Advanced node process characterization: novel chemical mechanical polishing with environmentally friendly abrasive free setup

Felix Köhler[a*], Matthias Stender[b], , Nikunjkumar Visaveliya[b], Conrad Guhl[a]

[a] Fraunhofer Institute for Photonic Microsystems IPMS, An der Bartlake 5, Dresden, 01109, Germany
[b] ChEmpower Corporation, 9225 NE Turing Ct., Ste 140, Hillsboro, Oregon 97006, USA

For copper metallization chemical mechanical polishing (CMP) is necessary to enable damascene processing. To planarize and selectively remove copper in a bulk polish step established solutions are available but rely on relatively cost intense as well as hazardous and environmental unfavourable CMP slurry. A potential alternative are functionalized CMP pads enabling a significant copper material removal without the need of classical copper bulk slurry. As the pads are chemically functionalized there is no abrasive involved in the process at all. In this work we present the characterization of this new consumable/process alternative for advanced node damascene structures.
For qualification of the novel process alternative an industry standard consumable set for copper damascene processing was used as benchmark. Both the benchmark process as well as the novel abrasive free process were used to polish blanket and patterned wafers on a 300 mm AMAT Reflexion CMP tool. Patterned wafers were designed to qualify a wide design range down to 45 nm CD typical for 28 nm technology.
Bulk polish performance was qualified for copper as well as typical BEoL stack materials (Tantalum barrier, SICOH and TEOS ILD). The tested abrasive free setup showed removal rates up to 850 nm/min for copper with very even removal over the wafer radius. Copper removal rate is slightly dependent on polish pressure allowing for profile control in manufacturing application (Fig. 1). Comparison to the POR polish showed similar copper removal rates with lesser within wafer non uniformity (without pressure control). Removal rates for barrier and ILD materials were negligible for both POR and alternative process, allowing a good stop on barrier performance.
Defect inspection on blanket wafers was challenging due to intense surface structures. SEM based defect review showed no pad residuals or critical scratches for wafers polished with the alternative process. The observed surface quality does not pose a critical challenge for the following barrier removal CMP step. Median of defect count with novel process is comparable or below POR value, with significant impact of slurry distribution (Fig. 2).
To compare the CMP performance on 28 nm node like structures patterned wafers with identical ILD, barrier and copper material were processed with both POR polish and alternative setup. Dishing in individual copper lines is known to be highly dependent on line width and density, thus values for a wide range of parameters were obtained. The novel process showed dishing values comparable to a standard polish (see Fig. 3). Small CD lines of 45 and 90 nm showed ~20 nm dishing, which is slightly more than the well-established POR (~5 and ~15 nm). The erosion of 45-450 nm CD line patterns was slightly less for the tested new consumable setup (see Fig 3). these CD lines, including those with wider widths, indicates values resembling to those of the POR, or in certain aspects, are less pronounced.

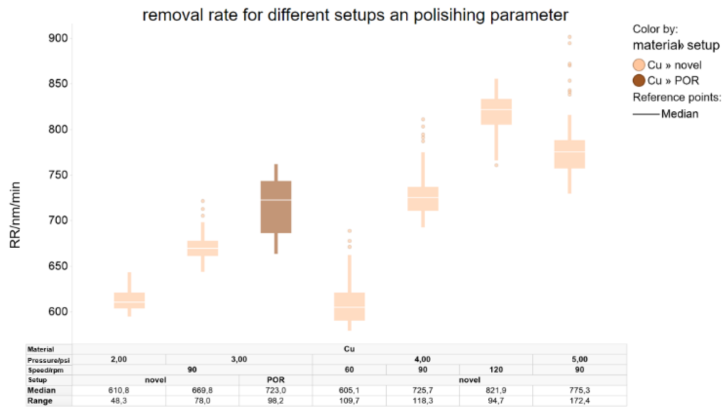

Figure 1: Copper blanket wafer removal rate comparison between novel setup at different polish pressure and speed and POR. Box size indicates within wafer non uniformity.

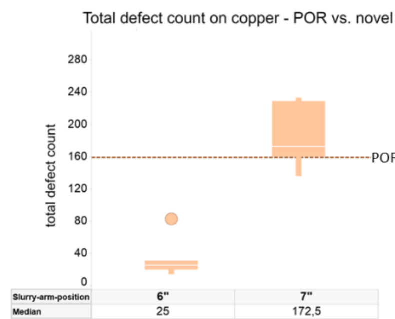

Figure 2: Defect counts on blanket wafers for different slurry arm positions in comparison to POR.

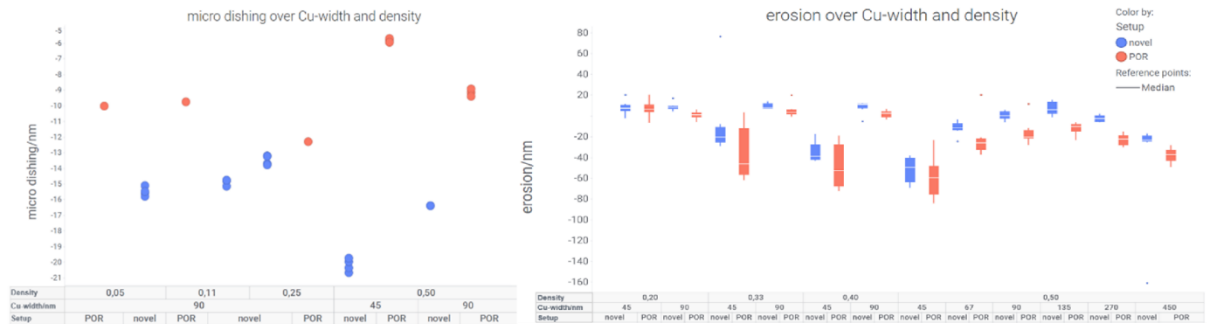

Figure 3: Microdishing in individual 45 and 90 nm lines measured by AFM (left). Line erosion depending on density and CD measured by profiler scan (right).