Characterization of PiezoMEMS $PbZr_{0.52}Ti_{0.48}O_3$ with IrO_2/Pt, IrO_2, and Pt Bottom Electrodes

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In piezoelectric microelectromechanical system (PiezoMEMS) devices with $PbZr_xTi_{1-x}O_3$ (PZT) as the ferroelectric, the bottom electrode can provide a template for oriented PZT growth. A hybrid IrO_2/Pt bottom electrode can improve resistivity for signal transmission along the transmission line due to lower resistance of the Pt in parallel with the higher resistance IrO_2 while retaining a conductive oxide interface with the PZT to allow oxygen vacancy mobility across the interface. IrO_2/Pt, IrO_2, and Pt bottom electrode layers were sputter deposited on TiO_2. The IrO_2 and Pt were found to be 100 and 111 oriented, respectively, by X-ray diffraction (XRD). XRD analysis also showed that PZT grown by the chemical solution deposition process without the use of a $PbTiO_3$ (PTO) seed layer exhibits {001} orientation and no {111} orientation, whereas on Pt the PZT has a {111} component. Scanning transmission electron microscopy (S/TEM) on FIB-cut cross-sectional TEM specimens through the PZT/bottom electrode samples showed that IrO_2/Pt, IrO_2, and Pt bottom electrodes are all highly textured. However, the PZT layer deposited on top of these three types of bottom electrodes exhibits partial-texture.

Dielectric constant (ε), loss tangent (tan δ), and polarization hysteresis loop vs applied electric field $P(E)$ measurements on clamped circular capacitors, and laser Doppler vibrometry (LDV) measurements on unclamped unimorph cantilevers were used to compare the influence of IrO_2, IrO_2/Pt, and Pt bottom electrodes on PZT. Polarization results show that PZT polarization is strong and stable for IrO_2/Pt bottom electrodes post-annealed prior to PZT deposition. Normalized strain was obtained from LDV deflection data for the PZT capacitors with the different bottom electrode types (Fig. 1) and comparisons made to determine their influence on PZT mechanical behavior. For devices with PZT on IrO_2/Pt bottom electrodes, dielectric constant, 1100, loss tangent, 0.07, maximum polarization, 0.40 C/m^2 at 40 MV/m, leakage current, 5 nA at 20 MV/m, and normalized strain, 0.003 at 20 MV/m, were obtained and are comparable to results for PZT on 100nm Pt-only bottom electrodes.

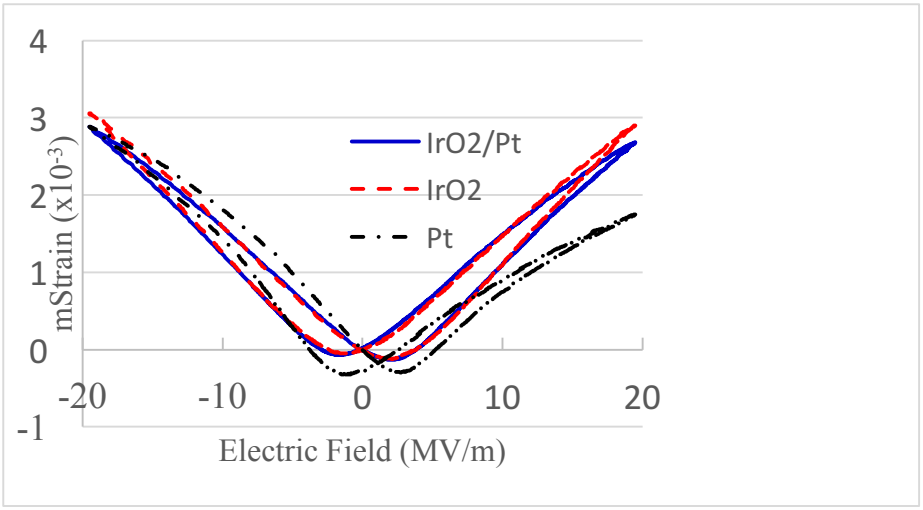

Fig. 1 – Normalized strain vs Electric Field loop for IrO_2/Pt, IrO_2, and Pt, poled at +20 MV/m for 5 minutes.