ABSTRACT

A detailed investigation of the structural, magnetic, electronic- and magneto-transport properties of the chemically synthesized perovskite manganite $Nd_{(1-x)}Sr_xMnO_3$ (x = 0.2, 0.3, 0.5, 0.55, 0.6 and 0.75) has been carried out with the variation of grain/particle size down to the nanometric regime. Structural and morphological characterizations have been carried out through high resolution x-ray diffraction and electron microscopy. The samples are found to be of single phase as confirmed through Rietveld refinement of the high resolution x-ray data. The lowest achieved average grain size is about 40-54 nm. It has also been found that there are no appreciable crystal-structural changes due to the change in grain size. We have studied dc (M(H), M(T) and M(t)) and ac (linear and non-linear susceptibility) magnetic properties employing homemade and commercial (SQUID-VSM) set ups. The electronic- and magnetotransport properties have been investigated employing helium refrigerator (2-300 K) and superconducting magnet (8 Tesla). The manganite $Nd_{0.8}Sr_{0.2}MnO_3$ (x = 0.2) displays a glassy magnetic state in bulk form. This glassy state is destabilized on size reduction and a Griffiths like phase emerges. We have also found a metallic state in the nanoparticles of insulating $Nd_{0.8}Sr_{0.2}MnO_3$. This effect has been attributed to the destabilization of the orbital polarons due to the surface disorder. We have observed the interesting effect of field-temperature history dependence of resistivity in the Gd substituted bulk and nanometric $Nd_{0.7}Sr_{0.3}MnO_3$ (x = 0.3). The low temperature transport anomaly (resistivity minima) is found to strongly depend on Gd concentration and grain size. Ferromagnetism and metallicity have been observed (through neutron diffraction and other measurements) in the nanoparticles of $Nd_{0.5}Sr_{0.5}MnO_3$ (x = 0.5) which is reportedly a charge ordered-antiferromagnetic-insulating system in bulk form. The antiferromagnetic samples with x = 0.55, 0.6 and 0.75 show enhanced ferromagnetism on size reduction. Further, the magnetic relaxation behaviour and memory effect have been studied in $Nd_{0.4}Sr_{0.6}MnO_3$ nanoparticles. These studies reveal that the effect of grain size reduction of $Nd_{(1-x)}Sr_xMnO_3$ strongly depends on the hole concentration (x). The observed size effects are mostly explained through surface disorder. We have also carried out a similar investigation of grain size reduction on a cobaltite $Nd_{0.5}Sr_{0.5}CoO_3$. Size dependent transport mechanism has been studied in this system. Finally, we have carried out the study on the effect of Mn substitution (for Co) in $Nd_{0.5}Sr_{0.5}CoO_3$.

Keywords: Manganite, Cobaltite, Nanoparticle, Spin/Cluster glass, Ferromagnetism, Charge/Orbital order, Magnetoresistance, Surface disorder, Neutron diffraction, Magnetic relaxation.