

## **Applied In-plane Strain Effects on the Polarization Response of Ferroelectric Hafnium Zirconium Oxide Thin Films**

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The influence of biaxial stress on the maximum and remanent polarizations of 10 nm thick hafnium zirconium oxide thin films in metal-ferroelectric-metal capacitor structures has been quantified. In the as-prepared state with a nominal biaxial tensile strain of 0.20% and no applied extrinsic stress, remanent and maximum polarizations of 7.6 and 13.1  $\mu\text{C}/\text{cm}^2$ , respectively, were measured using a 2 MV/cm applied electric field. Reducing the intrinsic strain by 0.111% through the application of a compressive uniaxial stress results in a decrease in the remanent and maximum polarizations to 6.8 and 12.2  $\mu\text{C}/\text{cm}^2$ , respectively. The polarization dependence on strain is nearly linear between these values. The observed variation in polarization with strain is consistent with strain impacting ferroelastic switching whereby inplane tension increases the fraction of the short polar axis orienting out-of-plane, hence increasing out-of-plane polarization. In contrast, reducing the in-plane strain through compression results in an increase in the fraction of the long non-polar axis orienting out-of-plane, thereby decreasing out-of-plane polarization.