

## Electronic Supplementary Information (ESI)

### Silver niobate-based lead-free ceramics with high energy storage density

Zhongna Yan, Dou Zhang, Xuefan Zhou, He Qi, Hang Luo, Kechao Zhou, Isaac Abrahams and Haixue Yan

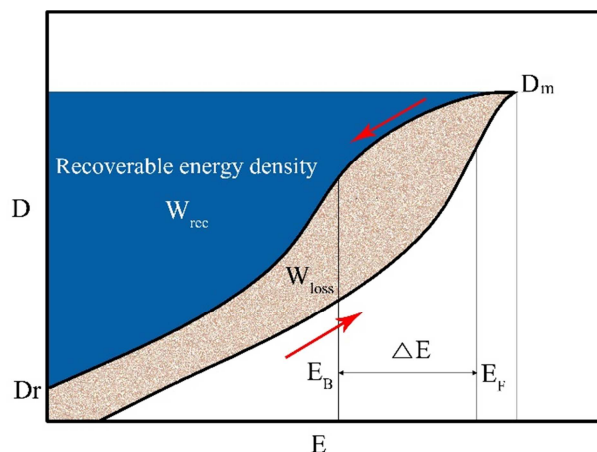


Figure S1 Schematic illustration showing how energy storage density can be obtained for an antiferroelectric ceramic from a unipolar  $D$ - $E$  loop. The recoverable energy density ( $W_{rec}$ ) and energy density loss ( $W_{loss}$ ) are represented by the blue and the light brown areas, respectively. The red arrows indicate the charging and discharging processes.

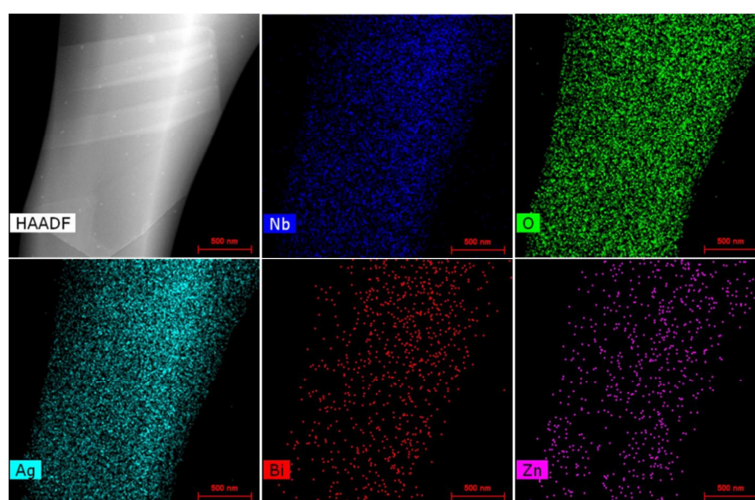


Figure S2 Element maps the showing a uniform distribution of the constituent elements Ag, Bi, Nb, Zn and O for the  $x = 0.010$  ceramic.

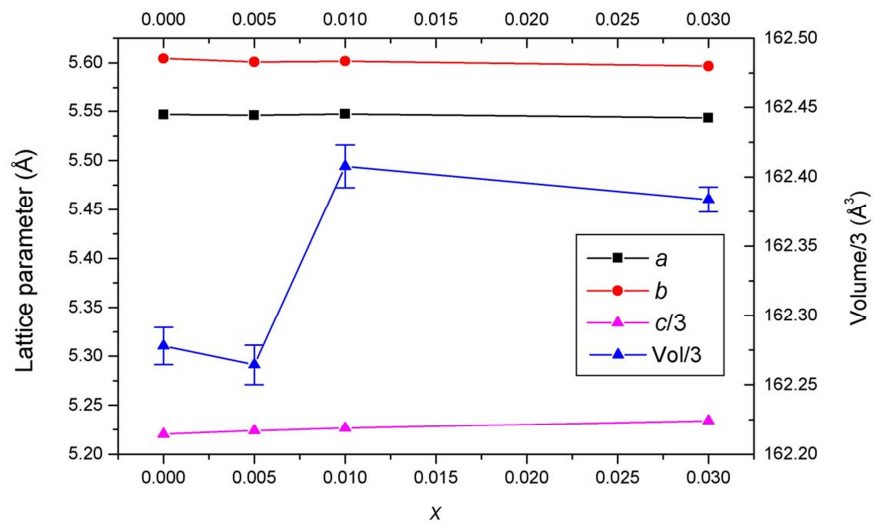


Figure S3 Compositional variation of pseudo-cubic lattice parameters in the  $(1-x)\text{AN}-x\text{BZN}$  ceramics (where the  $c$ -parameter and the volume of the pseudo cubic cell are 1/3 of those in the  $Pbcm$  model).

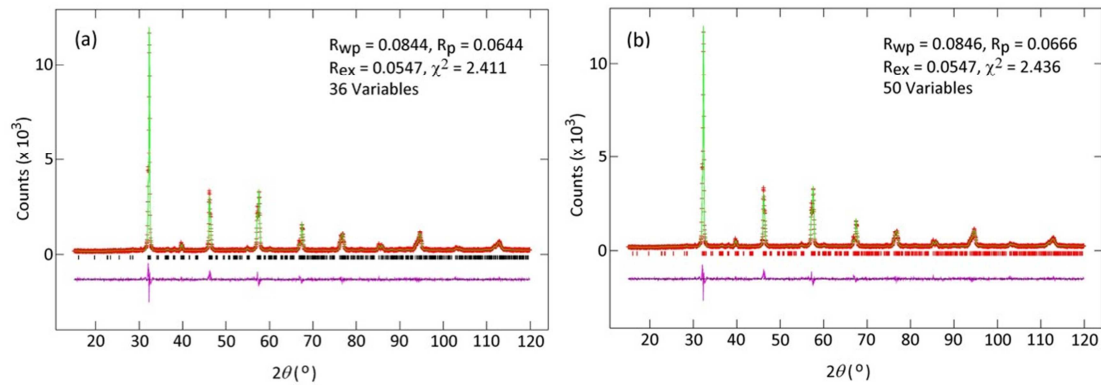


Figure S4 Fitted diffraction profiles the  $x = 0.010$  crushed ceramic powder showing fits using (a)  $Pbcm$  and (b)  $Pb_{21}m$  models. Observed (red + symbols), calculated (green line), difference (magenta line) profiles are shown, with reflection positions indicated by markers.

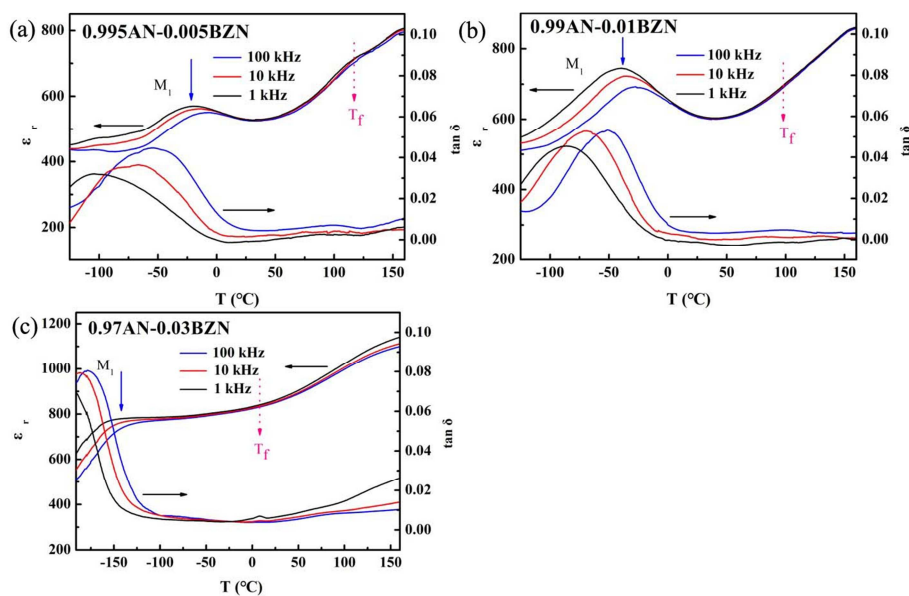


Figure S5 Low temperature dependence of relative permittivity and dielectric loss of  $(1-x)\text{AN}-x\text{BZN}$  ceramics from 1 kHz to 100 kHz. The dielectric anomaly peak  $M_1$  is shifted to below room temperature when  $x \geq 0.005$  mol. In addition, the dielectric anomaly peak associated with the freezing temperature  $T_f$  is also shifted to lower temperature and approximately shifted to 10 °C for the  $x = 0.030$  composition.

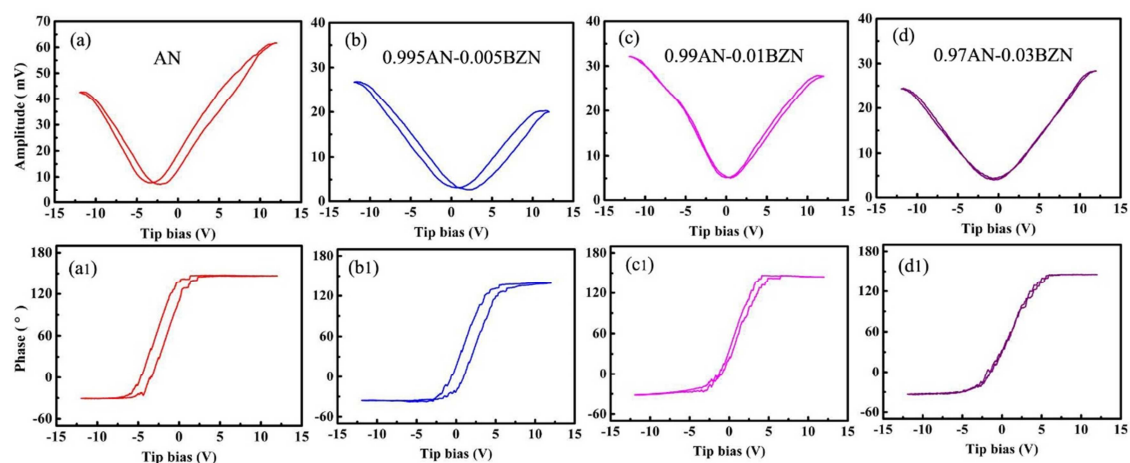


Figure S6 (a-d) Local butterfly and (a1-d1) phase angle loops of  $(1-x)\text{AN}-x\text{BZN}$  ceramics, measured under a tip bias voltage of 12 V.

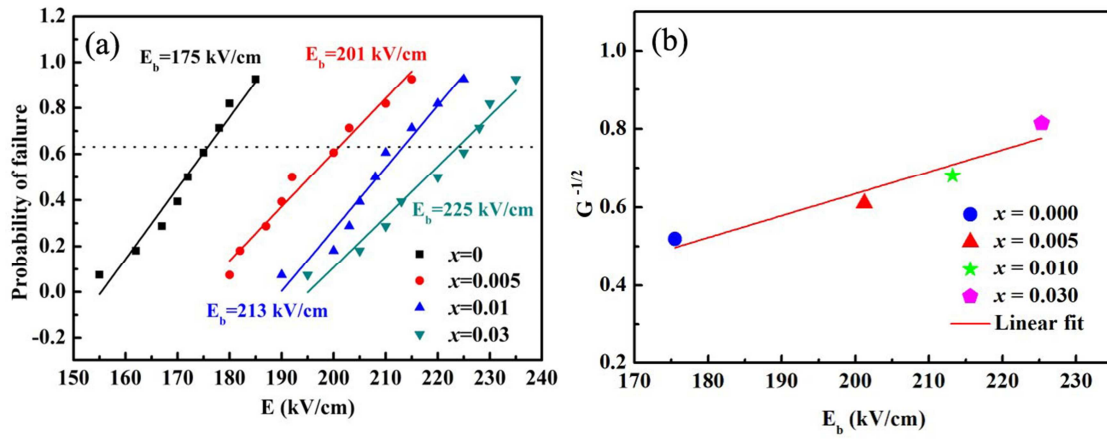


Figure S7 Weibull plots of dielectric breakdown strength (a) and variation of  $G^{-1/2}$  vs.  $E_b$  (b) for (1-x)AN-xBZN ceramics. The average  $E_b$  can be determined by finding the value of  $E_b$  corresponding to a cumulative probability of 63.2% from the fitted two-parameter Weibull plots, as depicted in Figure S7a. The data  $G$  (grain size) in Figure S7b are obtained from the statistical results in Figure 1.