Abstract

The multifunctional characteristics of both single and double perovskites are highly dependent on the specific rare earth/alkaline earth metal ions present at the *A* site and 3*d*/4*d*/5*d*-transition metal ions present at the *B* site. To manipulate the physical properties of perovskite materials for diverse technological applications, researchers have demonstrated that targeted doping of the *A* and *B* sites with alternative rare earth/alkaline earth metal ions and transition metal ions can be effectively utilized. In light of the above, the present study meticulously investigates the effects of dopants on the *A* and *B* sites of single and double perovskite oxide materials. Specifically, the impacts of 10% Nd/Gd doping at the Bi-site and 10% Co doping at the Fe-site of $BiFeO_3$ nanoceramics, as well as 10% and 50% Ni doping at the Co-site of La_2CoMnO_6 and 25% Sr doping at the Sm-site of Sm_2CoMnO_6 on a range of physical properties including dielectric, magnetodielectric, complex impedance, complex modulus, ac-conductivity, optical, magnetic, and ferroelectric properties are systematically investigated. The thesis significantly contributes to the underlying physics behind observed (i) room temperature multiferroicity in pure and doped $BiFeO_3$ nanoceramics ($Bi_{1-x}Nd_xFe_{1-y}Co_yO_3$/$Bi_{1-x}Gd_xFe_{1-y}Co_yO_3$ (x = 0, 0.1; y = 0, 0.1), (ii) magnetodielectric anomalies, magnetic frustration, and magneto transport properties in $La_2Co_{1-x}Ni_xMnO_6$ (x = 0, 0.1, 0.5) bulk systems and (iii) multimagnetic phases, giant conventional exchange bias effect and Griffiths phase behaviour in $Sm_{1.5}Sr_{0.5}CoMnO_6$ system. In order to demonstrate these concepts, chemically synthesized samples are subjected to thorough analysis using XRD, FESEM, XPS techniques, and comprehensive measurements of dielectric and ferroelectric properties, which are then rigorously investigated. Additionally, phase separation and magnetic field-induced phenomena are recorded and analyzed using a low temperature and high magnetic field VTI cryostat and SQUID/PPMS/VSM magnetometers. Within the scope of this study, we have observed the manifestation of weak ferromagnetism in both pure and Nd/Gd and Co co-doped $BiFeO_3$ nanoceramics, with a notable enhancement in ferroelectricity resulting from doping at *A* and *B* sites. Moreover, the doped nanoceramics exhibit improved dielectric properties due to the doping effects, and further analysis has revealed an increase in the optical bandgap upon Gd and Co co-doping. Furthermore, we have identified distinct relaxation effects present in these nanoceramic samples through the complex impedance spectroscopy technique. In the 10 % (x = 0.1) and 50 % (x = 0.5) Ni doped samples at 100 % Co site of La_2CoMnO_6 samples, improved dielectric properties, relaxation effects and magnetic frustration effects have been observed in the doped samples along with magnetodielectric effect. The behaviour of the temperature-dependent exponent function predicts the Overlapping Large Polaron Tunneling mechanism in the La_2CoMnO_6 system, while the Non-overlapping Small Polaron Tunneling model best describes the doped $x = 0.5$ system. Magnetic property investigations show an increase in the ferromagnetic transition temperature from ~ 230 K for the $x = 0$ to ~ 242 K for the $x = 0.5$ sample. Maximum magnetic field shift of ~ 3.43 kOe in exchange bias effect is observed in the $Sm_{1.5}Sr_{0.5}CoMnO_6$ system owing to the exchange couplings at the interfaces of FM/AFM at low temperature induced by *B*-antisite-disorder. Dc magnetic susceptibility measurements have confirmed the formation of Griffiths phase in this system due to the formation of short-range ferromagnetic clusters in the paramagnetic matrix. Our investigations on the structural, magnetic, dielectric, magnetodielectric, and ferroelectric properties of complex multiferroic single and double perovskite oxide systems have yielded valuable insights and elucidated critical correlations between these properties. Our comprehensive analysis enhances the fundamental understanding of these materials and can facilitate the development of novel, high-performance multifunctional devices for various practical applications.

Keywords: Multiferroic, Ferromagnetism, Double perovskites, Exchange Bias, Griffiths phase, Antisite Disorder