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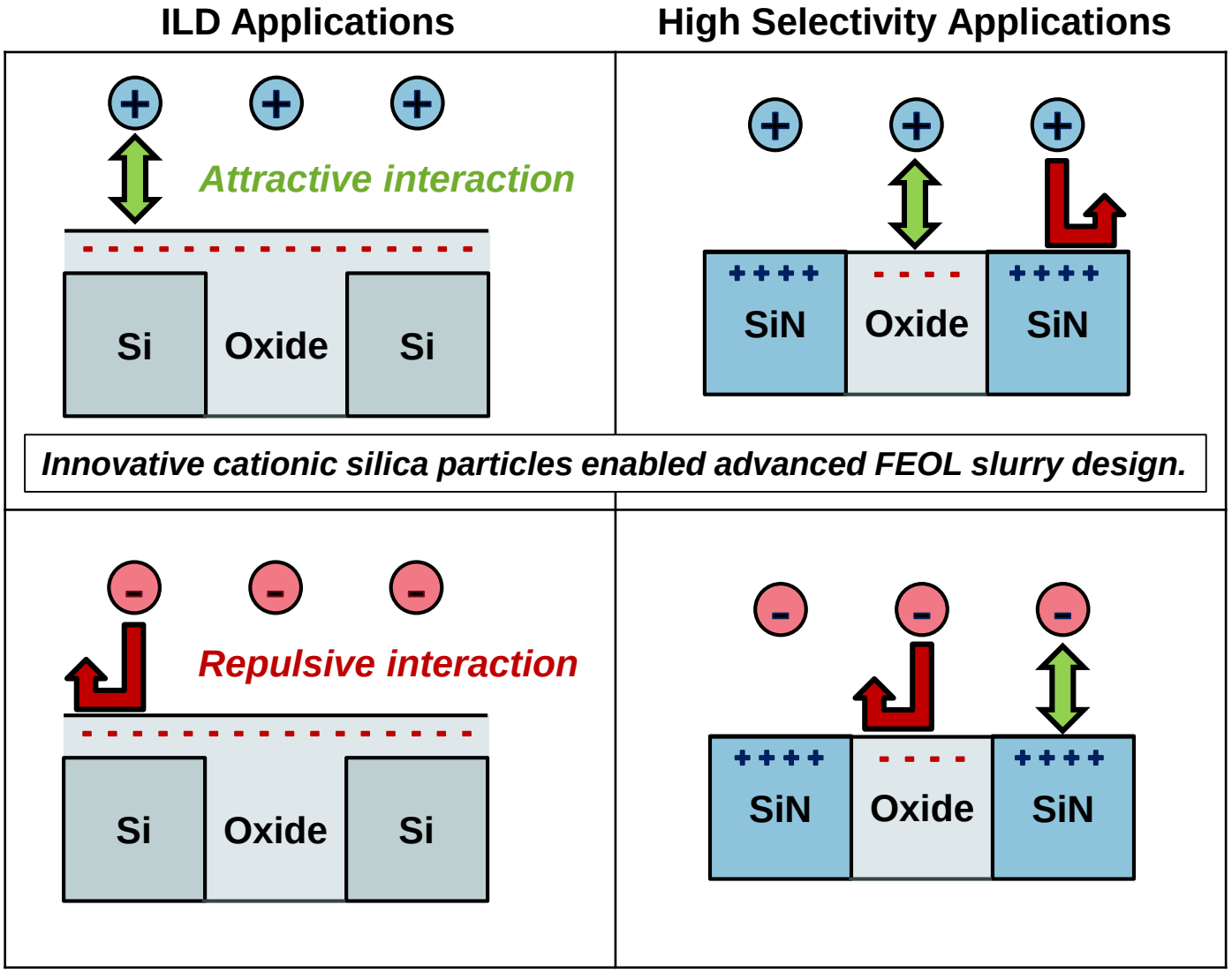
Overview

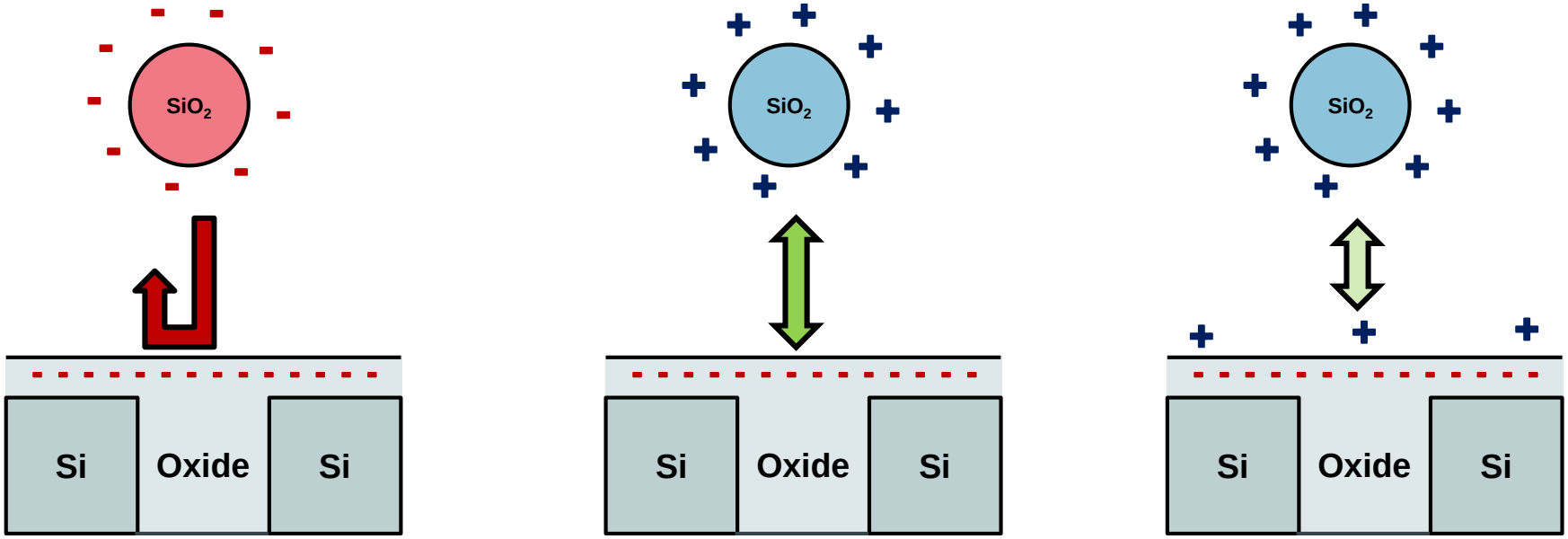
- Charge-centered FEOL slurry design
- Additive and pH effects on removal rate
- Silica ILD slurry development
- Slurry design and development for high selectivity applications

A Charge-Centered Approach to FEOL CMP



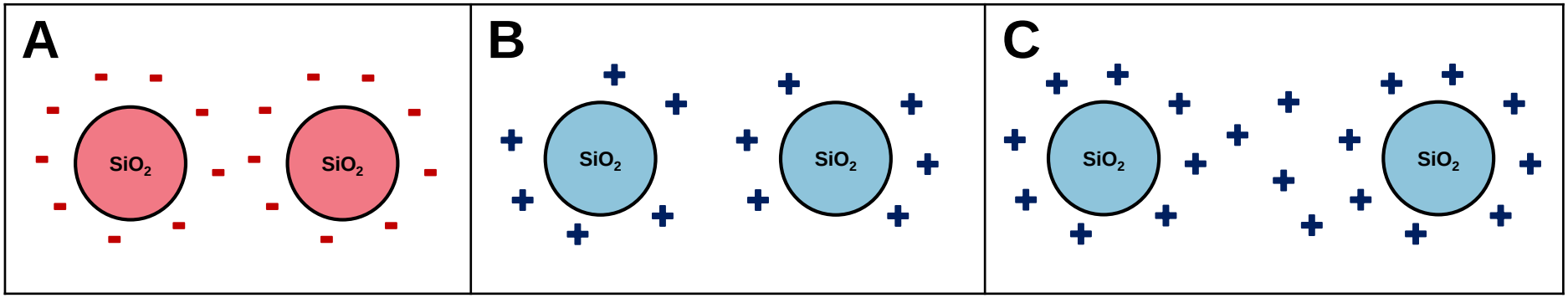
Cationic Silica Slurry Design

Traditional Colloidal Silica ***Optimized Additive Package*** ***Excess Additive***

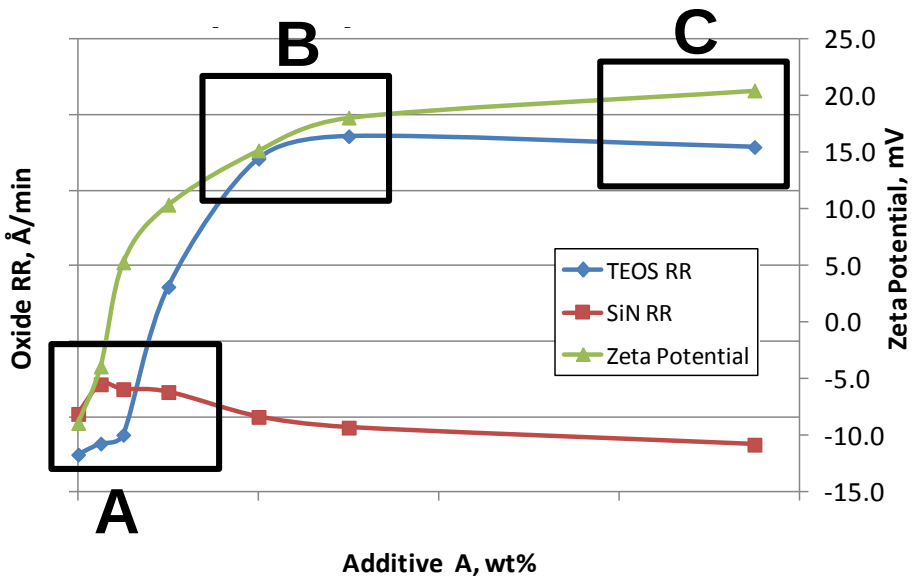


- In an acidic regime, charge on silica particles is made positive using charge-modifying additives.
- The resulting attractive forces between abrasive and dielectric film lead to higher removal rates at lower abrasive loading.
- Excessive additive in the bulk liquid may adsorb onto wafer surfaces, leading to weakened particle/wafer attraction and, consequently, diminished removal rate.

Additive Concentration and pH Affect Adsorption

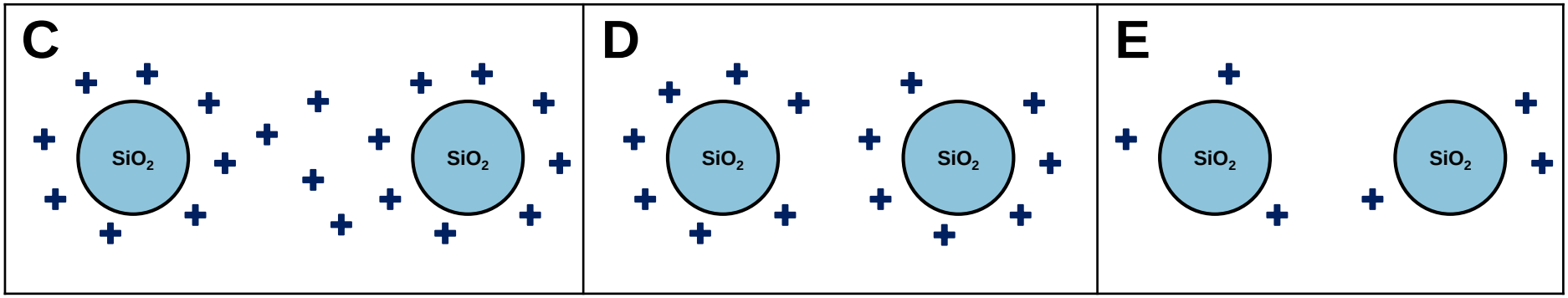


Fixed pH

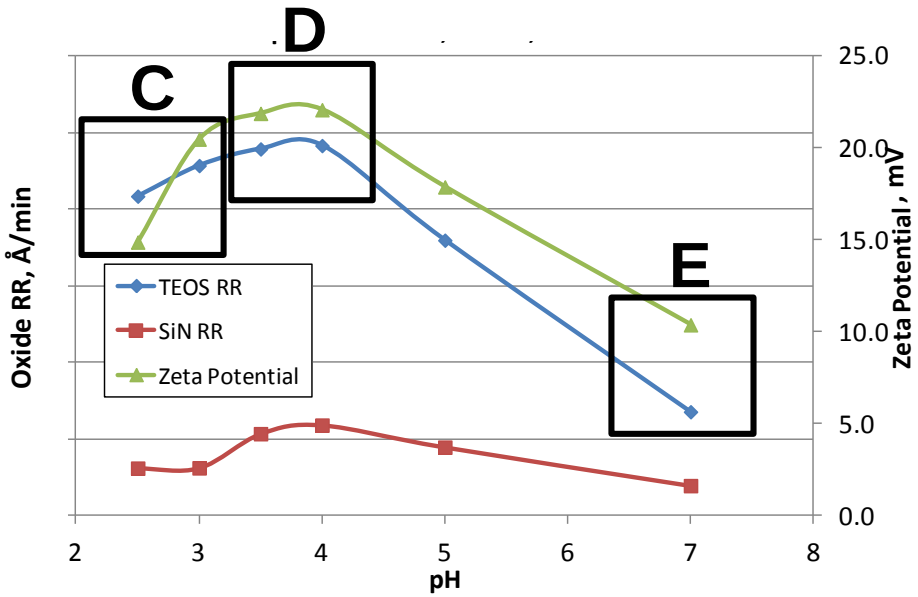


[Additive]: A < B < C
Additive saturates surface and then increases its bulk liquid concentration.

Additive Concentration and pH Affect Adsorption



Fixed [Additive]



pH: C < D < E
pH influences silanol ionization.
Ionized silanol groups neutralize additive cations on the surface.

Dow ILD Slurry Portfolio

Non-Formulated Klebosol® Colloidal Silica Slurry

Traditional Klebosol®

- **30% solids at POU**
- 80 nm spherical particle

Klebosol® 1630

- **16% solids at POU**
- 135 nm elongated particle
- Improved post-HF defectivity
- Low CoO

Dow Formulated ILD Slurry

Klebosol® 1730

- **16% solids at POU**
- **pH 10.8**
- 135 nm elongated particle + additive
- Higher RR
- Improved post-HF defectivity
- Low CoO

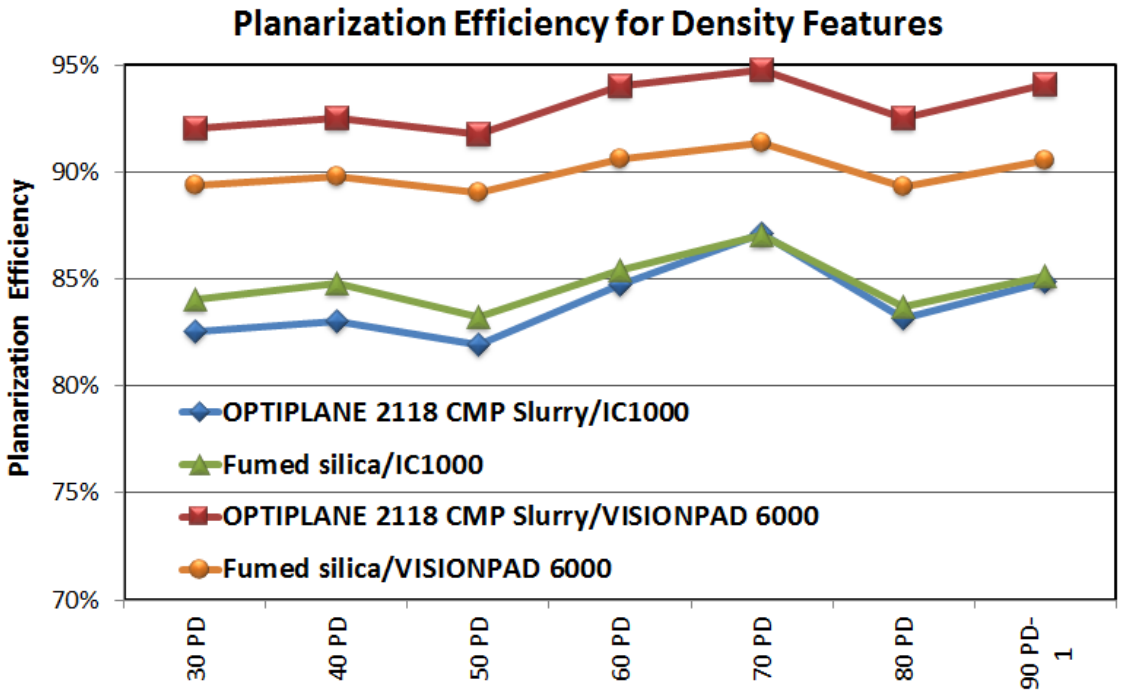
OPTIPLANE™ 2118

- **4-6% solids at POU**
- **pH 3**
- Spherical colloidal silica + additive
- Step improvement in post-HF defectivity
- Low CoO

Next Generation ILD Slurry

A lower abrasive slurry with higher rate and lower defectivity is in development.

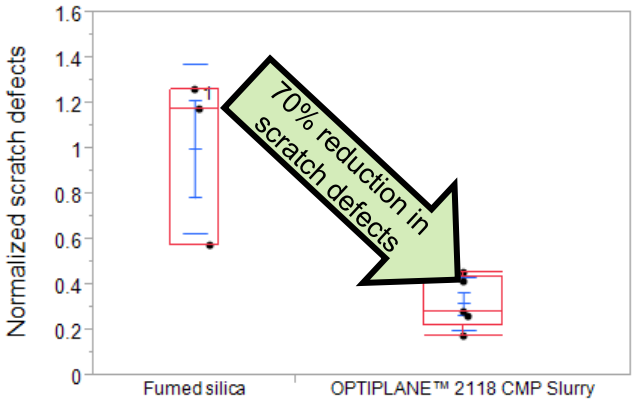
OPTIPLANE™ 2118 Slurry – Planarization Efficiency and Pad Synergy



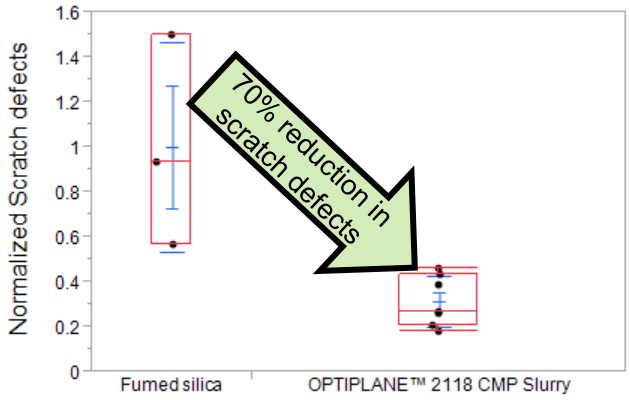
OPTIPLANE™ 2118 demonstrated improved performance with Dow's VISIONPAD™ 6000 pad over IC1000. Synergistic effects between pad and slurry allow performance tuning.

OPTIPLANE™ 2118 CMP Slurry Advantage – Low Scratch Defects

IC1000™ Pad

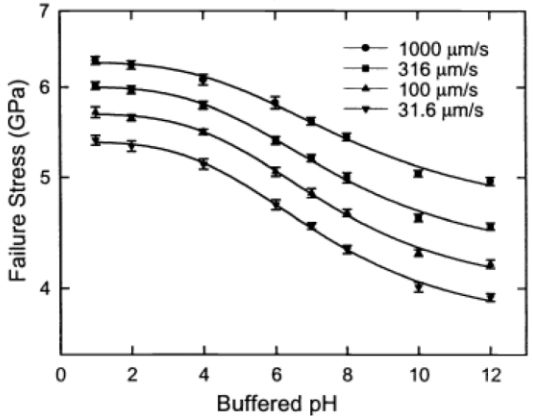


VISIONPAD™ 6000 Pad



A 70% or more reduction in defects was observed for acidic OPTIPLANE™ 2118 slurry compared to alkaline fumed silica slurry.

SiO_2 optical fiber



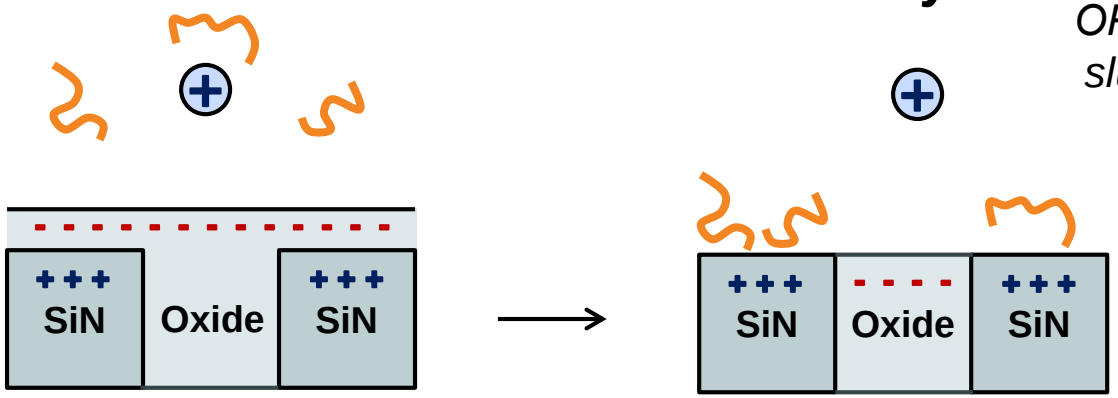
- Critical stress intensity for crack propagation in silicates driven by –OH catalyzed Si-O bond cleavage.[1]
- Strength required for initiating crack generally increases with decreasing pH.
  - Acidic pH may contribute to reduced defect counts.

[1] Proc. of SPIE, vol.4940, 83, 2003.

Cationic Silica Slurries for High Selectivity Applications

OPTIPLANE™ 1600 Slurry

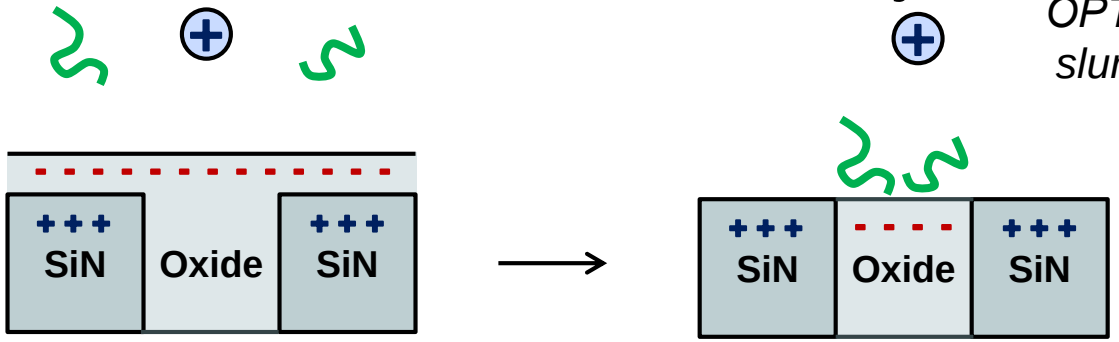
Zeta potential of OPTIPLANE™1600 slurry is +16 mV at POU pH.



An optimized component of OPTIPLANE™ 1600 slurry protects SiN surfaces through lubrication layer formation and cationic silica abrasive efficiently removes oxide.

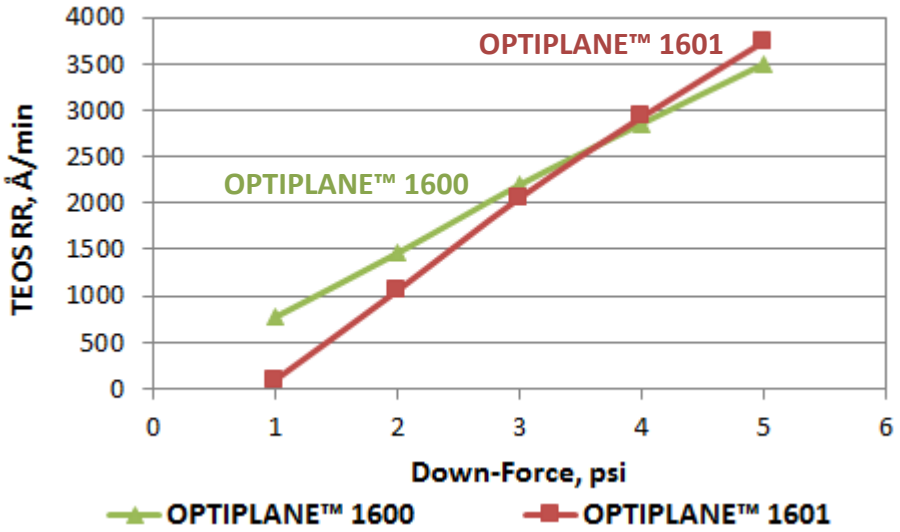
OPTIPLANE™ 1601 Slurry

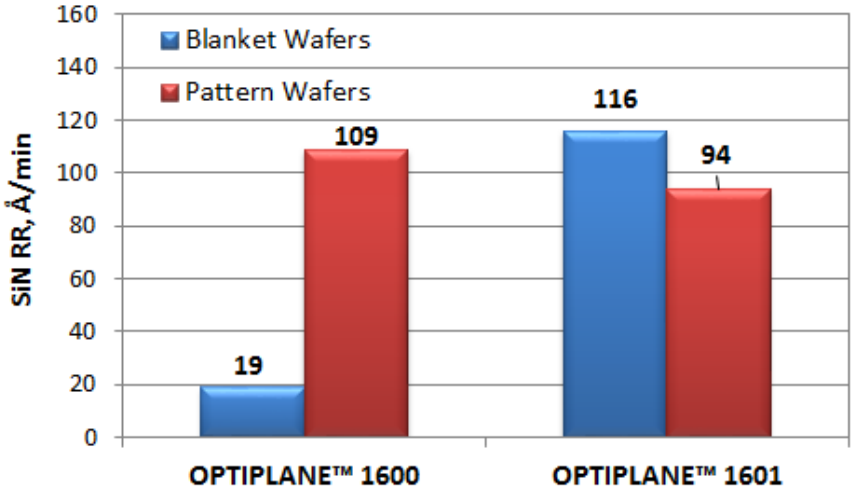
Zeta potential of OPTIPLANE™1601 slurry is +26 mV at POU pH.



A proprietary additive in OPTIPLANE™ 1601 slurry achieves dishing control and cationic silica removes oxide with selectivity to SiN through a charge repulsion mechanism.

OPTIPLANE™ 16XX Slurry Series for High Selectivity Applications





IC1010 pad, 93/87 rpm carrier/platen speed, 7 lbf pressure on Kinik AD3CS211250-1FN conditioning disk, 150 mL/min slurry flow rate, 3 psi down-force for SiN study.

The OPTIPLANE™ 16XX slurry series targets high selectivity applications with tunable removal rates, selectivities, and performance on patterns.

OPTIPLANE™ 1600 slurry offers a solution for high selectivity applications; OPTIPLANE™ 1601 slurry enables improved topography and dishing control.

OPTIPLANE™ 16XX Slurry Performance Summary

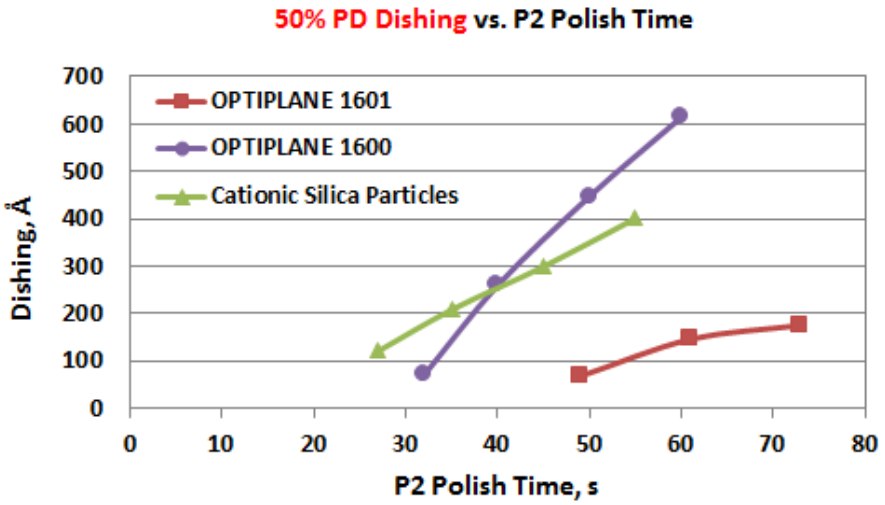
Performance Metric	OPTIPLANE™ 1600 Slurry	OPTIPLANE™ 1601 Slurry
Particle Loading	2%	3%
Blanket **TEOS RR** at 3 psi, Å/min	2198	2055
Pattern **HDP RR**, Å/min	2017	1088
Pattern **SiN RR**, Å/min	109	94
Pattern Oxide:SiN **Selectivity**	19	12
SiN Loss at 500 Å Overpolish, Å	23	55
Dishing at 500 Å Overpolish, Å	304	146

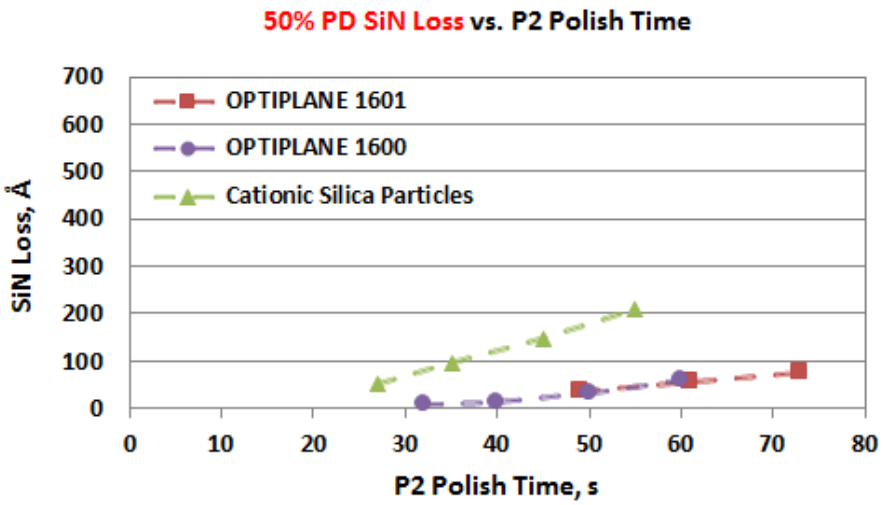
Data shown for pattern wafers pre-planarized on P1. STI performance of experimental slurries tested on P2 using IC1010™ pad. Performance is tabulated for the 50% pattern density feature.

OPTIPLANE™ 1601 slurry polishes with a lower pattern HDP RR relative to OPTIPLANE™ 1600 slurry, but with lower dishing.

IC1010 pad, 3 psi down-force, 93/87 rpm carrier/platen speed, 7 lbf pressure on Kinik AD3CS211250-1FN conditioning disk, 150 mL/min slurry flow rate.

OPTIPLANE™ 1601 Slurry Performance – 50% PD Feature





Low dishing was measured for OPTIPLANE™ 1601 slurry with respect to P2 polish time.

IC1010™ pad, 3 psi down-force, 93/87 rpm carrier/platen speed, 7 lbf pressure on Kinik AD3CS211250-1FN conditioning disk, 150 mL/min slurry flow rate.

Summary

- Innovative cationic silica particles and an effective additive portfolio enable tailoring of slurry platforms for desired performance.

- Surface interactions between modified silica abrasives and CMP substrates are tuned using surface active components to attain high oxide removal and selectivity to silicon nitride. Dishing control is achieved by incorporation of additives that reduce trench oxide loss in high selectivity applications.

- **OPTIPLANE™ 2118** slurry, **OPTIPLANE™ 1600** slurry, and **OPTIPLANE™ 1601** slurry capture the capabilities of cationic silica abrasives to enable improved performance in FEOL applications.

Thank You

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