Engineering HZO by Flat Amorphous TiN Achieving Uniform c-axis Alignment, High Breakdown Field, and Endurance > 4E12

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Abstract

Metal-ferroelectric-metal (MFM) capacitors with flat amorphous TiN are demonstrated to achieve the c-axis of orthorhombic phase (o-phase) well-aligned along the deposition direction, uniform electric field, negligible fatigue, and a high remanent polarization ($2P_r$) of 62 μC/cm^2. The large lattice misfit between crystalline TiN and HZO creates a larger barrier to form the o-phase HZO as compared to the amorphous TiN underlayer. Using chemical-mechanical polishing (CMP) can obtain a 0.3nm roughness flat TiN, measured by atomic force microscopy (AFM). HZO on flat amorphous TiN exhibits a uniform and record breakdown field (E_{BD}) of 4.8/-5.1 MV/cm for positive/negative voltage. A flat TiN mitigates the formation of oxygen vacancies (V_o) as compared to the rough TiN due to the weak and uniform electric field with few local extremes in HZO. After 4E12 endurance cycles, the HZO on the flat TiN exhibits a record final $2P_r$ of 56 μC/cm^2 due to small dipole pinning by V_o^{2+}. This work demonstrates the way to achieve uniformly high $2P_r$, large E_{BD}, and high endurance by the flat amorphous TiN.

Keywords - Ferroelectric HZO, Flat TiN underlayer, Endurance, C-axis aligment, Breakdown Field.