Supporting Informations for

High temperature stability dielectric properties of $(K_{0.5}Na_{0.5})_{0.985}Bi_{0.015}Nb_{0.99}Cu_{0.01}O_3$ ceramics with core-shell microstructures

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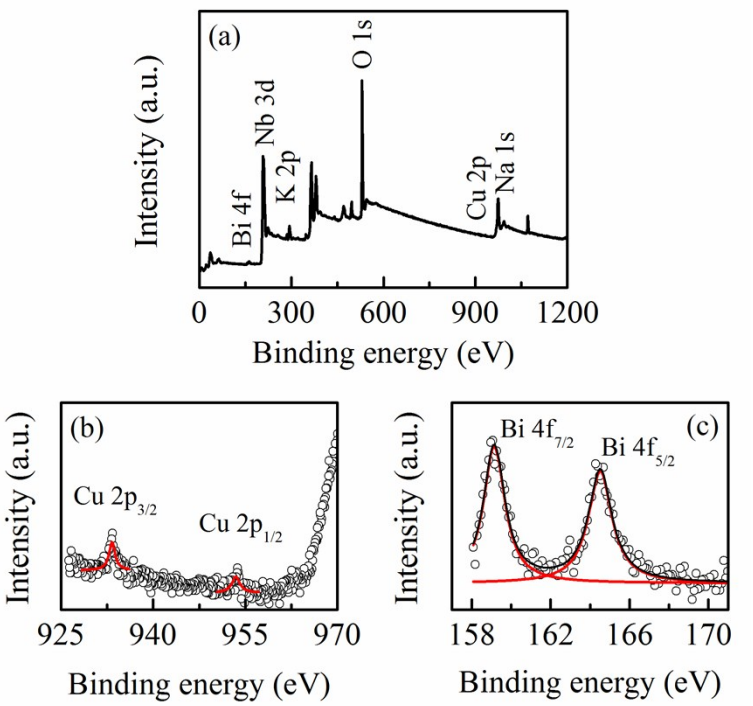

Fig. S1. (a) XPS survey spectra of KNN-0.015BC ceramic. High-resolution XPS spectra of (b) Cu 2p core levels and (c) Bi 4f core levels.

Fig. S1(a) shows the survey spectra of KNN-0.015BC ceramic, all of elements within the ceramic can be detected. To confirm the oxidation state of Cu ions, two fitting peaks by Gauss-Lorentz function for Cu 2p core levels as shown in Fig. S1(b). For KNN-0.015BC ceramic, the doped content of Cu ions is lower than 1.5%, the satellite peaks around in 940-945 eV zone are hard to detect. The typical XPS peaks of Cu (2p) at 953.6 and 933.3 eV, which is closed the value of ref. 1 and 2. It is demonstrate the existence of Cu^{2+} in KNN-0.015BC ceramic.

Fig. S1(c) displays spectra of the Bi 4f core level for KNN-0.015BC ceramic. The Bi 4f doublet consists of two peaks at 159.2/164.5 eV, which is mainly identified as a signal of Bi ($4f_{7/2}$)–O and Bi ($4f_{5/2}$)–O bonds, respectively. The spin–orbit splitting energy (Δ) of the

Bi 4f doublet is 5.3 eV, which is in good agreement with the Bi_2O_3 theoretical value (ΔBi 4f) of 5.31 eV.[3,4] From above analysis, the oxidation state of Bi ions in KNN-0.015BC ceramic is trivalent.

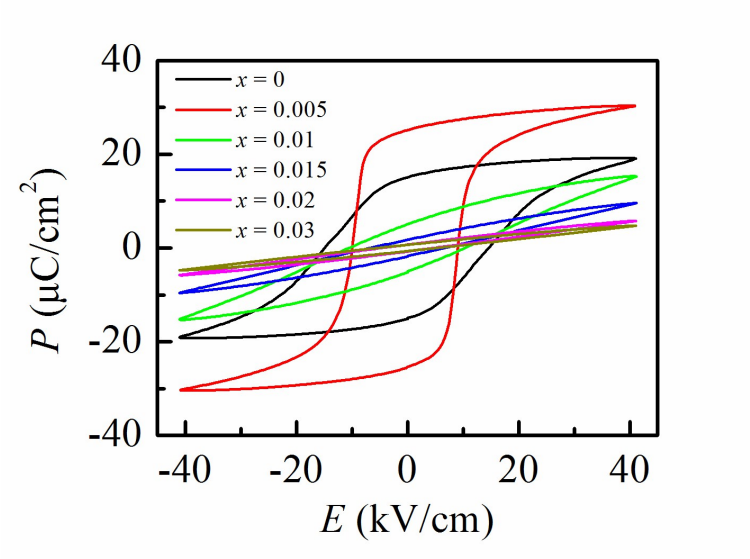

Fig. S2. *P*–*E* hysteresis loops of KNN-*x*BC ceramics.

Table S1 Summary of properties for KNN–*x*BC ceramics

Sample	Grain size (μm)	Density (g/cm^3)	ε' (150 °C)	tanδ (%) (150 °C)	Using temperature range (°C) ($\Delta\varepsilon'/\varepsilon'_{150°C} < \pm 15\%$)
$x = 0$	8	4.12	460	6.0	-
$x = 0.005$	8	4.21	425	4.9	-
$x = 0.01$	0.21	4.39	1496	2.5	89-371
$x = 0.015$	0.20	4.42	1350	2.0	40-520
$x = 0.02$	0.19	4.40	1084	2.0	29-520
$x = 0.03$	0.17	4.33	897	4.2	57-520

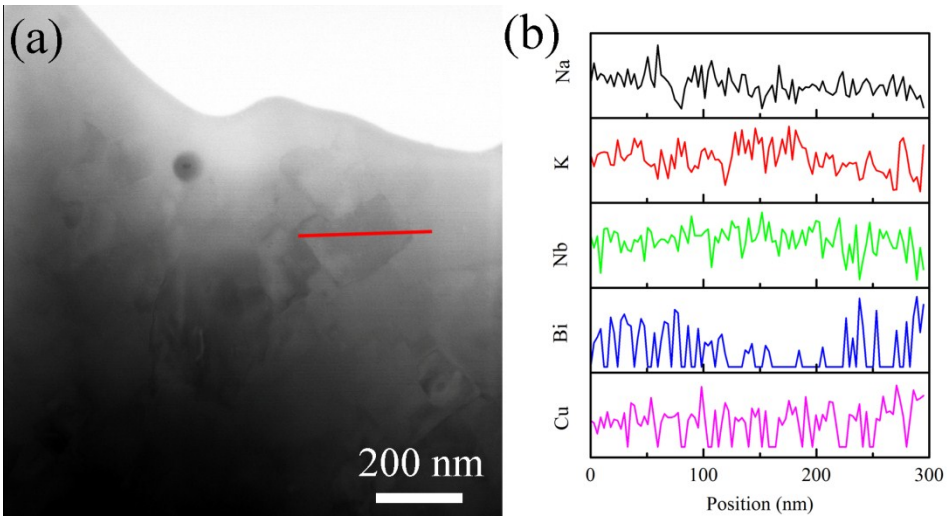

Fig. S3. TEM–EDS line scans of KNN–0.02BC ceramic. The TEM-HAADF image (a) displays the position of the line scan in relation to the core–shell grain, and EDS plots (b) show the relative elemental content along the scan. The EDS elemental line map revealed compositional segregation between the grain-interior and the outer region (shell). The outer shell was enriched in Bi element; the Na, K, Nb, and Cu levels were consistent across the entire grain.

References

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