Structural and Magnetic Properties of B-site Cr Doped $LaFe_{1-x}Cr_xO_3$

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Abstract
B-Site Cr doped $LaFe_{1-x}Cr_xO_3$ with x = 0.1 and 0.2 solid solutions were synthesized by the solid state reaction route. XRD patterns confirm the phase formation with some impurities. The micrographs show the decrease in grain size with increasing concentration of Cr content. The density of samples also follows the same trend. Magnetic hysteresis loops revealed a week magnetic ordering in the solid solutions.

Keywords
X-ray diffraction, FE-SEM VSM.

I. Introduction

An Orthoferrite is a chemical compound with the formula $RFeO_3$ (where R is rare earth element). Orthoferrites have orthorhombic crystal structure with weak magnetic ordering. In recent years Orthoferrites are considered as one of the main candidates for their multifunctional behavior including gas sensors, solid oxide fuel cells, colossal dielectric constant materials and key component in modern electronic technology [1-4].

$LaFeO_3$ is the pervoskite which comes into the category of orthoferrites exhibits antiferromagnetic behavior. It is characterized by Neel temperature, TN =750K. The AFM alignment results from the super exchange interaction (coupling) of the iron ions via the π orbital of the oxygen ions. The buckling of these Fe-O-Fe bonds to about 155° induces the orthorhombic distortion of the unit cell and is responsible for the high Neel temperature which is in good accordance with Lyubuten et al. It is well known that in orthorhombic perovskites the rare earth cations are 9 fold to 12 fold coordinated by oxygen anions while the iron ions are octahedrally co-ordinated by oxygen cations. The change in the A (A is a large ion usually rare earth ion) site cation radius induces lattice distortions by affecting on the $\{F_eO_6\}$ octahedron as Fe-O-Fe distance and angle [5-7].

Our purpose to study the effect on magnetic properties of B-Site Cr doped $LaFe_{1-x}Cr_xO_3$.

II. Experimental

$LaFe_{1-x}Cr_xO_3$ with x = 0.1 and 0.2 samples were prepared by conventional solid state reaction route method. The raw materials La_2O_3, Fe_2O_3 and Cr_2O_3 (all 99% pure) weighed in the stoichiometric proportions and mixed in ball milling (Zirconia balls used) in the propan-2-ol (as medium) for 12 hours. The samples were dried and then calcined for 12 hours at 1000°C. The calcined powder was then mixed with 2% PVA as a binder. The pallets of size 10mm × 0.5mm were prepared with uniaxial hydraulic press. These pallets are sintered at 1200°C for two hours. The structural characterization was done with XRD (SHIMADZU MAXima XRD-7000). The surface morphology was seen by FE-SEM (Carl Zeiss Supra 55) and Magnetic Study was done by VSM (Microscence EZ-9).

Results and Discussion:

The room temperature XRD pattern of B-Site Cr doped $LaFe_{1-x}Cr_xO_3$ for x = 0.1 and 0.2 are shown in fig.1. The room temperature X ray diffraction pattern is indexed according to the cubic phase (space group Pm3m with group No. 221). The marked peaks are due to the secondary phases.

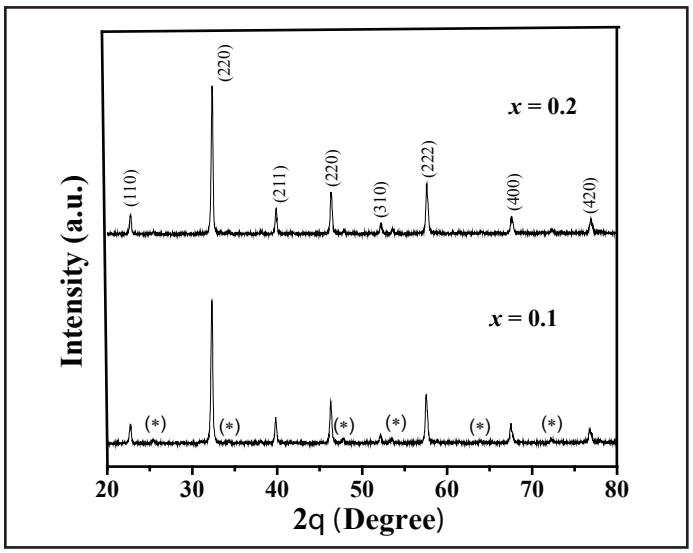

Fig. 1: XRD Pattern of $LaFe_{1-x}Cr_xO_3$ with x = 0.1 and 0.2 samples

The morphological study was done by using FE-SEM. Fig. 2. show the SEM micrographs of all the samples taken at same magnification. It is clearly seen that grain size appears to be decreases with increasing the concentration of Cr. The density of samples decreases from 6.1 g/cm³ to 5.6 g/cm³ as x varies from 0.1 to 0.2.

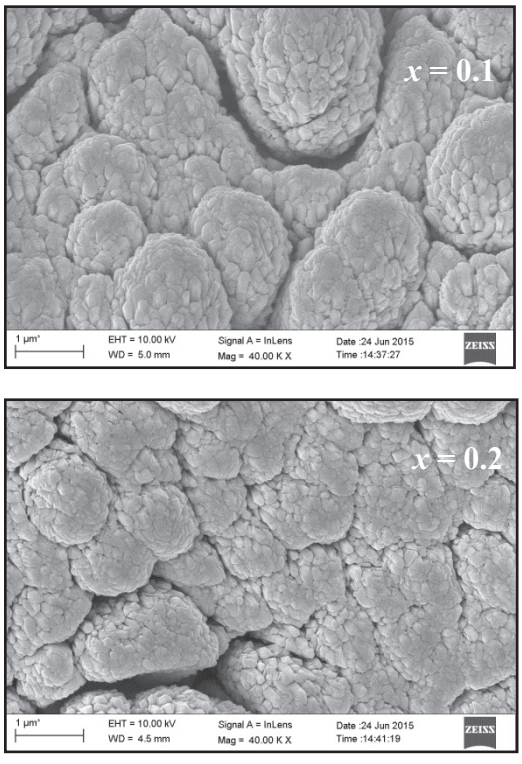

Fig. 2: SEM Micrographs of $LaFe_{1-x}Cr_xO_3$ with x = 0.1 and 0.2 samples

The M-H curves at room were performed with the help of VSM (Vibrating Sample Magnetometer). The M-H at room temperature shows the antiferromagnetic behavior in both solid solutions.

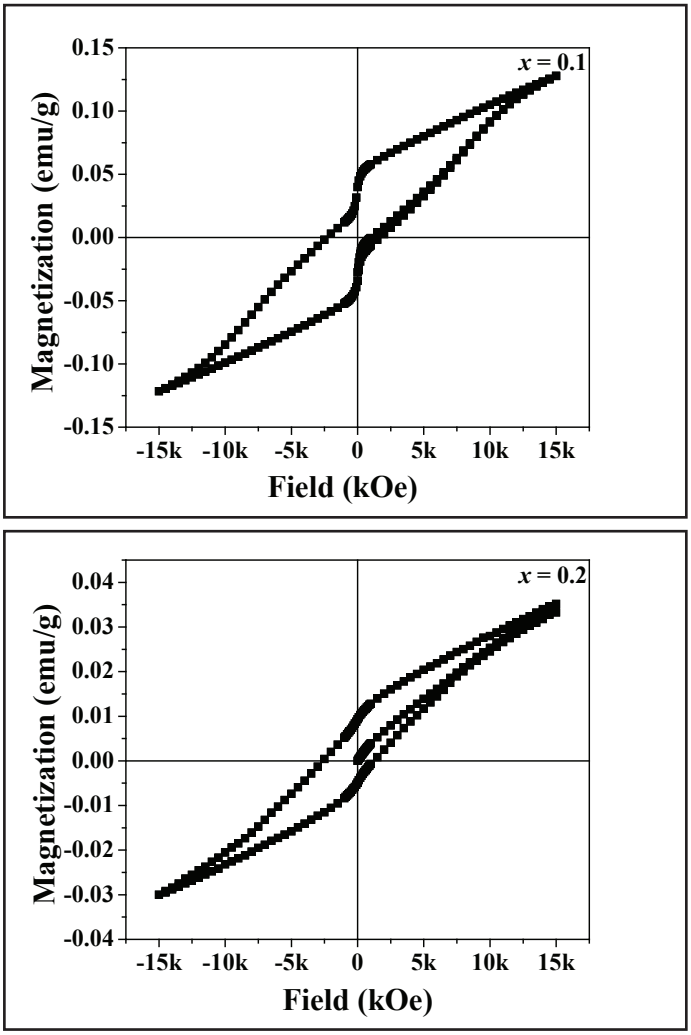

Fig. 3: M-H curve at room Temperature of $LaFe_{1-x}Cr_xO_3$ with x = 0.1 and 0.2 solid solution

III. Conclusion

XRD pattern revealed $LaFe_{1-x}Cr_xO_3$ with x = 0.1 and 0.2 prepared by solid state reaction route technique showed phase formation with some impurities. The micrographs show a decrease in grain size with increase in concentration Cr content. The Room temperature magnetic hysteresis loops shows the weak magnetic ordering in B-Site Cr doped $LaFe_{1-x}Cr_xO_3$ solid solutions.

References

[1] Piezoelectric Ceramic by Bernard Jaffe , William R. Cook and Hans Jaffe.
[2] Introduction to Ceramics by W.D. Kingery, H.K.Bowen and D.R. Uhlmann (Second Edition)
[3] Bhargav, K.K., Ram, S., and Majumder, S.B., "Physics of the multi-functionality of lanthanum ferrite ceramics" J.Appl. Phys. 115, 204109 (2014).
[4] Sora, I.n., Caronna, T., Fontana, F., fernandez, C.D.J., Caneschi, A. and Green, M. "Crystal structure and magnetic properties of strontium and copper doped lanthanum ferrites" Journal of Solid State Chemistry. 191, 33-39 (2012).
[5] Qi, X.W., Zhou, J., Yue, Z.X., Gui, Z.C. and Li, L.T. Ceramic International, 29, 347 (2003).
[6] Ginnakas, A.E., Ladavos, A.K., Pomonis, P.J. Appl. Catal. B: Environ. 49, 147 (2004).
[7] Y. Wang, J. Zhu, L. Zhang, X. Yang, L. Lu, X. Wang, Mater. Lett. 60 , 1767 (2006).