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Lead-free piezoelectrics and mechanisms of high electro-mechanical coupling

DRAGAN DAMJANOVIC, Swiss Federal Institute of Technology - EPFL

The high electromechanical coupling of the most versatile piezoelectric, Pb(Zr,Ti)O3 (PZT), originates in combination of lattice effects, motion of domain walls and presence of a morphotropic phase boundary (MPB). In search for the lead-free alternatives, it is tempting to look at materials that are structurally and chemically similar to PZT. This approach has so far focused on a number of Bi containing compounds and solid solutions possessing an MPB. Interestingly, evaluation of domain walls motion has so far been largely neglected in lead-free piezoelectrics even though it is known to account for more than half of the response in PZT. In this presentation, relative contributions of domain walls, lattice and MPB to the piezoelectric response of Pb-based and some lead-free materials (K,Na)NbO3, (Na,Bi)TiO3, BiFeO3) are discussed. By using recent reports on direct observation of domain walls motion in polycrystalline ferroelectrics, it is shown how complex boundary conditions on microscopic scale lead to unexpected average behavior and make difficult estimation of the macroscopic properties from lattice and domain walls motion..