Supporting Information

Developing a novel high performance $NaNbO_3$-based lead-free dielectric capacitor for energy storage application

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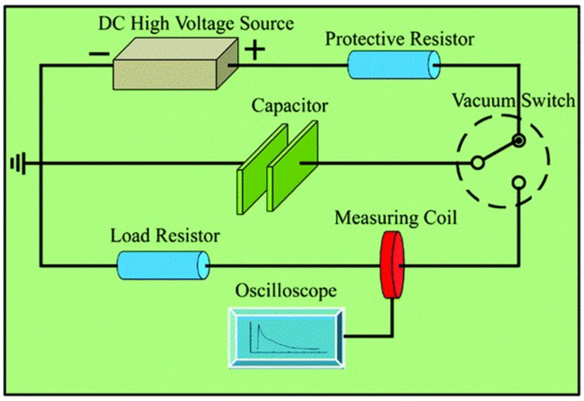

Fig. S1 A schematic of the pulsed charge-discharge platform.[1]

In order to investigate the relaxor behavior for xBBKT-NN ceramics, the modified Curie-Weiss equation is given as follow:

$$\frac{1}{\varepsilon_r} - \frac{1}{\varepsilon_m} = \frac{(T - T_m)^\gamma}{C} \quad \text{(S1)}$$

where γ is the diffuseness of a transition. The value of γ = 1 indicates a normal ferroelectric with a sharp phase transition, and it representing an typical relaxor transition with large deviation from the Curie-Weiss law when γ = 2. The plot of $\ln(1/\varepsilon_r - 1/\varepsilon_{max})$ as a function of $\ln(T\text{-}T_{max})$ for xBBKT-NN ceramics at 100 kHz is displayed in Fig. S2 by linear fitting with modified Curie-Weiss equation to calculate the γ value. The data about 100 kHz were chose here to minimize any space charge contribution to the dielectric constant. The values of γ are 2.06, 2.02, 1.92, and 1.83 for x = 0.26, 0.28, 0.30, and 0.32, respectively, which indicates strong relaxation behavior in xBBKT-NN ceramics.

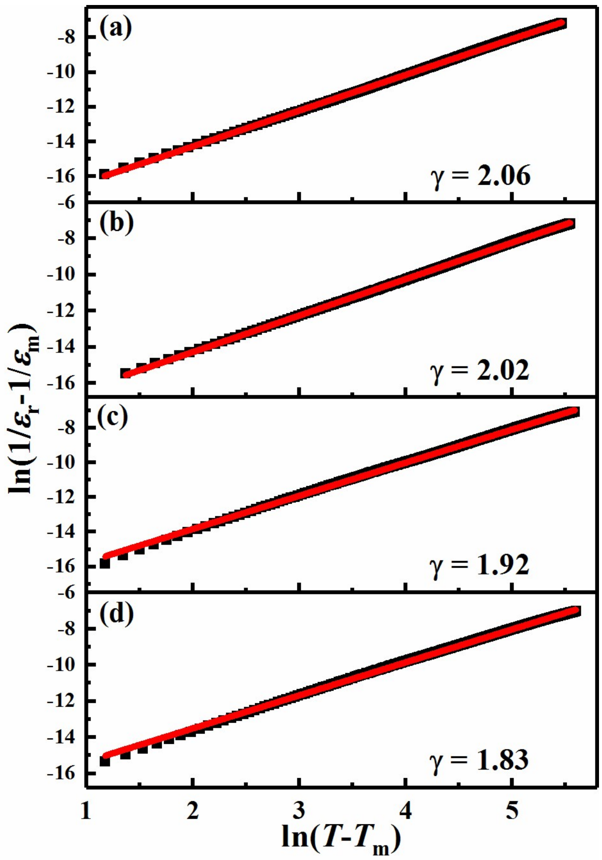

Fig. S2 Plots of ln($1/\varepsilon_r$-$1/\varepsilon_{max}$) versus ln(T-T_m) for the xBBKT-NN ceramics.

To obtain the Burns temperature (T_B, the transition temperature at which polar nano-regions appear), the temperature dependence of dielectric constant are fitted by the Curie-Weiss law:

$$\varepsilon_r = \frac{C}{T - T_{CW}} \tag{S2}$$

where C and T_{CW} are the Curie constant and Curie-Weiss temperature. The T_B value is determined as the temperature at which the reciprocal dielectric constant deviates from the Curie-Weiss relation on cooling. The data also measured at 100 kHz were used to eliminate the possible space charge effect. For the compositions with x = 0.26-0.32, the values of are in the range 202-158 °C. The relatively high T_B values indicate that the xBBKT-NN ceramics belong to relaxor ferroelectric state at room temperature.

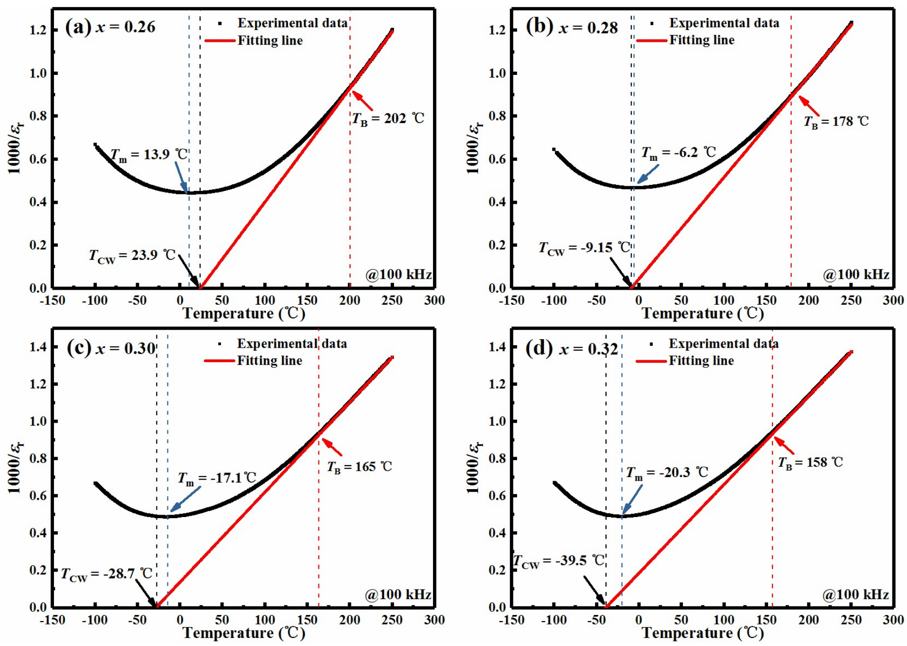

Fig. S3 1000/ versus temperature curves of the *x*BBKT-NN ceramics. The experimental data were fitting by Curie-Weiss law (red lines).

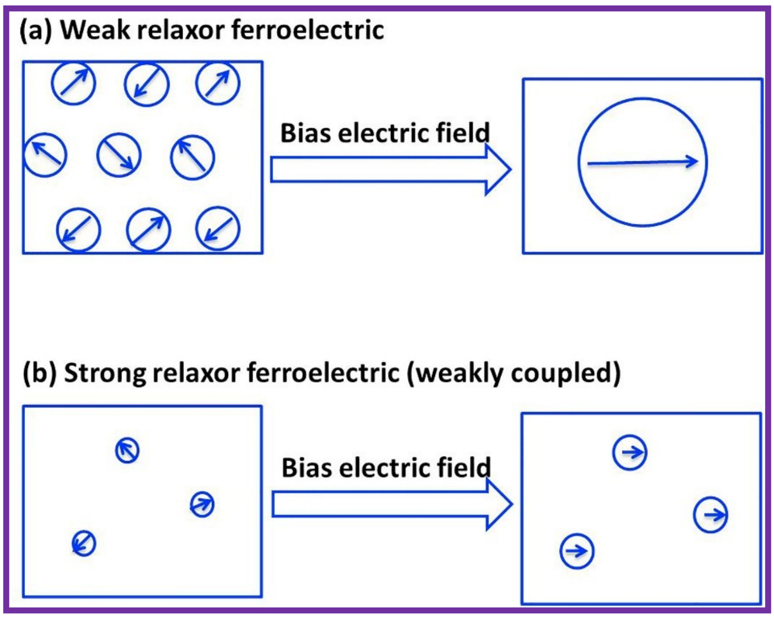

Fig. S4 The evolution of polar nano-regions under a bias field for the (a) weak relaxor ferroelectric and (b) strong relaxor ferroelectric (weakly coupled).[2]

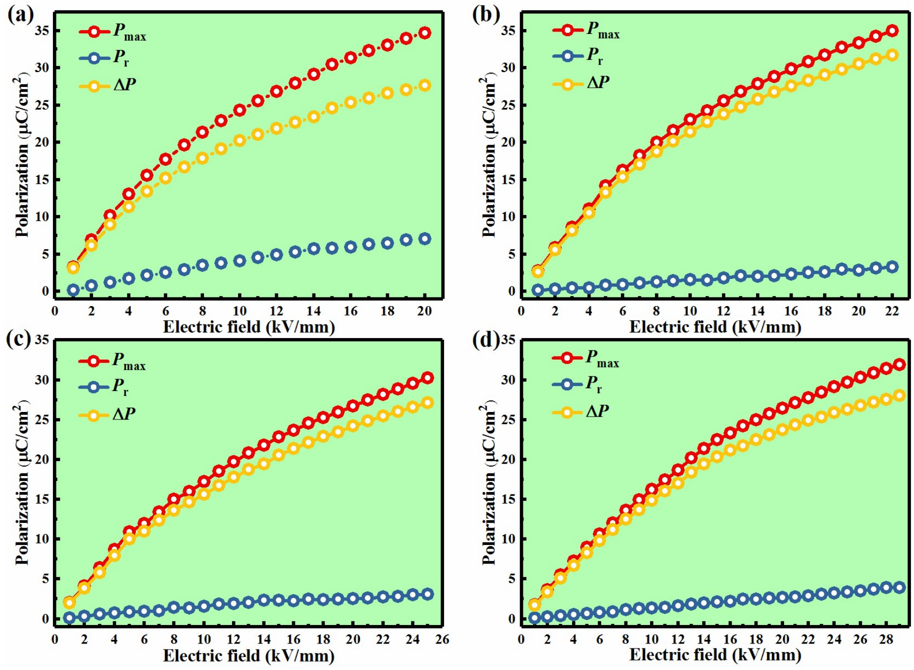

Fig. S5 Electric filed dependences of P_{max}, P_{r}, and ΔP for the xBBKT NN ceramics: (a) $x = 0.26$, (b) $x = 0.28$, (c) $x = 0.30$, and (d) $x = 0.32$.

References

1. Y. Li, N. Sun, J. Du, X. Li and X. Hao, *J. Mater. Chem. C,* 2019, **7**, 7692-7699.
2. X. Zhao, R. Liang, Z. Zhou and X. Dong, *Ceram. Int.*, 2017, **43**, 14473-14475.