Improved Matching Impedance Detected by Magneto-Dielectric Coupling in $Bi_{1-x}Y_xFeO_3$ ceramics for Wave Guided Antenna

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Abstract

This study explores the structural and microstructural effects of Yttrium (Y^{3+}) substitution at the Bi^{3+} site in $BiFeO_3$ (BFO), a prominent multiferroic material known for its ferroelectric, magnetic, and dielectric properties. Compositions of $Bi_{1-x}Y_xFeO_3$ with x = 0, 0.05, 0.10, and 0.15 were synthesized using the sol-gel method. The X-ray diffraction (XRD) analysis confirms a rhombohedral perovskite structure (R3c space group) with reduced lattice parameters upon Y^{3+} doping due to its smaller ionic radius. Microstructural analysis reveals a decrease in grain size and increased lattice strain, attributed to reduced diffusion rates and lattice distortion. The dielectric and magnetic properties are significantly improved, with increased impedance matching and reduced dielectric loss. Elastic and thermodynamic studies indicate a reduction in Young's modulus, bulk modulus, and Debye temperature (θ_D) due to altered bonding configurations and increased bond lengths. Frequency-dependent analyses demonstrated enhanced domain wall motion, reduced magnetic loss, and lower energy dissipation. These findings highlight the potential applications of Y^{3+}-doped $BiFeO_3$ as a promising multifunctional material for advanced applications in spintronics, sensors, microwave devices, electromagnetic interference shielding and miniature antenna.

Keywords: BYFO, Microstructure, Elastic constants, permeability, Matching Impedance