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Exploring the evolution of the polarization behavior for Nb-PZT based on the electric field-pressure-temperature conditions

C. DiAntonio*, W. Dong, T. Hughes, T. Chavez, L. Haden, P. Yang and K. Meyer
Sandia National Laboratories
PO Box 5800, Albuquerque, New Mexico 87185
cbdiant@sandia.gov*

Lead zirconate stannate titanate ceramic (Pb(Zr,Sn,Ti)O3) is an important family of ferroelectrics and is usually modified by niobium (Nb) or lanthanum (La) to tailor its properties. In particular, compositions close to the phase boundary of the ferroelectric (FE) and antiferroelectric (AFE) have attracted considerable interest for many years. Near the FE/AFE phase boundary, the free energy difference between the FE and AFE phase is very small, indicating that the FE/AFE phase transition can occur easily with an applied electric field or pressure. These phase transitions are usually accompanied by a volume expansion/contraction, a development/release of electrical polarization, or an incommensurate modulation in structure, resulting in the possibility for many engineering applications. Niobium modified lead zirconate titanate ceramic with a Zr:Ti ratio of 95:5 (95/5 PZT) undergoes a hydrostatic pressure induced phase transformation from rhombohedral ferroelectric to orthorhombic antiferroelectric. In the FE state, electric fields can induce a remnant polarization due to domain restructuring within the material. During the phase transformation from the FE to the AFE state, the remnant polarization goes to zero. This study will present work on experimental measurements of the effect of combined bipolar electric field cycles and hydrostatic pressure on the FE-AFE phase transformations in various formulations of Niobium modified Pb(Zr,Ti)O3. Specifically investigating the evolution of the hysteresis looping behavior as a function of the applied hydrostatic pressure. The motivations for this work include; development of an improved understanding of the large electric-field dielectric displacement-electric field behavior of the FE-AFE phase transformation, potential for construction of phase diagrams for electric field-pressure-temperature conditions, and the possibility for an improved understanding of the physics of the FE-AFE phase transformation for use in the creation of phase transforming material models.

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