Electronic Supplementary Information

Anisotropic temperature-electric field phase diagrams and domain structure evolutions in rhombohedral Mn-doped PIN-PMN-PT single crystals

Yaming Zhou[a], Qiang Li*[a], Chao Xu[a], Fangping Zhuo[a], Donglin Liu[a], Qingfeng Yan[a], Yiling Zhang[b] and Xiangcheng Chu[b]

[a.] Department of Chemistry, Tsinghua University, Beijing 100084, China

[b.] State Key Laboratory of New Ceramics and Fine Processing, Tsinghua University, Beijing 100084, China.

*E-mail: qiangli@mail.tsinghua.edu.cn

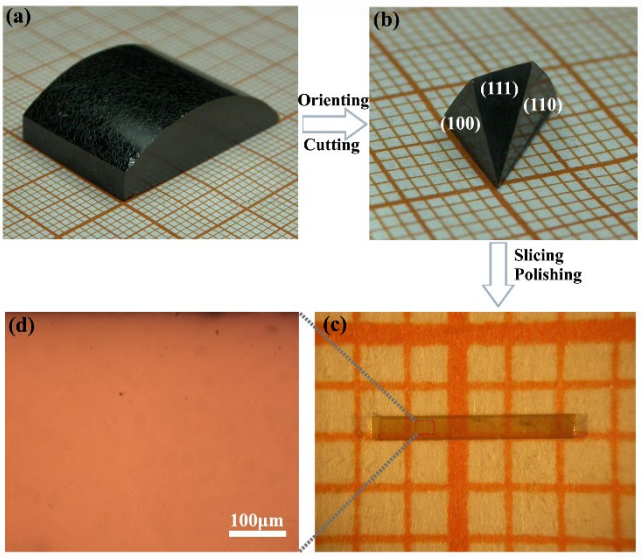

Fig. S1 The experimental process of samples preparation for the domain structure observations in Mn:PIN-PMN-PT single crystals. The as-grown crystals were oriented and sliced ((a)-(b)) to the [100]-, [110]- and [111]-oriented samples with three mutually vertical surfaces of (100)/(010)/(001), (001)/(110)/$(1\bar{1}0)$ and (111)/$(1\bar{1}0)$/$(11\bar{2})$within the pseudocubic coordinates, respectively. And then the crystals with optical surface were polished to a thickness of ~100 μm ((c)-(d)). A smooth surface of thin crystals can meet the conditions of domain structure observation under a crossed polarized light microscope.

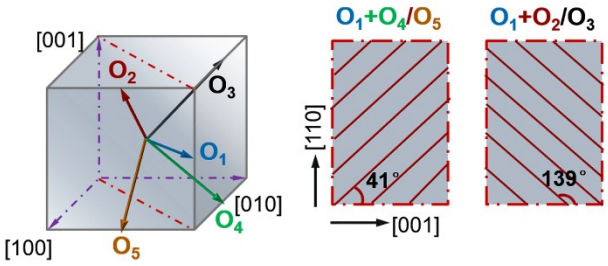

Fig. S2 Permissible domain configurations and the 60° domain patterns at 130 °C in [110]-oriented Mn:PIN-PMN-PT single crystals. When electric field is removed, the single-domain state (1O) is not stable and partly depolarize into polydomain state. In the [110]-poled crystal analyzed in this work, the four types of 60° domain twins are formed with a dominated [110] domain variant and four adjacent domain variants. The traces of these twin domain walls on $(1\bar{1}0)$ planes form 41° or 139° angles with respect to [001].

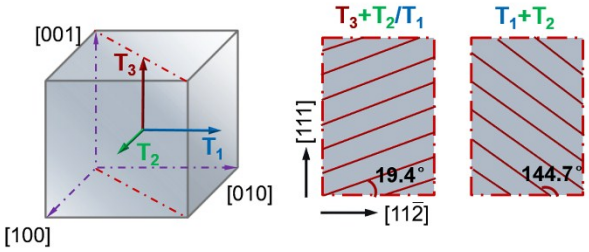

Fig. S3 Permissible domain configurations and the 90° domain patterns at 140 °C in [111]-oriented Mn:PIN-PMN-PT single crystals with 3T engineered domain configuration. The traces of the domain walls on $(1\bar{1}0)$ planes form 19.4° or 144.7° angles with respect to $[11\bar{2}]$.

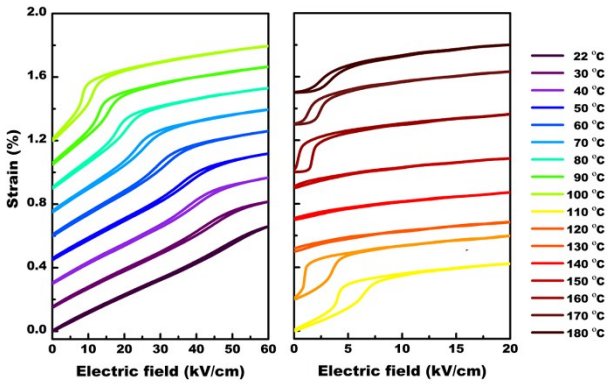

Fig. S4 Unipolar strain-electric field loops for [100]-oriented Mn:PIN-PMN-PT single crystals at various temperatures.

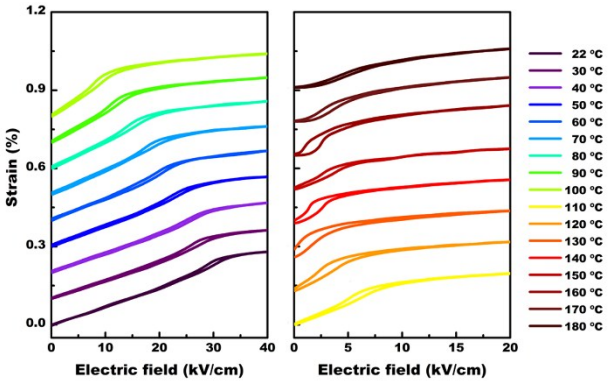

Fig. S5 Unipolar strain-electric field loops for [110]-oriented Mn:PIN-PMN-PT single crystals at various temperatures.

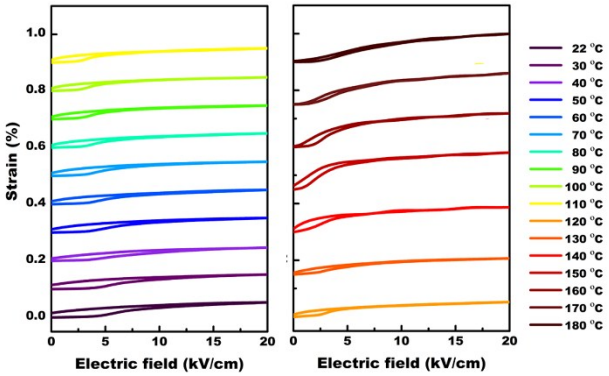

Fig. S6 Unipolar strain-electric field loops for [111]-oriented Mn:PIN-PMN-PT single crystals at various temperatures.