Enhanced electrical, optical and magnetic properties of perovskite nanoparticles co-doped with Y and Cu

Tanmoy Kumar Ghosh[1], M. K. R. Khan[1], M. M. Rahman[1], Md. Sarowar Hossain[2], Suravi Islam[3], Nazia Khatun[3], and M. S. I. Sarker[1*]

[1]Department of Physics, Rajshahi University, Rajshahi 6205, Bangladesh

[2]Department of Physics, Faculty of Science and Technology (FST), American International University-Bangladesh (AIUB), Dhaka1229, Bangladesh

[3]Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka, Bangladesh

*Email: samiul-phy@ru.ac.bd

Abstract

The present work includes the fabrication of pure $BiFeO_3$ and $Bi_{0.9}Y_{0.1}Fe_{1-x}Cu_xO_3$ (x = 0.05, 0.10, 0.15) nanoparticles by the usual sol-gel route. The characterization of structural, morphological, optical, electrical, and magnetic properties of the synthesized samples was achieved through x-ray diffraction spectroscopy, Raman spectroscopy, Fourier transform infrared spectroscopy, scanning electron microscopy, an impedance analyzer, and a vibrating sample magnetometer. The Fourier transform infrared study confirmed the presence of Bi–O and Fe–O bonds. The x-ray diffraction patterns confirmed the rhombohedral (R3c) structure as a major phase with the orthorhombic (Pnma) structure as a secondary phase in all samples, and few amount of impurity phase of $Bi_{25}FeO_{40}$ was also determined. The surface morphology analysis showed a variation of particle size from 63 to 174 nm. The Raman spectra of 13 optical phonon modes, including 4A1 and 9E symmetric phonons, are observed for all samples, and the positions of these modes are almost similar, except for the intensities of A1 modes. The optical measurements show a reduction in bandgap from 2.17 to 2.03 eV with co-doping, revealing itself as a more promising applicant in photovoltaics. An enhanced value of the dielectric constant is observed for different doped samples at different frequency regions from 100 Hz to 10 MHz. Magnetic investigation demonstrates the improved ferromagnetism with co-doping of Y and Cu due to distortion in the FeO_6 octahedron. A maximum saturation magnetization of 0.26 emu/gm and a coercivity of 2915 Oe were found for Y concentration of 10% and Cu concentration of 15%.

Keywords: $BiFeO_3$, Structural Analysis, Band Gap, Magnetic Properties, Dielectric Properties.