**Investigation of Validity of Tribo-Chemical Model of Copper CMP using Fixed Abrasive Pad**

**Seungchun Choi, Prof. Fiona M. Doyle, Prof. David A. Dornfeld, UC Berkeley**

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### Motivation
- The integrated tribo-chemical model for copper CMP considers abrasive and pad properties, process parameters (speed, pressure etc.), and slurry chemistry to predict material removal rates.
- Information on the abrasive-copper and/or asperity copper interaction force and frequency is needed to complete the integrated tribo-chemical modeling of copper CMP.
- Direct and indirect methods to investigate abrasive-copper interaction force and frequency have been tried, but turned out to be ineffective.
- A fixed abrasive (FA) pad can be used for studying the validity of the tribo-chemical model of copper CMP because it has a well-defined spatial distribution of flat asperities, which provides information on its interaction with copper.

### 2008 Main Objectives
- Complete the comprehensive model of CMP for homogeneous substrate, and start adapting this to account for pattern dependence.
- Complete the model that links mechanical and electrochemical characteristics using abrasive-wafer and asperity-wafer interactions as the physical link.
- Investigate whether the surface potential of the pad influences material removal rates (pH effect).
- Draw on abrasive-scale and pattern-scale capabilities to extend the model to DfM applications.

### Tribo-Chemical Model of Copper CMP*

- Passivation kinetics
  - Film growth kinetics
  - Oxidation rate

- Interconnection Conf.

- Film formation kinetics.

- Potentiodynamic polarization curves of copper, 0.01M glycine, 10⁻⁴M CuNO₃, at pH 4 (0.05M buffer) with and without BTA.

- Current decay of copper in 0.01M glycine, 10⁻⁴M CuNO₃, at pH 4 (0.05M buffer) with and without BTA.

- Difficulties in studying abrasive-copper interaction on pad asperities:
  - Lack of understanding of abrasive-pad interaction on pad asperities.
  - inability to predict and control material removal rate and defects.

- Limits application to Design for Manufacturing (DfM) and Manufacturing for Design (MfD).

- Material removal rate increases as the rotational speed of the platen and head increases.

- Material removal rate is much higher in pH 12 solution than in pH 4 solution.

### Effect of Difference in Passivation Kinetics on MRR

- Copper in this solution forms a protective passive film.
- Copper dissolution curve and passive film formation curve might have different shapes (in log-log scale) characteristic of the environment in which copper is oxidized.
- If the dissolution curve has a steeper slope than the passive film formation curve, then doubling the interaction frequency will increase the MRR more than double. (shown for pH 4 solution)
- In the opposite case, doubling the interaction frequency will increase the MRR less than two-fold (shown in figure for the case of pH 12 solution)

### Results: Material Removal Rate

- Slurry chemistry (pH, conc. of abrasive, inhibitor & complexing agent).
- Pad properties (topography, surface potential, & complexing agent).
- Abrasive (type, grit size).

- Post-polish film characterization (pressure, velocity, V).
- Incoming topography.
- Material being polished.

- Lack of understanding of abrasive-pad interaction on pad asperities.
- inability to predict and control material removal rate and defects.
- Limits application to Design for Manufacturing (DfM) and Manufacturing for Design (MfD).

### Future Goals
- Further verification of the tribo-chemical model of copper CMP using asperity-defined pad other than FA pad.
- To investigate novel methods for studying abrasive-copper interaction and abrasive-asperity interaction.
- To develop computational model of tribo-chemical model of copper CMP.
- To apply this model to modeling of the pattern-dependence of CMP, and to DfM.