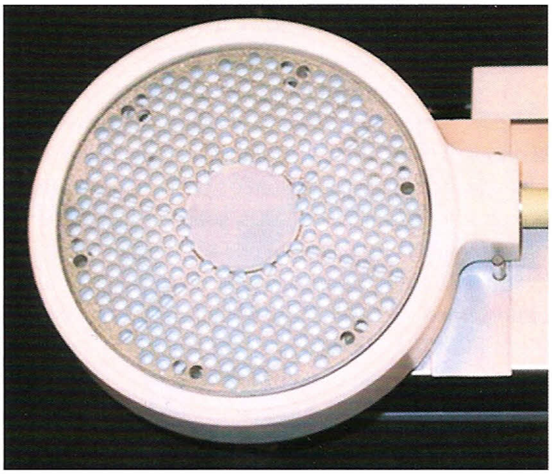
Pad Conditioner Improves CMP Efficiency

Optimization of CMP processes is typically carried out using test or monitor wafers with off-line analysis of wafer surfaces for defects and quality, coupled with yield and reliability data from product wafers. The effectiveness of this iterative optimization process is dependent on consistent, time-independent CMP process conditions. However, typical CMP processes are moving targets; operating in a constant state of decay. For example, polishing stages are challenged by the continuous dilution of starting chemistry and the decay of pad surfaces. The pad and wafers are rinsed with copious amounts of DI water between wafers, resulting in process instability and excessive water consumption. It is well recognized that microscratches are a fundamental problem for ILD and STI CMP, resulting in yield loss (i.e., high leakage current) and reliability issues (i.e., insufficient TDDB).[1,2,3] It has also been noted that CMP debris is responsible for surface scratches.[1]

Confluense (Allentown, Pa.) has developed a pad conditioning system designed to improve the utilization efficiency of CMP consumables by dramatically reducing the mean residence time of these spent materials.[4] This conceptually simple enhancement cleans the pad surface immediately after passing under the wafer.[5] This Pad Surface Manager (PSM) can be used to condition the pad, flush the pad, supply fresh slurry, deliver supplemental chemistries, and remove process and conditioning debris from the pad. It allows real-time analysis of the process effluent for a variety of parameters, such as pH, conductivity, ionic content, solids content, particle size distribution, chemical composition, etc.(Figure).



The conditioner can be used to condition the pad, flush the pad, supply fresh slurry, deliver supplemental chemistries, and/or remove process and conditioning debris from the pad.

We have performed studies using the PSM to measure pH and conductivity of effluent versus polish time. Samples of slurry were taken at 10 second intervals through a PSM during an STI polish. We determined that the conductivity varied by an order of magnitude and required nearly two minutes to return to a value near the reference, measured at time zero. This variation in conductivity indicated significant variation in ionic content in the waste stream. The pH variation appeared to be less dramatic; however, changes of several pH units could significantly alter surface potential and passivator effectiveness, yielding altered chemical activity with a resultant variation in removal rate and film uniformity.

Measurement of conductivity data of effluent over time for a copper polish process showed the ability to detect the CMP endpoint. A noticeable change in conductivity of the effluent occurred when reaching the copper and barrier endpoints, due to a change in ionic character and content in the waste stream.

Data from experiments at Clarkson[6] indicate it is possible to perform both the copper and barrier layer polishing processes on a single platen by using the PSM to flush the pad, remove process residues, and change the polishing chemistry. Slurry carryover between the copper and barrier polish steps for a typical one-platen process would be near 70%, potentially causing agglomeration or reduced removal rates. In these experiments, less than 10% carryover was observed, showing the potential for PSM to allow use of a single platen for a Cu/barrier polishing process.[6] Furthermore, the conditioning pad could be used to introduce copper passivators in a single-platen process to eliminate the need for a second (or third) platen for a rinse/buff step.

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