This journal is © The Royal Society of Chemistry 2024

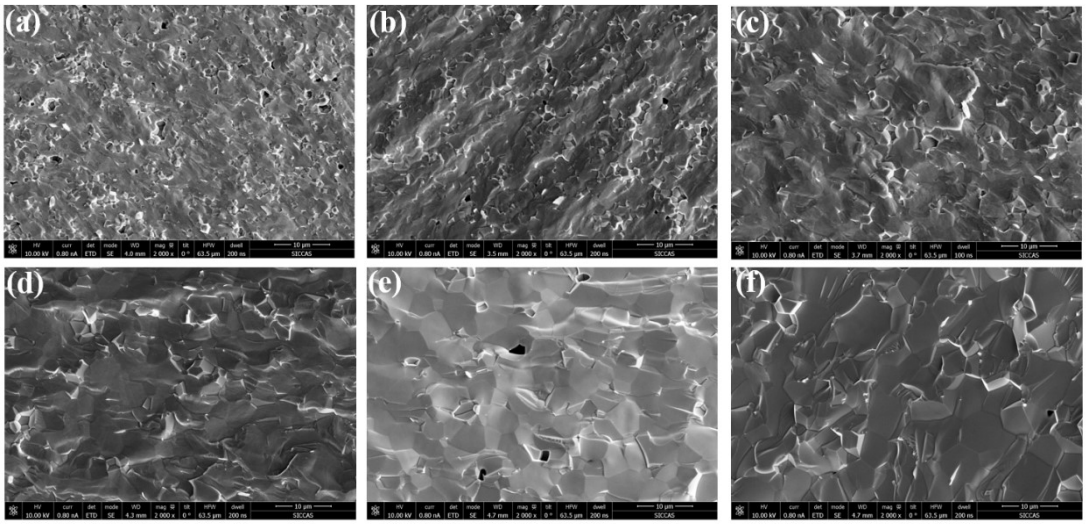

Fig. S1 cross-section SEM images of PLZT ceramics (x=0.4-0.14).

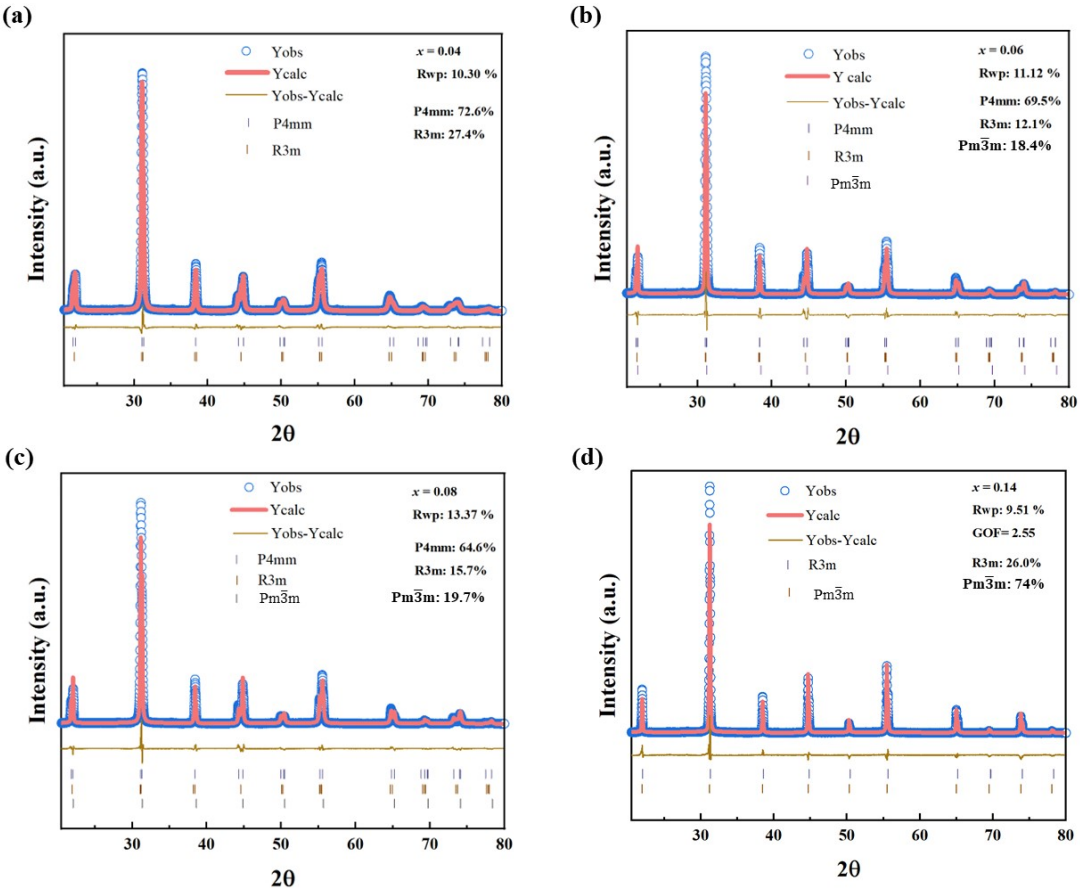

Fig. S2. (a-d) Rietveld refinement of XRD results for x=0.04, 0.06, 0.08, 0.14

Table S1: Lattice parameter and refined structure parameter of PLZT(x) ceramics

Sample	**Phase1, P4mm**	**Phase 2, R3c**	**Phase 3, Pmm**	**Phase fraction**	**Fitting parameter**
x=0.04	a=b=4.04 c=4.09 V=66.896	a=b=5.76 c=7.01 V=201.44	—	P4mm=72.6% R3m=27.4%	Rwp=10.3%
x=0.06	a=b=4.05 c=4.08 V=66.895	a=b=5.76 c=7.01 V=201.44	a=b=c=4.04 V=66.22	P4mm=69.47% R3m=12.15% Pmm=18.38%	Rwp=11.12%
x=0.08	a=b=4.04 c=4.09 V=67.044	a=b=5.76 c=7.01 V=201.44	a=b=c=4.04 V=66.22	P4mm=69.47% R3m=12.15% Pmm=18.38%	Rwp=13.37%
x=0.10	a=b=4.05 c=4.08 V=66.936	a=b=5.76 c=7.01 V=201.44	a=b=c=4.045 V=66.216	P4mm=63.24% R3m=9.6% Pmm=27.14%	Rwp=12.74%
x=0.12	—	a=b=5.76 c=7.01 V=201.44	a=b=c=4.059 V=66.874	R3m=30.5% Pmm=69.5%	Rwp=10.30%
x=0.14	—	a=b=5.76 c=7.01 V=201.44	a=b=c=4.059 V=66.877	R3m=26% Pmm=74%	Rwp=9.51%

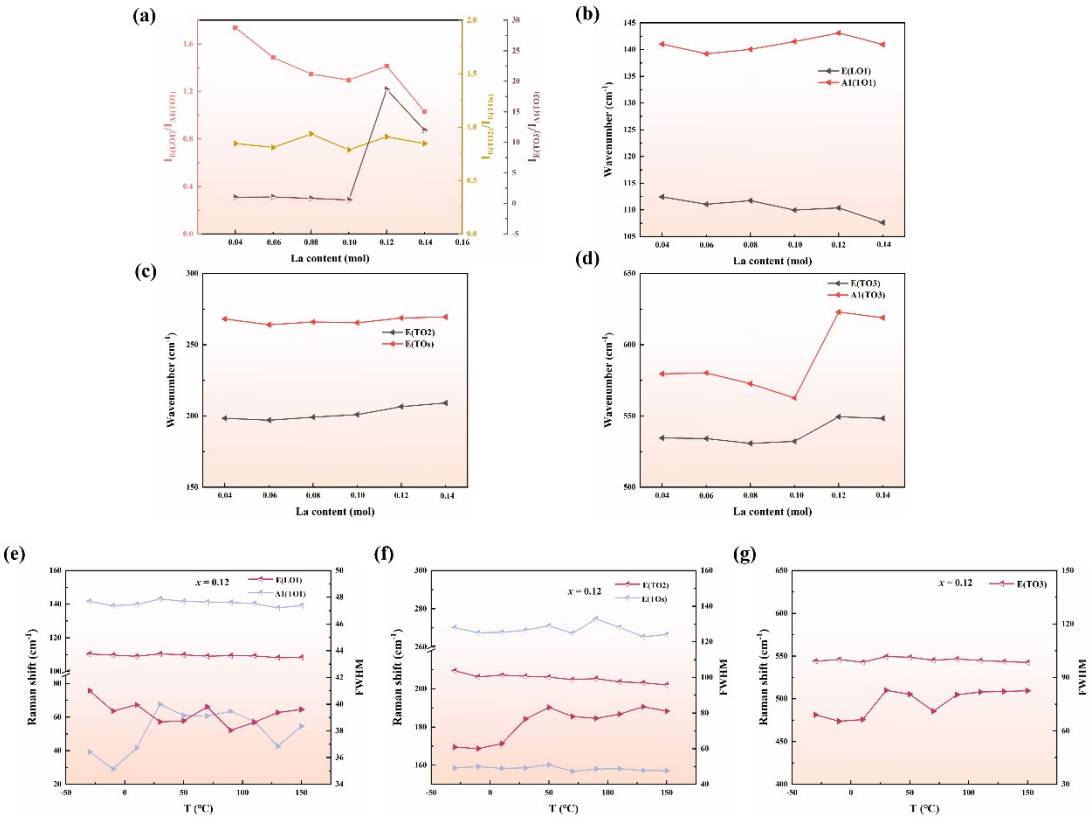

Fig. S3 The evolution of (a) the intensity ration and (b-d) Raman shift of E and A modes as a function of La content in PLZT ceramics. The variance of Raman shift and full width at half maximum (FWHM) from -30 °C to 150 °C for x=0.12 sample in (e-g) E and A modes, respectively.

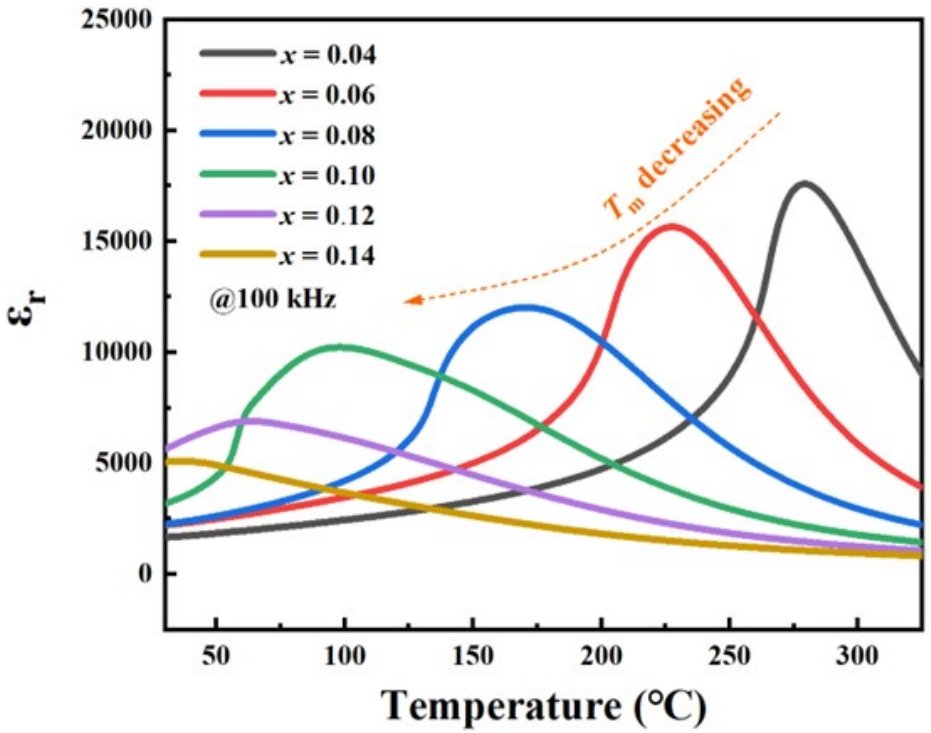

Fig. S4. Temperature-dependence ε_r-T curves for PLZT (x=0.04 ~0.14) ceramics at 100 kHz.

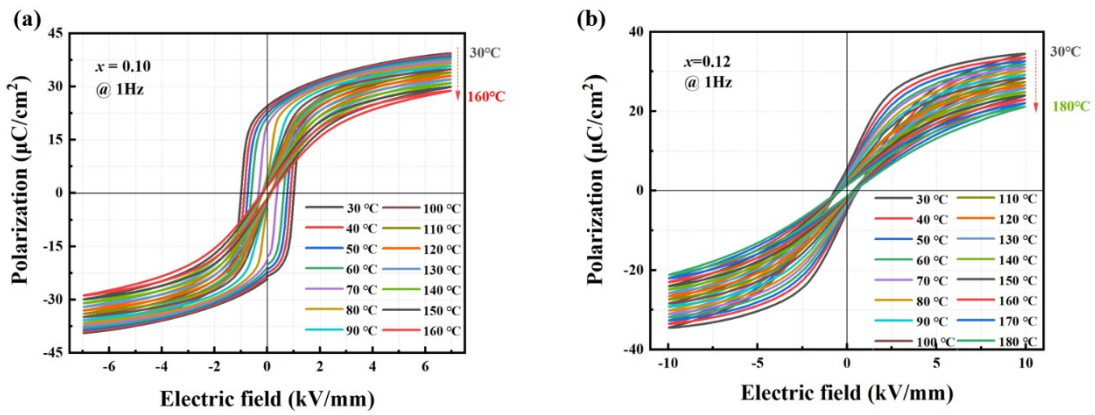

Fig. S5. (a-b) Temperature-dependence P-E loops for PLZT (x=0.10, 0.12) ceramics.

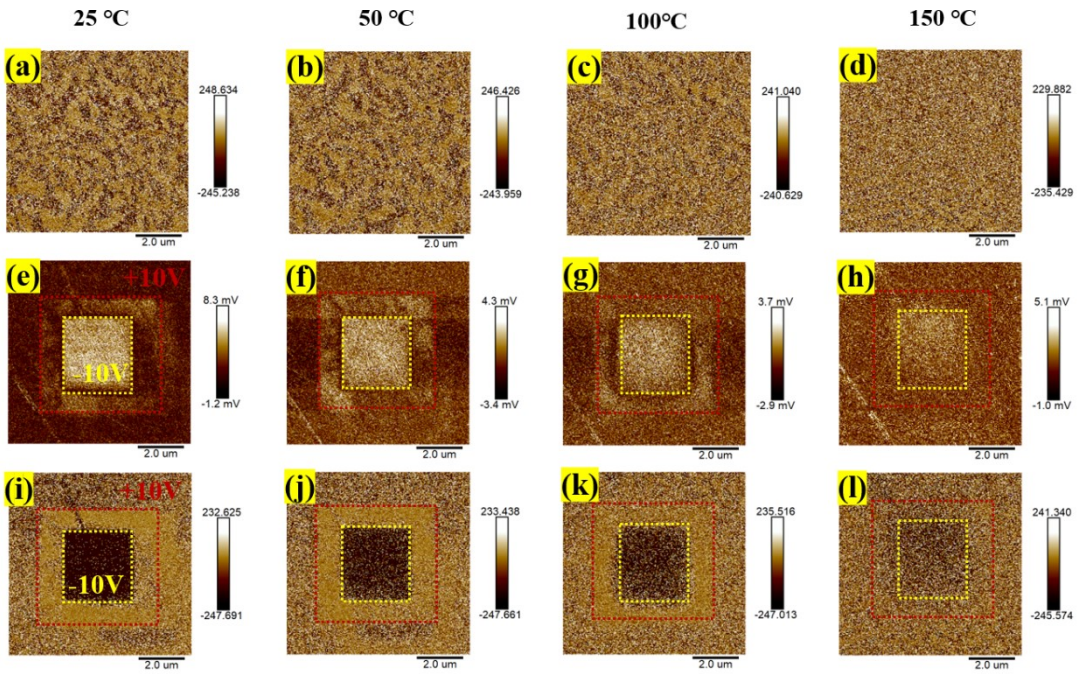

Fig. S6 (a-d) in situ variable temperature in PFM phase images for PLZT (x=0.10); in situ variable temperature in PFM amplitude images (e-h) and phase images (i-l).

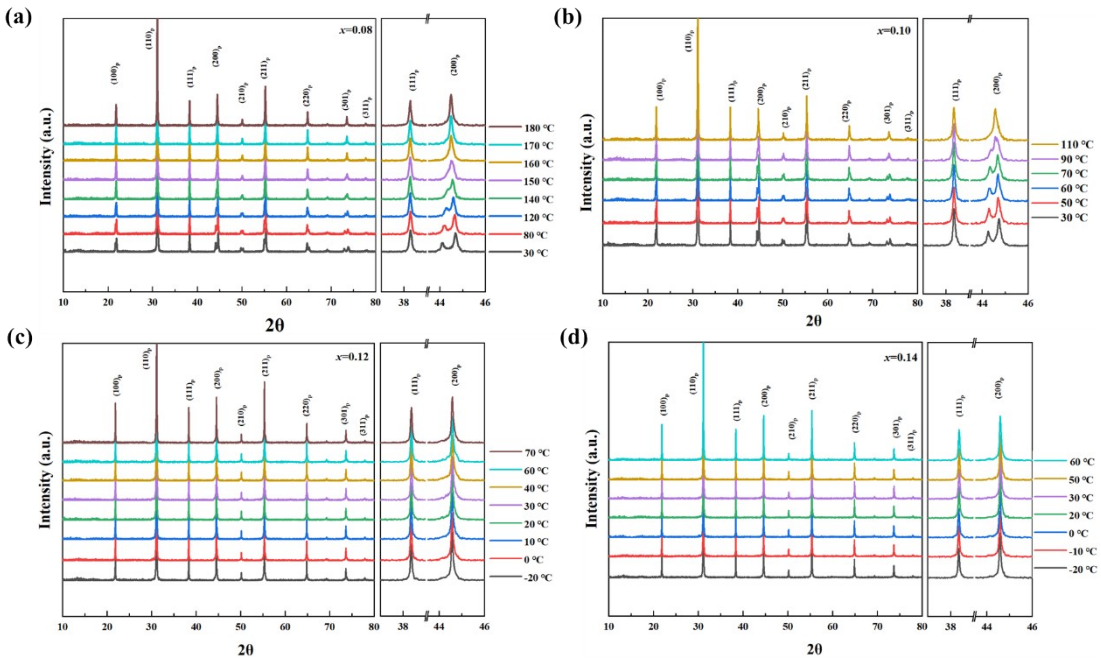

Fig. S7. In-situ temperature-dependence X-Ray diffraction for PLZT (x) ceramics: (a) x=0.08; (b) x=0.10; (c) x=0.12; (d) x=0.14.