World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:18, No:09, 2024

Polar Nanoregions in Lead-Free Relaxor Ceramics: Unveiling through Impedance Spectroscopy

Authors : Mohammed Mesrar, Hamza El Malki, Hamza Mesrar

Abstract : In this study, ceramics of (1-x)(Na0.5Bi0.5)TiO3 x(K0.5 Bi0.5)TiO3 were synthesized through a conventional calcination process (solid-state method) at 1000°C for 4 hours, with x(%) values ranging from 0.0 to 100. Room temperature XRD patterns confirmed the phase formation of the samples. The Rietveld refinement method was employed to verify the morphotropic phase boundary (MPB) at x(%)=16-20. We investigated the average crystallite size and lattice strain using Scherrer's formula and Williamson-Hall (W-H) analysis. SEM image analyses provided additional evidence of the impact of doping on structural growth under low temperatures. Relaxation time extracted from Z″(f) and M″(f) spectra for x(%) = 0.0, 12, 16, 20, and 30 followed the Arrhenius law, revealing the presence of three distinct relaxation mechanisms with varying activation energies. The shoulder response in M″(f) indirectly indicated the existence of highly polarizable entities in the samples, serving as a signature of polar nanoregions (PNRs) within the grains.In this study, ceramics of (1-x)(Na0.5Bi0.5)TiO3 x(K0.5 Bi0.5)TiO3 were synthesized through a conventional calcination process (solid-state method) at 1000°C for 4 hours, with x(%) values ranging from 0.0 to 100. Room temperature XRD patterns confirmed the phase formation of the samples. The Rietveld refinement method was employed to verify the morphotropic phase boundary (MPB) at x(%)=16-20. We investigated the average crystallite size and lattice strain using Scherrer's formula and Williamson-Hall (W-H) analysis. SEM image analyses provided additional evidence of the impact of doping on structural growth under low temperatures. Relaxation time extracted from Z″(f) and M″(f) spectra for x(%) = 0.0, 12, 16, 20, and 30 followed the Arrhenius law, revealing the presence of three distinct relaxation mechanisms with varying activation energies. The shoulder response in M″(f) indirectly indicated the existence of highly polarizable entities in the samples, serving as a signature of polar nanoregions (PNRs) within the grains.

Keywords : (1-x)(Na0.5Bi0.5)TiO3 x(K0.5 Bi0.5)TiO3, Rietveld refinement, Scanning electron microscopy (SEM), Williamson-Hall plots, charge density distribution, dielectric properties
Conference Title : ICC 2024 : International Conference on Chemistry
Conference Location : London, United Kingdom
Conference Dates : September 19-20, 2024