

Impact of local structural heterogeneity on the piezoelectric properties of perovskite ferroelectrics

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

Relaxor-PT ferroelectrics show superior 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]. 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 ABO₃ perovskite solid solutions. The modified polycrystalline ceramics 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 the following Table I [3]. The relationship between local structure and macroscopic properties has been established, try to understand the impact of local structure on the piezoelectric properties, to explore high performance ferroelectric materials for energy harvesting and transducer applications.

Table 1 | Comparison of the piezoelectric coefficients and relative dielectric permittivities of the 2.5Sm-PMN-29PT and 2.5Sm-PMN-31PT ceramics with PMN-36PT and state-of-the-art ‘soft’ PZT ceramics

Ceramics	ϵ_{33}/ϵ_0	d_{33} (pC N ⁻¹)
2.5Sm-PMN-29PT	13,000	1,510
2.5Sm-PMN-31PT	10,000	1,250
PMN-36PT	5,100	620
PHT-PNN	6,000	970
Commercial PZT5H	3,400	650
Commercial PZT5	1,700	500

The piezoelectric coefficients d_{33} are measured by a Berlincourt d_{33} -meter. The errors in the data are within $\pm 5\%$.

References:

- [1] F. Li, et al., Nature Communications, 7, 13807 (2016).
- [2] F. Li, et al., Adv. Funct. Mater., 27, 1700310 (2017).

[3] F. Li, et al., Nature Materials, 17, 349-354 (2018).