High Piezoelectricity in relaxor-PT based Materials with Local Structural Heterogeneity

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Background, Motivation and Objective

Among all known ferroelectric materials, the perovskite ferroelectric materials exhibit the highest piezoelectric coefficient, and thus are at the heart of numerous electronic devices, such as imaging transducer, piezoelectric sensors and energy harvesting, to name a few. PZT based ceramics with perovskite structure have been the mainstay piezoelectric materials and occupy the largest share of the piezoelectric ceramics market for numerous applications, due to their large piezoelectric coefficients and electromechanical coupling factors near the morphotropic phase boundary (MPB) and the ability to tailor properties between soft and hard piezoelectric responses [1]. Relaxor-PT ferroelectrics show high dielectric and piezoelectric properties, far outperforming conventional PZTs, greatly benefit medical ultrasound imaging. The good properties of relaxor-PT based materials are inherently associated with the unique local structural heterogeneity: the existence of nanoscale heterogeneous regions that coexists with normal ferroelectric matrix [2-3].

Statement of Contribution/Methods

Based on the above paradigm, recent developments have experimentally confirmed that modest changes in the polarizability of local structure, which is induced by the A site donor dopants, such as rare earth Sm^{3+}, can be regarded as "seeds" to further enhance the dielectric properties of ABO_3 perovskite solid solutions. Different rare earth dopant elements were judiciously introduced to the A site of the $Pb(Mg_{1/3}Nb_{2/3})TiO_3$-$PbTiO_3$ (PMN-PT) considering their relative similar ionic radius, which will enhance the local structural heterogeneity. The polycrystalline ceramics were fabricated by solid state sintering method at 1250°C, while the single crystals were grown using modified Bridgman method directly from the melt.

Results/Discussion

The modified polycrystalline ceramics exhibit ultrahigh dielectric and piezoelectric properties, compared to their non-modified counterparts, being on the order of 13,000 and 1500pC/N, respectively [4]. Of particular significance is that giant piezoelectric coefficient, being on the order of ~4000pC/N, was achieved in Sm^{3+} modified PMN-PT single crystals, taking advantages of the synergistical contributions from the local structural heterogeneity, morphotropic phase boundary and engineered domain configuration [5]. The relationship between local structure and macroscopic properties has been established, try to understand the impact of local structure on dielectric properties, to explore high performance ferroelectric materials for various electromechanical applications [6-7].

References:

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