Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Stabilization of ferrielectric phase in $NaNbO_3$-based lead-free ceramics for wide-temperature large electrocaloric effect

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Jie Wu and Hui Liu contributed equally to this work.

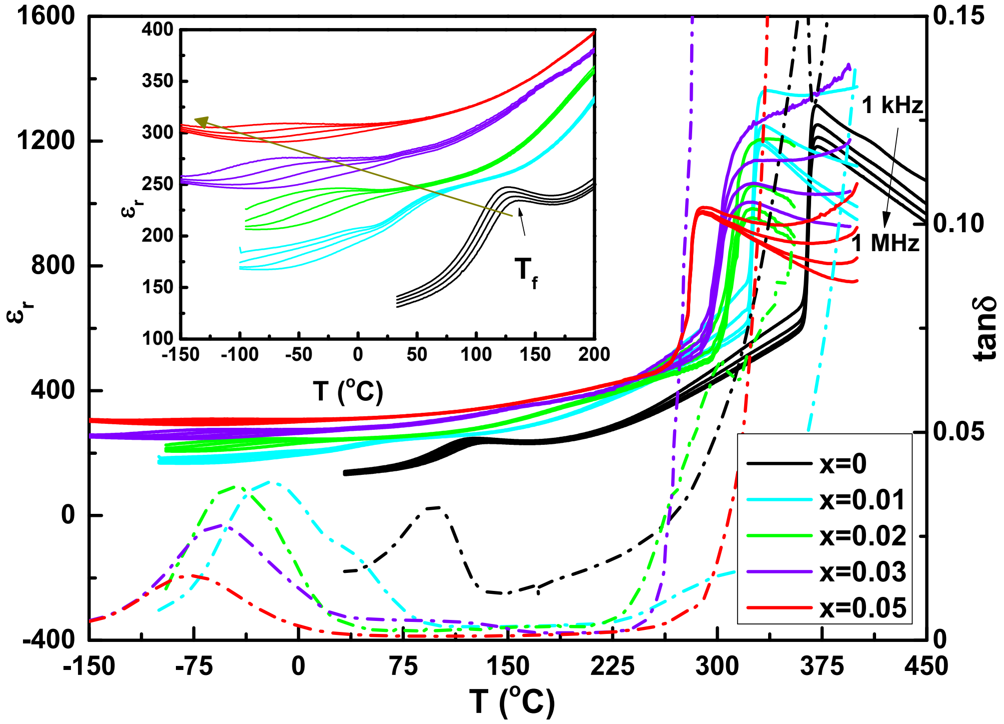

Fig. S1 Temperature dependent dielectric permittivity and dielectric loss at the frequency of 1 kHz-1 MHz for the NN-CZ ceramics. The inset is the evolution of T_f with changing CZ content.

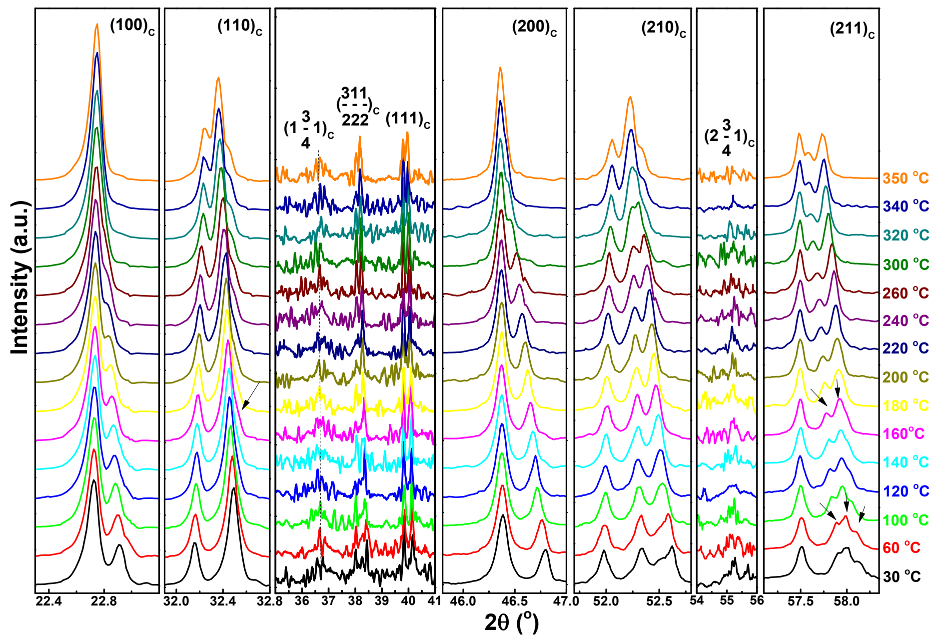

Fig. S2 Temperature-dependent XRD pattern of the NN sample.

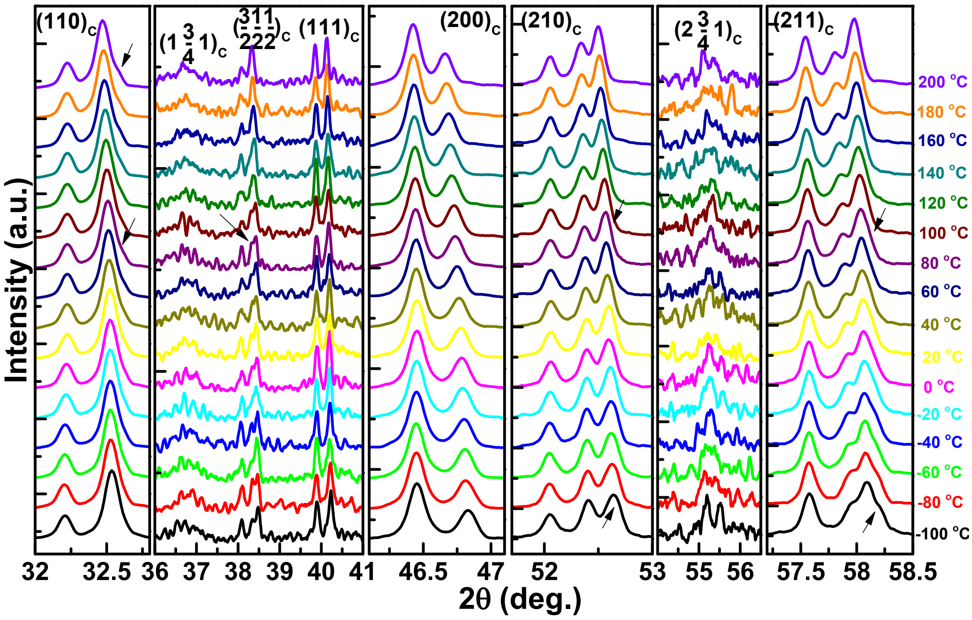

Fig. S3 Temperature-dependent XRD pattern of the NN-0.01CZ sample.

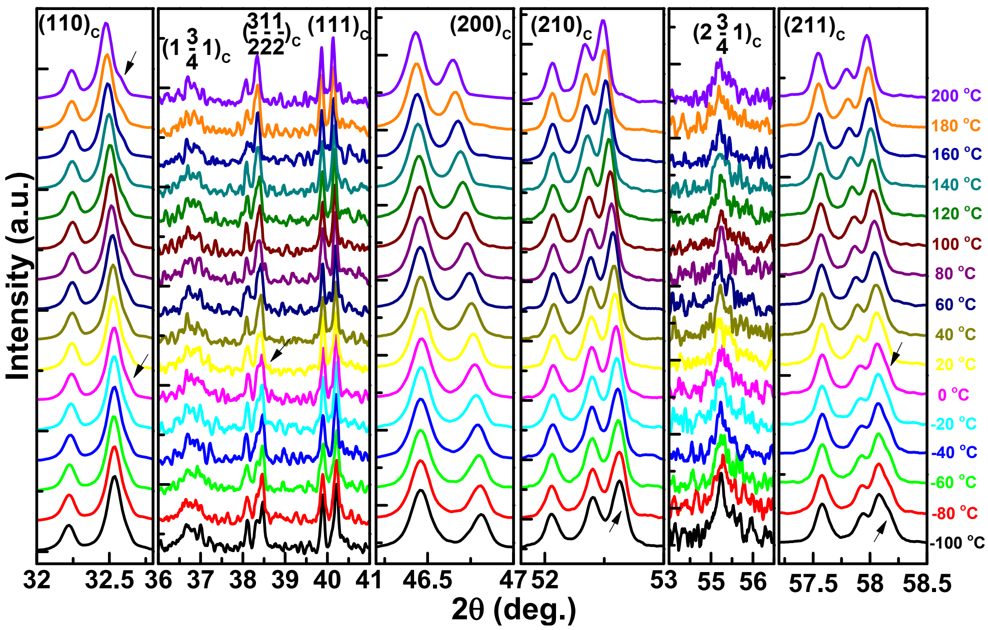

Fig. S4 Temperature-dependent XRD pattern of the NN-0.02CZ sample.

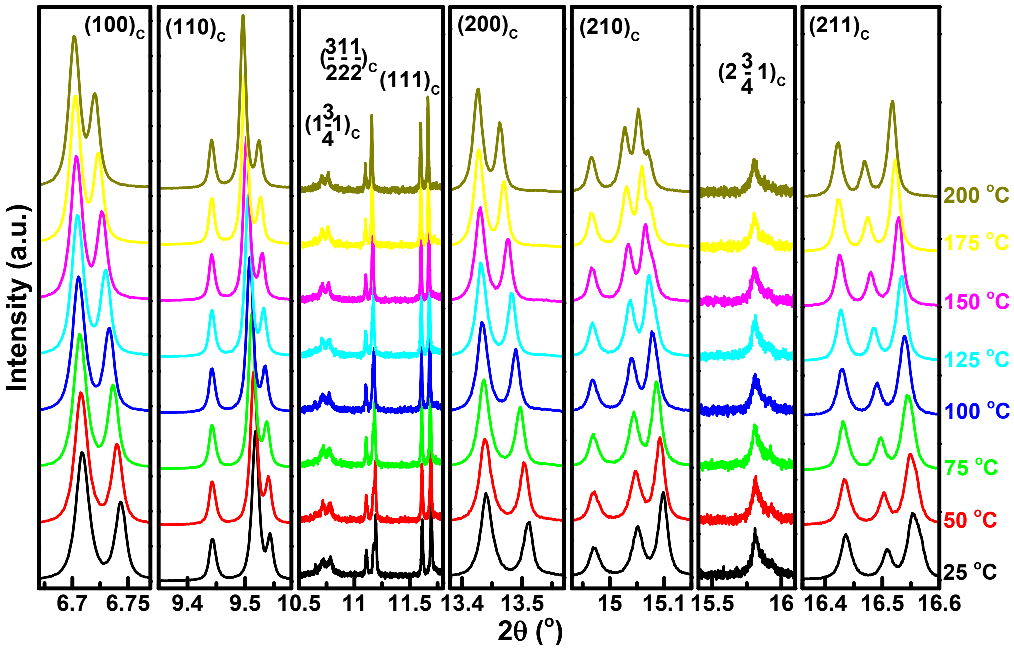

Fig. S5 Temperature-dependent synchrotron XRD pattern of the NN-0.02CZ sample.

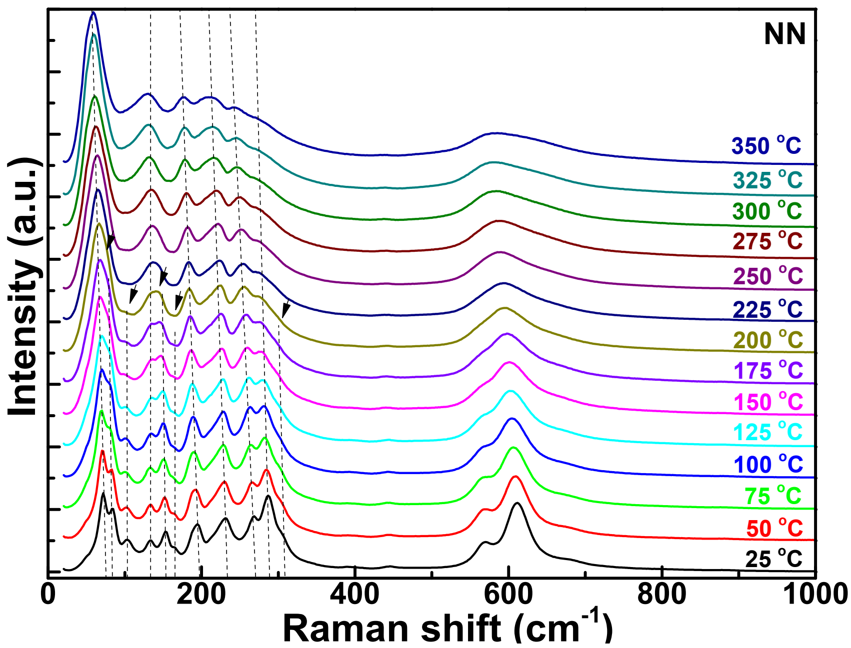

Fig. S6. Temperature-dependent Raman spectra of NN sample.

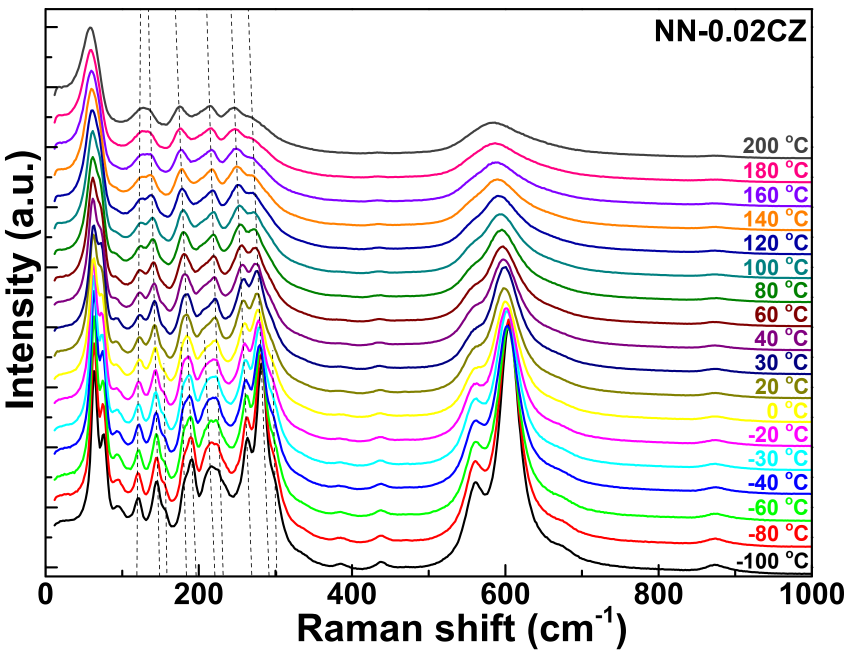

Fig. S7. Temperature-dependent Raman spectra of NN-0.02CZ sample.

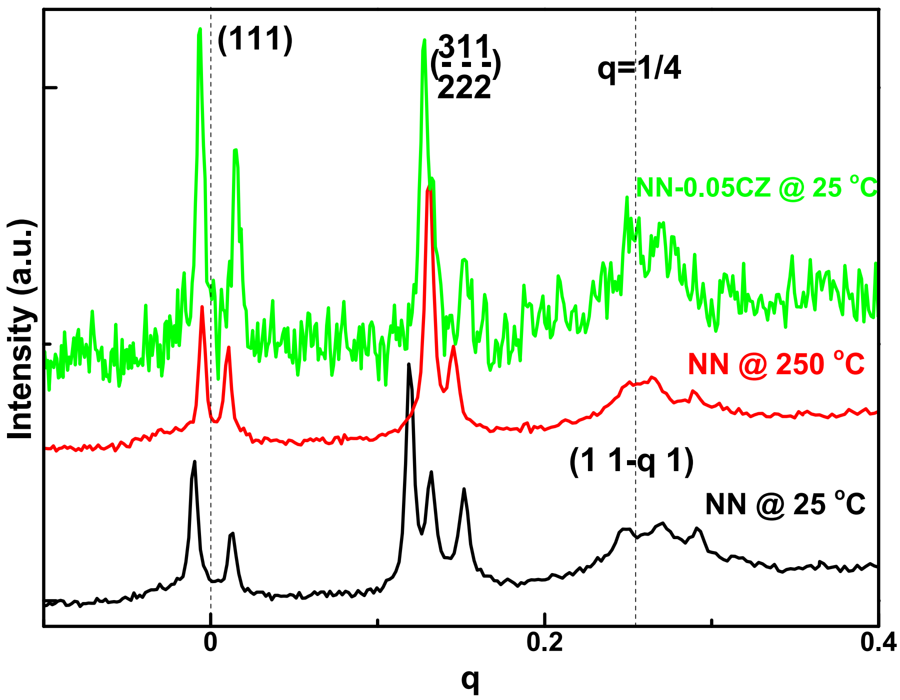

Fig. S8. The corresponding intensity profiles of (1, 1-**q**, 1) superlattice reflections and (111) basic reflections for NN-*x*CZ ceramics.

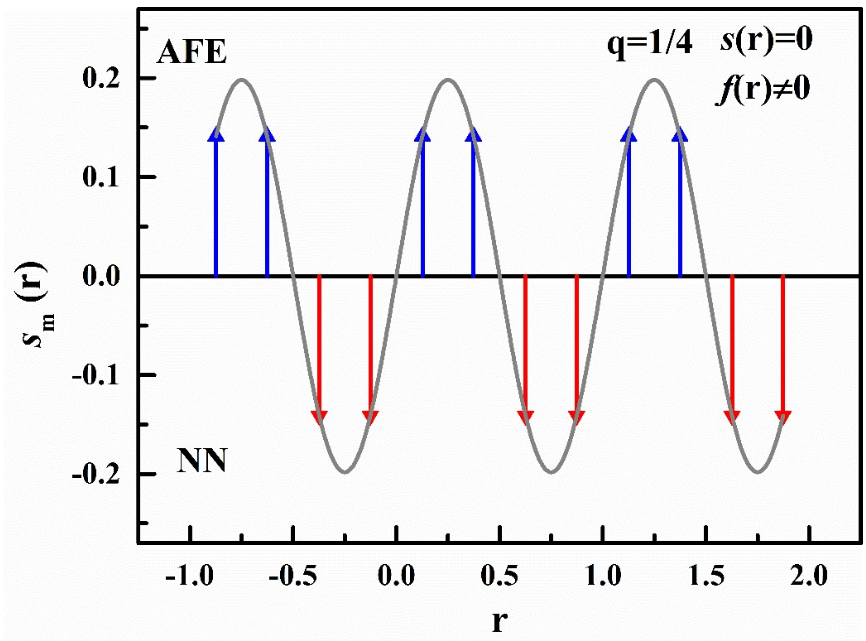

Fig. S9 The proposed configuration for **q**=1/4 phase of NN ceramic**.**

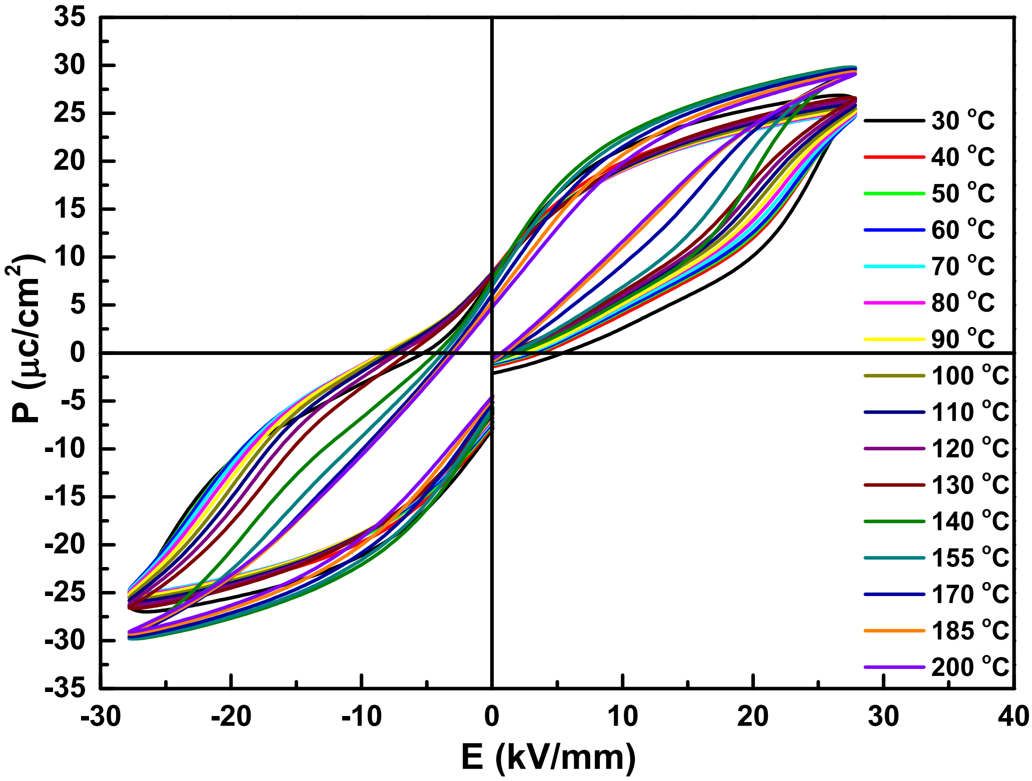

Fig. S10 Temperature-dependent P-E hysteresis loops at 10 Hz of the NN-0.05CZ sample.

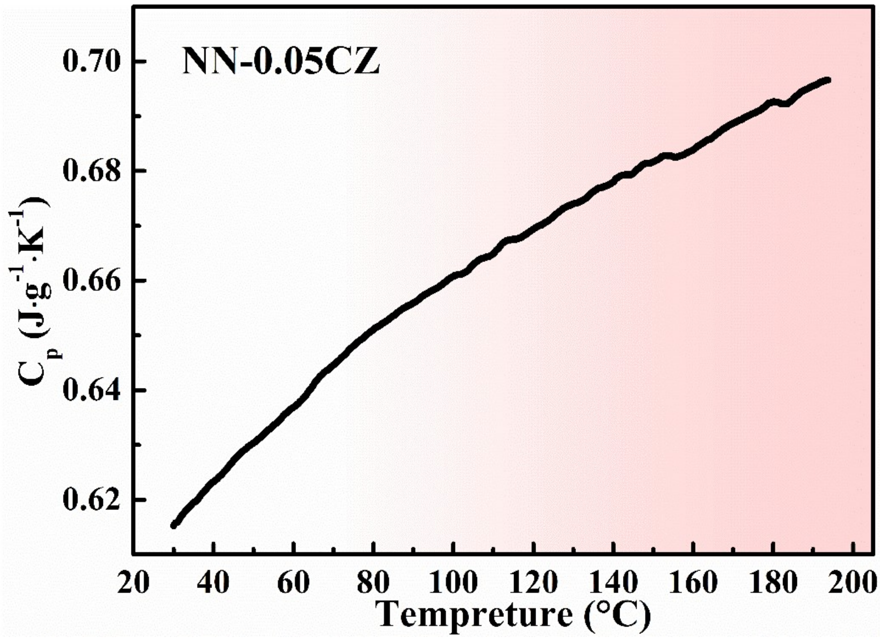

Fig. S11 Temperature dependence of the specific heat curve for the NN-0.05CZ ceramic.

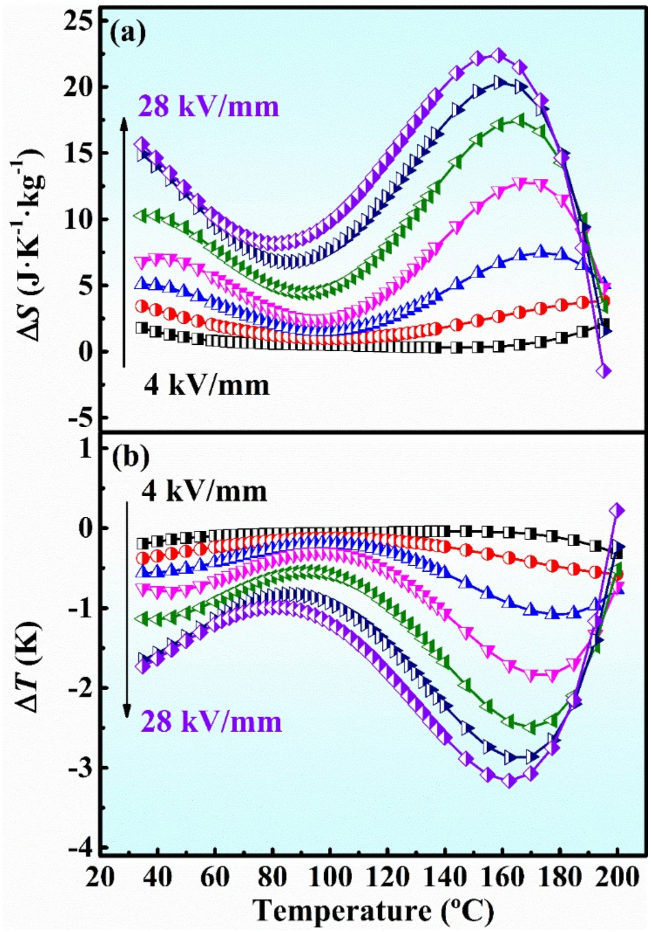

Fig. S12 The ECE (a) ΔS and (b) ΔT for the NN-0.05CZ sample under different applied fields, which exhibits excellent ECE compared with other lead-free ceramics.[1-7]

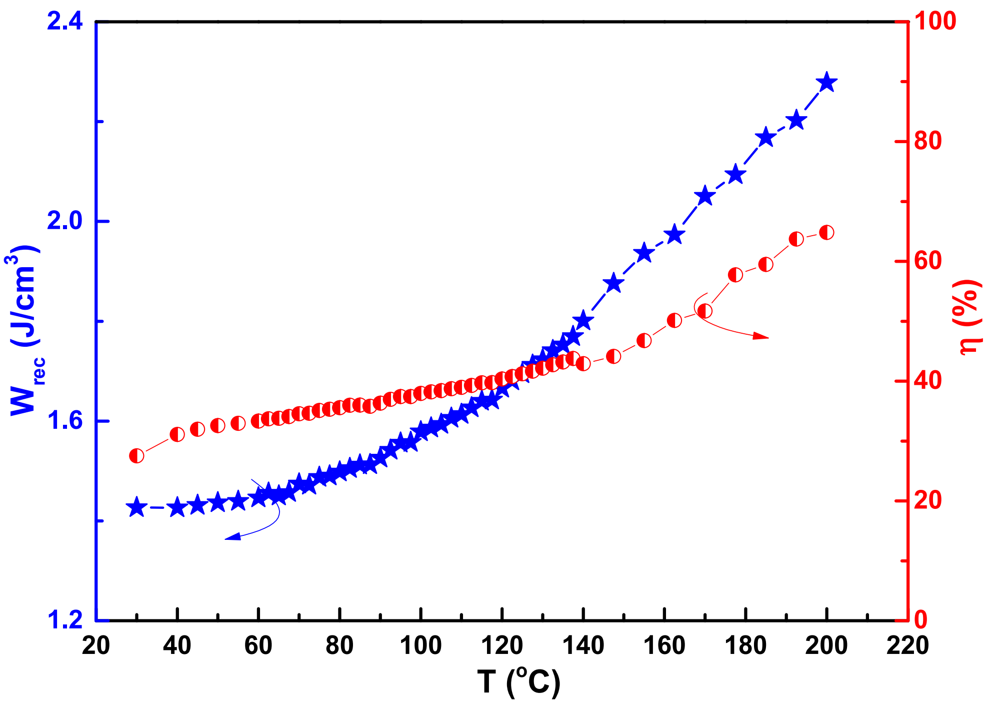

Fig. S13 The temperature dependent recoverable energy storage density W_{rec} and efficiency η of the NN-0.05CZ ceramic.

W_{rec} and η can be calculated as follows:

$$W_{rec} = \int_{P_r}^{P_{max}} E \, dP$$

$$W_{total} = \int_{0}^{P_{max}} E \, dP$$

$$\eta = W_{rec}/W_{total}$$

where P_{max}, P_r, E and W_{total} are the maximum polarization, remanent polarization, applied electric field and total energy density.

References

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