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Optical properties, dielectric relaxor behavior, impedance and modulus spectroscopy of $0.8BiFeO_3$-$0.2CaTiO_3$ composite

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HIGHLIGHTS

- Sol-gel synthesis is used to synthesize 0.8BFO-0.2CTO composites.
- Composite 0.8BFO-0.2CTO exhibits relaxor-type ferroelectric behavior.
- AC-conductivity shows NTCR behavior and follows Jonscher's power law.
- Non-Debye type relaxation phenomenon is observed with a decrement in relaxation.
- At room temperature, magneto-dielectric coupling is investigated.

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ABSTRACT

$0.8BiFeO_3$-$0.2CaTiO_3$ (0.8BFO-0.2CTO) was synthesized by the sol-gel route. Structural characterization was performed by X-ray diffraction which confirms the rhombohedral structure. FESEM analysis reveals the irregular grains that are inhomogenous and slightly dense. Temperature-dependent dielectric permittivity shows a dielectric anomaly near the magnetic phase transition temperature (T_N) of $BiFeO_3$ as well as relaxor-type ferroelectric properties. The PE loop confirms the presence of ferroelectricity in the sample. Frequency-dependent ac conductivity exhibits low frequency dispersion and was well explained by Jonscher power law. The obtained fitting parameters A (pre-exponential factor that indicates polarizability) and n (dimensionless frequency exponent) show maxima and minima at the transition temperature. The electrical properties were further analysed by impedance and modulus spectroscopy. According to these analysis, the relaxation time was distributed and does not follow the Debye type behaviour. Nyquist plots had been used to estimate grain and grain boundary contributions. A typical negative temperature coefficient of resistance (NTCR) behaviour was apparent due to the decrement in bulk and grain boundary resistances as the temperature increases. The temperature-dependent relaxation time revealed Arrhenius's behaviour. 0.8BFO-0.2CTO exhibits absorption and shows a transmittance of 40–44% in the visible region of spectra. The obtained value of E_g was ~2.26 eV, which implies the application in ultrafast optoelectronic devices. The good ability of absorption in visible region, high transmittance, the increase of extinction coefficient with wavelength, and low band gap makes 0.8BFO-0.2CTO an extraordinary material for optical devices application. The sample also shows a decrease in magneto-capacitance and increase in magneto-impedance which reflects the presence of strong magneto dielectric coupling in 0.8BFO-0.2CTO at room temperature.

1. Introduction

In multiferroics, at least two of the ferroic orders, such as ferromagnetism, ferroelectricity, and ferroelasticity, are present simultaneously. Generally, the term multiferroic refers to materials displaying both ferroelectric and ferromagnetic (or ferrimagnetic, or antiferromagnetic) orders simultaneously, whether in single phase or multiphase. Further, they show a phenomenon called the magneto-

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