I. Deliverable:

Name: Report summary of the influence of bath composition on Cu-ECMP results
Task ID: 425.016
Task Title: EHS Impact of Electrochemical Planarization Technologies
Task Leader: Alan C. West – Columbia University

II. Abstract:

The use of high down forces, abrasive slurry particles, and strong oxides make chemical mechanical planarization (CMP) techniques unfavorable for the future of CMOS device fabrication. The current work is focused on studying electrochemical mechanical planarization (ECMP) as a possible replacement or compliment to CMP. ECMP has not been well studied and information about key factors such as electrolyte composition, i.e., influence of additives, pad/wafer interactions, pad/electrolyte interactions, applied electrical potential, effect of down force, tool geometry, are crucial to understand before ECMP will be considered for mainstream wafer processing. The technical results section will highlight results obtained by our ECMP tool, as well as more extensive electrolyte studies using microfluidic and RDE setups. Removal rates at various applied voltages are established and the effect of pad type is currently being investigated. Planarization results using the ECMP tool are also being performed using a basic test structure.

III. Technical Results:

Phosphate based electrolytes are being investigated for use during Cu ECMP in this study. Using conventional electrochemical techniques (LSV, amperometry), an electrolyte of 1M pH 2 was chosen as the optimal electrolyte composition for Cu ECMP. The conductivity is high, removal rates are also high, and surface roughness is not increased post voltage treatment. Figure 1 shows polarization curves of 1 M pH 2 electrolytes with varying BTA concentrations, using an RDE. BTA is most effective between the operating voltages of 0.5 V to 1.0 V, while still maintaining adequate removal rates. After a potential of 1.0 V, BTA loses most of its passivation abilities and therefore would no longer be appropriate for use during polishing because lower features would not be protected which is necessary to achieve planarization. This was confirmed while using the ECMP tool at potentials above 1.0 V when polishing blanket Cu wafers. Figure 2 is a plot of removal rates achieved when performing ECMP on wafer samples. Removal rates increase linearly with applied voltages ranging from ~12 to 40 nm/s. Removal rates vary significantly with pad type and applied voltage, current experiments are working to establish removal rates for all combinations. Planarization is being investigated using a test structure we designed. Figure 3 shows a control experiment using the tool before and after 300 seconds of polishing at 0.5 V in an electrolyte containing no BTA. No planarization occurred and it is shown in the profile because it is almost exactly the same as before and after polishing. This is a good indication that we will be able to achieve acceptable polishing rates while planarizing with the correct inhibitor concentration. Currently we are working on planarization data using various BTA concentrations and pad types to obtain SHR information. In addition to experiments performed on the tool, we are also investigating using microfluidics as a means to study BTA adsorption and desportion on the Cu surface. This information is important for optimizing voltage treatment, BTA concentration, and for determining the type of BTA complex forming on the Cu surface. Results can be seen in Figure 4.

Figure 1: Anodic polarization curves at 100 RPM of pH 2 containing BTA at concentrations of (A) No BTA (B) 0.001 M (C) 0.005 M (D) 0.01 M

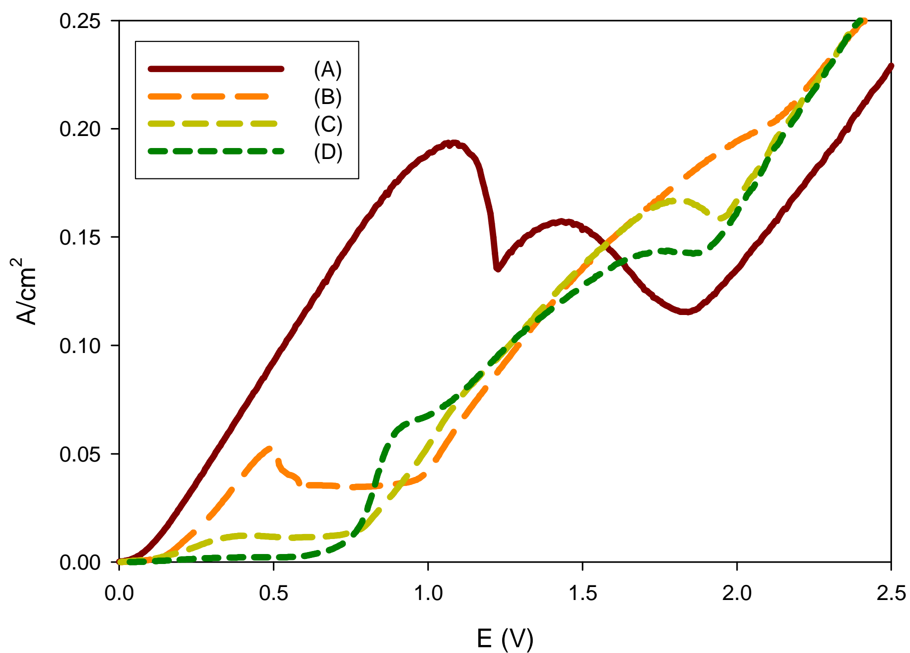

Figure 2: eCMP Removal rates using 1 M pH 2 applied voltages from 0.5 V to 1.0 V vs Ag/AgCl

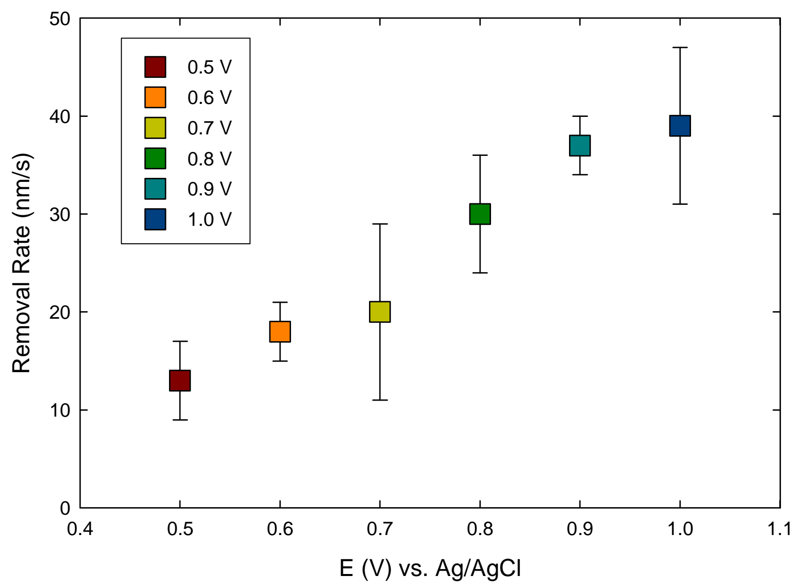

Figure 3: Profilometry scans before and after polishing using the eCMP tool for 300 s at 0.5 V vs Ag/AgCl with electrolyte 1 M pH 2 containing no BTA

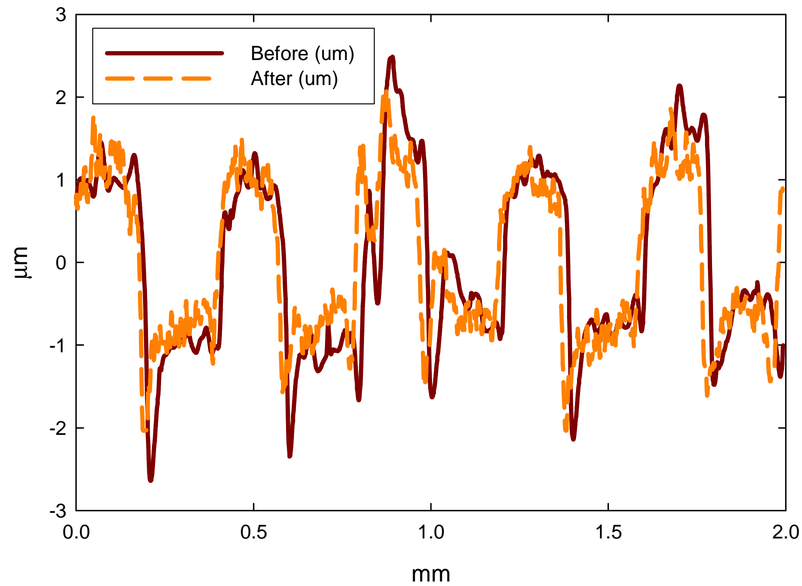

Figure 4: Microfluidic experiments showing the adsorption time of BTA (injected 30 s) to Cu electrode and possible desportion (base injected after 150 s) for electrolytes containing 0.001 M BTA (left) and 0.01 M BTA (right)