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Positive effect of an internal depolarization field in ultrathin epitaxial ferroelectric films

The effect of intentionally introducing a large depolarization field in (001)-oriented, epitaxial Pb(Zr0.2 Ti0.8)O3 (PZT) ultra-thin films grown on La0.67 Sr0.33 MnO3 (LSMO) buffered SrTiO3 (STO) substrates is investigated. Inserting between 3 to 10 unit cells of STO between two 3nm thick PZT films significantly influences the out-of-plane (c) lattice constant as well as the virgin domain state. Piezoresponse force microscopy images reveal a nanoscale (180°) polydomain structure in these films. In comparison, a "reference" single layer PZT sample (6 nm thick without STO spacer) exhibits an elongated PZT c-axis (0.416nm) and is preferentially "down"-polarized with large regions of monodomain contrast. It shows asymmetric switching loops (i.e. imprint) coupled with sluggish domain switching under external bias. We show that the insertion of STO drives a monodomain to 180° polydomain transition in the as-grown state, which reduces the imprint by 80%. The insertion of the STO also profoundly improves dielectric leakage and hence the distribution of the applied electric field. Consequently, the critical pulse duration of the electric field required to initiate domain switching is reduced by two orders of magnitude relatively to the reference sample. These results demonstrate the possibility of manipulating the depolarization field in such a way that it has positive effects on the ferroelectric behavior of ultrathin PZT films. This work is published in Advanced Electronic Materials DOI: 10.1002/aelm.201500288

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