Mechanism of Leakage Variation with Aspect Ratio in ALD High-*k* ZrO_2 and HZO Dielectrics

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DRAM capacitors require ALD of ultrathin high-*k* dielectrics, such as ZrO_2 or $(Hf,Zr)O_2$ (HZO), throughout high aspect ratio (HAR) features. However, device performance may be compromised by trap states and other defects due to non-ideal ALD at high aspect ratios, constraining achievable capacitance. We demonstrate a simple, low-cost lateral high aspect ratio (LHAR) platform to link material properties, ALD process parameters, and device performance as a function of equivalent aspect ratio. Metal-insulator-metal capacitor (MIMcap) structures were prepared with physical vapor deposited TiN electrodes and ALD ZrO_2 or HZO dielectrics grown in the LHAR test structure using metal-organic precursors (ZyALD, ZrD-O4, TDMAHf, HfD-O4) and ozone. As expected, the ALD film thickness decreases with equivalent aspect ratio. However, we also observe intrinsic variation of the leakage performance, indicating increasingly non-ideal ALD behavior deeper in the trench. Physical characterization and kinetic modeling of the deposition process explains these trends, informing future process design to mitigate defects which worsen leakage at high aspect ratios.