Properties of amorphous Zr$_{0.2}$Sn$_{0.2}$Ti$_{0.6}$O$_2$, a high performance dielectric

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Composition dependence:
A composition spread technique was used to rapidly search composition space of the zirconium, tin, titanium oxide system for compositions which support a high areal charge: $Q_{\text{max}}/A = CV_{\text{bbr}}/A = \varepsilon E_{\text{bbr}}$.

Composition spreads were deposited by off-axis rf sputtering at 200 deg C in a 60% Ar, 40% O$_2$ atmosphere.
Single composition samples have also been prepared at the same temperature and atmosphere by on-axis rf or pulsed dc sputtering.

High figure of merit is not system dependent:
Single composition samples with the identified composition Zr$_{0.2}$Sn$_{0.2}$Ti$_{0.6}$O$_2$ have been prepared in two different vacuum systems, using three different deposition techniques: off-axis rf sputtering, on-axis rf sputtering, and on-axis pulsed-dc sputtering. The resulting dielectric material has demonstrated quantitatively consistent properties, given the level of optimization for each technique.

Material properties:

A J-E characterization for a sample deposited using on-axis rf sputtering. The leakage current is nA/cm$^2$ and increases with temperature. Breakdown voltages give an $E_{\text{br}} = 2.5$ MV/cm.

The change in capacitance with dc voltage for four capacitors on an off-axis rf sputtered sample. This material demonstrates high linearity with increasing voltage in marked contrast to (Ba,Sr)TiO$_3$. The quadratic term, $A_2$, is about 1000 times smaller than the observed nonlinearity in silicon dioxide for the same capacitive density.

Variation of capacitance with frequency measured on an HP 4274A LCR meter (up to 100 kHz) and an HP 4191A Impedance Analyzer (above 1 MHz). No strong frequency dependence is observed up to 10 MHz.

Conclusions:
An amorphous zirconium tin titanate oxide Zr$_{0.2}$Sn$_{0.2}$Ti$_{0.6}$O$_2$ is a well behaved dielectric suitable for applications requiring a high areal charge. This figure of merit remains high through the tested variations in temperature, frequency, and voltage.

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