WCMP contact slurry influence on the formation of TaNTa barrier residues after metal 1 CuCMP

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It is well known that the morphology of incoming wafers to the CMP process is critical for its proper execution. Additionally, it is understood that various CMP processes can influence the successful polishing of the upper layers [1-2].

In this work, we present a comprehensive study on one of the root causes of barrier residue formation during the Metal 1 Chemical Mechanical Planarization (CMP) process in single damascene structures. This type of defect is particularly critical as it can lead to shorts, compromising the functionality of the device. Our focus is specifically on the influence of two different slurries used during the Tungsten CMP (WCMP) process of the underlying layer.

Typically, in the WCMP process, oxide erosion is closely tied to the tungsten pattern density. Structures with a high density of contacts, exhibit a higher local removal rate, which induces erosion. This phenomenon is further exacerbated by the use of tungsten-selective slurries (Fig. 1). These slurries demonstrate a higher tungsten removal rate, leading to increased erosion compared to non-selective slurries. Moreover, the low oxide removal rate of these slurries is insufficient to mitigate the resulting non-uniformity (Fig. 2). In high contact density structures, we observed erosion values more than tripled when using a selective slurry process (Fig. 3).

The topography created by contact WCMP is subsequently transferred to the Metal 1 layer, as copper puddle [3] especially if high copper to barrier selective slurries are used. During the Copper CMP (CuCMP) process, the non-uniform morphology cannot be adequately compensated, resulting in the presence of copper and barrier residues within the depressions formed by the erosion of the underlying layer. This defect becomes even more critical in CuCMP processes when consumables approach end-of-life, as the barrier removal capability decreases (Fig. 4).

This study aims to elucidate the mechanisms behind barrier residue formation and provide insights into optimizing the CMP process to minimize such defects. By understanding the impact of slurry selection and pattern density on erosion and residues formation, we can enhance the reliability and performance of semiconductor devices.

References

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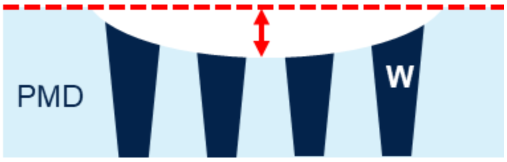
Selective



Unselective

Figure 1 Sketch of erosion mechanism on dense contacts at WCMP process using different slurries.

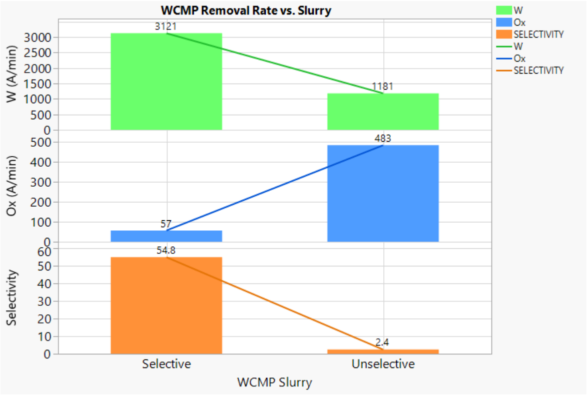
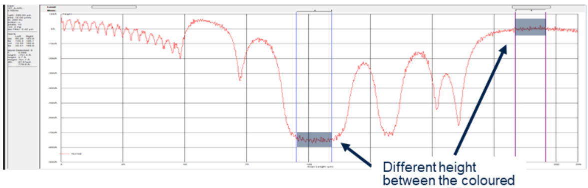


Figure 2 Removal Rate and selectivity at WCMP vs. Slurry

Selective slurry



Unselective slurry

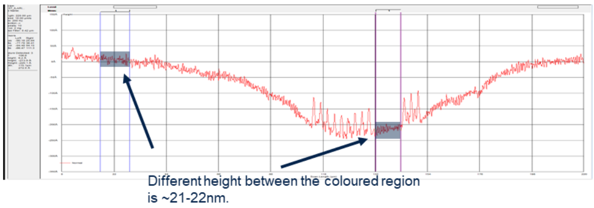


Figure 3 Profilometer post WCMP of a critical structure polished with selective and unselective slurry

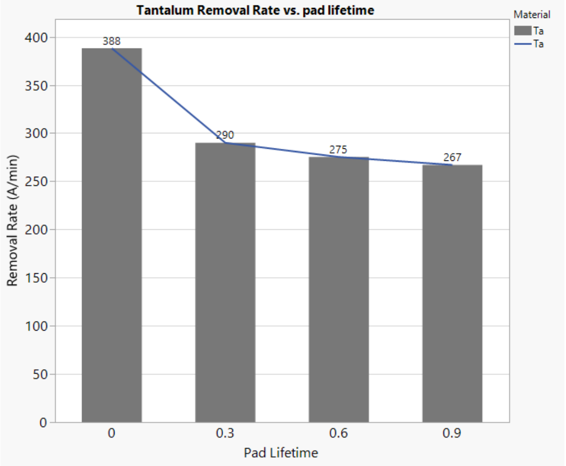


Figure 4 Tantalum removal rate vs. pad lifetime.