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Microstructural and magnetic properties of microwave synthesized La-Sr-Mn-O: ferrite nanocomposites

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Abstract

Microwave assisted synthesis was carried out for the preparation of 50 mol % $La_{0.67}Sr_{0.33}MnO_3$ (LSMO): 50 mol % ferrite [soft $NiFe_2O_4$ (NF) and hard $CoFe_2O_4$ (CF)] nanocomposites using kitchen microwave oven. Different characterization techniques such as XRD, SEM, density and M-H loop have been used to study the properties of these composites. X-ray diffraction confirms the presence of two phases (LSMO and NF/CF) without any impurities. The crystallite size of these two phases is found to be around 40 nm. LSMO and ferrite phases are uniformly distributed with nearly spherical morphology as observed from the back-scattered SEM micrographs. Composite of LSMO: CF indicated higher saturation magnetization (45 emu/g) as well as higher coercivity (300 Oe) and remanent magnetization (6.3 emu/g) as compared to LSMO: NF composites.

Keywords: Manganite; Ferrite; Nanocomposites; Magnetic; Microwave synthesis; Microstructural.

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Introduction

Nanocomposites of manganite, a colossal magnetoresistance perovskite and ferrite, an insulating magnetic oxide are of interest because of their unusual magnetic as well as electrical properties [1-4]. Manganite-ferrite nanocomposites are of interest due to the magnetic coupling between these two phases that affects the microstructural and

magnetic properties [5-7]. These composite materials are of enormous technological importance, as these materials can be used as read heads for hard disks, magnetic storage and sensing devices. In this work, microwave assisted synthesis was carried out for the preparation of $La_{0.67}Sr_{0.33}MnO_3$ (LCMO): $NiFe_2O_4$ (NF)/$CoFe_2O_4$ (CF), nanocomposites using kitchen microwave oven. This technique has the inherent advantage of uniformly distributing the two phases with similar grain size as compared to other techniques such as sol-gel, precipitation, auto-combustion etc. In this work, microstructural and magnetic properties of microwave synthesized LSMO: CF and LSMO: NF nanocomposites were studied in detail.

Experimental

Stoichiometric amounts of La-acetate, Sr-Chloride, Mn-acetate, $NiCl_2{\cdot}6H_2O$/$CoCl_2{\cdot}6H_2O$ and $FeCl_3$ salts were partially dissolved in ethylene glycol to obtain a precursor solution. Addition of KOH to this solution at ≈ 80 °C converts the acetate to hydroxides and leads to a gel formation at pH ~ 11. The gel solution was refluxed using a microwave heat source (250 MHz, 980 W) for a period of 1h using kitchen microwave oven. The precipitate obtained after refluxing was centrifuged, washed and dried. The calcined (800 °C for 1h) powder was cold pressed into a pellet and sintered at 1200 °C for 2h. Different characterization techniques such as X-ray diffractometer [XRD, PANalytical, (model: DY-1656)], scanning electron microscopy [SEM (JEOL- model 6480 LV)], density (Archimedes principle) and M-H loop (Magneta, Mumbai) have been used to study the properties of these composites.

Results and discussion

The presence of various phases and crystallite size were determined from the X-ray diffraction pattern. Figure 1 (a) and (b) show the X-ray diffraction patterns of LSMO: NF and LSMO: CF nanocomposites, sintered at 1200 °C, respectively. The diffraction patterns showed various peaks indicating the presence of crystalline phases. In these composites, all peaks are identified with both LSMO and NF/CF without any impurity or secondary phases. The peaks of LSMO, NF and CF are compared with JCPDS number 47-0444, 80-0072 and 22-1086, respectively. The crystallite size of LSMO, NF or CF, calculated using the Debye Scherrer relation is found to be around 40 nm.

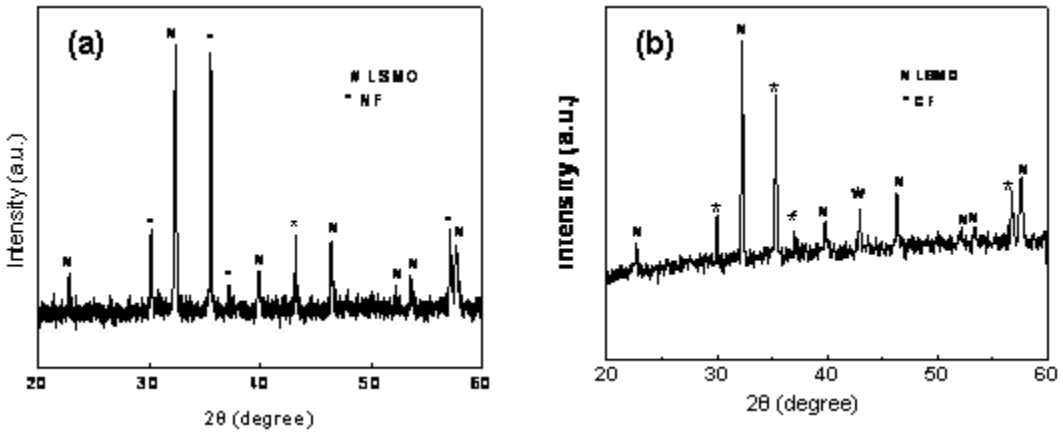

Fig. 1: X-ray diffraction patterns of (a) LSMO: NF and (b) LSMO: CF nanocomposites

In order to get a more direct and complete picture of the morphology, SEM in back-scattered mode was performed on LSMO: ferrite composites pellets. Figure 2 (a) and (b) show the SEM micrographs of LSMO: NF and LSMO: CF nanocomposites, respectively. It was confirmed that the LSMO and CF phase were well distributed with uniform size of around 1 μm. In these microstructures, the white portions indicate the presence of LSMO phase and the black portion indicates the presence of CF phase. The density of both composites was found to be more than 90 % of the theoretical density.

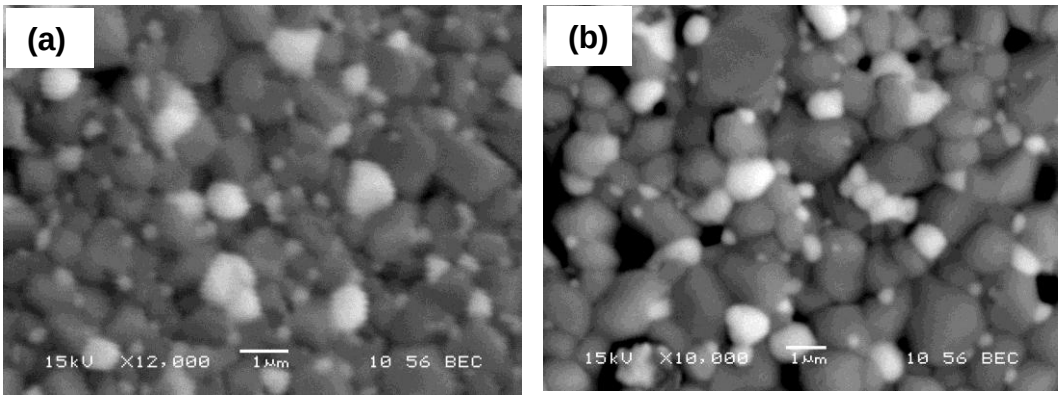

Fig. 2: SEM micrographs of (a) LSMO: NF and (b) LSMO: CF nanocomposite

Room temperature magnetization as a function of field was studied to understand the magnetic properties of these composites. Figure 3 (a) and (b) show the MH-loop of LSMO: NF and LSMO: CF composites, respectively. The MH-loop behavior was

saturating in nature for LSMO: NF composites having M_s value of 27 emu/g, whereas, non-saturating behavior was observed for LSMO: CF composites. The coercivity of LSMO: NF and LSMO: CF was found to be ~ 138 Oe and ~ 300 Oe, respectively.

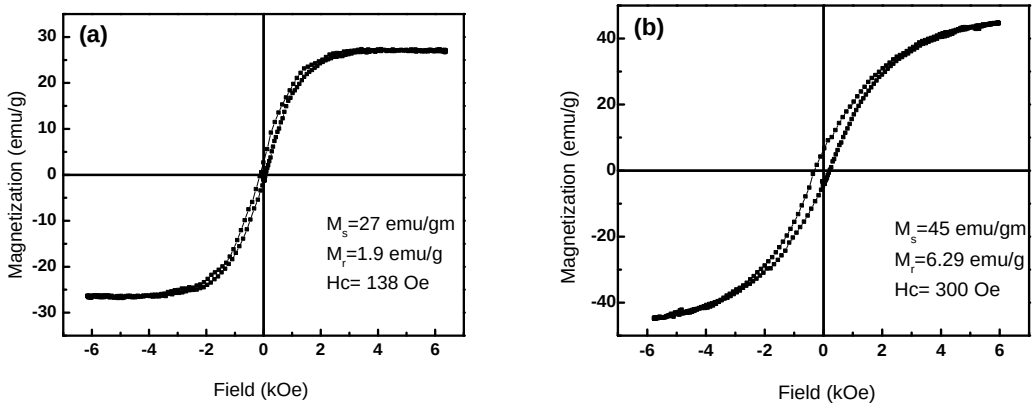

Fig. 3: Room temperature MH-loop of (a) LSMO: NF and (b) LSMO: CF composites

Conclusions

Composites of LSMO: ferrite (NF or CF) were successfully prepared through microwave assisted synthesis route using kitchen microwave oven. In these composites, both LSMO and ferrite phases were well distributed having grain size ~ 1 μm. The LSMO or ferrite particles are nearly spherical in shape. Higher saturation magnetization (45 emu/g) as well as higher coercivity (300 Oe) and remanent magnetization (6.29 emu/g) was obtained in LSMO: CF composite.

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References

1. Colossal Magnetoresistive Oxides, edited by Y. Tokura (Gordon & Breach, Tokyo, 1999).
2. T. Tang, S. Y. Zhang, R. S. Huang, and Y. W. Du, *J. Alloys and Comp.*, **353**, 91 (2003).
3. R. Müller, W. Schüppel, T. Eick, H. Steinmetz and E. Steinbeiß, *J. Magn. Magn. Mater.*, **217**, 155 (2000).
4. B. B. Nayak, S. Vitta, D. Bahadur, A.K. Nigam, *Mater. Sci. Engg. B*, **113**, 50 (2004).
5. C.H. Yan, Z.G. Xu, T. Zhu, Z.M. Wang, F.X. Cheng, Y.H. Huang, C.-S. Liao, *J. Appl. Phys.*, **87**, 5588 (2000).
6. Q. Huang, J. Li, X. Huang, C. K. Ong, X. S. Gao, *J. Appl. Phys.*, **90**, 2924 (2001).
7. B. B. Nayak, S. Vitta, D. Bahadur, *Mater. Sci. Engg. B*., **139**, 171 (2007).