Defect Characterization of ALD Grown SiO_2 Films: A Systematic Approach

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Atomic layer deposited SiO_2 films find numerous emerging applications in semiconductor fabrication such as liners for through-silicon vias (TSVs) and spacers for double patterning. Systematic studies of plasma activated ALD-SiO_2 films were done to investigate the nature and origin of defects in these films, and the effects of post deposition treatments. Several films were processed at temperatures ranging from 50-400˚C as well as different plasma conditions. Together with different processing parameters, post-anneal treatments in N_2 and forming gas (FG) were completed. Electrical characterization studies demonstrate that interface trap charge formation is controlled by both temperature and plasma conditions, while bulk oxide traps are dominantly controlled by plasma conditions alone. A linear correlation between the flatband voltage,$V_{fb,}$ and oxide thickness at the center of the wafer is suggestive of dominant interface fixed charge . However, at the edge of the wafer both interface and bulk defects appear to exist, evidenced by a non-linear trending of V_{fb} with thickness. These results were correlated to the XPS spectra of samples taken from the center and edge points. The wafer center appears to have more Si^{4+} character and less Si^{3+} character than at the edge, suggesting that increased hole-type or positively charged defects are present at the edge compared to the center. Films processed at 50˚C have a higher defect density than those processed at temperatures greater than 200^{o}C, suggesting incomplete oxidation at lower temperatures. Significant improvements in defect density of these films are seen after post-anneal treatment in N_2 and FG environments at 400˚C. We will present key takeaways from these investigations and discuss potential strategies towards achieving defect-free ALD-SiO_2 films for advanced applications.