Measurement 44 (2011) 938–945

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Magneto-transport properties of Fe-doped LSMO manganites

Leena Joshi, Sunita Keshri *

Department of Applied Physics, Birla Institute of Technology, Mesra, Ranchi 835 215, Jharkhand, India

ARTICLE INFO

Article history:
Received 8 October 2009
Received in revised form 4 June 2010
Accepted 23 February 2011

Keywords:
LabVIEW
Virtual instrument
CMR
Magneto-transport properties
Bond percolation model

ABSTRACT

Magneto-transport measurements have been performed on $La_{0.67}Sr_{0.33}Mn_{1-x}Fe_xO_3$ ($x = 0.0$, 0.05 and 0.07) manganites synthesized by solid state route. The overall nature of AC susceptibility is found to be frequency independent. With the substitution of Mn by Fe, the transport properties dramatically change suppressing the double-exchange interaction. This in turn weakens the ferromagnetism and consequently decreases the paramagnetic to ferromagnetic transition temperature (T_c). However, DC electrical resistivity of the samples show board hump at metal–insulator transition temperature (T_{MI}) in contrary with sharp transition at T_c and $T_{MI} < T_c$ indicating decoupling of electrical and magnetic properties. Resistivity behavior of these samples can be well explained by the consideration of bond percolation model which is basically developed from effective approximation method.

1. Introduction

From many decades Perovskite manganites of type $R_{1-x}A_xMnO_3$ where R is La^{3+}, Pr^{3+}, Nd^{3+} and A is Ca^{2+}, Sr^{2+}; have been the focus of interest because of their unusual magnetic and transport properties, especially the colossal magnetoresistance (CMR) [1,2]. These materials have potential applicability as magnetic sensors, hard disks, infrared detectors, etc. [3–5]. The properties of these materials are governed by several factors such as method of preparation, percentage and size of divalent ions. Traditionally properties of CMR have been explained on the basis of double exchange (DE) and/or superexchange interactions, charge localization via Jhan–Teller distortion with polaron formation, phase separation and site disorder. Still due to complexities involved there has been a disagreement on the theoretical explanation of CMR behavior.

Among such materials, $La_{1-x}Sr_xMnO_3$ is of particular interest as the sample with $x = 0.3$ of this series possesses the largest ferromagnetic (FM) ordering temperature nearly equal to 370 K [6]. These compositions with $x = 0.1$–0.3 are explored for application as solid oxide fuel cell materials [7,8] also. Moreover, from fundamental point of view, these samples possess large bandwidth due to which substitution at Mn site is supposed only to alter the magnetic and transport properties without taking into account the electron–phonon interactions which is the characteristic of narrow bandwidth compositions. Despite the long history of such work, studies on such series with Fe-substitution at Mn site are comparatively less explored. For example, Mostafa et al. [9] have studied Mössbauer spectroscopy and electrical resistivity behavior of $La_{0.7}Sr_{0.3}Mn_{1-x}Fe_xO_3$ ($x = 0.05$, 0.06 and 0.07) samples, but not their PM––FM transition behavior. Huo et al. [10] have observed insulating resistive behavior for $La_{1-x}Sr_xMn_{1-x}Fe_xO_3$ ($0.3 \leqslant x \leqslant 0.7$) series. So, more extensive work on such samples is still required. The substitution of Fe at Mn site is of particular interest because of the large extent to which it can replace Mn without any structural deformation, as both have similar ionic radii having values 0.645 and 0.64 Å for Fe^{3+} and Mn^{3+} respectively. Since the spin, charge, lattice and orbital degrees of freedom are intimately linked to the Mn ion, any perturbation at the Mn site is expected to modify ground state properties of such manganites. In this work, we report the structural and magneto-transport properties of

* Corresponding author. Fax: +91 651 2275401.
E-mail addresses: s_keshri@bitmesra.ac.in, sskeshri@rediffmail.com (S. Keshri).

0263-2241/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.measurement.2011.02.005

polycrystalline $La_{0.67}Sr_{0.33}Mn_{1-x}Fe_xO_3$ ($x = 0.0$, 0.05 and 0.07) samples. The paper also describes designs of two LabVIEW virtual instruments developed for the measurements of AC susceptibility and DC resistivity of this series.

2. Experimental

The compounds $La_{0.67}Sr_{0.33}Mn_{1-x}Fe_xO_3$ (with $x = 0.00$, 0.05 and 0.07), hence after known as LSMO, LSF5 and LSF7 respectively, were prepared by traditional solid-state reaction in air. The stoichiometric amount of La_2O_3, $SrCO_3$, $(CH_3COO)_2Mn{\cdot}4H_2O$ and Fe_2O_3 were taken; mixed thoroughly in a ball mill with isopropyl alcohol. The mixture thus obtained were first dried and then fired in air at 900 °C for 24 h and then at 1100 °C for 18 h with intermediate grindings. The powder thus obtained was pelletized and sintered at 1250 °C for 72 h with intermediate grindings and repelletization, and finally furnace cooled to room temperature. The grown phase was confirmed by powder X-ray diffraction (XRD) patterns at room temperature using Rigaku diffractometer with Cu Kα radiation.

AC susceptibility and DC resistivity of the samples were measured using conventional mutual inductance and four

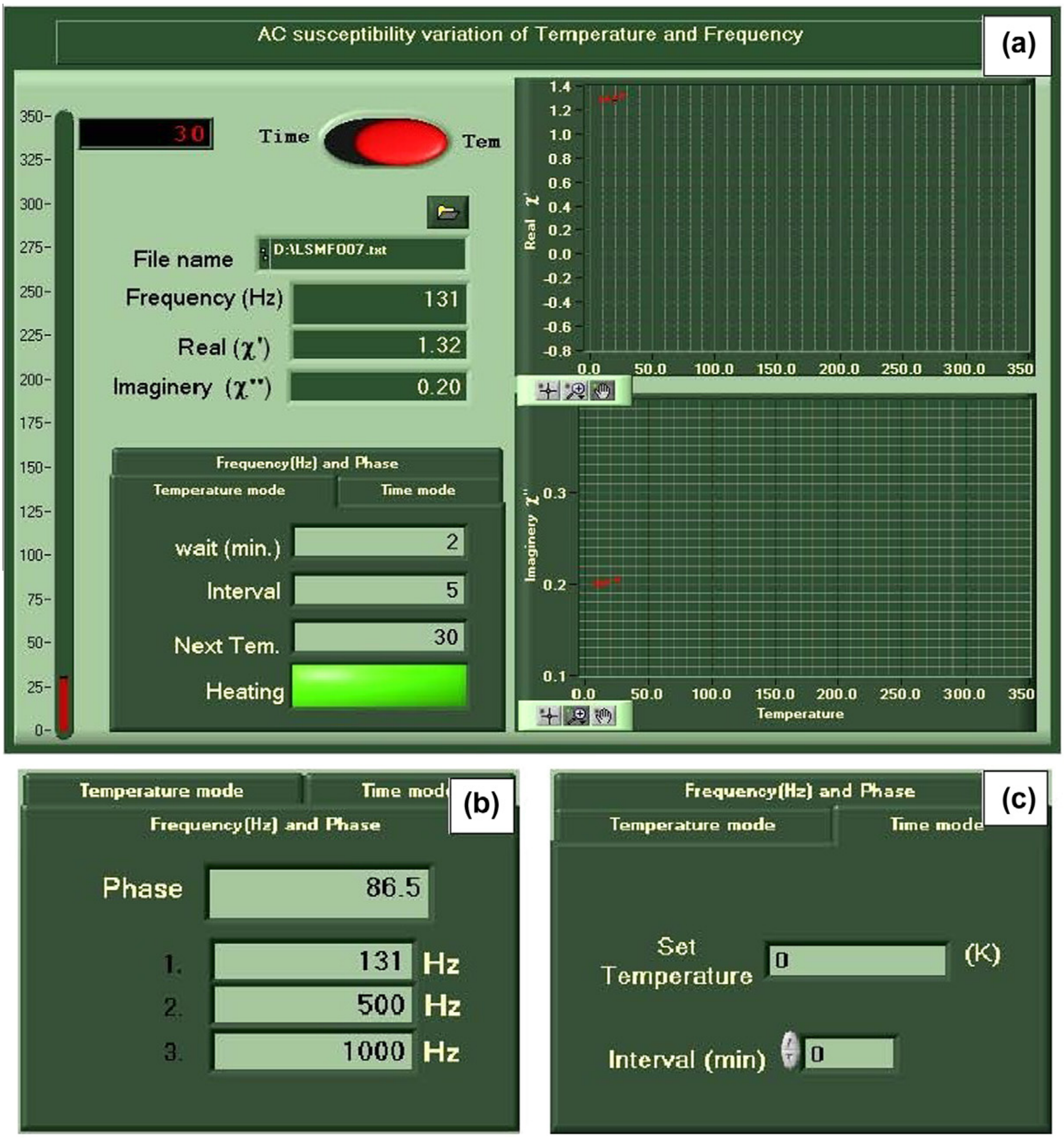

Fig. 1. (a) Front panel of VI for susceptibility measurement, (b) tab for 'Frequency' mode and (c) tab for 'Time' mode.