Unraveling the Slurry/Substrate Interfacial Reaction Mechanism for Wide Band Gap (WBG) Chemical Mechanical Planarization (CMP)

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Wide band gap (WBG) semiconductors have become of great interest in order to extend Moore's Law beyond the limitations of current Si IC technology. WBG materials (i.e., Gallium Nitride (GaN) and Silicon Carbide (SiC)) are known to operate at greater switching speeds, temperatures, and frequencies leading to enhanced processing performance. However, as a result of their chemical properties, they are chemically inert impeding the ability to effectively planarize the surface at low chemical mechanical planarization (CMP) processing time and with minimized defectivity. The industry standard CMP processes for WBG material involve the use of aggressive redox chemistry and harsh polishing conditions (i.e., increased nanoparticle loading and higher shear force), which leads to an increase in material removal rate (MRR) but results in increased surface defects.

This work focuses on understanding the synergy between slurry additives and substrate surface energy to modulate critical interfacial reactions (covalent or non-covalent). In order to achieve surface planarity with reduced defectivity, the material removal mechanism is dependent on the formation and tunability of a modified surface layer that promotes a more chemically active environment. More specifically, modulating the slurry composition (i.e., nanoparticle, oxidizer, redox-active additives), an optimized slurry-substrate environment can be obtained to reduce the overall mechanical stress needed for enhanced removal. Figure 1 is an example of two different slurry formulations designed for low shear force removal of SiC. These results show that Slurry 2 clearly exhibits a higher removal rate when compared to Slurry 1 which can be directly related to the surface modifying redox additives present.

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It is believed that the chemically modified surface film penetrates deeper into the SiC substrate but requires less mechanical energy to remove. Using a modified AFM technique, the indentation depth (Table 1) of a nanoparticle functionalized tip on the ability to penetrate the SiC surface was measured. Initial results show that the modified surface has an increase depth of penetration which can be attributed to greater interfacial reactions. This is directly correlated to the overall increase in removal rate and initial results have indicated significant lower scratch defects. This presentation will further expand on the additive/process synergy required to enhance dynamic surface modification. Structure function correlations will be presented and direct relationships to removal rate, shear force, and defectivity will be presented.

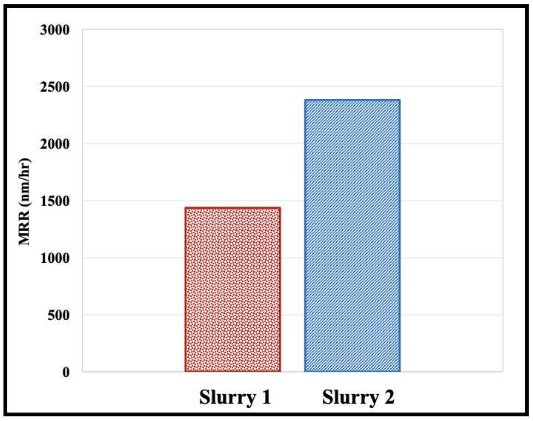

Figure 1: Material removal rate of SiC with different slurries of varying additive composition

Modified Surface Thickness	
Slurry 1	176 nm
Slurry 2	261 nm

Table 1: Modified surface thickness of SiC obtained via force distance measurements on an AFM

Preference: ☐ Oral X Poster

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