Advancements in Dielectric Materials: A Comprehensive Study on Properties, Synthesis, and Applications

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Abstract : The solid-state reaction method was used to synthesize ferroelectric systems with lead-free properties, specifically (1-x-y)($Na_{0.5}Bi_{0.5}$)TiO_3-x$BaTiO_3$-y($K_{0.5}$ $Bi_{0.5}$)TiO_3. To achieve a pure perovskite phase, the optimal calcination temperature was determined to be 1000°C for 4 hours. X-ray diffraction (XRD) analysis identified the presence of the morphotropic phase boundary (MPB) in the (1-x-y)NBT xBT-yKBT ceramics for specific molar compositions, namely (0.95NBT-0.05BT, 0.84NBT-0.16KBT, and 0.79NBT-0.05BT-0.16KBT). To enhance densification, the sintering temperature was set at 1100°C for 4 hours. Scanning electron microscopy (SEM) images exhibited homogeneous distribution and dense packing of the grains in the ceramics, indicating a uniform microstructure. These materials exhibited favorable characteristics, including high dielectric permittivity, low dielectric loss, and diffused phase transition behavior. The ceramics composed of 0.79NBT-0.05BT-0.16KBT exhibited the highest piezoelectric constant (d_{33}=148 pC/N) and electromechanical coupling factor (k_p = 0.292) among all compositions studied. This enhancement in piezoelectric properties can be attributed to the presence of the morphotropic phase boundary (MPB) in the material. This study presents a comprehensive approach to improving the performance of lead-free ferroelectric systems of composition 0.79($Na_{0.5}Bi_{0.5}$)Ti O_3-0.05$BaTiO_3$-0.16($K_{0.5}Bi_{0.5}$)TiO_3.

Keywords : solid-state method, (1-x-y)NBT-xBT-yKBT, morphotropic phase boundary, Raman spectroscopy, dielectric properties
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