Integrated Copper CMP Barrier Slurry Development to Achieve Adjustable Rates and Selectivities

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Key Drivers for New Cu CMP Barrier Slurries

- Current and future ICs employ > 6 metal levels requiring high degree of planarization and topography correction

- Non-selective to low selectivity barrier slurries are needed to correct topography and planarize

- Fabs will require different selectivities to correct topography
  - Required selectivity is dependent on incoming wafer topography from 1st Step Cu CMP process and on the requirements of the integration scheme

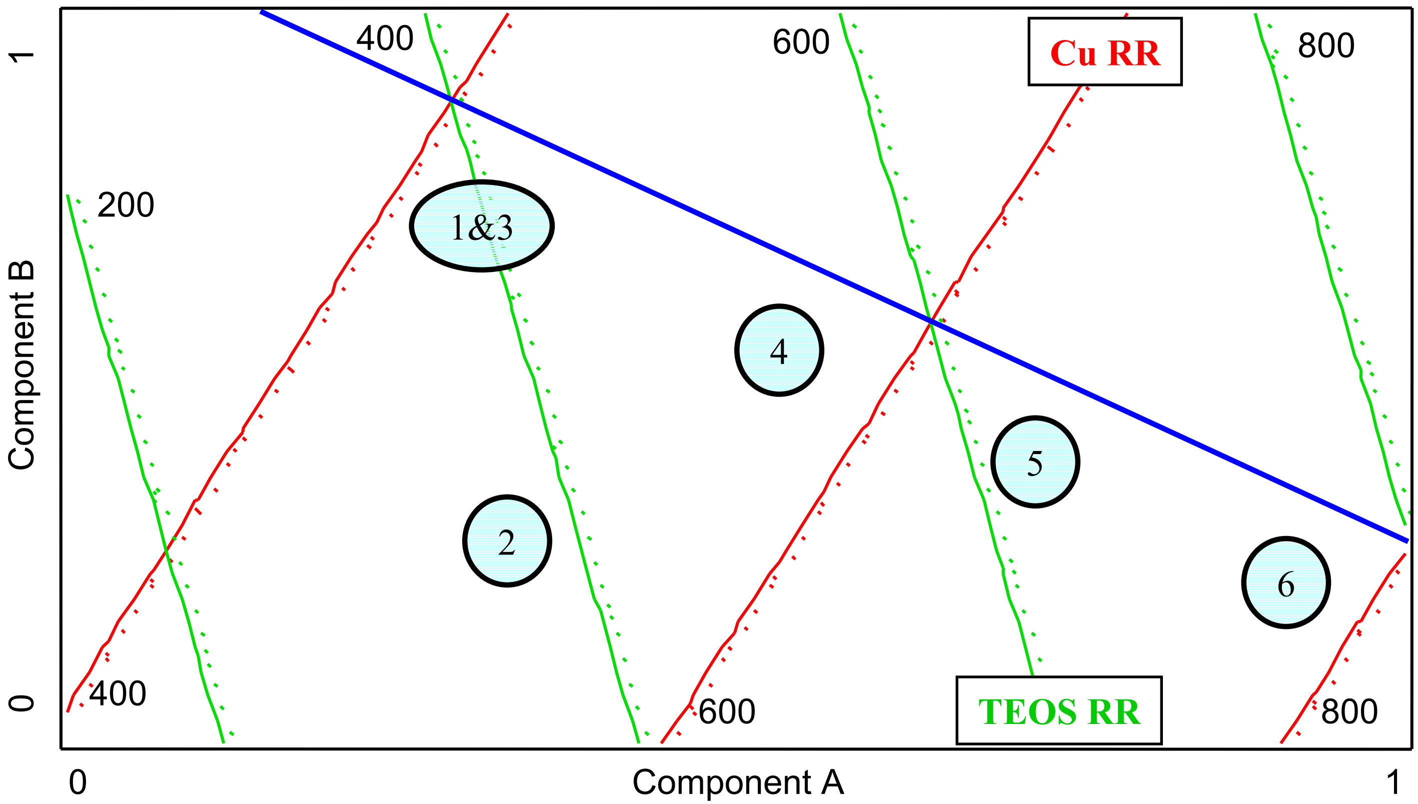
- Barrier slurry needs to balance the removal rates of various films to achieve the desired topography, planarization and dielectric loss targets

Development of Tunable Formulations

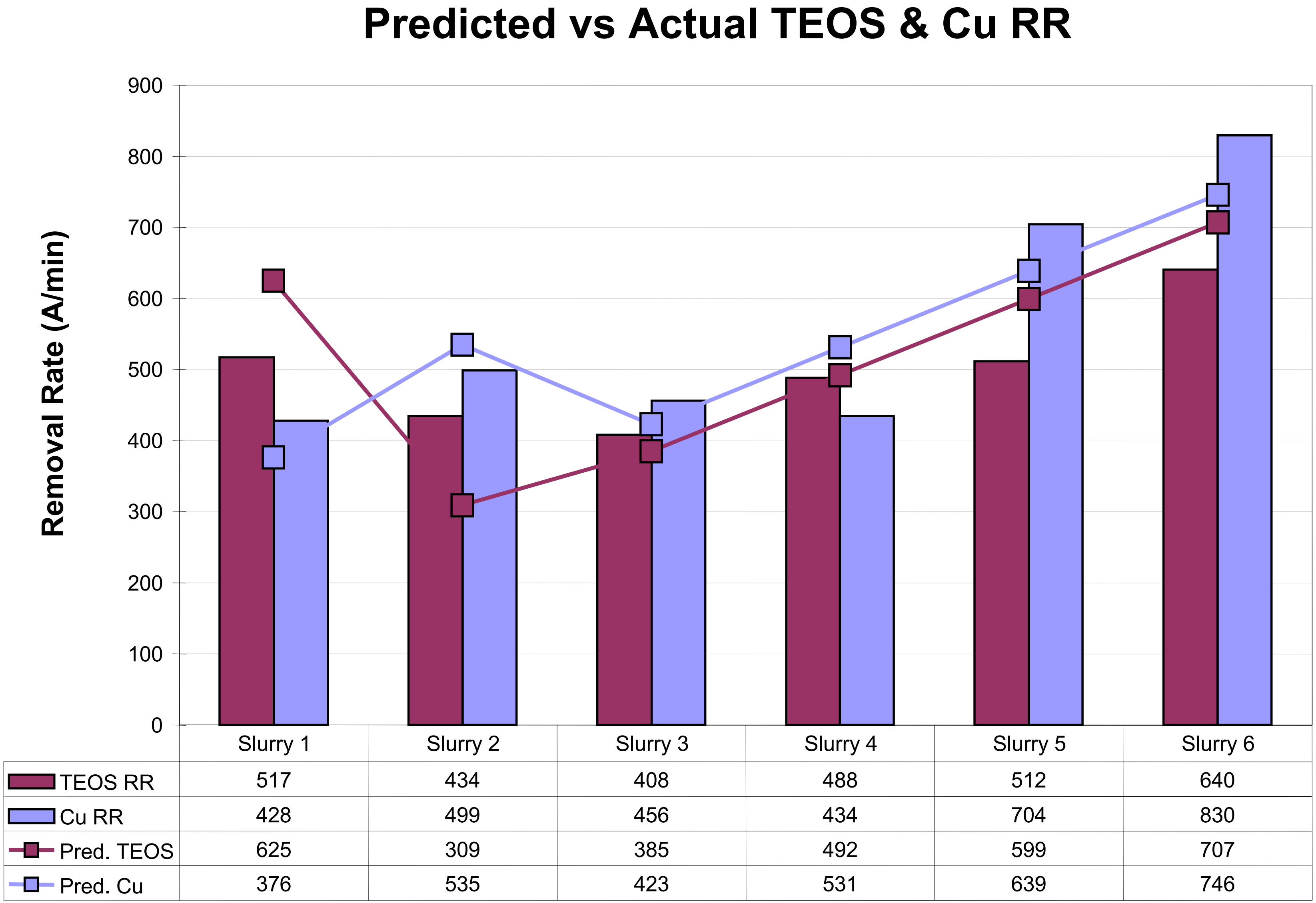
- Objective: Meet varying customer performance requirements with a tunable family of barrier slurries with low TEOS:Cu selectivities
- Outcome: A model was developed to predict non-patterned removal rate and pattern topography data as a function of slurry parameters for the Politex and IC pad families
  - Given a customer's removal rate, selectivity, metal loss, ILD loss and topography requirements, Rodel uses the model to predict which barrier slurries may be most effective in a customer's process
  - Testing of the candidate slurries identified by the model allows Rodel to rapidly identify the product that best meets an individual customer's needs

Tunable Slurry Development Model

- Models have been developed to predict blanket removal rates and final pattern topography
  - All slurry components and their interaction/impact on removal rates have been modeled
  - This model is used to predict which barrier slurries may be most effective in meeting process requirements



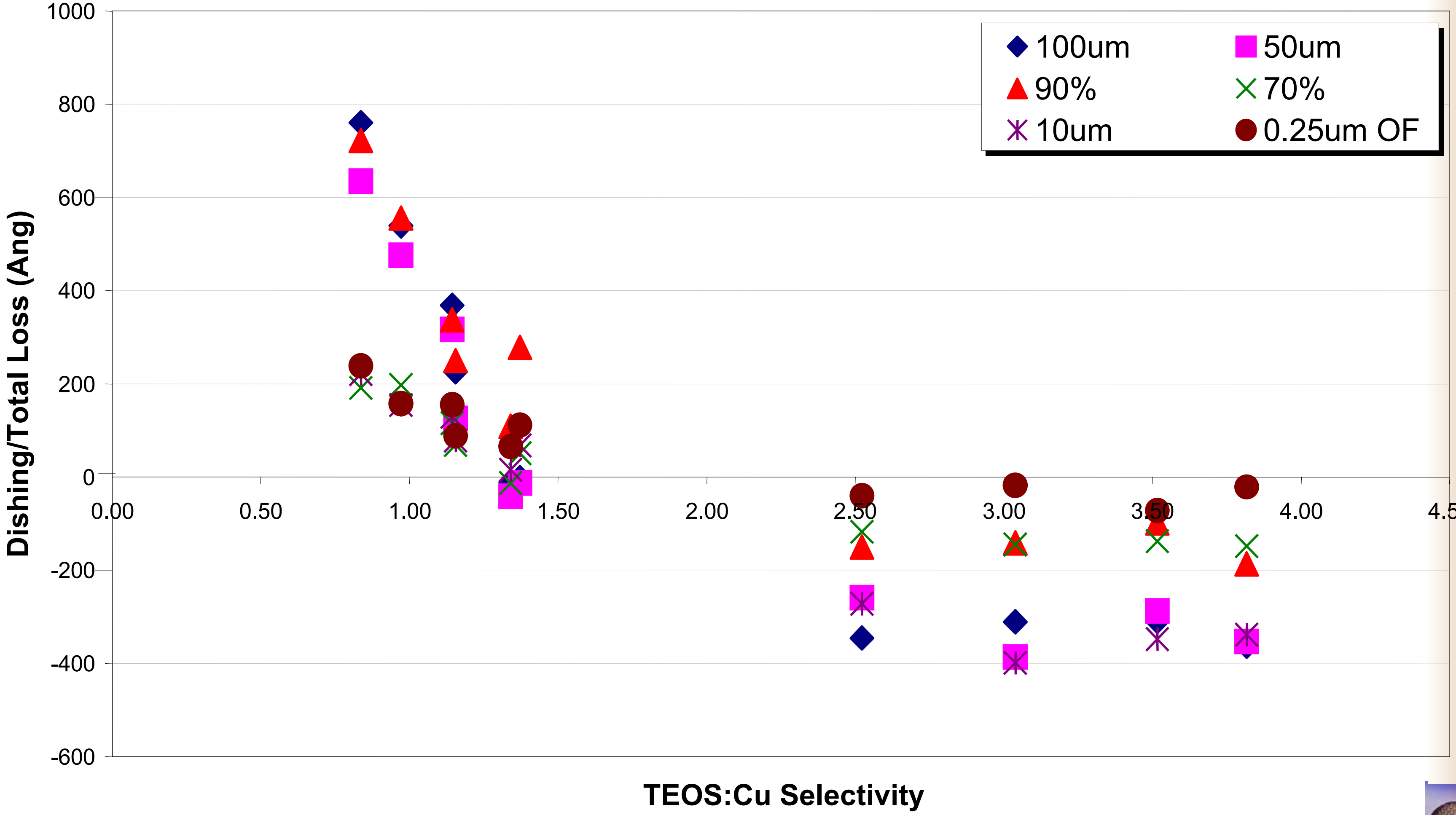
Predictive Value of Development Model



	Slurry 1	Slurry 2	Slurry 3	Slurry 4	Slurry 5	Slurry 6
▬ TEOS RR	517	434	408	488	512	640
▭ Cu RR	428	499	456	434	704	830
—■— Pred. TEOS	625	309	385	492	599	707
—□— Pred. Cu	376	535	423	531	639	746

Development Model Summary

Dishing/Total ILD Loss vs. TEOS:Cu Selectivity



Negative values indicate protruding copper

Development Model Summary

- TEOS:Cu selectivity correlates closely with the degree of feature non-planarity observed (dishing)
- For the incoming topography generated with Rodel’s 1st step copper process, minimum final dishing was obtained with a TEOS:Cu selectivity of 1.3-1.4
- For TEOS:Cu selectivities well above two, excessive oxide removal results in protrusion of Cu features above the wafer plane
- For TEOS: Cu selectivities below two, the higher copper rate affords increasing Cu recess as selectivity decreases.
- Ta and TaN barrier removal rates can be tuned to > 500 Å/min for high throughput
- ILD loss is generally between 100-300 Å after two-step Rodel Cu process (copper slurry EPL2361 followed by barrier slurry CUS1331)

CUS1300 Family of Barrier Slurries

- The CUS1300 family of barrier slurries were developed based on Rodel’s slurry development models and our understanding of customer performance requirements.

- The relative removal rates of the barrier, copper and ILD films are engineered to maintain or improve upon the dishing and erosion results obtained after the first step process while minimizing ILD loss.

- Multiple slurries within this family of products are available to meet the requirements of a specific integration scheme. The first products commercialized from this family are CUS1331 and CUS1351.

Attributes of CUS1300 Family Barrier Slurries

- Reduced erosion/recess vs. 1st generation products
- Low total metal loss with good dishing performance
- Reduced defectivity
- Improved surface quality
- Wide process window

Summary

- A low selectivity barrier removal slurry family has been developed with the following features:
  - Tunability of the relative removal rates of Cu and dielectric allows optimization of final wafer topography for a specific customer integration scheme
  - High barrier removal rates provide high throughput
  - Significant reduction in topography can be achieved during the barrier removal step without compromising dielectric loss
  - Formulations afford low defectivity and excellent surface quality
  - Slurry component interactions are fully modeled to allow Rodel to predict the best slurry to meet a given set of performance requirements
    - Good experimental agreement with model was obtained for both blanket and pattern wafer responses

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