FUJIMI CORPORATION

Silica-Based Ru Barrier Slurry

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Outline

- Introduction
  - Motivation for Ru integration
  - Ru slurry design
- Results
  - Increasing Ru removal rate – colloidal silica + chemistry
  - Reducing Ru/Cu galvanic corrosion - formulation optimization with electrochemical methods
  - Cu removal rate instability – complexor effects
- Model for Cu rate instability and approach to fix
- Summary
- Acknowledgements

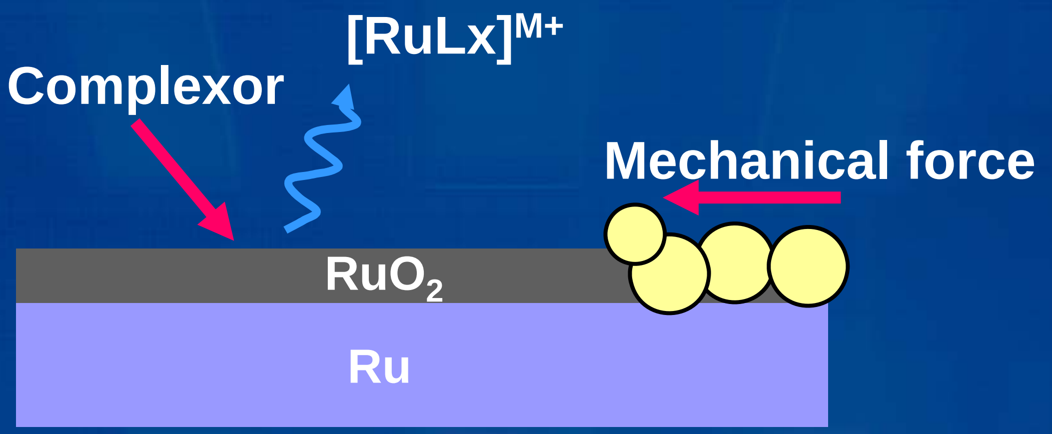
Motivation for Ru Integration

- Ideal physical properties:
  - -high melting point prevents interfacial film interactions
  - -lower resistivity compared to conventional barrier materials
  - -conductive oxide allows for direct Cu electroplating
- Applications:
  - -DRAM bottom electrodes
  - -diffusion barrier in interconnect metallization

Ru Slurry Design

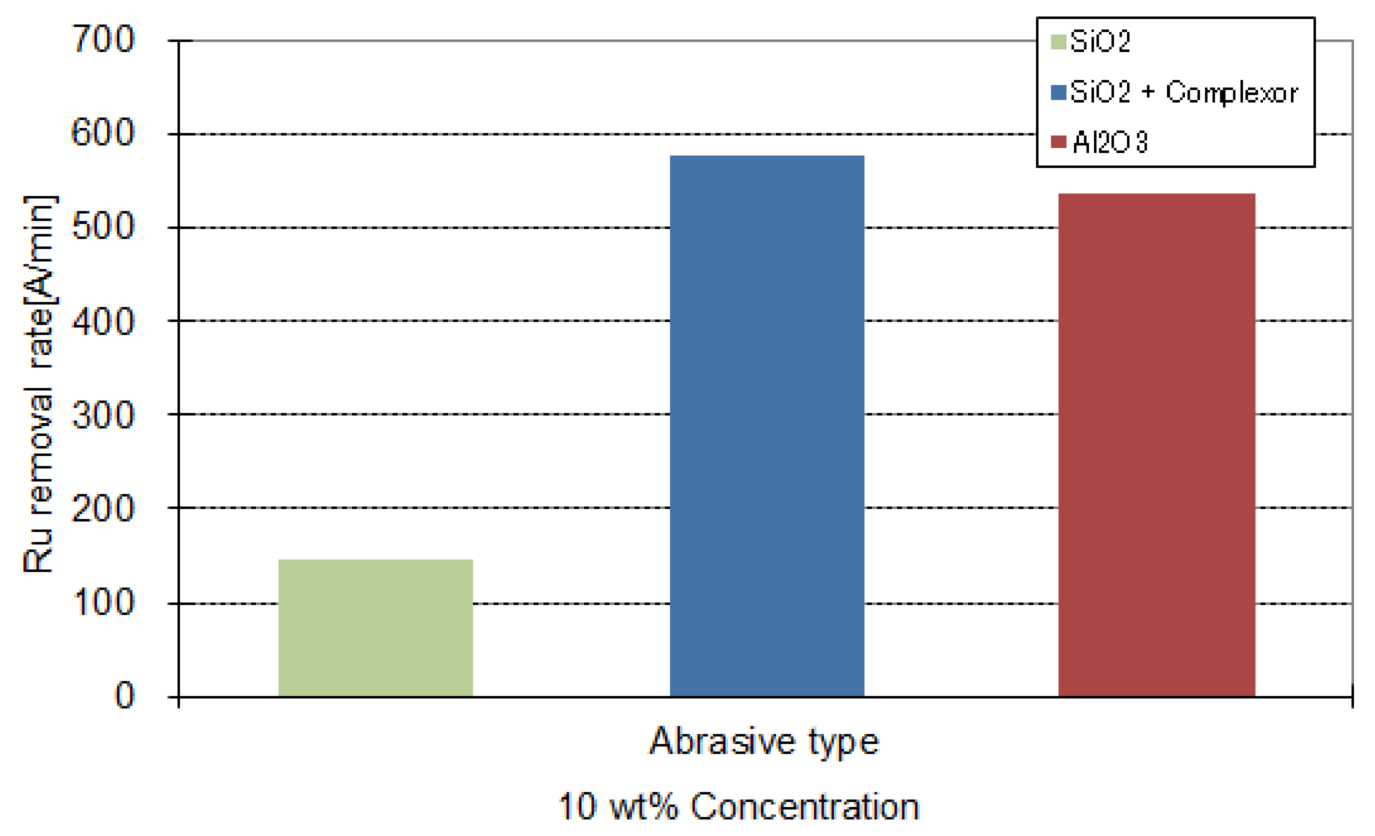
- Incorporating a Ru complexor enables slurry design features:
  - suppress scratch defects
  - suppress Ru/Cu galvanic corrosion
  - enable surface quality

Model: Increasing Ru Removal Rate



- Increased Ru removal rate can be achieved thru complexing agent that enhances oxide film removal

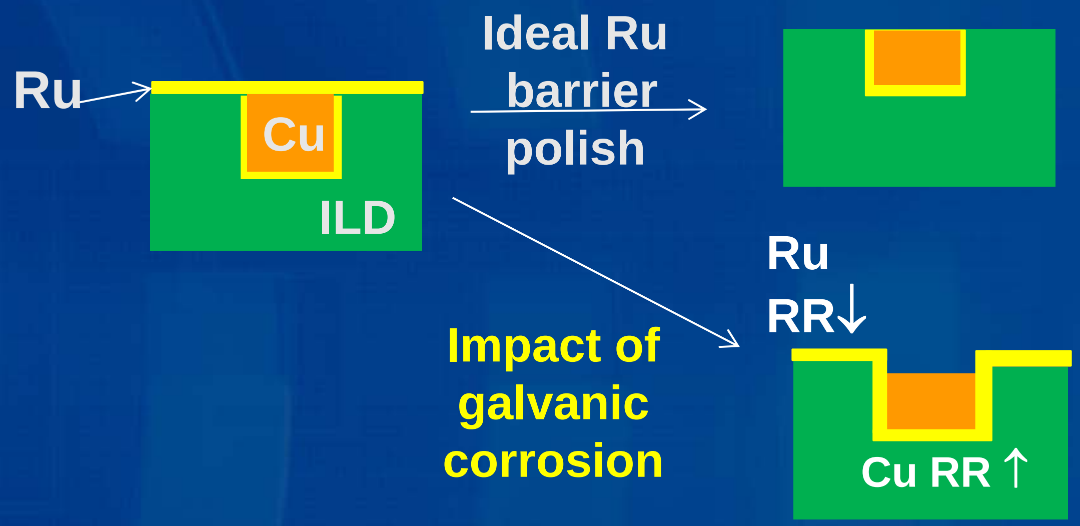
Ru Removal Rate: Complexor Effect



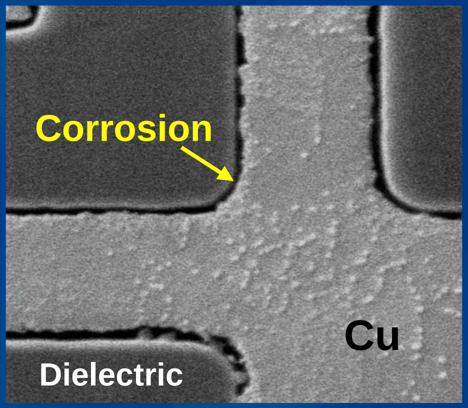
- Complexor + colloidal silica approach provides similar removal rate as milled alumina on soft pad

Galvanic Corrosion

Topography



Defects

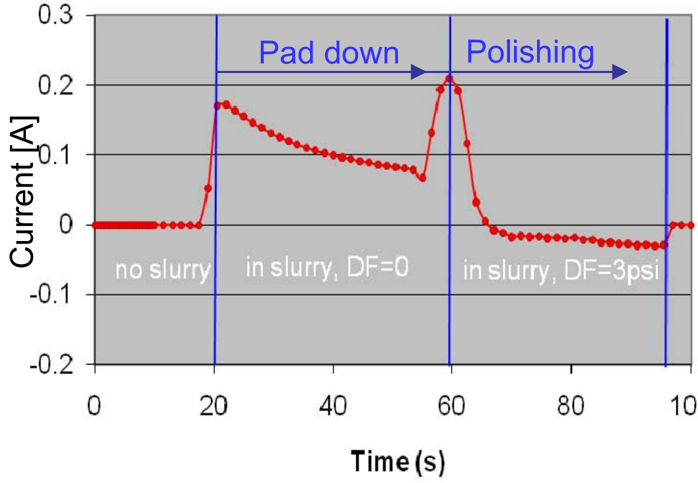


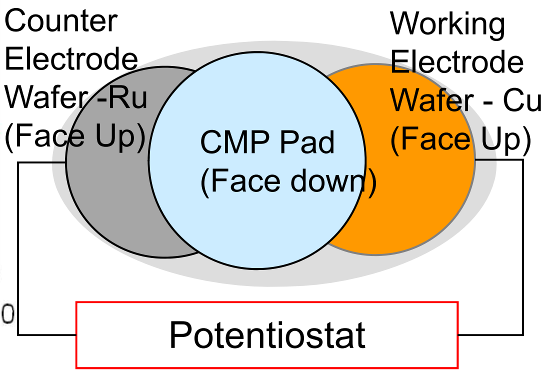
After barrier CMP
SEM – top view

- Galvanic corrosion can increase topography and defects
- Slurry chemistry critical to suppress galvanic corrosion through Cu surface protection

Electrochemical Analysis Set-up

In-situ electrochemical analysis





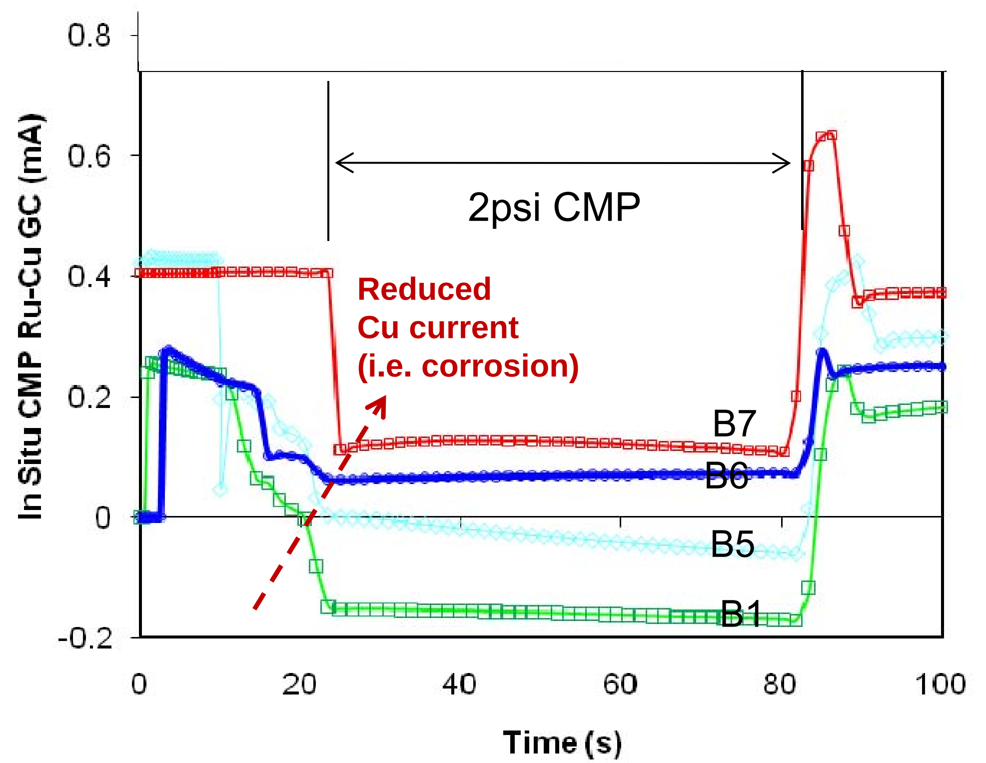
- FUJIMI has tools to conduct in-situ (dynamic system) electrochemical analysis during polishing
- These tools can aid in Ru CMP slurry formulation design

Miller, A., Huo , J., 2008 “CMP Electrochemical Study of Ru Barrier Slurries”, *CAMP* 13th CMP Symposium , Lake Placid, NY.

In-Situ CMP GC Current: Complexor Effect

Influence of slurry components on in situ CMP GC current

Slurry	Ru Complexor	Corrosion Inhibitor
B1	0	0
B5	1x	0
B6	1x	1x
B7	2x	1x

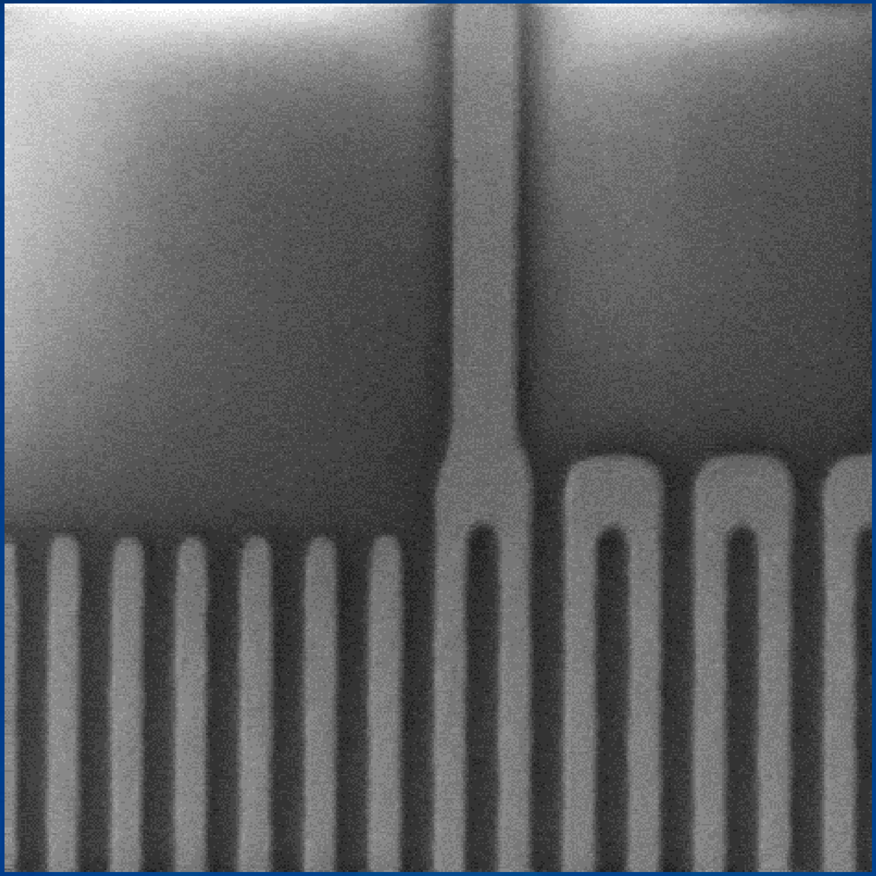


Ru complexor and corrosion inhibitor have positive influence on Ru-Cu galvanic corrosion current during CMP

→ increase Ru RR and suppress Cu RR

Miller, A., Huo , J., 2008 "CMP Electrochemical Study of Ru Barrier Slurries", *CAMP* 13th CMP Symposium , Lake Placid, NY.

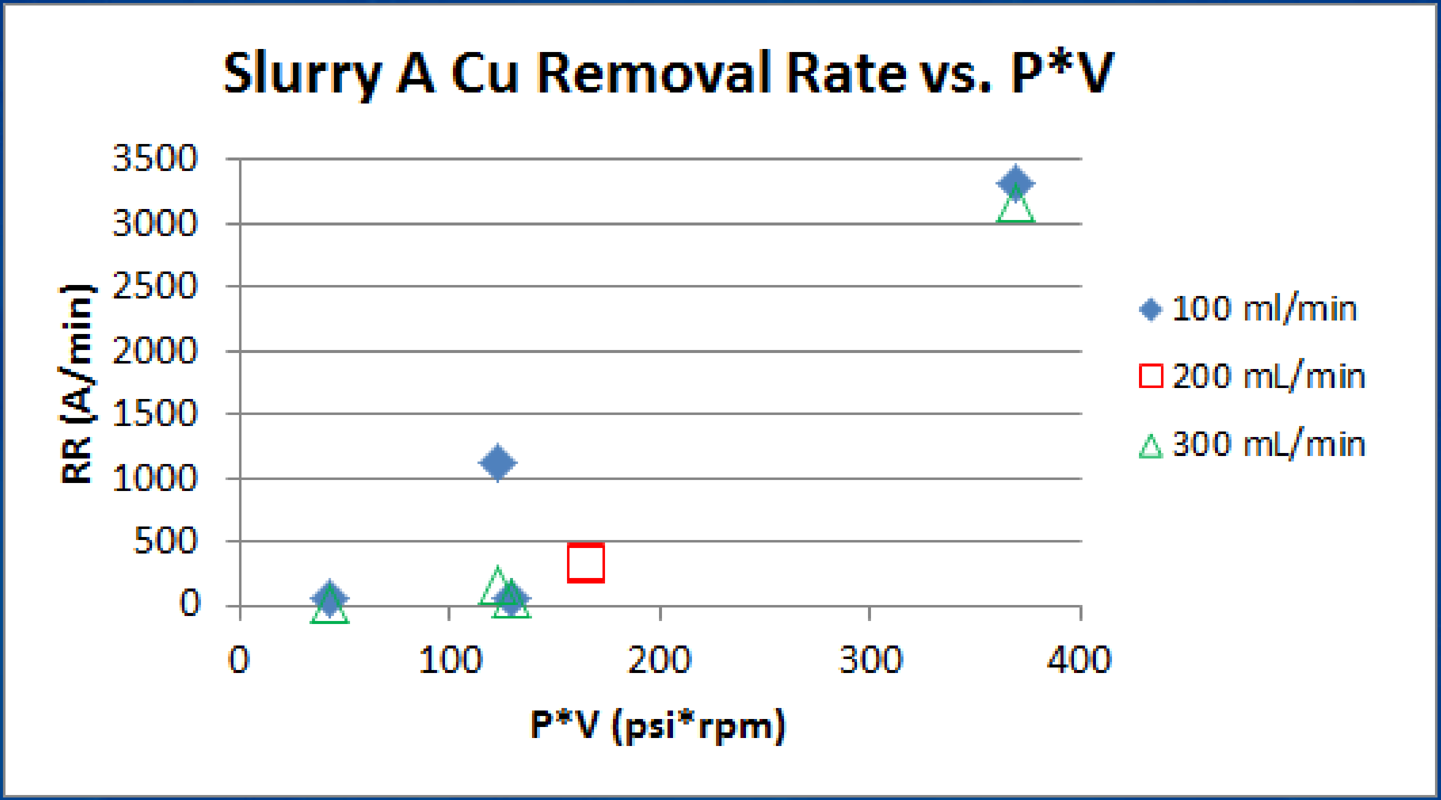
Surface Quality



Cu/ 60A Ru / ~35A Ta / ~35A TaN /110 nm lines

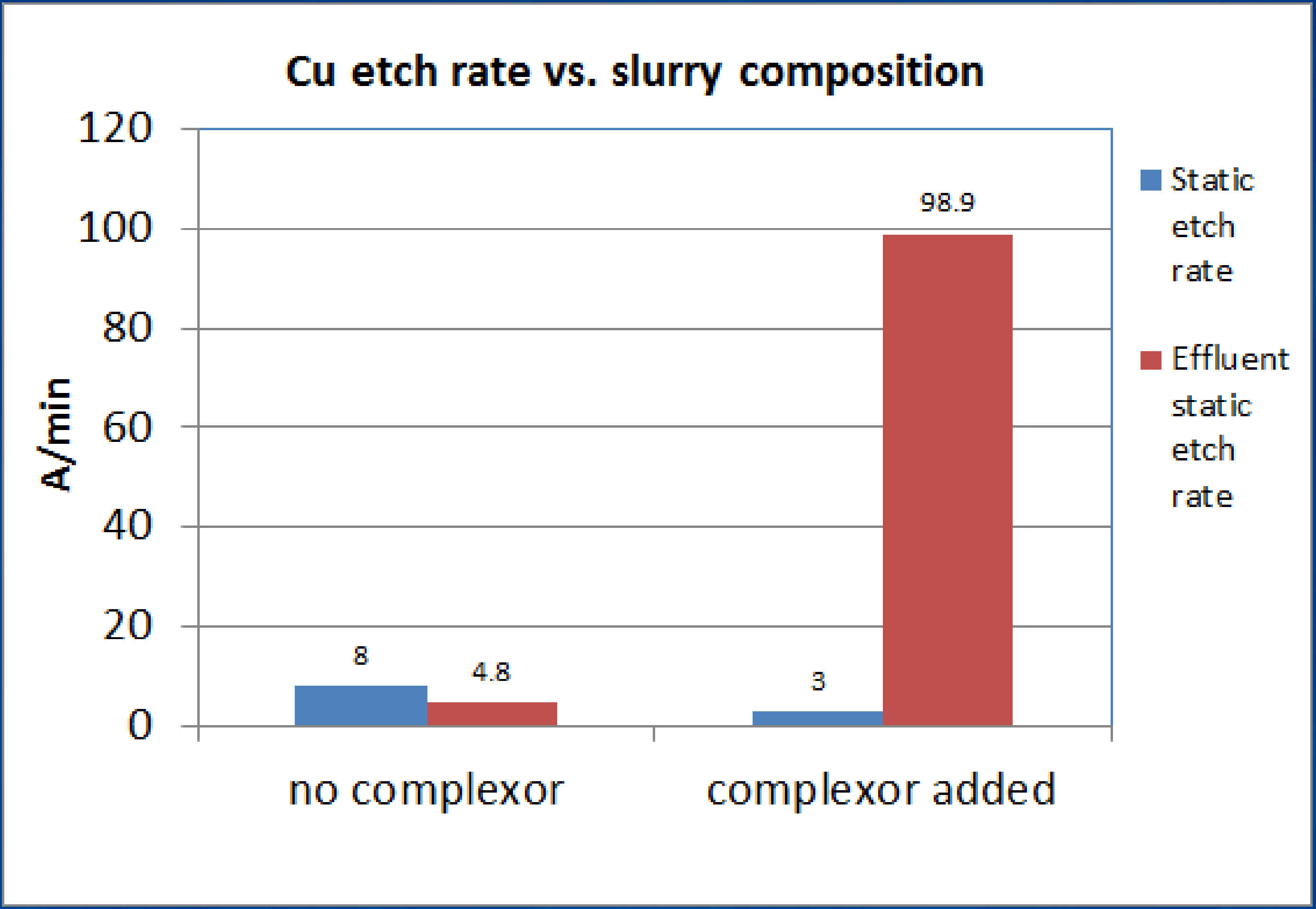
- Hydrogen peroxide based slurry has the benefit of good surface quality on narrow lines

Cu Removal Rate: PVF on Soft Pad



- An issue with the complexor approach was an unstable Cu removal rate behavior

Cu Etch Rate: Complexor Effect



- Complexor addition results in an increase in the effluent Cu static etch rate

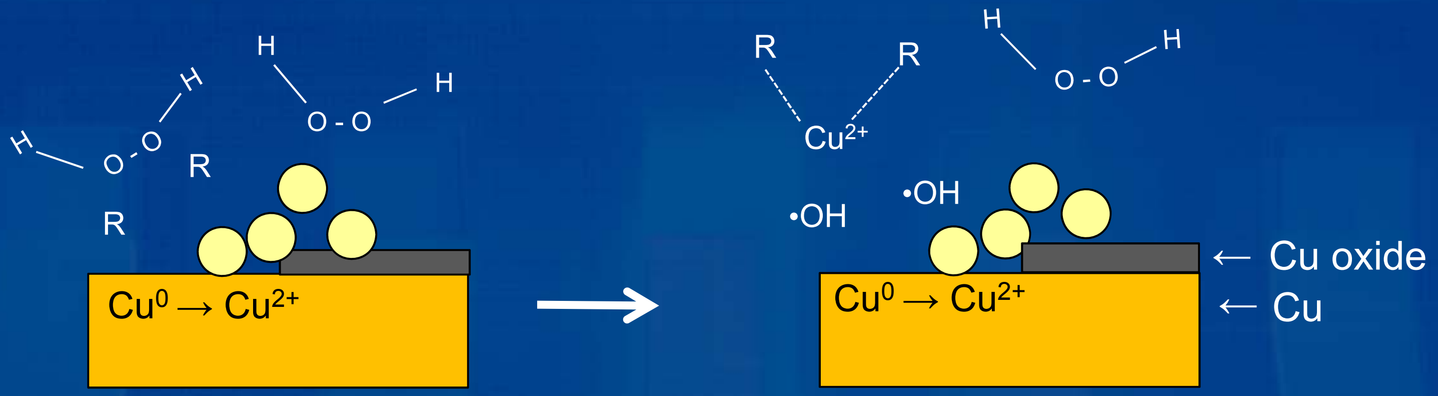
Model: Cu Removal Rate Acceleration

$Cu^0 + R + H_2O_2 \longrightarrow \{R \dashrightarrow Cu^{2+} \dashleftarrow R\} + 2 \bullet OH + 2e^- \longrightarrow$

R= amino acids/ chelating agents (e.g. glycine, citric acid, etc.)

Catalytic Cu complex

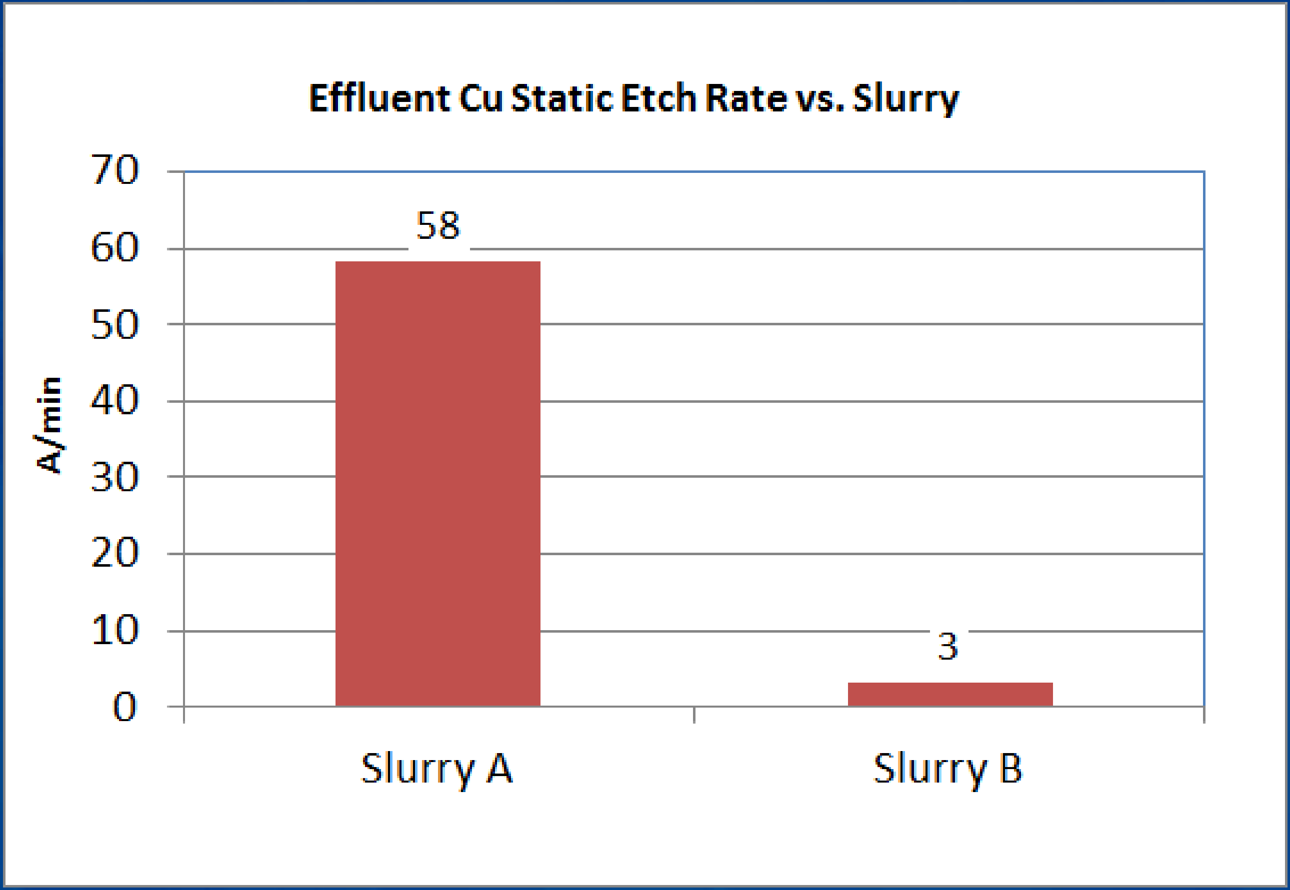
Hydroxyl radical is a stronger oxidizer than H_2O_2 → Cu oxidation is accelerated



Similar to glycine based slurries, our model for complexor behavior is the autocatalytic effect of the $Cu^{2+}[R]_x$ complex on H_2O_2 decomposition

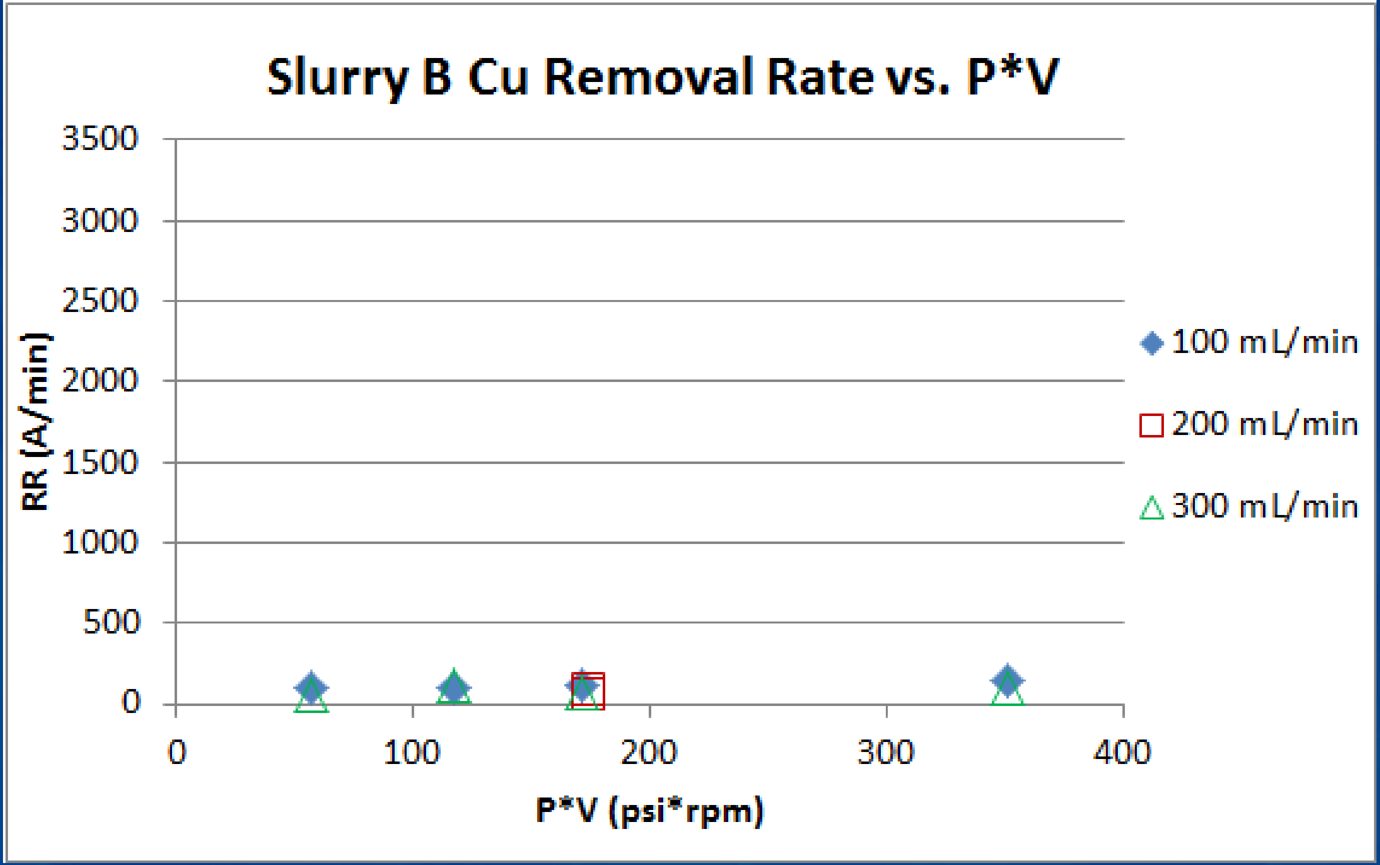
M. Hariharaputhiran, J. Zhang, S. Ramarajan, J.J. Keleher, Y. Li, S.V. Babu , *J. Electrochem. Soc.*, **147,** 3820 (2000)

Effluent Cu Static Etch Rate



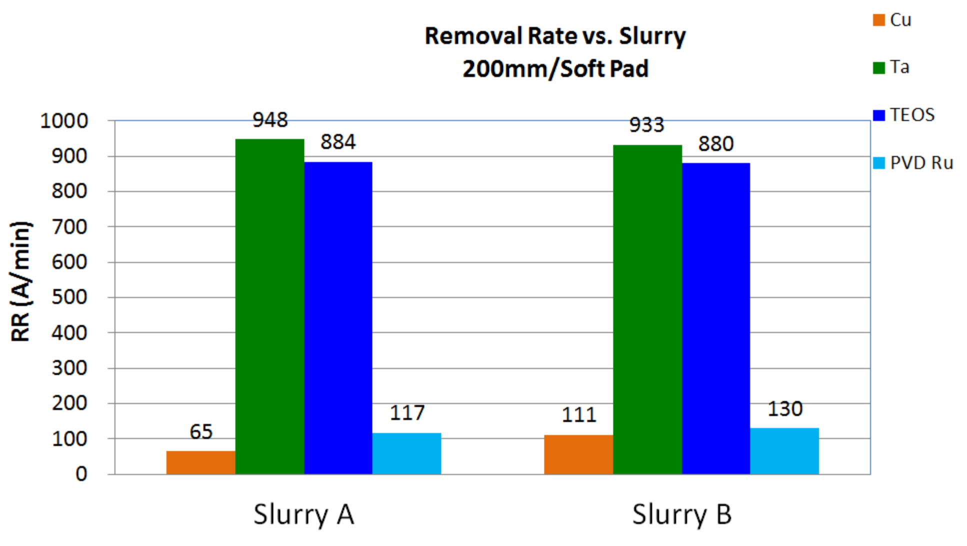
- Modification of the Cu corrosion inhibitor reduces effluent Cu static etch rate on a soft pad

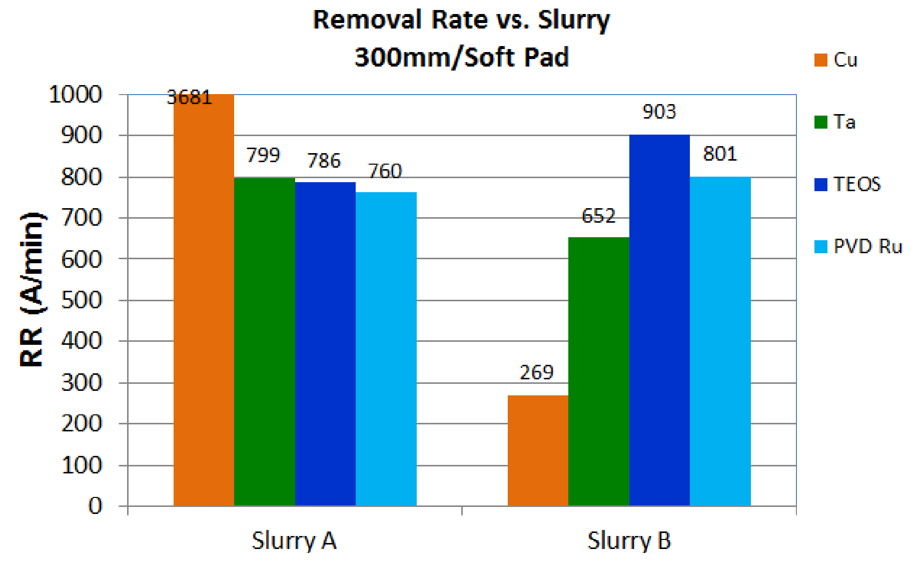
Cu Removal Rate: PVF on Soft Pad



- By improving the Cu surface film quality, the Cu removal rate was maintained at high P*V

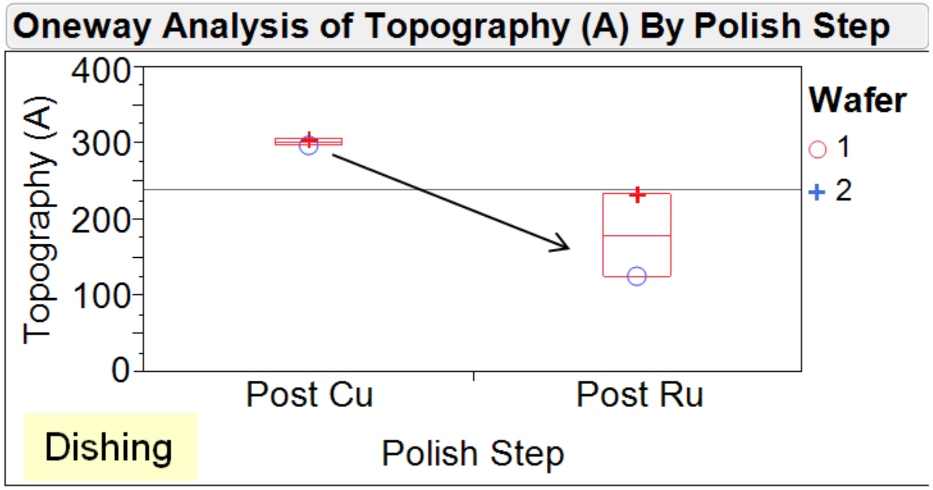
Gap – 200mm vs. 300mm – Cu Instability

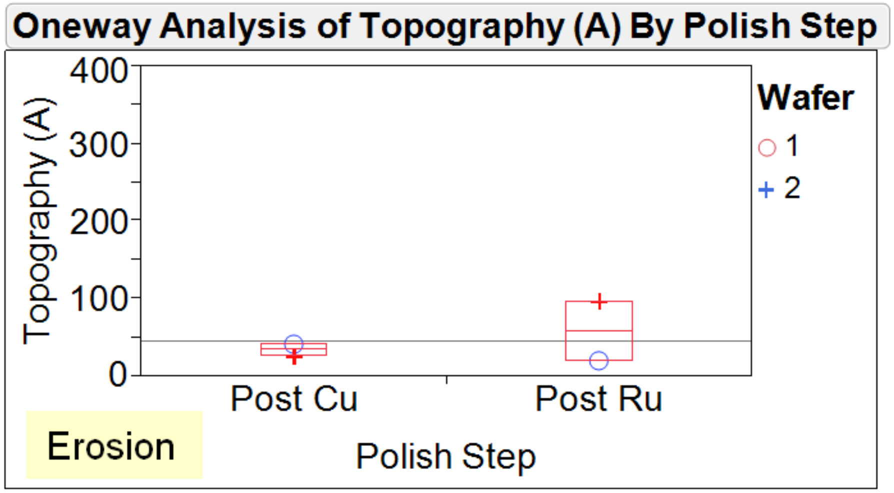




- Slurry B is stable at high linear velocity and achieves controlled Cu rate on 200 mm and 300 mm platforms

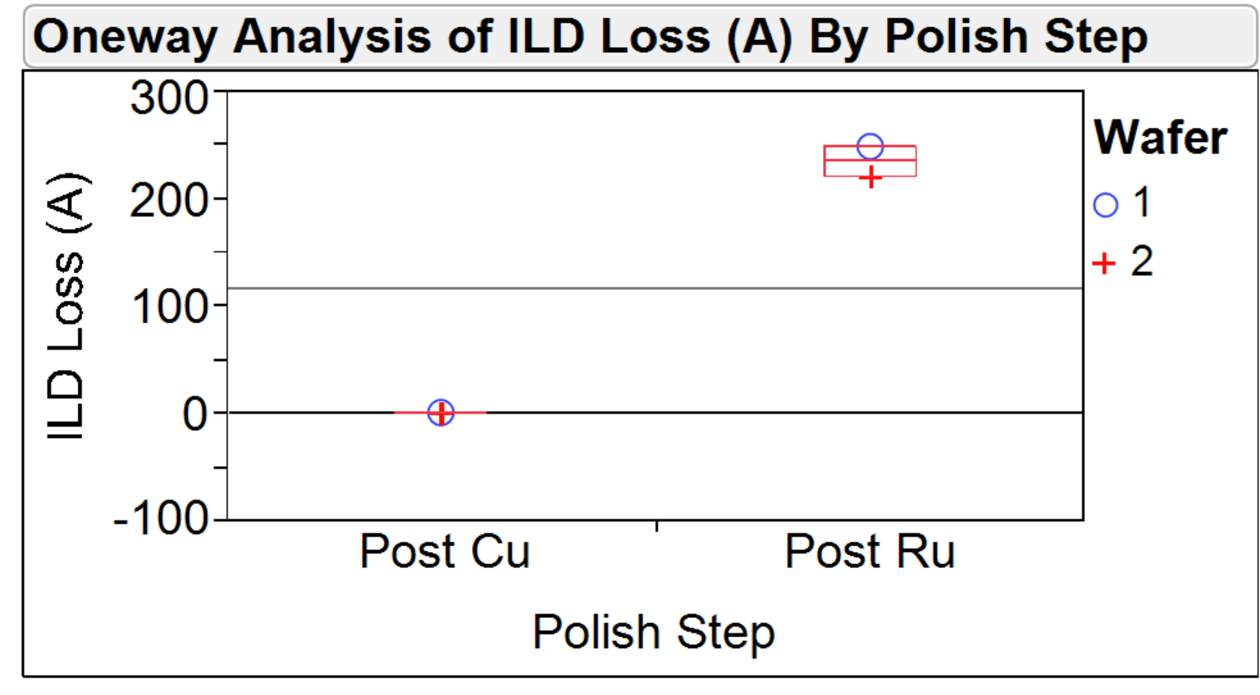
Topography: Dishing and Erosion





- Slurry B shows ability to correct dishing and maintain low erosion < 100 A on Cu/Ru/Ta/TEOS

Topography: ILD Loss



- A low ILD loss, consistent with requirement for future generations, is achieved with slurry B

Summary

- Colloidal silica based Ru slurry was developed using a Ru complexor approach to enable polish rate and defectivity
- A key issue with this approach was a Cu rate instability
- The model for this instability is an increase in the effluent static etch rate due to the effect of Cu complex on peroxide
- Formulation tuning to reduce the effluent static etch was used to overcome this issue

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