Multifunctional oriented nanocrystalline $Pb_{0.91}La_{0.06}Zr_{0.8}Ti_{0.2}O_3$ relaxor ferroelectric thin film for chip power and thermal management

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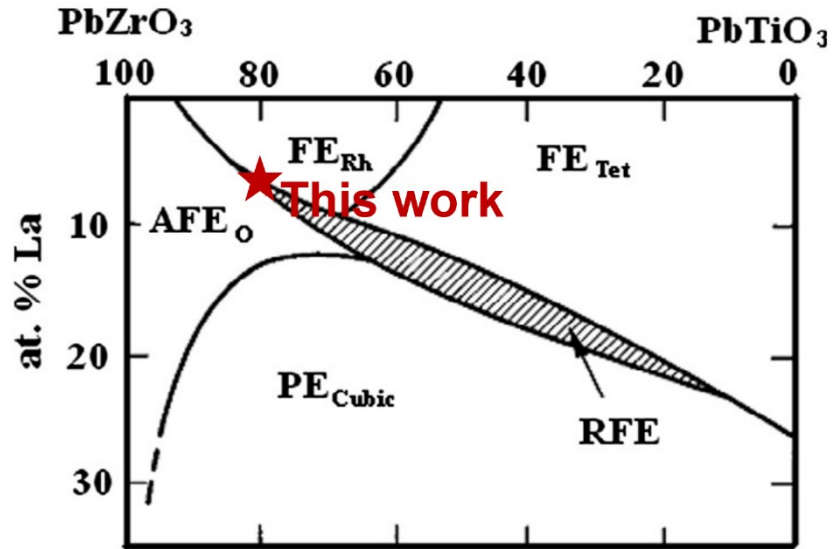
Prof. Y. Bai, Email: baiy@mater.ustb.edu.cn

Fig. S1. The phase diagram of (PbLa)(Zr,Ti)O$_3$ system; the investigated composition in this work is located on the red star.
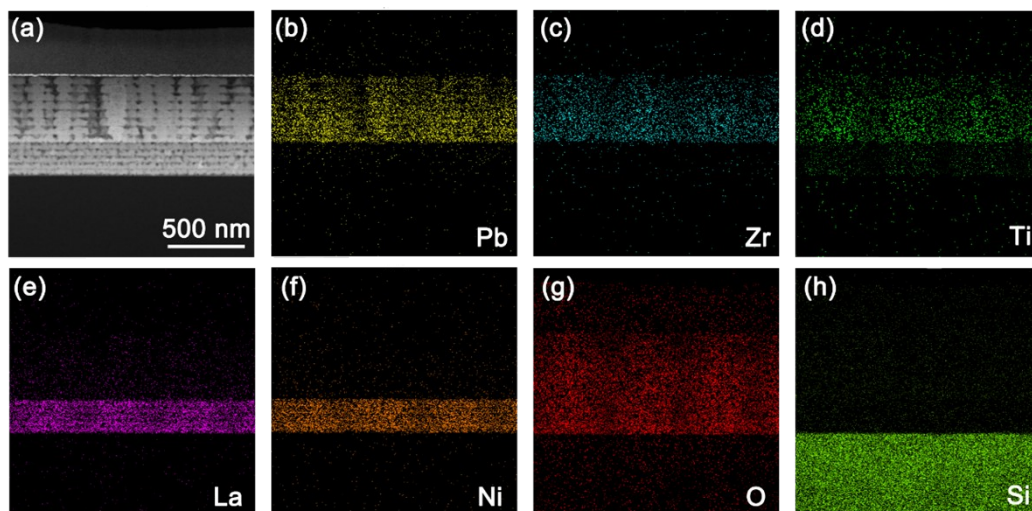

Fig. S2. (a) HAADF- STEM image and (b-h) elemental distribution mapping of the PLZT/LNO/Si thin film.
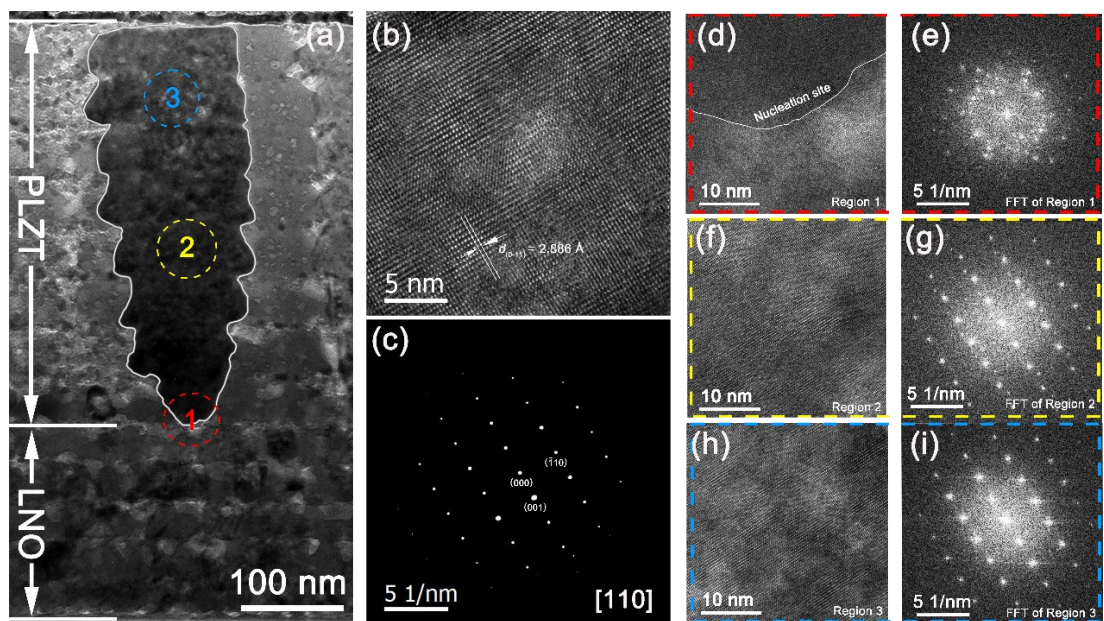
Fig. S3. (110)-oriented grain structure of the PLZT 6/80/20 thin film. (a) [110] direction grain morphology (inside the white solid line); (b) HRTEM atomic image and (c) SAED patterns of the grain viewing from the [110] direction; (d-i) separately show the morphology and corresponding FFT images of region 1, 2 and 3 inside the grain of (a).
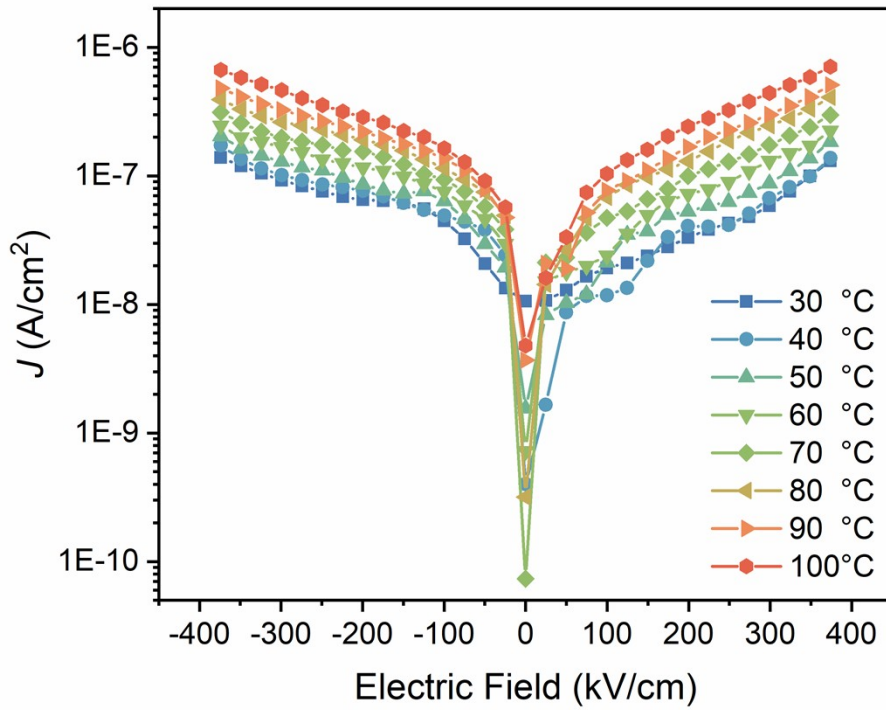
Fig. S4. The leakage current density-electric field (*J*–*E*) plots of the PLZT 6/80/20 film
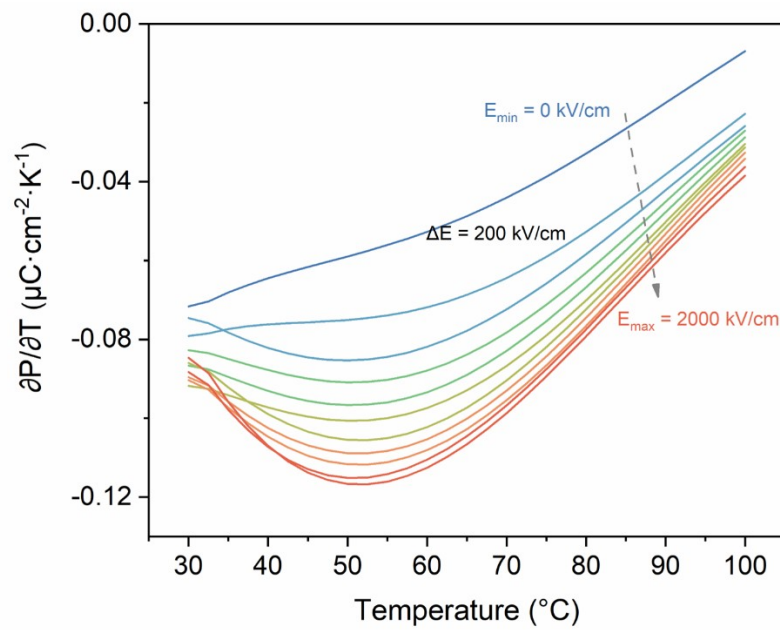
measured under different temperatures

Fig. S5. $\partial P/\partial T$ obtained from six-order polynomial fitting of raw *P–T* data
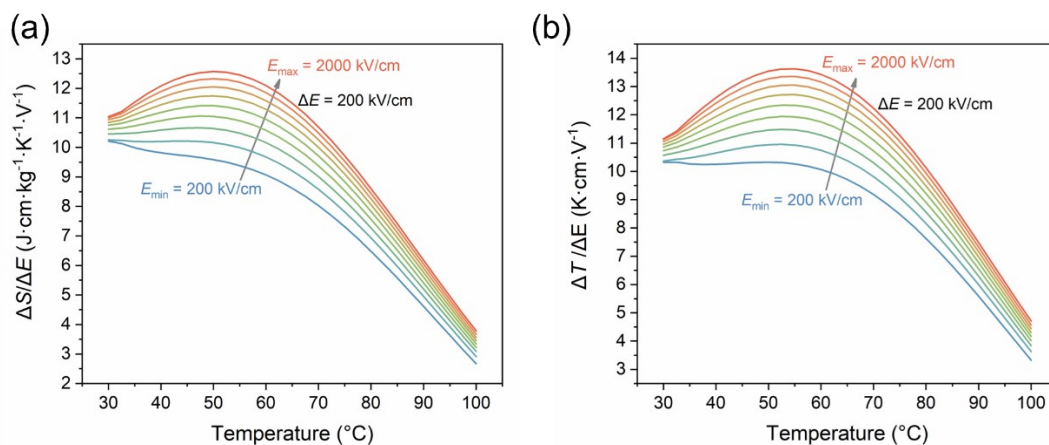
Fig. S6. Electrocaloric strength of the PLZT 6/80/20 thin film. (a) isothermal entropy change strength and (b) adiabatic temperature change strength.
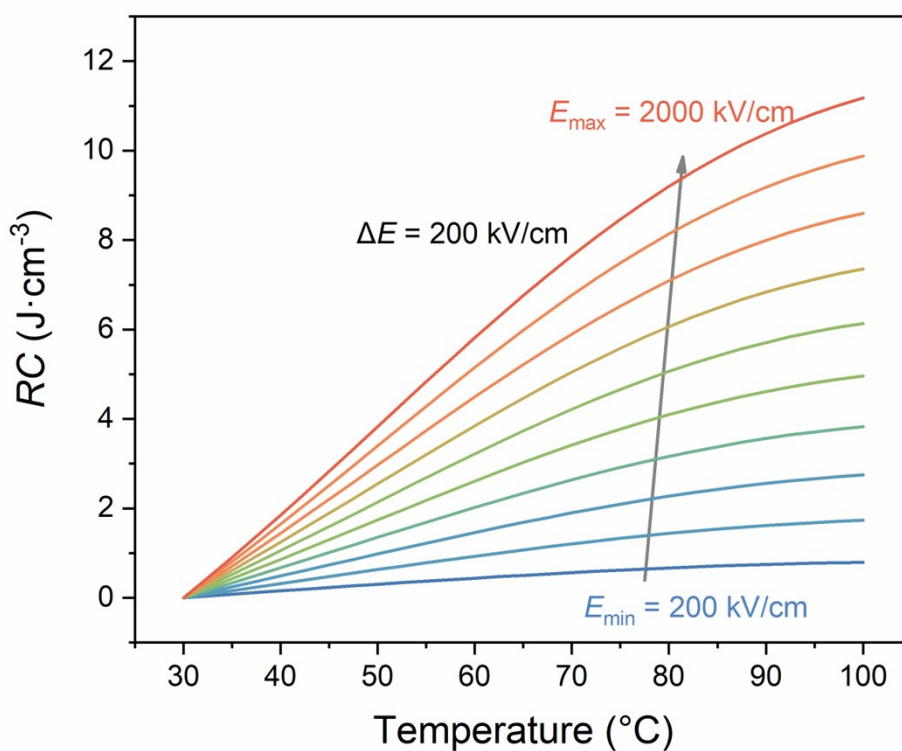

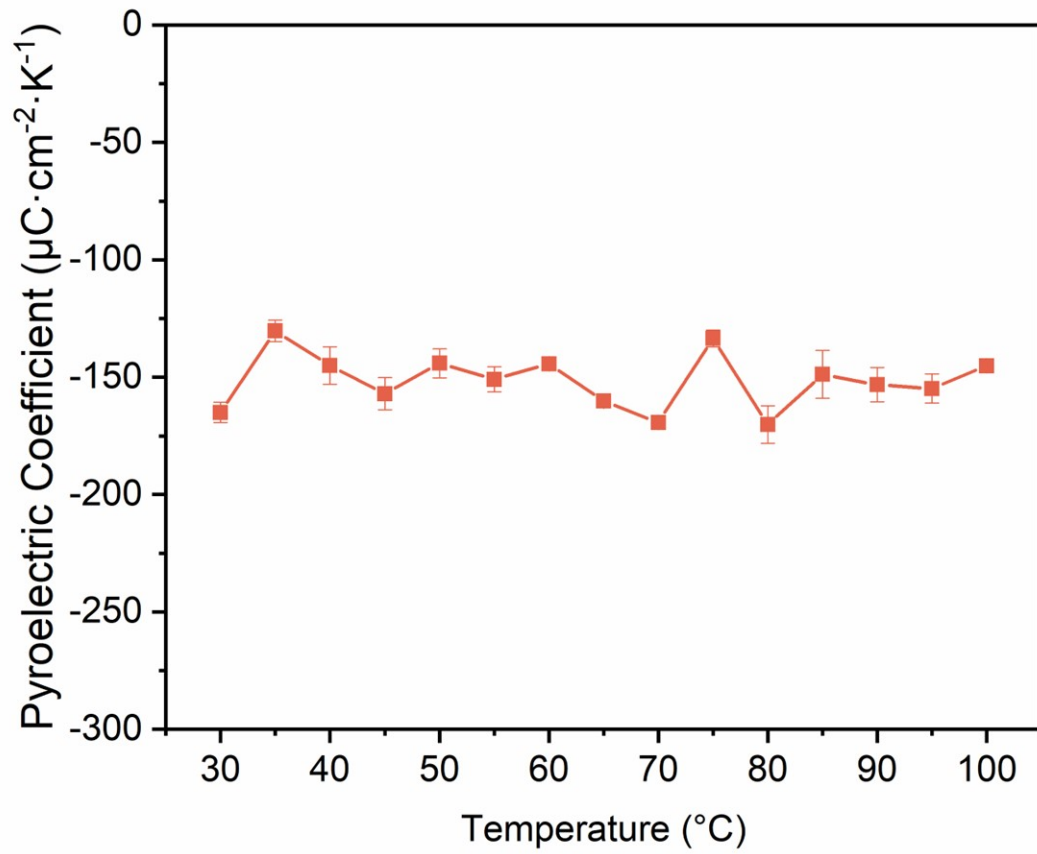**Fig. S7.** Refrigerant capacity of the PLZT 6/80/20 thin film at different electric field.

Fig. S8. The pyroelectric coefficient of the PLZT 6/80/20 thin film within the temperature range of 30 ~ 100 °C.