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Supporting Information

Developing a novel high performance NaNbO₃-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 *x*BBKT-NN ceramics, the modified Curie-Weiss equation is given as follow:

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

where γ is the diffuseness of a transition. The value of $\gamma = 1$ 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 $\gamma = 2$. The plot of $\ln(1/\varepsilon_r - 1/\varepsilon_{max})$ as a function of $\ln(T - T_{max})$ for *x*BBKT-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 *x*BBKT-NN ceramics.



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

To obtain the Burns temperature ($T_{\rm B}$, 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 *x*BBKT-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 *x*BBKT NN ceramics: (a) x = 0.26, (b) x = 0.28, (c) x = 0.30, and (d) x = 0.32.

References

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