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Effect of sintering on structural and electrical properties of (Ba,Sr)(Zr,Ti)O3 ceramics for energy storage applications

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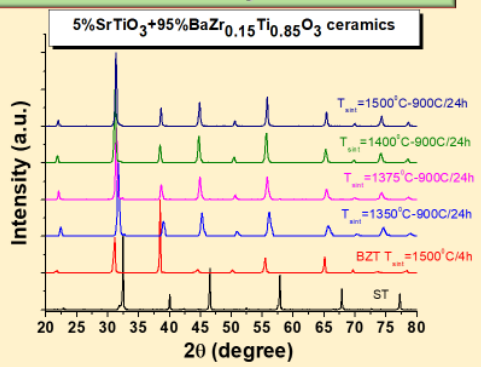
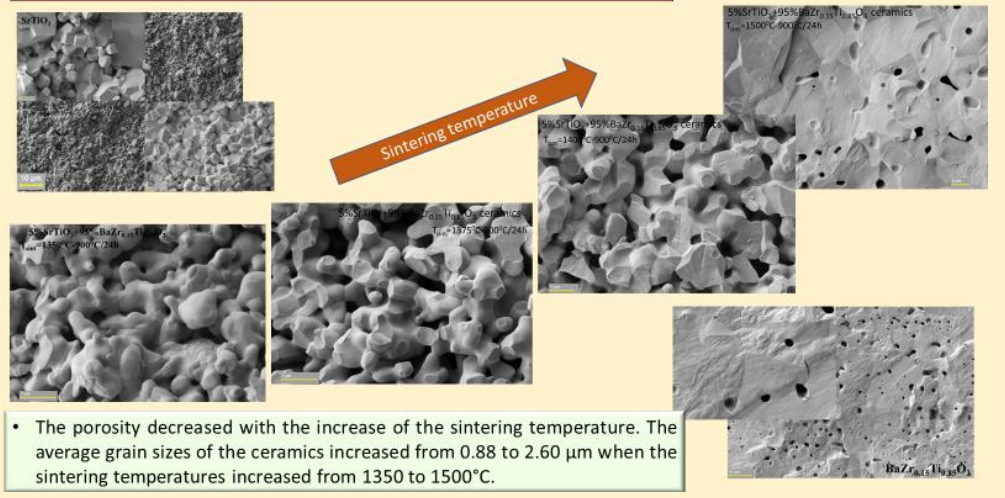
Abstract. The $SrTiO_3$ (ST) and $BaZr_{0.15}Ti_{0.85}O_3$ (BZT) powders were combined and prepared through the solid state reaction method. The mixt 5%ST+95%BZT compound was sintered at different temperatures, from 1350°C to 1500°C, and the effect of sintering temperature on structural and electrical properties has been studies. The X-ray diffraction investigation of the ST, BZT and the composite ceramics, confirmed the formation of pure perovskite phase with a cubic structure. The functional properties (dielectric, ferroelectric and non-linear properties) were investigated and discussed. The efficiency and energy storage were calculated from P(E) hysteresis loops and they have shown that the ST-BZT composites present higher storage energy and efficiency than in ST and BZT ceramic, which are making them suitable for energy storage applications.

Structural characterization by: - XRD



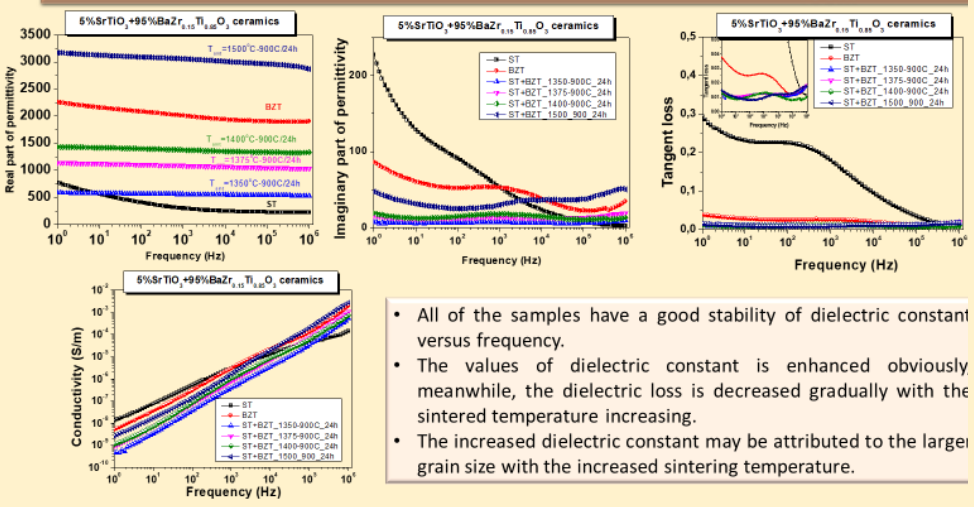
- X-ray data shows that the samples sintered at low temperatures (up to 1400C) present both ST and BZT phases.
- BZT pure ceramic as well as composite samples possess sharp and intense diffraction peaks, which indicates the high crystallinity of synthesized ceramics.

Microstructural investigation by: - SEM



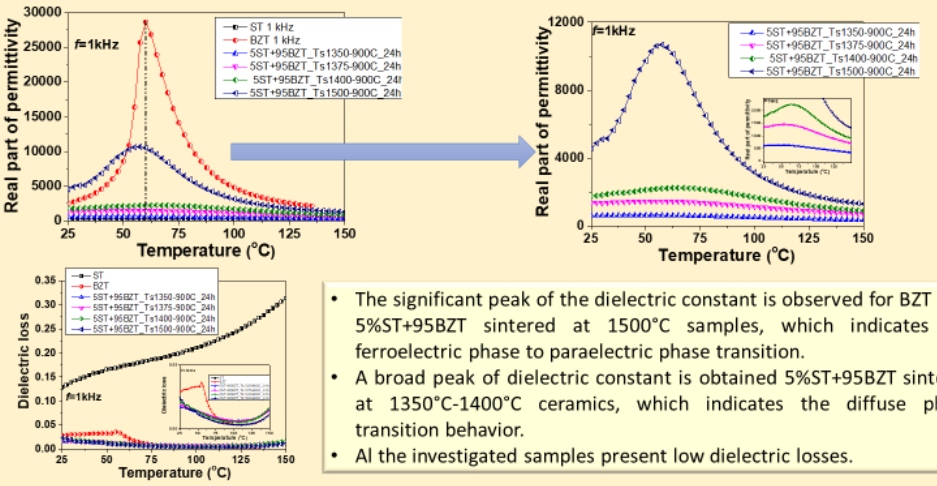
- The porosity decreased with the increase of the sintering temperature. The average grain sizes of the ceramics increased from 0.88 to 2.60 μm when the sintering temperatures increased from 1350 to 1500°C.

Dielectric properties – at low electric field and T_{room}



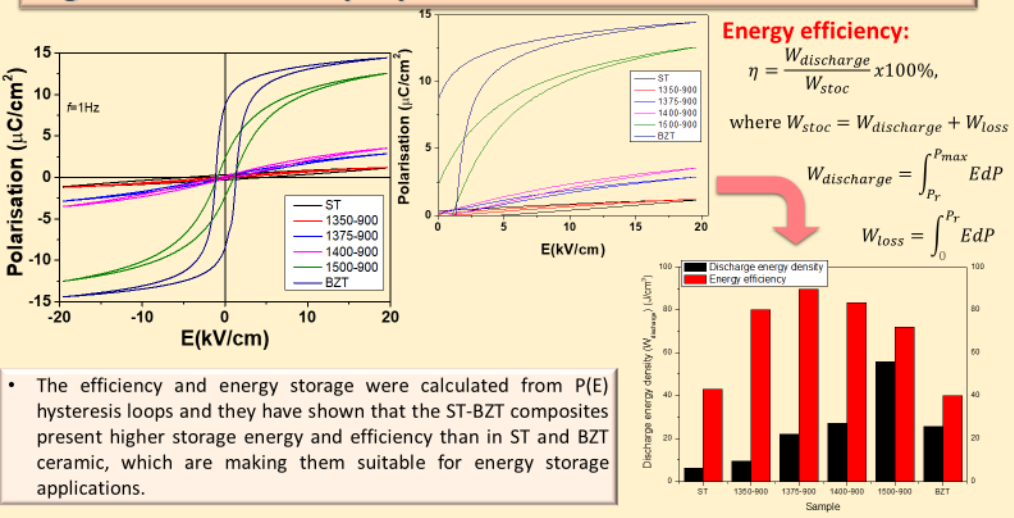
- All of the samples have a good stability of dielectric constant versus frequency.
- The values of dielectric constant is enhanced obviously meanwhile, the dielectric loss is decreased gradually with the sintered temperature increasing.
- The increased dielectric constant may be attributed to the larger grain size with the increased sintering temperature.

Dielectric properties - Phase transition behavior



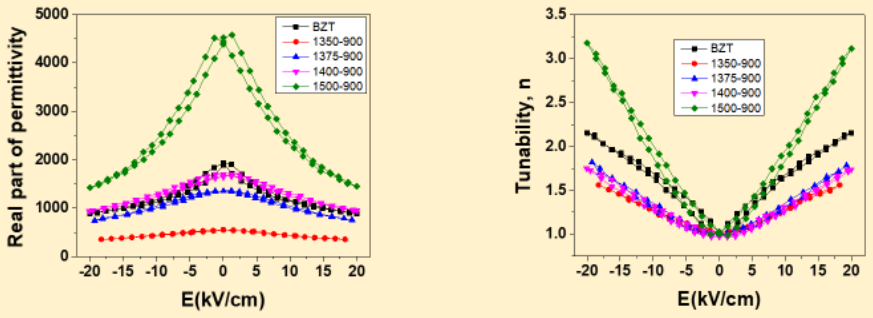
- The significant peak of the dielectric constant is observed for BZT and 5%ST+95BZT sintered at 1500°C samples, which indicates the ferroelectric phase to paraelectric phase transition.
- A broad peak of dielectric constant is obtained 5%ST+95BZT sintered at 1350°C-1400°C ceramics, which indicates the diffuse phase transition behavior.
- Al the investigated samples present low dielectric losses.

High field electrical properties



- The efficiency and energy storage were calculated from P(E) hysteresis loops and they have shown that the ST-BZT composites present higher storage energy and efficiency than in ST and BZT ceramic, which are making them suitable for energy storage applications.

• Permittivity vs. dc electric field under an increase/decrease field cycle



- The ST+BZT ceramic sintered at 1500°C shows substantially high tunability under 20 kV/cm dc electric field with very low dielectric loss value of 0.0025 at room temperature, suggesting the ST+BZT ceramics could be a promising alternative to traditional $(Ba,Zr)TiO_3$ ferroelectrics for developing high frequency tunable dielectric devices.

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