$Bi_{1/2}Na_{1/2}TiO_3$-$SrTiO_3$: A core-shell piezoceramic for actuator applications

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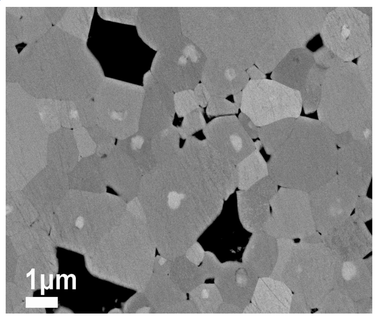
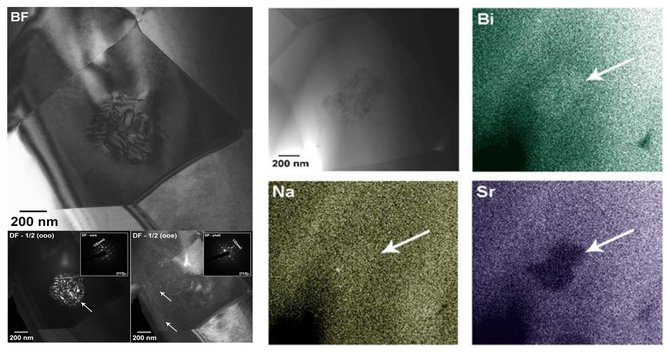
Research on increasing length scale

Microstructural Characterization

Microscopy study



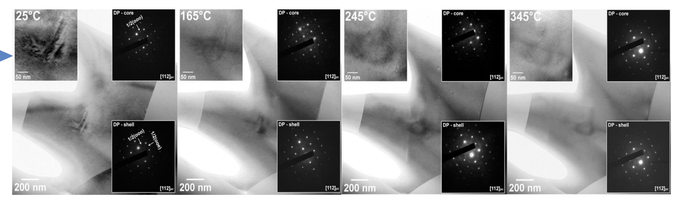
- SEM-BSE microstructure



- Core: Sr-depleted/(Bi,Na)-rich with R3c SSR
- Shell: Sr-rich/(Bi,Na)-depleted with R3c and P4bm SSR

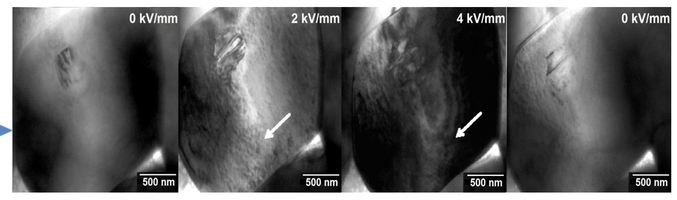
Thermodynamic variables

T



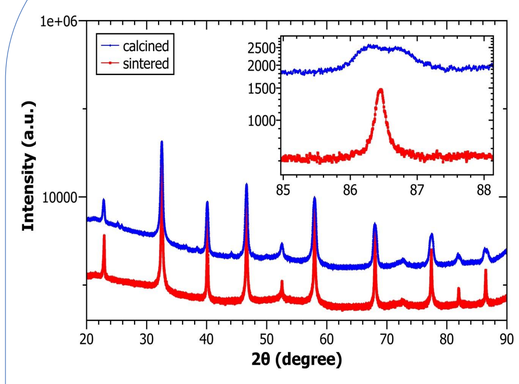
- Homogenization of domain-like contrast

E

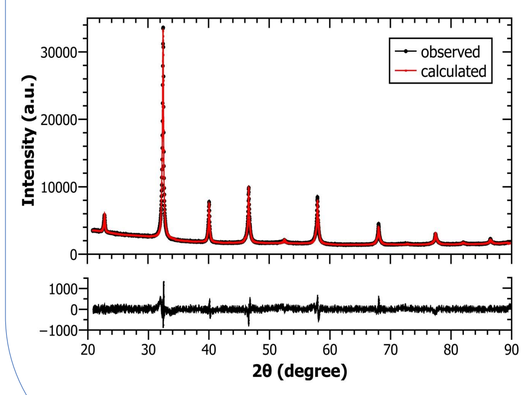


- Stable re-oriented domains in core
- Almost full reversible domain formation in shell

Diffraction study



- Perovskite structure without second phases
- Evolution from non-coherent to semi/coherent interface during sintering



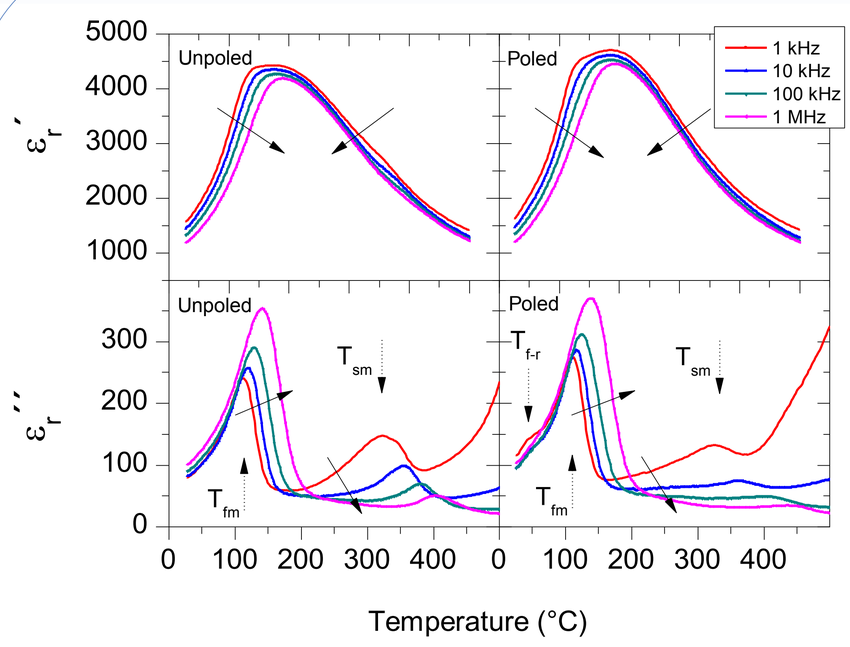
- Sintered samples
  - Peaks are sharp and narrow with non-cubic distortions
  - Coherency modifies intensity and not amplitudes of the diffracted waves

Connecting basic-knowledge

Dielectric and electromechanical properties of the $Bi_{1/2}Na_{1/2}TiO_3$ -25 mol % $SrTiO_3$ were studied as a function of temperature and frequency. This material presents a d_{33}*~600 pm/V at 4 kV/mm for input frequencies ranging from 0.1 up to 100 Hz. The system constitutes a promising lead-free candidate to replace the $Pb(Zr_xTi_{1-x})O_3$ family in stack actuator applications working in the large signal regime. The high strain of the system is attributed to a reversible electric-field induced phase transition from a mixed relaxor state (i.e., ergodic and non-ergodic coexisting states) to a ferroelectric one. The induced electric-field phase transition is aided by a core-shell structure. The core-shell evolution under field and temperature is studied by means of transmission electron microscopy and high resolution X-ray diffraction.

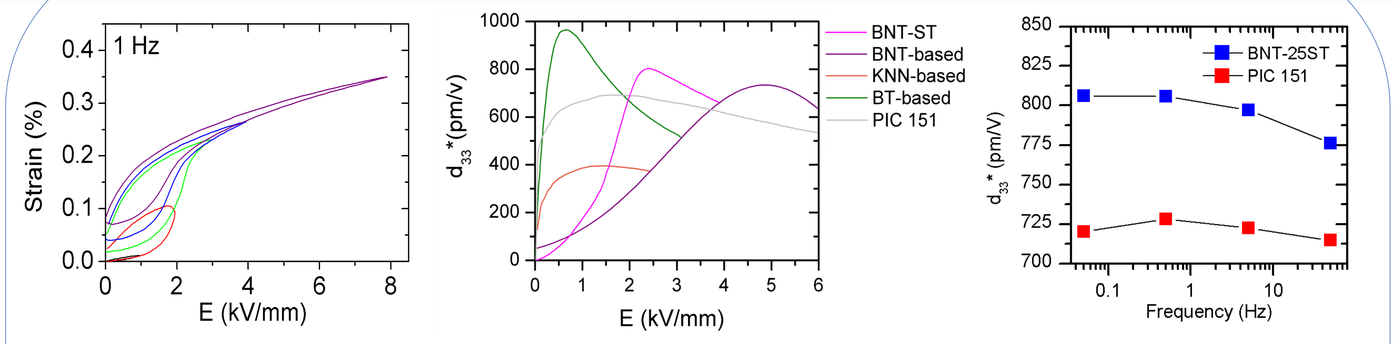
Delimiting Performance

Dielectric properties

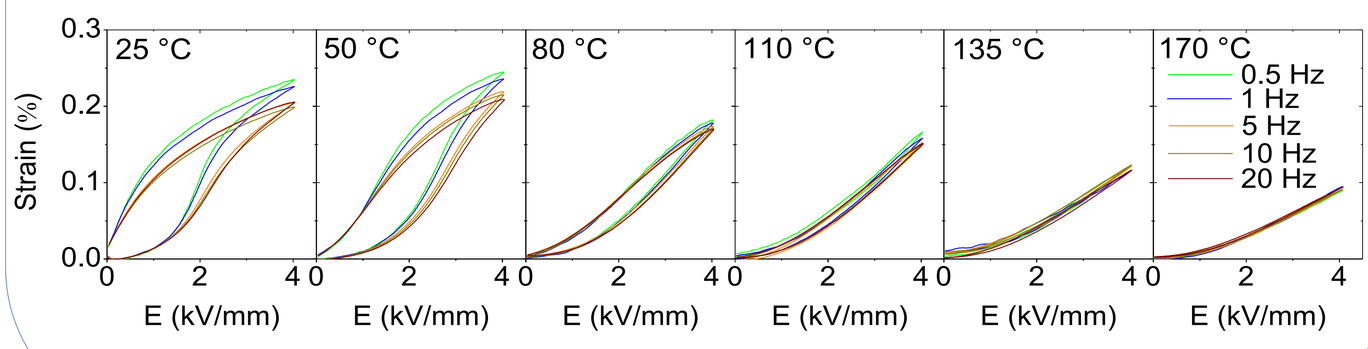


- Two local maxima T_{fm} ~110 °C and T_{sm} ~320 °C are clearly discerned in ε_r'' which are fingerprints for relaxor features
- Diffuse shoulder in ε_r'' in poled state ~70 °C: field-induced ferroelectric phase transforms into a relaxor phase ($T_{F\text{-}R}$)

Electromechanical properties



- S_{max} increases abruptly at 3 kV/mm reaching reproducible and reversible saturation at 4 kV/mm
- Reduced field operational range compared to other BNT-based materials with good frequency stability



- Operational range limited to ~80-110 °C due to thermally destabilized incipient state

Electrical Characterization

Application-oriented research

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