Journal of Physics: Conference Series

PAPER • OPEN ACCESS

The structural and electrical properties of polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ manganites

To cite this article: F Ruli *et al* 2018 *J. Phys.: Conf. Ser.* **1011** 012002

View the article online for updates and enhancements.

The structural and electrical properties of polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ manganites

F Ruli[1], B Kurniawan[1*] and A Imaduddin[2]

[1]Department of Physics, FMIPA Universitas Indonesia, Kampus UI Depok, Depok 16424, Indonesia
[2]Metallurgical Research Center, Indonesian Institute of Sciences, Puspiptek-Serpong 15314, Indonesia

*Corresponding author: bkuru@fisika.ui.ac.id

Abstract. In this paper, the authors report the electrical properties of polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ manganites synthesized using sol-gel method. The X-ray diffraction (XRD) patterns of polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ samples reveal an orthorhombic perovskite structure with *Pnma* space group. Analysis using energy dispersive X-ray (EDX) confirms that the sample contains all expected chemical elements without any additional impurity. The measurement of resistivity versus temperature using cryogenic magnetometer was performed to investigate the electrical properties. The results show that the electrical resistivity of polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ exhibits metalic behavior below 244 K. The temperature dependence of electrical resistivity dominantly emanates from electron-electron scattering and the grain/domain boundary play a important role in conduction mechanism in polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$.

Introduction
Perovskite manganites with general formula $La_{1-x}A_xMnO_3$ (A = divalent ions) have been a popular research subject due to its high magnetoresistance (MR) and magnetocaloric effect [1–5]. A theoretical explanation of relation among the level of A doping, electrical conductivity and magnetic properties was initially explained by Zener double exchange interaction [6]. It is a transfer of e_g electron from Mn^{3+} ions to Mn^{4+} ions through O^{2-} ions [6,7]. According to this model, the electrical conductivity is proportional to the level of A doping [6].
A perovskite material $La_{0.8}Ca_{0.2}MnO_3$ has a high MR and magnetocaloric effect but its Curie temperature (T_c) and metal-insulator transition temperatur (T_{M-I}) below room temperature [8–10]. Monovalen ions oxidizes Mn^{3+} ions to Mn^{4+} ions twice as much as divalent ions [11]. For low doping monovalent Ag, Pi et al reported that doping Ag in La site of lanthanum manganite induced an increase of MR, Curie temperature and metal-insulator transition temperature [12]. In this present work, the authors partially subtitute divalent ion Ca in $La_{0.8}Ca_{0.2}MnO_3$ with monovalent ion Ag to form a perovskite manganite $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$. We study the structural, and electrical properties of that perovskite mananites.

Experimental
The perovskite manganite material $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ was synthesized by sol-gel method. Stoichiometric amounts of La_2O_3, $Ca(NO_3)_2.4H_2O$, $AgNO_3$, $Mn(NO_3)_2.4H_2O$ were used as precursor materials. La_2O_3 was dissolved in nitric acid solution. Then, lanthanum nitrate solution was mixed

IOP Conf. Series: Journal of Physics: Conf. Series **1011** (2018) 012002 doi:10.1088/1742-6596/1011/1/012002

with other metal nitrate solution. Citric acid was added to the solution with molar ratio of 1.2 between citric acid and metal nitrate. the pH value of solution was adjusted to 7 by adding amonia solution while stirring the solution at temperature of 80 ^oC until the gel was formed. The gel was heated at 120 ^oC for dehidration. It was burned at 600 ^oC for 5 h to remove produced organic materials. The materials obtained from this process were ground by using an agate mortar. The powders were pressed into pellets and then heated at 900 ^oC for 24 h.
Identification of the phase and structural analysis of the sample was determined by X-ray diffractometer (XRD) using monochromatic CuKα radiation. The composition of elements was analyzed using energy dispersive X-ray spectroscopy (EDX). The electrical properties of samples was determined by cryogenic magnetometer at temperature 12-255 K.

Results and discussion

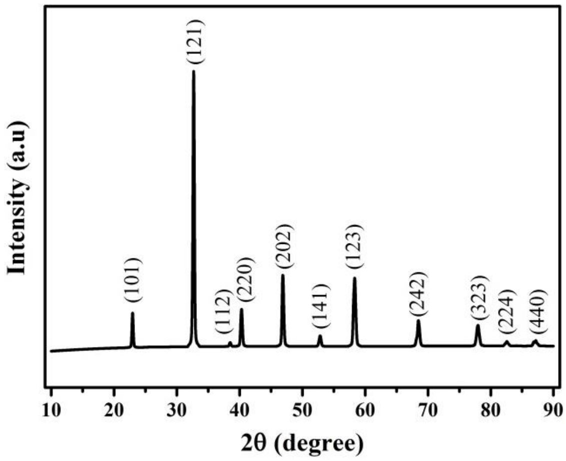

Figure 1. XRD patterns of $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$

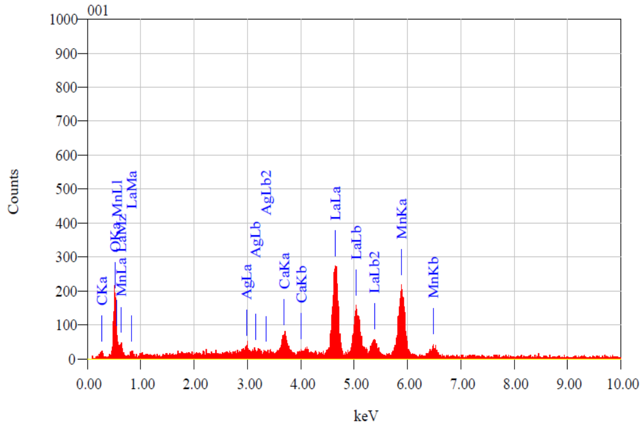

Figure 2. The EDX results for $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$

The XRD pattern of polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ is shown figure 1. The analysis results using Rietveld refinement method confirm that the sample is a single phase since no peaks belongin to the other phase detected. The diffraction peaks can be indexed in an orthorombic perovskite structure with space group *Pnma*. The refinement results are shown in table 1. The quality of the refinement of the XRD data is evaluated by the goodness of the fit indicator χ^2. The Energy Dispersive X-ray (EDX) analysis shown in figure 2 reveals the presence of all expected elements. It shows that there is no quantifiable loss of each elements.

Table 1. Lattice parameters, unit cell volume and googness of fit (χ^2)

Parameters	**$La_{0.8}Ca_{0.1}Ag_{0.1}MnO_3$**
a (Å)	5.472
b (Å)	7.739
c (Å)	5.499
Volume (Å^3)	232.89
Goodness of fit	1.055

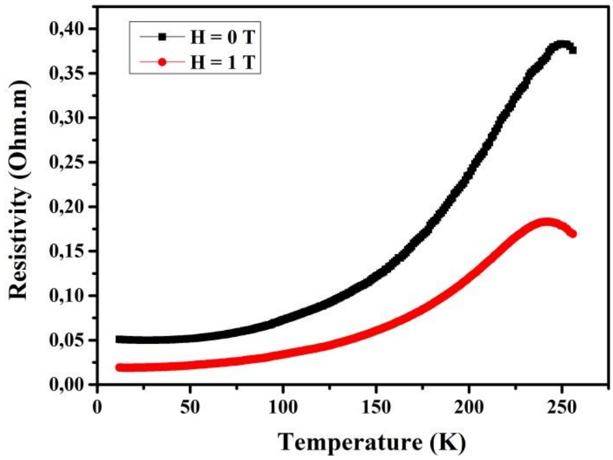

Figure 3. The temperature dependence of electrical resistivity of polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$

The temperature dependence of electrical resistivity of polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ at zero applied magnetic field and 1 T is shown in figure 3. The electrical resistivity decreases when magnetic field 1 T is applied. The polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ shows a metal-insulator transition temperature (T_{M-I}) at 244 K. Below 244 K, The electrical resistivity of policrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ exhibits metalic behavior which electrical resistivity increases with increment of temperature. To analyze the conduction mechanism at metalic region, the experimental data of policrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ at zero applied magnetic field and 1 T are fitted using equation [3,13,14]:

$$\rho(T) = \rho_o + \rho_2 T^2 + \rho_{4.5} T^{4.5} \tag{1}$$

Where ρ_o, ρ_2 and $\rho_{4.5}$ are resistivities due to grain/domain boundary scattering, electron-electron scattering, and combinations of electron-electron, electron-magnon and electron-phonon scattering processes, respectively [3,13,14]. The fitting results are shown in figure 4 and the fitting parameters are presented in table 2. The quality of fitting is evaluated by the square of linear correlation coefficients R^2 [3]. The values of ρ_o, ρ_2 and $\rho_{4.5}$ decrease when a magnet field 1 T is applied. The value of ρ_2 is higher than that of $\rho_{4.5}$ which indicates that the temperature dependence of electrical resistivity dominantly emanates from electron-electron scattering. The value of ρ_0 is the highest indicates that grain/domain boundary play a important role in conduction mechanism in polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$.

Table 2. Fitting paramater of electrical resistivity data of polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$

	ρ_o (Ohm.m)	ρ_2 (10^{-3} Ohm.m/K^2)	$\rho_{4.5}$ (10^{-6} Ohm.m/$K^{9/2}$	Adj. R-Square
H=0	0.047	0.223	2.116	99,95%
H=1	0,019	0,054	1,252	99,99 %

IOP Conf. Series: Journal of Physics: Conf. Series **1011** (2018) 012002 doi:10.1088/1742-6596/1011/1/012002

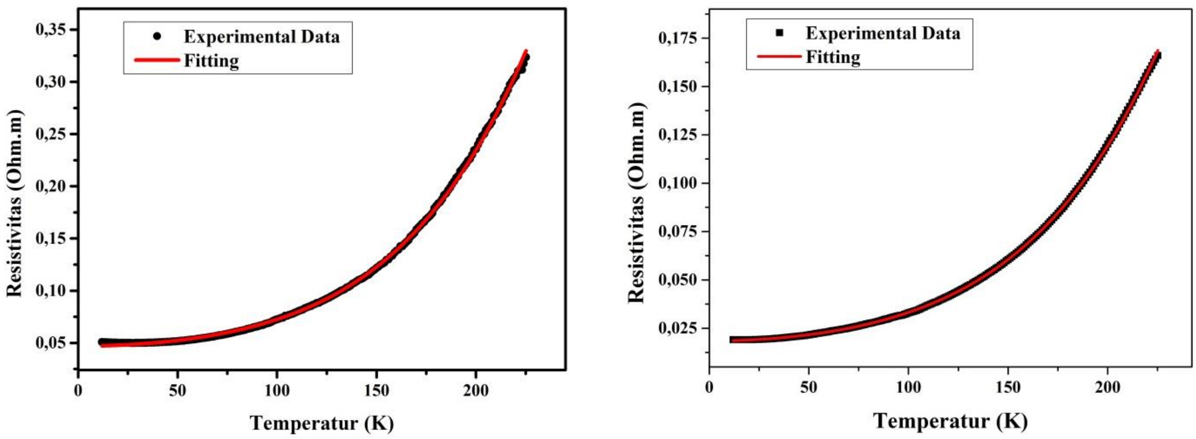

Figure 4. Theoretical fitting of resistivity data in metallic region at zero magnetic field (left) and applied magnetic field 1 T (right)

Magnetoresistance (MR) as a function of temperature measured at a temperature of 12-255 K is shown in figure 5. The magnetoresistance (MR) is calculated using equation [15]:

$$MR(\%) = \frac{\rho_0 - \rho_H}{\rho_0} \times 100\% \tag{2}$$

Where ρ_0 and ρ_H are the resistivities in the zero magnetic field and the presence of magnetic field, repectively. The polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ has the highest value of MR at lowest temperature and decrease with temperature increment. At temperature near $T_{I\text{-}M}$, the value of MR increase with increment of temperature. Magnetoresistance (MR) effect in polycrystaline lanthanum manganite emanate to two contribution. First, the intrinsic MR originates from suppression of spin fluctuation when the magnetic field is applied [16]. The intrinsic MR reaches maximum around the paramagnetic-ferromagnetic transition temperature [17]. The second contribution emanates from spin polarized tunneling process at grain boundary which is dominant at low temperature [16,17]. The spin at the grain boundary is highly disorder [18]. That spin aligns to the applied magnetic field direction which reduces electron scattering by the grain boundary and increase electron tunneling [9,16]. The magnetoresistance of polycrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ reveals an extrinsic MR at lower temperature and an intrinsic MR around $T_{I\text{-}M}$.

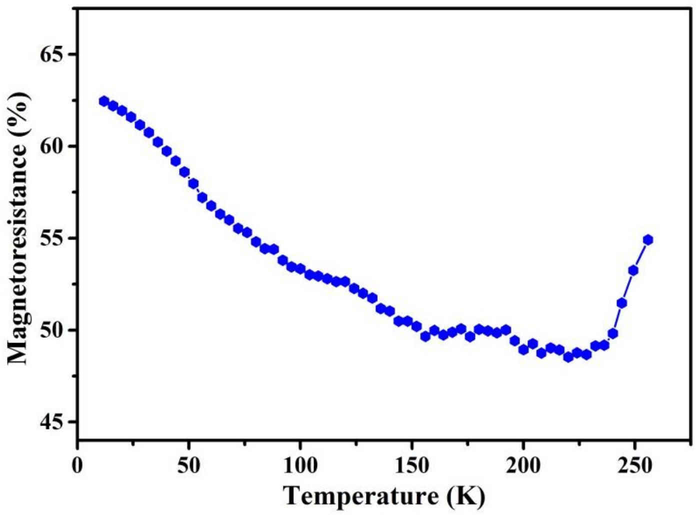

Figure 5. Magnetoresistance as a function of temperature

Summary
The structural and electrical properties of polyicrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ samples (x = 0, 0.03) prepared by sol-gel method are investigated. The X-ray diffraction (XRD) patterns of polyicrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ samples reveale an orthorhombic perovskite structure with *Pnma* space group. Analysis using energy dispersive X-ray (EDX) confirm that the sample contains all expected chemical elements without any additional impurity. Below 244 K, The electrical resistivity of polyicrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ exhibits metalic behavior. The temperature dependence of electrical resistivity dominantly emanates from electron-electron scattering and the grain/domain boundary plays a important role in conduction mechanism in polyicrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$. The magnetoresistance of polyicrystalline $La_{0.8}Ca_{0.17}Ag_{0.03}MnO_3$ reveals an extrinsic MR at lower temperature and an intrinsic MR around $T_{I\text{-}M}$.

Acknowledgements
This work was supported in part by research grant of Ministry of Research, Technology and Higher Education (contract No. 2699/UN.2.R3.1/HKP.05.00/2017) and Indonesia Endowment Fund for Education (LPDP).

References
[1] M. Phan and S. Yu 2007 *IEEE Trans. Magn.* **308** 325
[2] S. Xi, W. Lu and Y. Sun 2012 *J. Appl. Phys.* **111** 63922.
[3] S. O. Manjunatha, A. Rao and G. S. Okram 2015 *J. Alloys Compd.* **640** 154 .
[4] J. C. Debnath and A. M. Strydom 2015 *J. Alloys Compd.* **621** 7.
[5] A. G. Gamzatov and A. B. Batdalov 2012 *Phys. Solid State* **54** 70 (2012).
[6] C. Zener 1951 *Phys. Rev.* **82** 440.
[7] P. W. Anderson and H. Hasegawa 1955 *Phys. Rev.* **100**.
[8] R. Skini, A. Omri, M. Khlifi, E. Dhahri and E. K. Hlil 2014 *J. Magn. Magn. Mater.* **364** 5.
[9] R. Skini, M. Khlifi, M. Wali, E. Dhahri, E. K. Hlil and P. Lachkar 2014 *J. Magn. Magn. Mater.* **363** 217.
[10] Z. B. Guo, Y. W. Du, J. S. Zhu, H. Huang, W. P. Ding and D. Feng 1997 *Phys. Rev. Lett.* **78** 1142.
[11] S. Ravi and M. Kar 2003 *Phys. B* **348** 169.
[12] L. Pi, M. Hervieu, A. Maignan, C. Martin and B. Raveau 2003 *Solid State Commun.* **126** 229.
[13] S. Manjunatha, A. Rao, V. P. S. Awana and G. S. Okram 2015 *J. Magn. Magn. Mater.* **394** 130.
[14] S. Hcini, S. Zemni, A. Triki, H. Rahmouni and M. Boudard 2011 *J. Alloys Compd.* **509** 1394.
[15] P. Siwach, U. K. Goutam, P. Srisvastava, H. K. Singh, R. S. Tiwari and O. N. Srivastava 2006 *J. Phys. D: Appl. Phys.* **39** 14.
[16] H. Y. Hwang, S. Cheong, N. P. Ong and B. Batlogg 1996 *Phys. Rev. Lett.* **77** 2041.
[17] S. Das and T. K. Dey 2005 *Solid State Commun.* **134** 837.
[18] S. P. Isaac, N. D. Mathur, J. E. Evetts and M. G. Blamire 1998 *Appl. Phys. Lett.* **72** 2038.