

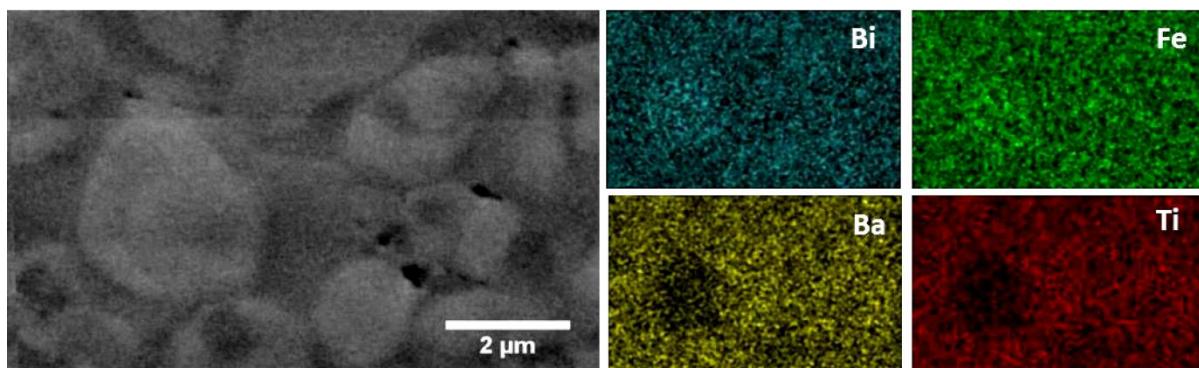
## ELECTRONIC SUPPORTING INFORMATION

### Chemical heterogeneity and approaches to its control in BiFeO<sub>3</sub>-BaTiO<sub>3</sub> lead-free ferroelectrics

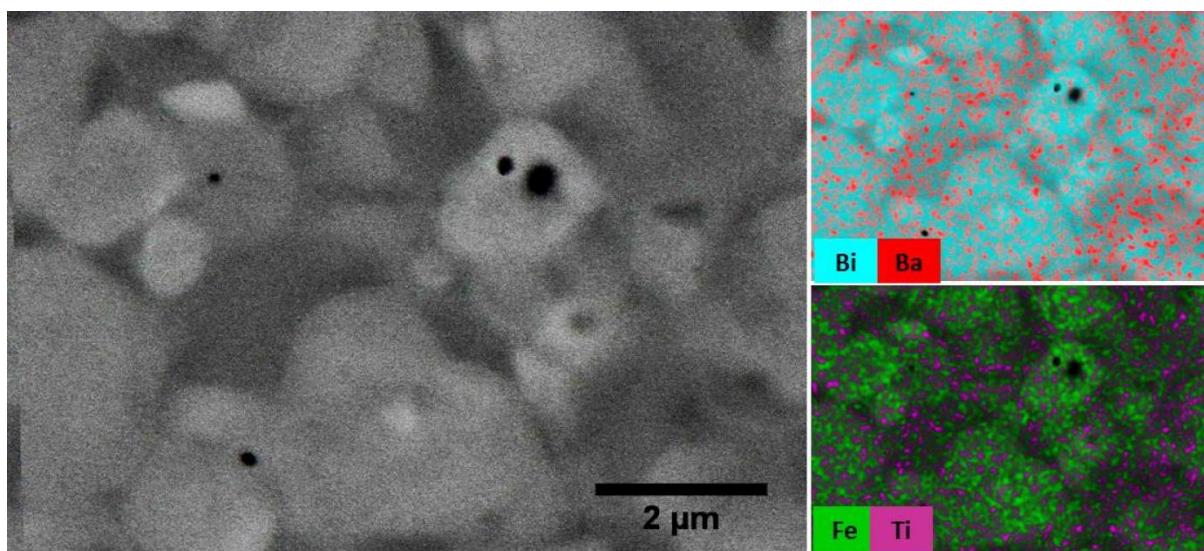
Ilkan Calisir\* and David A. Hall

*School of Materials, University of Manchester, M13 9PL, Manchester, UK*

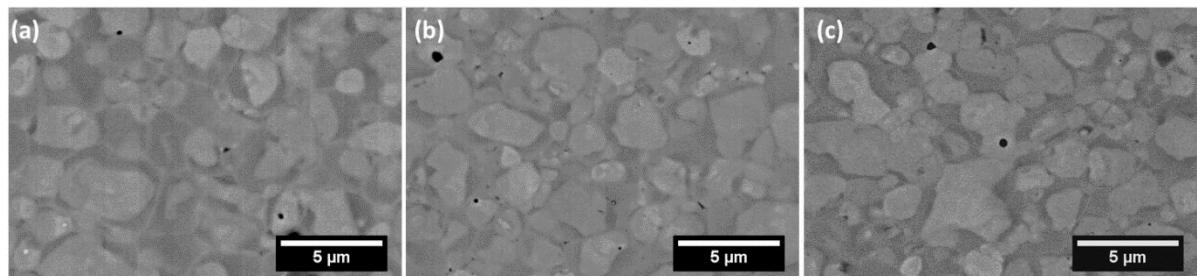
\*[ilkan.calisir@manchester.ac.uk](mailto:ilkan.calisir@manchester.ac.uk)



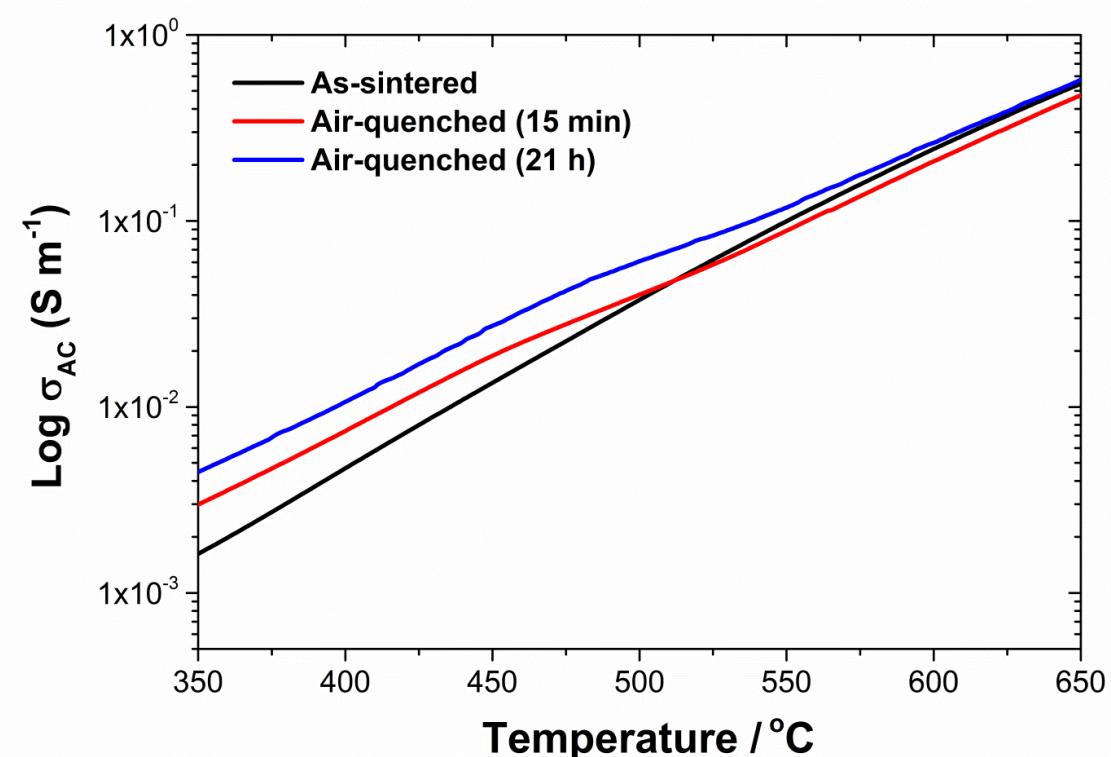
**Figure S1.** SEM-EDS elemental mapping results of air-quenched (15 min) Mn-AC ceramics. As-sintered Mn-AC was subjected to annealing at 750°C for 15 min, then directly quenched to room temperature. Brighter regions under SEM-backscattered electron mode are mostly associated with depletion of Ba and Ti elements which are prone to segregate in the shell.



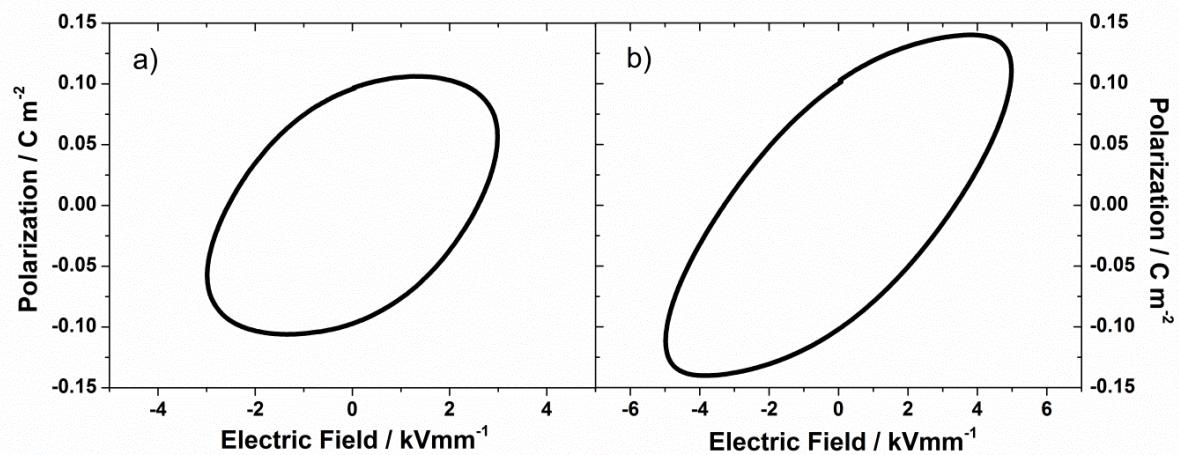
**Figure S2.** SEM-EDS elemental mapping results of air-quenched (21h) Mn-AC ceramics. As-sintered Mn-AC ceramic was annealed at 750°C for 21 h, then directly quenched to room temperature. The signals of Bi and Fe elements are prominently collected from the brighter regions under SEM-backscattered mode, which could be the evidence of persistent chemical heterogeneity in the air-quenched even after prolong annealing treatment.



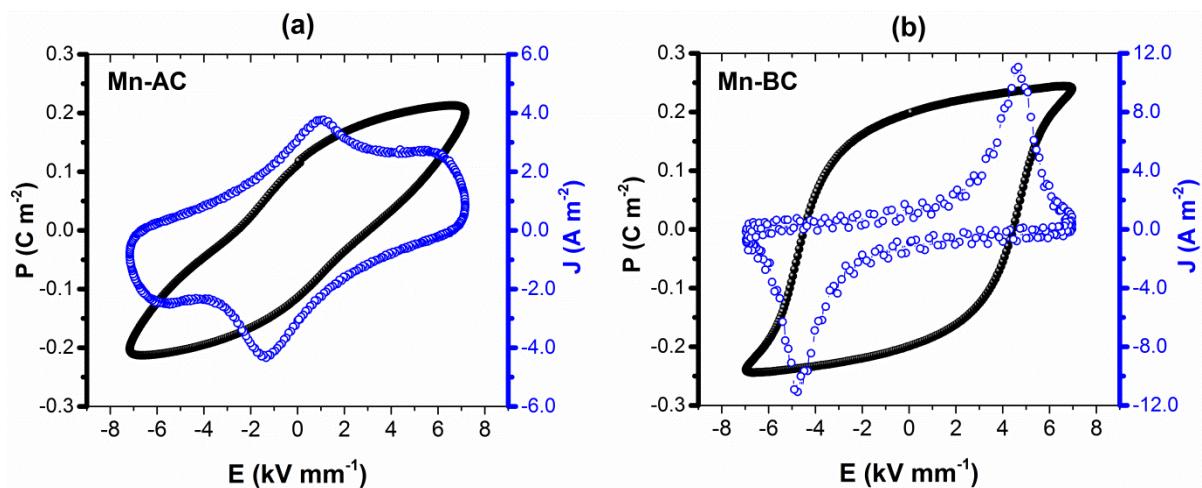
**Figure S3.** Microstructure of none-etched polished surfaces of **a)** as-sintered Mn-AC, **b)** air-quenched(15min) Mn-AC and **c)** air-quenched (21h) Mn-AC. All images were taken under SEM-backscattered mode.



**Figure S4.** Temperature dependence of AC conductivity,  $\sigma_{AC}$  for as-sintered, air-quenched (annealed at 750°C for 15 min and 21 h) Mn-AC ceramics, measured at 100 kHz.



**Figure S5.** Ferroelectric P-E hysteresis loops of **a)** undoped 75BFBT and **b)** 3 mol%  $\text{MnO}_2$  (BC). Observed rounded P-E loops indicate high conductivity without  $\text{MnO}_2$  and with excessive  $\text{MnO}_2$  addition in 75BFBT ceramics.



**Figure S6.** P-E and J-E loops of **a)** Mn-AC, and **b)** Mn-BC ceramics sintered at 1050°C for 2h.