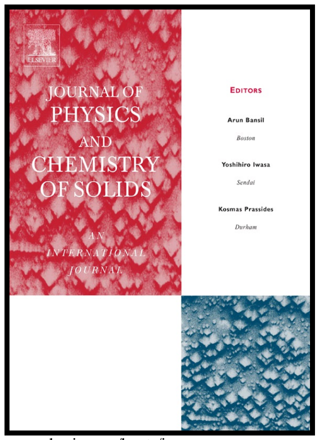
Author's Accepted Manuscript



www.elsevier.com/locate/jpcs

Chracterization of nonOhmic electrical transport in Double Perovskite Compounds through bias scale and nonlinearity exponent

D. Chakraborty, U.N. Nandi, D. Jana, P. Dasgupta, A. Poddar

PII: S0022-3697(16)30193-7
DOI: http://dx.doi.org/10.1016/j.jpcs.2016.09.001
Reference: PCS7850

To appear in: *Journal of Physical and Chemistry of Solids*

Received date: 22 June 2016
Accepted date: 2 September 2016

Chracterization of nonOhmic electrical transport in Double Perovskite Compounds through bias scale and nonlinearity exponent

D. Chakraborty[1,2], U. N. Nandi[1], D. Jana[2], P. Dasgupta [3] and A. Poddar[3]
[1]Department of Physics, Scottish Church College, 1 & 3, Urquhart Square, Kolkata-700 006, India
[2]Department of Physics, University of Calcutta, 92, A P C Road, Kolkata-700 009, India
[3]Condensed Matter Physics Division, Saha Institute of Nuclear Physics, 1/AF, Bidhannagar, Kolkata 700 064, India

Scaling analysis of nonOhmic electrical transport in double perovskite (DP) compounds like La_2NiMnO_6 and $Sr_2Fe_{0.3}Mn_{0.7}MoO_6$ is presented over wide range of electric bias and temperatures. It is shown that the voltage $V_0(T)$ at which conductance deviates from its Ohmic value $\Sigma_0(T)$ scales with $\Sigma_0(T)$ as $V_0(T) \sim \Sigma_0(T)^{x_T}$, x_T being the onset exponent characterizing the onset of nonOhmic conduction. Interestingly, it was found that x_T is negative and insensitive to the nature of conduction mechanism in DPs but is related to the characteristic temperature T_0 and the mean hopping length H_m. We provide a scaling formalism in terms of the parameters $V_0(T)$ and x_T in DPs for deeper understanding of the spintronic application and the electrode functioning in solid oxide fuel cells (SOFC). Inelastic multi-step tunneling is found to be the suitable mechanism of electronic transport characterized completely by these two parameters.

Keywords
Double perovskite compounds, nonOhmic conduction, scaling, onset bias scale, nonlinearity exponent

1. Introduction

Double perovskite (DP) compounds show a number of physical properties such as large colossal magneto-resistance (CMR)[1], magneto-dielectric properties[2,3], correlation between magnetic and electrical transport properties[4] and high ionic conductivity[5] etc. and are widely used as memory elements with large storage densities, faster data processing speeds along with less power consumption in spintronic devices[6,7] and spin tunneling junctions[8]. These technological applications need ferromagnetic semiconductors with a Curie temperature (T_C) at or above the room temperature[9]. DPs like La_2NiMnO_6 ($LNMO$) and Sr_2FeMoO_6 ($SFMO$) exhibit high T_C (respectively $300K$[10–12] and $420K$[13]) which enhances the scope of these materials in spintronic applications. Recently DPs are being used as electrode materials in solid oxide fuel cells (SOFC)[14,15] to meet the worldwide requirement of renewable energy sources. In SOFC, the materials used as electrodes need to have the characteristics of mixed ionic and electronic conductors (MIECs) which is possessed by half metallic $SFMO$ as predicted from the theoretical band calculations[1,16] and this makes it the most promising material for SOFCs as electrodes[15]. These applications demand systematic electrical characterization of DPs both in Ohmic and nonOhmic regimes. In this article, we present a coherent scaling description of nonOhmic electrical transport in DPs like $LNMO$ and $Sr_2Fe_{0.3}Mn_{0.7}MoO_6$ ($SFMMO$) in different magnetic phases with different conduction mechanism over an appreciable range of electric bias and temperatures and analysed with the help of scaling to extract the voltage scale $V_0(T)$ and nonlinearity exponent x_T for the electrical characterization of DPs in spintronic applications.

$LNMO$ is a rare example of single material platform in which spins, electric charges and dielectric properties can be tuned by external magnetic[2,17] or electric field whereas $Sr_2Fe_{0.3}Mn_{0.7}MoO_6$ ($SFMMO$) is an intermediate polycrystalline compound with 30% ferromagnetic half metal $SFMO$ and 70% antiferromagnetic insulator $Sr_2MnMoO_6(SMMO)$[18]. Though a number of measurements[17–24] and theoretical calculations[3,16,25] have been performed in these DPs focusing on the electronic structure and the magnetic properties but the studies on nonOhmic conduction is rather scant and needs to be addressed. The basic feature of nonOhmic transport is that conductance $\Sigma(= I/V)$ is a function of voltage V and remains constant to its zero-voltage Ohmic value Σ_0 at low V. With increase in V, Σ increases monotonically from Σ_0 at a voltage known as the onset voltage $V_0(T)$ and finally increases rapidly at higher voltages. $V_0(T)$ sets the voltage scale in the system[26,27] and helps to identify and characterize the pattern of the problem in the bias plane and to generalize the proposition made at one level of a scale to another.

2. Experimental

Single phase $LNMO$ and $SFMMO$ double perovskites were prepared respectively via conventional sol-gel process and solid state reaction method. For the preparation of $LNMO$, stoichiometric amounts of high purity (99.999%) La_2O_3 and nickel powder were mixed with nitric acid to form $La(NO_3)_3, 6H_2O$ and $Ni(NO_3)_2, 6H_2O$. These nitrate solutions and $Mn(CH_3COO)_2, 4H_2O$ were mixed with citric acid to form the gel which is then dried up. Finally the dry gel was annealed in powder form in air at 600^oC to obtain nanosized $LNMO$ sample. For the preparation of polycrystalline $Sr_2Fe_{0.3}Mn_{0.7}MoO_6$, stoichiometric mixtures of high purity $SrCO_3$, Fe_2O_3, MnO_2, MoO_3 and Mo powder were ground together and pressed, then annealed in inert gas atmosphere for 3 hours at 1000^oC. The pellets were then reground, pressed and reheated with sintering in a steam of H_2/Ar gas for 6 hours at 1300^oC. The end product of each