Supporting Information

Developing a novel high performance NaNbO$_3$-based lead-free dielectric capacitor for energy storage application

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

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

where $\gamma$ 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 $\ln(1/\varepsilon_r - 1/\varepsilon_{\text{max}})$ as a function of $\ln(T - T_{\text{max}})$ for $x$BBKT-NN ceramics at 100 kHz is displayed in Fig. S2 by linear fitting with modified Curie-Weiss equation to calculate the $\gamma$ value. The data about 100 kHz were chose here to minimize any space charge contribution to the dielectric constant. The values of $\gamma$ are 2.06, 2.02, 1.92, and 1.83 for $x = 0.26, 0.28, 0.30, \text{ and } 0.32$, respectively, which indicates strong relaxation behavior in $x$BBKT-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:

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

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/\(T\) 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 $P_{\text{max}}$, $P_r$, and $\Delta P$ for the xBBKT NN ceramics: (a) $x = 0.26$, (b) $x = 0.28$, (c) $x = 0.30$, and (d) $x = 0.32$.

**References**