The impact of local structural heterogeneity on electric properties of perovskite ferroelectrics

Zhang, S.[1], Li, F.[2], Chen, L.[2] and Shrout, T.[2]

[1] University of Wollongong, Australia, [2] Pennsylvania State University, United States

Perovskite ferroelectric materials are at the heart of numerous electronic devices, such as imaging transducer, piezoelectric sensors, energy harvesting and electrical energy storage capacitors, to name a few.

Relaxor-PT ferroelectrics show superior dielectric/piezoelectric properties, outperforming conventional ferroelectric PZTs, which greatly benefit medical ultrasound imaging. The good properties of relaxor-PT based materials are inherently associated with their unique local structural heterogeneity: the existence of nanoscale heterogeneous regions that coexists with normal ferroelectric domains. The contribution of these local structures has been theoretically modelled to be the origin of the ultrahigh dielectric and piezoelectric activities of relaxor based perovskite ferroelectric crystals, accounting for 50-80% of their respective room temperature values [1-2], as shown in Fig. 1a. Based on the paradigm, recent developments have experimentally confirmed that modest changes in the polarizability of local structure, can be regarded as "seeds" to further enhance the dielectric properties of ABO_3 perovskite solid solutions. The modified polycrystalline ceramics have been shown to exhibit ultrahigh dielectric and piezoelectric properties compared to their non-modified counterparts, being on the order of 12,000 and 1,500pC/N, respectively, as given in Figs. 1b &c [3]. In addition, the energy storage performance of the local structure tuned perovskite ferroelectrics is greatly enhanced, with energy density of >9J/cc (20 microns ceramic layer) and energy efficiency of >90% [4]. 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 energy harvesting and energy storage applications.

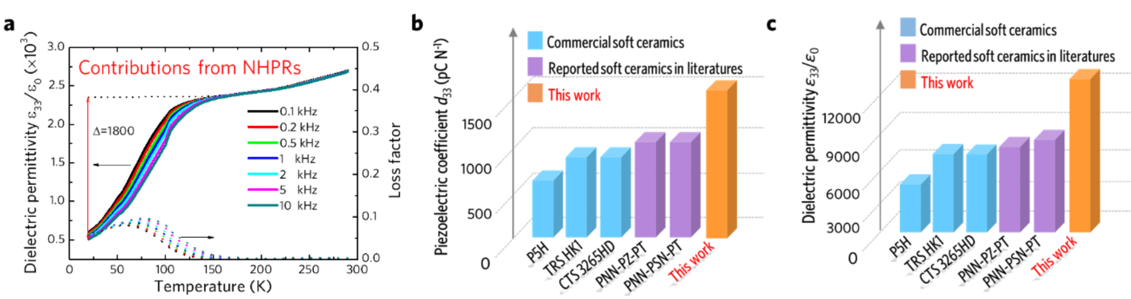

Figure 1 a**,** Dielectric permittivity vs. temperature of a single domain PZN-0.15PT crystal, showing significant contribution from nanoscale heterogeneous polar-regions. b and c give the comparison of dielectric and piezoelectric coefficients for the ceramics developed in this work and the state-of-the-art "soft" piezoelectric ceramics.

References:

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