Title: Influence of Zr doping on the microstructure and dielectric behavior of $Ba_{0.9}La_{0.1}TiO_3$ ceramics

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Abstract: The current study describes the making of $Ba_{0.9}La_{0.1}Zr_xTi_{1-x}O_3$ ($0 \leq x \leq 0.10$) ceramics utilizing the usual solid state reaction method. X-ray diffraction (XRD), Raman spectroscopy, Fourier-transform infrared (FTIR) spectroscopy, transmission electron microscopy (TEM) and impedance analysis were used to study the structural, morphological, optical, and electrical characteristics. FTIR spectra indicate Ti–O bonds at around 447 cm^{-1}. As the Zr concentration goes up, the peaks shift slightly, which means that the lattice is distorted and the perovskite is formed successfully. X-ray diffraction verified the emergence of a dominant tetragonal perovskite phase (*P*4*mm* space group), the XRD patterns show no impurity peaks, indicating the samples are phase pure. TEM micrographs revealed distinct grains (∼170 nm), and EDX validated consistent elemental distribution. Raman spectra exhibited several optical phonon modes, nearly identical positions across all samples but varying $E_1(TO_2)$, $A_1(LO_3)$, $A_1(TO_1)$ mode variation arises from Zr-induced lattice distortions and relaxor behavior mode intensities. The dielectric and impedance investigations revealed that the x = 0.07 composition exhibited the greatest dielectric constant ($\varepsilon' = 501.41$) and the lowest resistances for both grain and grain boundaries. Nyquist plot analysis indicated non-Debye type relaxation, but the Maxwell–Wagner model proposed charge transfer by hopping conduction. The optical band gap dropped to 1.45 eV at x = 0.07, signifying increased electronic interaction. Thus, Zr doping efficiently reduces the band gap and adjusts the optical and transport properties, rendering these ceramics appropriate for applications in spintronics, optoelectronics, and energy-related devices.

Keywords: Solid state synthesis; Zr doping; BLT; Crystal structure; Dielectric property

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