ABSTRACT

Multi-functionalities of the magneto-electric-relaxor (MER) multiferroics have triggered the research and researchers to understand the intriguing physics for recent technological applications. The lead based and lead free perovskite based relaxor materials such as; lead magnesium niobate ($PbMg_{1/3}Nb_{2/3}O_3$) and barium zirconate titanate ($BaZr_{0.4}Ti_{0.6}O_3$) show interesting physical properties varying as a function of external parameters (temperature, frequency and electric field). Moreover, to serve the MER purpose, these relaxors can be used to form some solid solution or composite with well-known multiferroic/magnetic materials such as; bismuth ferrite ($BiFeO_3$) and cobalt ferrite ($CoFe_2O_4$). Therefore, to fabricate MER, solid solutions of $PbMg_{1/3}Nb_{2/3}O_3$ and $BiFeO_3$, and composite samples of $BaZr_{0.4}Ti_{0.6}O_3$, and $CoFe_2O_4$ were synthesized. The solid solutions of $PbMg_{1/3}Nb_{2/3}O_3$ and $BiFeO_3$ ($Pb_{1-x}Bi_xMg_{1/3-x}Nb_{2/3-x}Fe_xO_3$, x = 0.0, 0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.40) exhibit cubic perovskite structure for compositions x = 0.0 - 0.20 and single phase rhombohedral perovskite structure for compositions x = 0.25, 0.30 and 0.40. Interestingly, the consequence of structural change is reflected in micro-structural, relaxor and electrical properties. Relaxor behavior in this group of materials is observed up to x = 0.20. Relaxor to ferroelectric crossover is observed for compositions above x = 0.20. The composite materials of $BaZr_{0.4}Ti_{0.6}O_3$ and $CoFe_2O_4$ (1-x ($BaZr_{0.4}Ti_{0.6}O_3$) - x ($CoFe_2O_4$), x = 0.0, 0.10, 0.15, 0.20, 0.25) exhibit cubic crystal structure. $BaZr_{0.4}Ti_{0.6}O_3$ exhibits single phase cubic perovskite structure whereas all other materials of this group exhibit both cubic peroskite and cubic spinel structure. Similar to $Pb_{1-x}Bi_xMg_{1/3-x}Nb_{2/3-x}Fe_xO_3$ solid solutions, 1-x ($BaZr_{0.4}Ti_{0.6}O_3$) - x ($CoFe_2O_4$) composite materials exhibit relaxor behavior up to x = 0.20 and a relaxor to ferroelectric crossover is observed for x = 0.25. Detailed analysis of electrical properties in complex impedance and modulus planes reveal a Cole-Cole type relaxation in all the synthesized materials. Frequency responses of ac conductivity of $Pb_{1-x}Bi_xMg_{1/3-x}Nb_{2/3-x}Fe_xO_3$ materials follow double power law. Also, the ac conductivity responses of all the studied materials exhibit ionic conductivity up to some intermediate frequency limit (10^3-10^5 Hz).

Key Words: Relaxor; Solid-solution; Composite; Impedance spectroscopy