Motivation

Copper CMP is a high cost of ownership process; need to
- Increase removal rate
- Decrease consumable use
- Increase yield
- Decrease non-reproducible, high yield process

Current CMP/Process design empirical. Doesn’t meet new requirements
- e.g. CMP of copper on porous low-k dielectrics causes failures
- New low down-force CMP process

2008 Main Objectives

- Continue development of comprehensive model of CMP: Continue development of model building on the abrasive scale, pattern scale capability to integrate additional chemical process elements and include coupling elements for linking key inferences of chemical and mechanical activity and slurry agglomeration and heating. Consider pad/wafer contact elements.

C-MP model validation and design for manufacturing validation: Validate model capability with full scale model verification by simulation and test (with industrial partners). Develop strategies for model-based process optimization. Consider use of model for DfM relative to process variation.

The Problem

There remain shortcomings with existing models and mechanism studies

- Primarily from mechanical perspective
- Many fundamental physical parameters not measured
- Continuum treatment of material behavior
- Assume that the chemical reaction rates are not influenced by the mechanical interactions

Goals:
- Fundamental quantitative understanding of the physical mechanisms – synergy between mechanical and electrochemical phenomena
- An integrated modeling approach

Copper CMP: At Abrasive Scale

Relative motion of wafer and pad

Copper CMP: At Abrasive Scale

Pad Properties: elasticity & hardness (both likely influenced by slurry, roughness, proximity)

Passivation Thickness (L) (nm)

Bare copper: ~100nm. passive film: ~10nm. passive film minus substrate: ~100nm

Copper CMP: Abrasive, nN

Force on an abrasive

Contact area reduces with time

Force on an abrasive

Copper in pH 12 aqueous solution containing 0.01M glycine: with and without BTA: a capacitive effect is observed.

Passivation Kinetics: Polarization in Passivating and Inhibiting (BTA) Solutions

Copper in pH 4 aqueous solution containing 0.01M glycine: with and without BTA: effect of scan rate: very strong inhibition from BTA

Conclusion: Integrated Tribo-Chemical Modeling

Future Goals

- Multi-Scale CMP optimization
- Change pad hardness (e.g. wear level)
- Inhibition & Governing features of the pad

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