Effect of conditioning downforce on Removal Rate stability for ILD CMP application using a ceria-based slurry

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This work investigates the effect of the conditioner downforce on the Removal Rate (RR) stability on oxide Chemical Mechanical Polishing (CMP) with a ceria-based slurry.
Thanks to its efficient bond breaking of SiO_2 [1], ceria-based slurries are widely used for dielectric CMP modules such as shallow trench isolation (STI) and inter-level dielectric (ILD). Since the latter sets the topography seen by tungsten (W) and copper (Cu) metallization, in a continuous-production environment a stable oxide removal rate (RR) is required to control erosion and resistance of the metal layers.

Specifically, we tested 3 different conditioner downforces, and we evaluated the removal rate stability on oxide wafers by using a ceria-based slurry. Multiple runs of 10 blanket SiO_2 wafers were polished at different conditioner downforces, ranging from 5lbf to 6lbf in-situ 100% conditioning.

For mechanically driven processes, the RR increases with the roughness of the pad surface and therefore with the conditioning time and downforce [2]. As shown in Fig. 1, oxide CMP with a ceria-based slurry exhibits a different and nontrivial behaviour: both the value and the stability of the RR increase as the applied conditioner downforce is lowered. We attribute this behaviour to ceria particle de-adsorption from the pad surface: high conditioning loads deplete active abrasives from the surface reducing the RR and degrading its stability over continuous polishing; on the other hand, a lower downforce is able to preserve ceria particles within and above the pad asperities and therefore promotes a more stable RR. A similar mechanism has been proposed in [3], where different RR values were achieved by varying the in-situ conditioning time ratio.

In conclusion, the value of the conditioning downforce in CMP employing ceria-based slurries can be exploited to achieve RR stability and simultaneously higher RR values while preserving the desired radial profile (Fig. 2). Here, only 100% in-situ conditioning has been used: a future work could explore the RR response to variations both in conditioning downforce and time.

References
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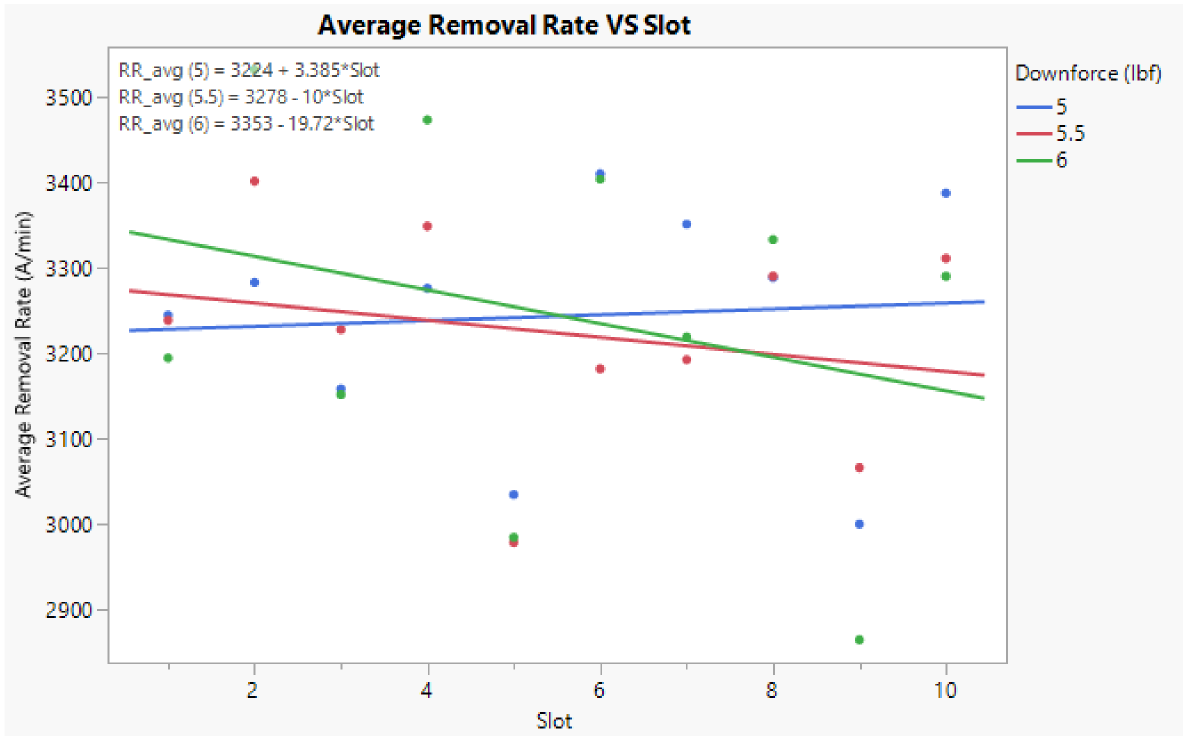

Figure 1 – Average removal rate over the sequence of processed blanket oxide wafers. Each run is done at different conditioner downforce. By comparing the slopes, RR is more stable at lower conditioner downforce. The observed variability is due to different head behaviors, but the trend is confirmed.

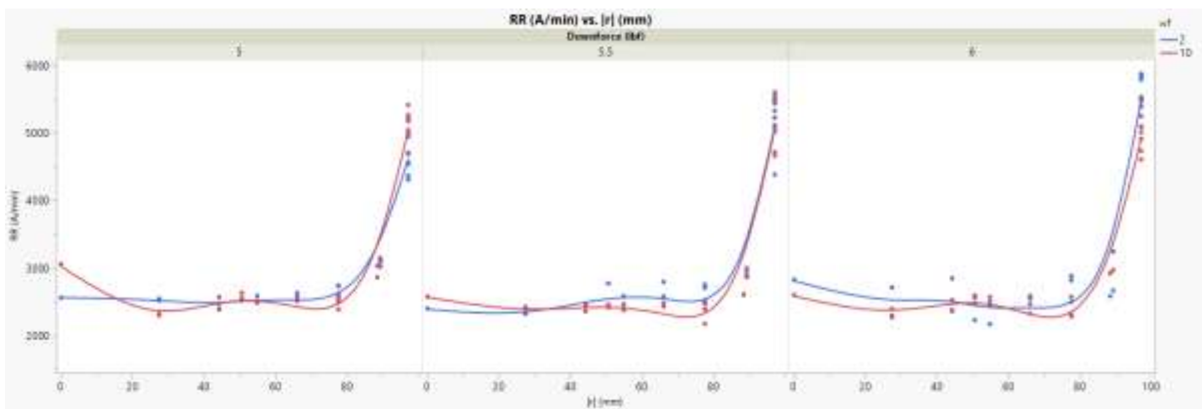

Figure 2 – Removal Rate profile of the first and last wafer processed of the sequence, single head. We observe that the edge is invariant for the 5.5lbf run, while it is decreasing for the higher downforces and increasing for the lower downforces.