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EHS Friendly Slurries with High Poly Si Removal Rate and Nearly Zero ILD Loss

Haiyan Li[1*], Akira Endou[2], Annette Schaper[1], Todd Eck[1], Toshio Shinoda[2], Anne Miller[1*]

[1]Fujimi Corporation, Oregon, USA 97062
[2]Fujimi Incorporated, Gifu, Japan 509-0108
*Contacts: hli@fujimico.com, amiller@fujimico.com

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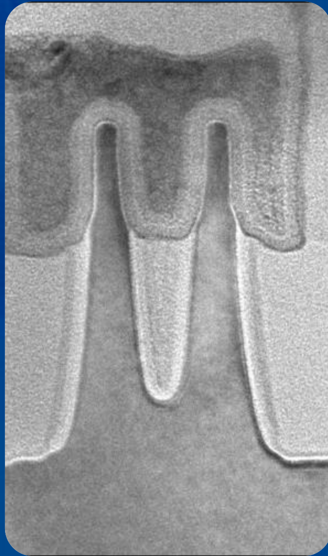
Outline

- ✓ Introduction
- ✓ Design principle
  - ✓ Stop on TEOS
  - ✓ Poly Si RR enhancement
- ✓ Summary and future work

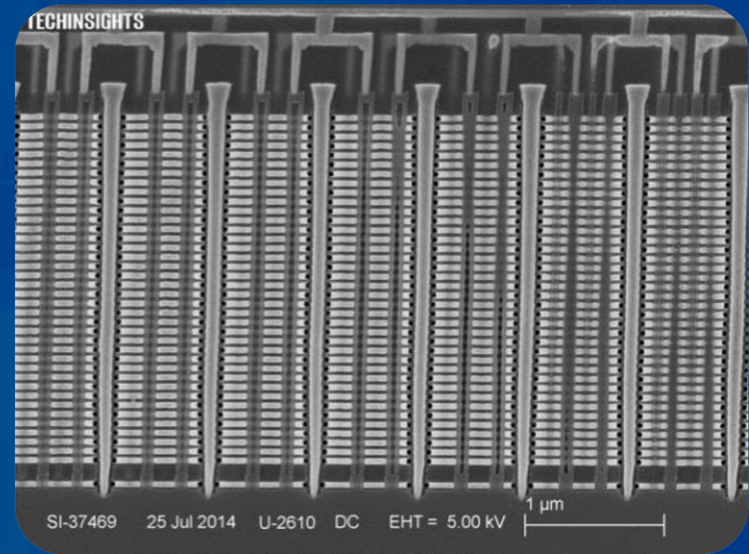
Introduction

High performance polysilicon CMP slurries are required for FinFET and 3D NAND



Cited from Intel.com

14 nm Tri-gate Transistor



Cited from pcper.com/news

Samsung 3D V-NAND flash array

Requirements:

- High selectivity (>1000) on TEOS
- High poly Si removal rate (RR)
- EHS friendly

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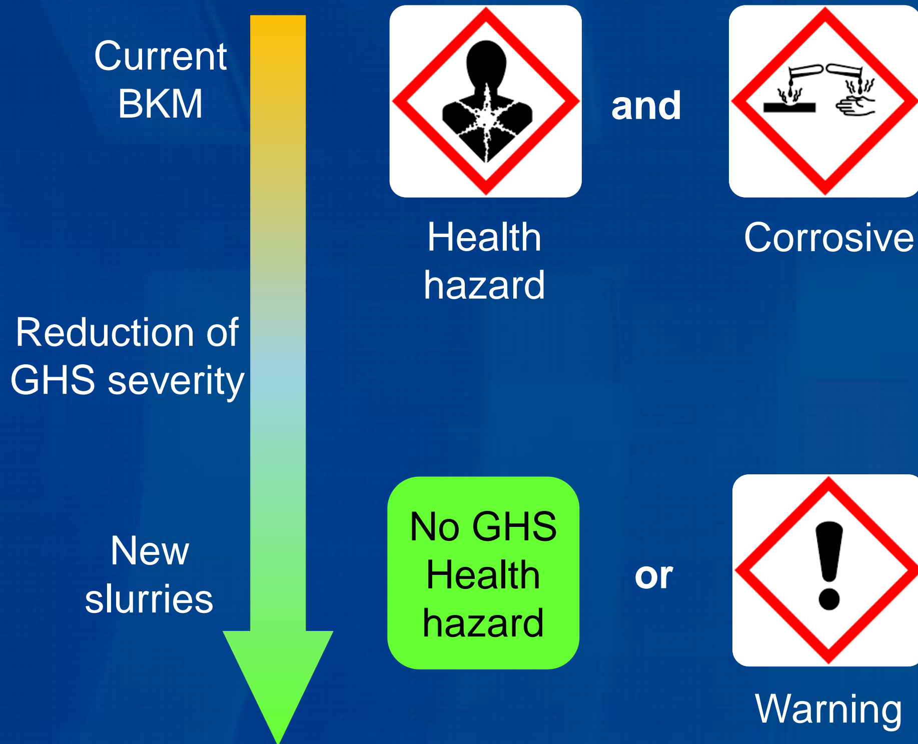
EHS friendly poly Si CMP slurry



Goal:

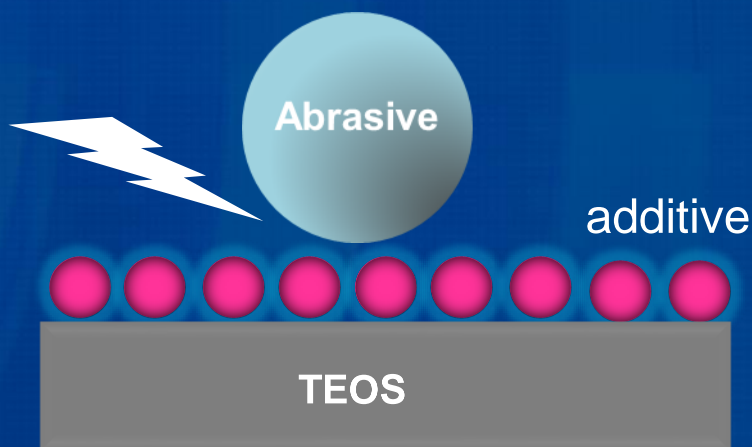
Reduce the severity of GHS classification

GHS: Globally Harmonized System classification of hazards

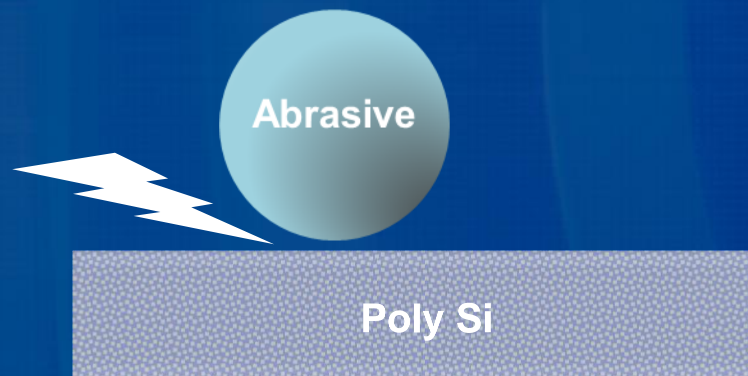
Formulation design

Reduce TEOS loss by protecting its surface with a film of additive

Stop on TEOS

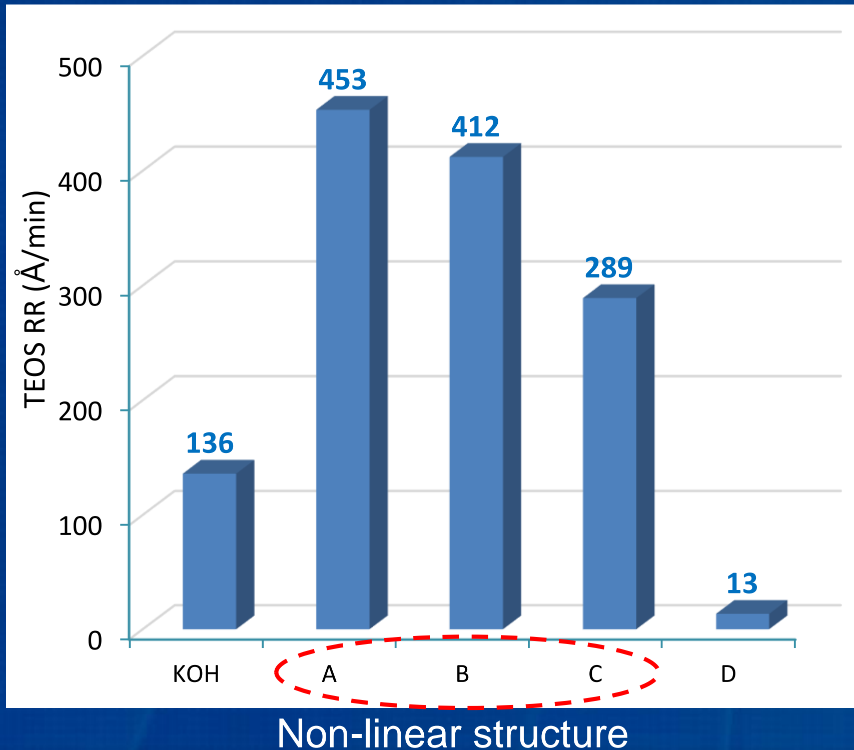


Polish poly Si



TEOS RR suppression

- Additive D dramatically suppresses TEOS RR
- Compared to additive A-C, D has a longer carbon chain and a linear structure



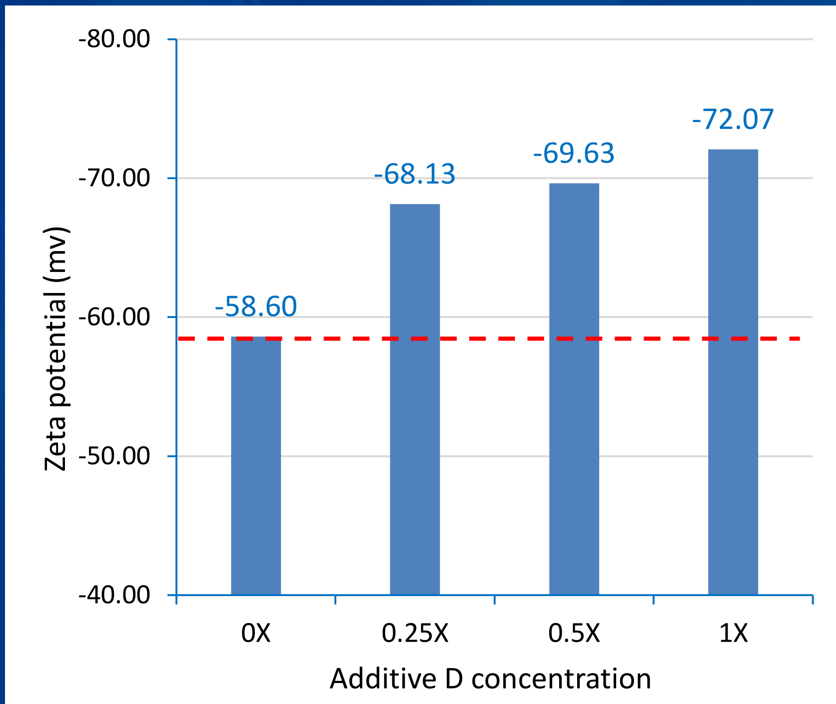
Non-linear structure

Additive D

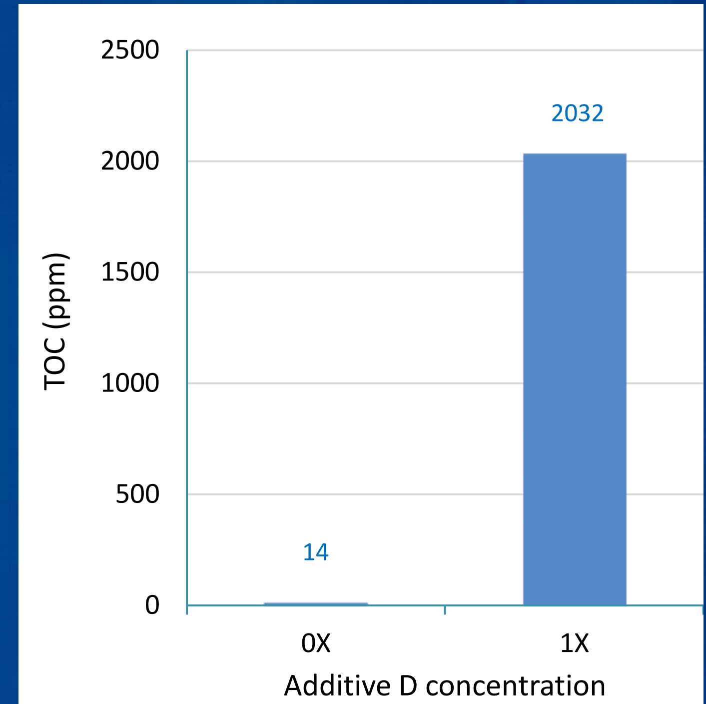
Does additive D coat on TEOS (oxide) surface ?

Additive D is absorbed on oxide particle

- Additive D increase zeta potential magnitude of oxide surface
- Evidence of additive D absorption on oxide surface



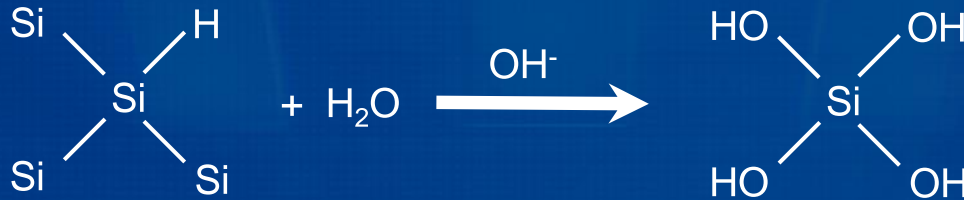
Surface charge vs. additive D concentration

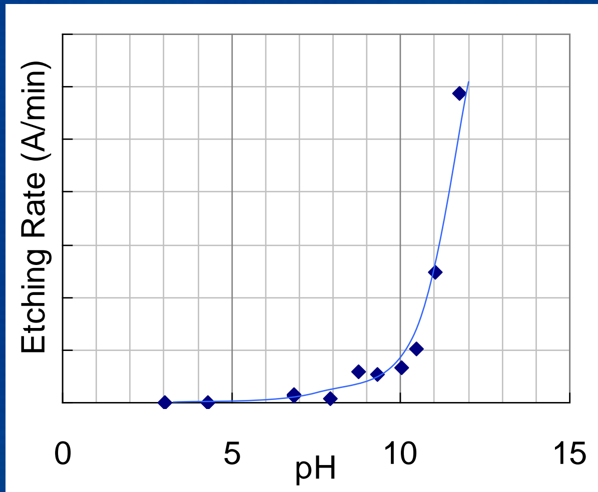


Total organic carbon on oxide particles

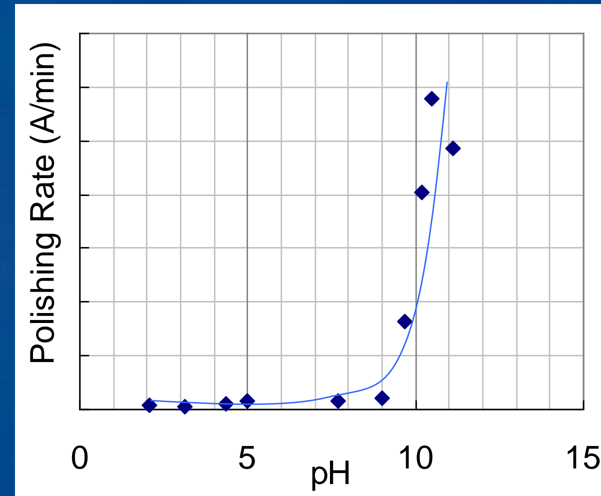
pH dependence of poly Si RR

Hydrolysis of poly Si is enhanced by OH- at high pH





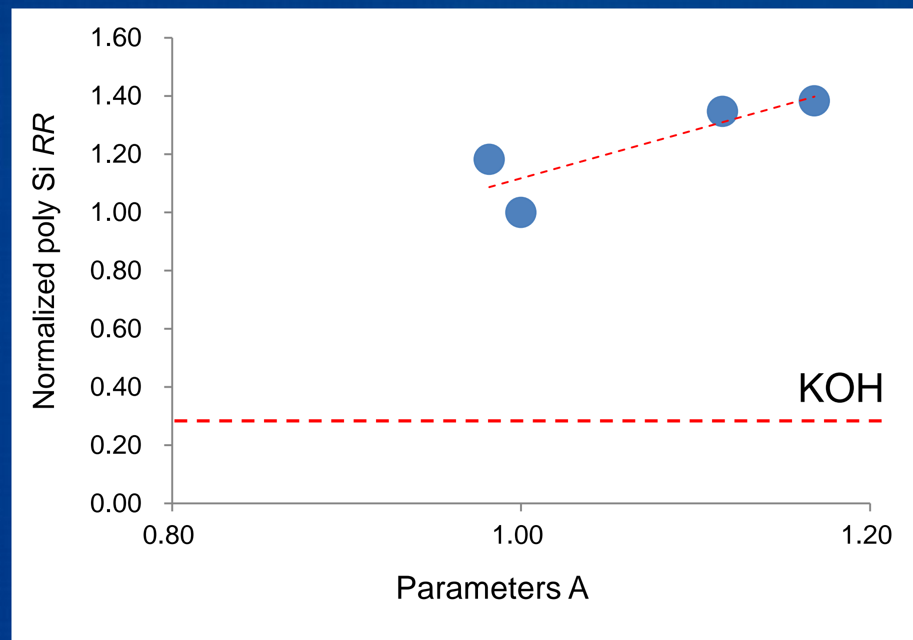
pH dependency of Si etching rate



pH dependency of Si polishing rate

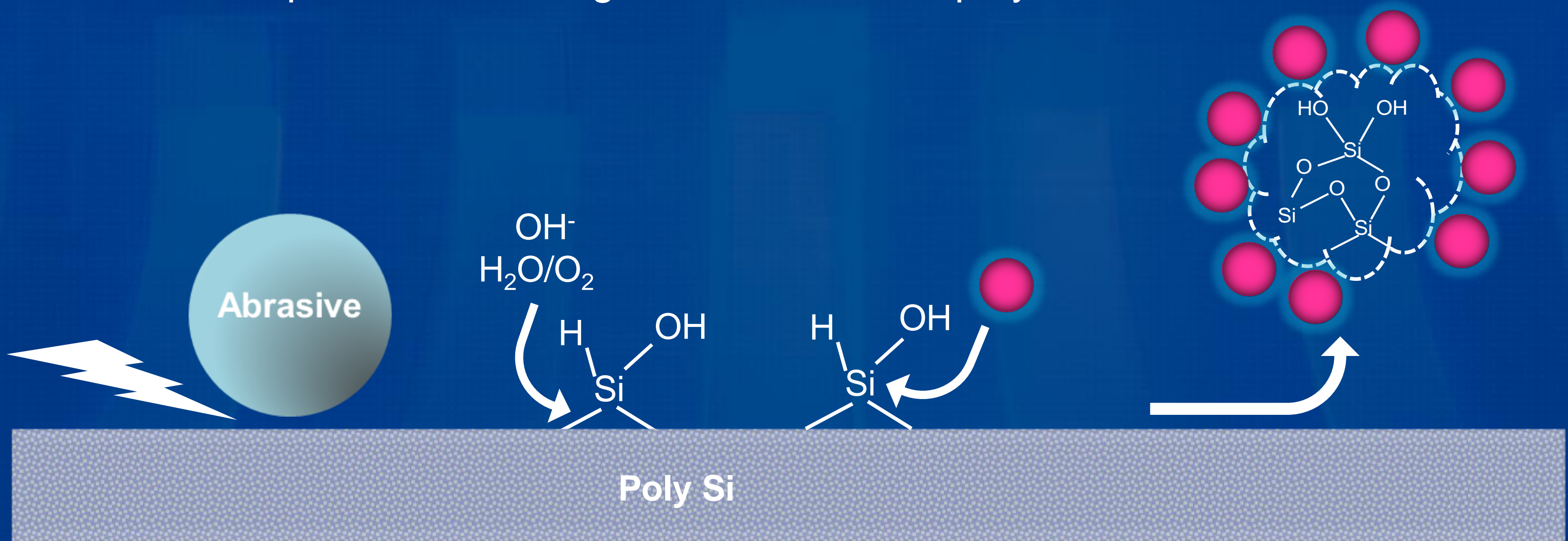
Poly Si RR driven by Type A interaction

- Type A interaction is modeled by a "parameter A" in computation chemistry
  Proc. Int. Symp. Semi Manu 2014, PO-O-046
- Type A interaction dramatically increases poly Si RR
- Additive with larger parameter A demonstrates higher polishing RR



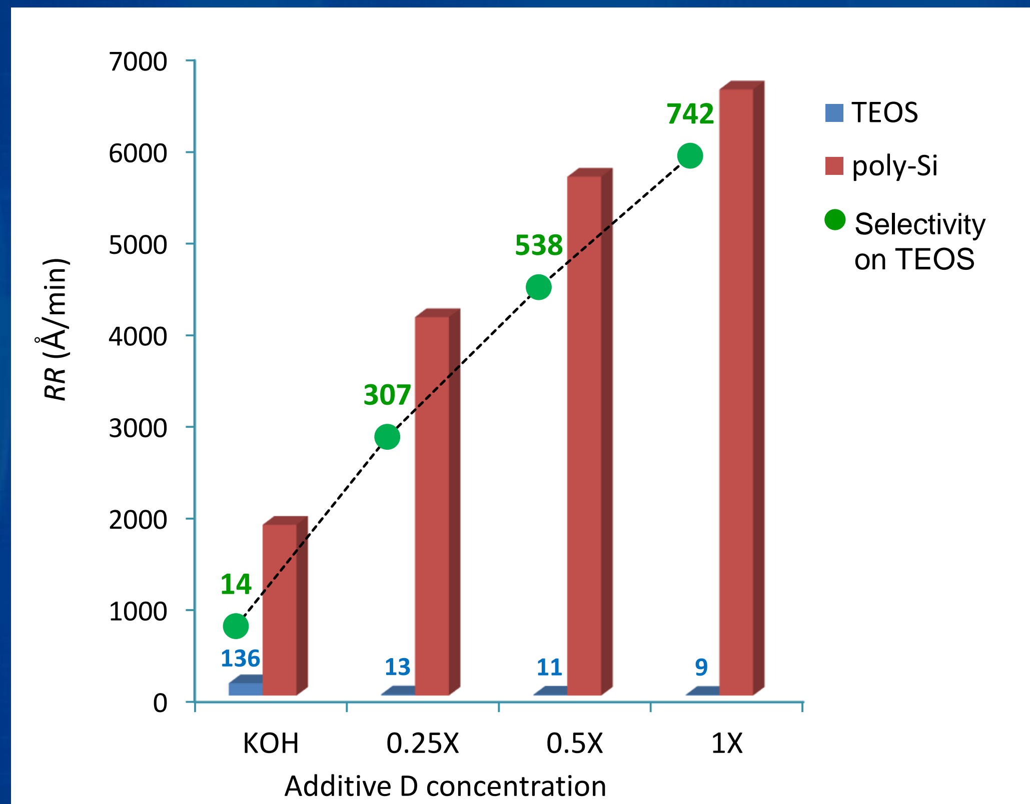
Driving forces accelerate poly Si RR

- Mechanically polished by abrasives in the absence of a strong protection layer on poly Si
- High pH provides sufficient hydrolysis and etching Si
- Type A attack of Si by additives accelerates hydrolysis and etching of Si
- Additive helps clean resulting silica debris from poly Si surface



Additive concentration skew

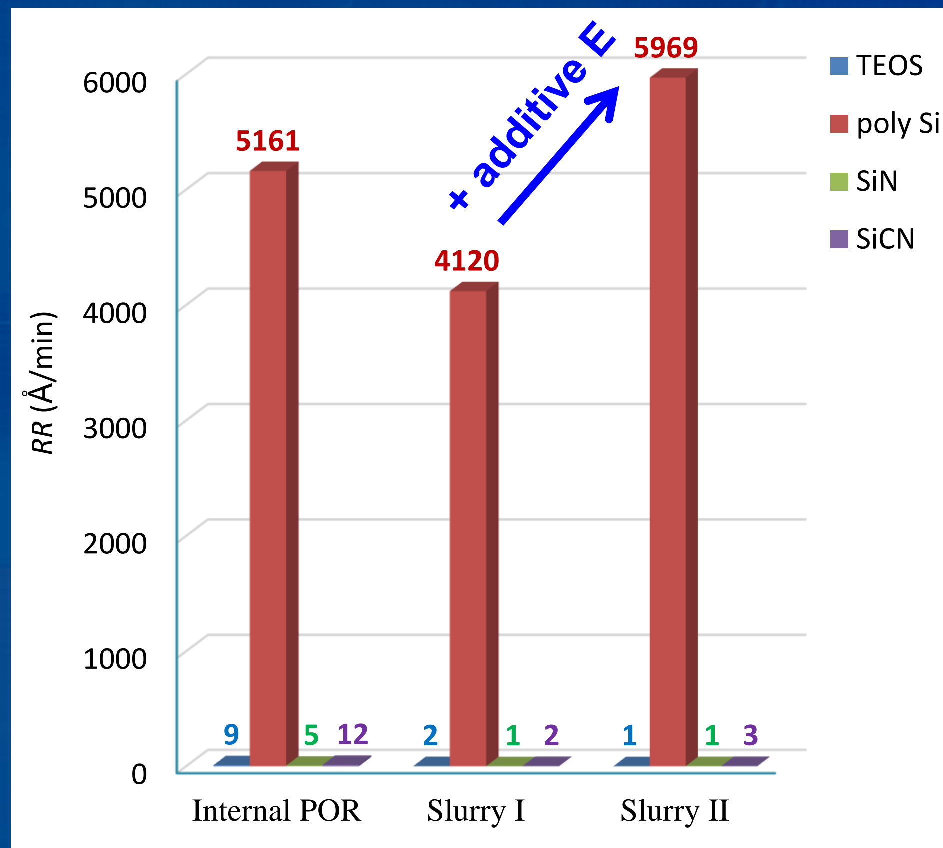
- Increasing additive concentration significantly increases Si RR and slightly decreases TEOS RR, thus significantly improves selectivity on TEOS.



EHS friendly slurries

- Slurry I meets the selectivity target (>1000)
- To meet the RR target of our internal POR, additive E was identified to provide enhanced Type A reaction driving force for poly Si RR

Selectivity	Internal POR	Slurry I	Slurry II
Poly Si/TEOS	590	1953	6030
Poly Si/SiN	1002	4578	4234
Poly Si/SiCN	438	1753	1919



No GHS Health hazard

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Summary

- Identified additive D as an effective and EHS friendly oxide RR suppressor
- Analyzed potential driving forces of additive D for poly Si RR enhancement
- Developed two EHS friendly poly Si CMP slurries I and II with high poly Si RR and high selectivity to various ILD films

Next step

- Evaluate performance of Slurries I and II on patterned wafers

Acknowledgment

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Thank you!