Characterizing the Tribological, Thermal and Kinetic Attributes of Non-Selective Tungsten "BUFF" CMP Slurries in Conjunction with Different Pads

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Tungsten contact CMP continues to be a critical process in advanced node semiconductor device manufacturing that enables metal interconnection. As it is essential for device performance, any defects caused by the final stages of the tungsten CMP process (what we typically refer to as the "BUFF" step) have a direct effect on product yield. Among these defects, one of the highest yield killers is topographic in nature. That is, metal dishing and oxide erosion which need to be kept in check by ensuring removal rate non-selectivity between the two materials being polished. Our work centered around using pre-polished brand-new 200-mm tungsten wafers, and brand-new PE-TEOS-based silicon dioxide wafers, and testing the performance of two different proprietary tungsten BUFF slurries (Slurry 1 and Slurry 2) on two very different polishing pads (A and B, each synthesized and grooved differently) at multiple polishing pressures and velocities (i.e., P×V values). For tungsten, we used pre-polished wafers to mimic the state of the film after it had undergone bulk polishing.

Regardless of slurry and pad types, the apparent activation energy was determined to be 0.38 eV for tungsten and 0.12eV for silicon dioxide. For the wide range of P×V values investigated, we observed significant differences in mean COF, mean pad surface temperature and mean removal rates for the types of slurries and materials being polished. This was in spite of the fact that al pad-slurry-wafer combinations tested resulted in a tribological mechanism that was "Boundary Lubrication" in nature. Marked differences were also evident when Pad A was used as opposed to Pad B. Results are summarized in Fig. 1. Bars represent mean values while the lines represent "minimum" and "maximum" values for all 9 P×V combinations.

Regarding removal rate, both slurries exhibited non-Prestonian behavior for both types of films. Albeit this departure from non-Prestonian behavior as greater for Slurry 1 in conjunction with Pad A. Regarding tungsten-to-oxide removal rate selectivities, we observed large differences in the metric as a function of slurry type, pad type and the particular P×V value of the process (Fig. 2). The work underscored the importance of selecting the right pad-slurry combination as well as the right values of pressure and velocity to vastly improve polish performance at the "BUFF" step.

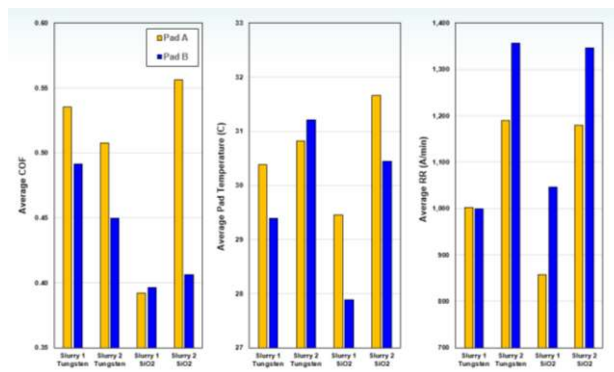

Fig. 1 – Average values of COF, pad temp. and RR.

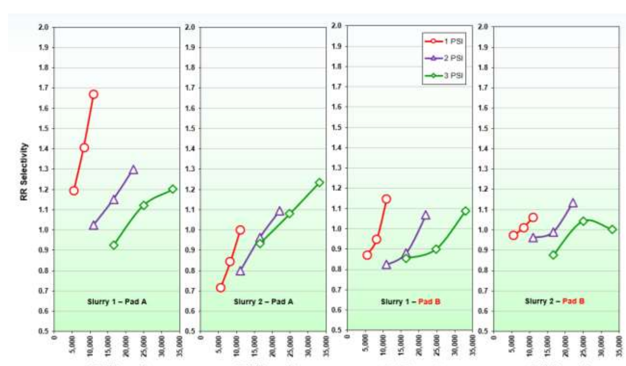

Fig. 2 – Summary of tungsten-to-oxide RR selectivities.

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