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Effect of the Grain Size on the Magnetic Phase Separation in $La_{0.8}Sr_{0.2}MnO_3$ by Magnetic Force Microscopy

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Perovskite manganites have been the focus of worldwide research during the last two decades because of the observation of colossal magnetoresistance (CMR) effect. These materials have potential applications in magnetic field sensors, spin filters, infrared bolometers and cathodes for solid oxide fuel cells [1]. Such manganites are also important from the fundamental study viewpoint as they offer interplay among various degrees of freedom viz. spin, lattice and charge ordering [2]. Moreover, phase separation may occur in manganites with low concentration of the dopant [3]. In such scenario, ferromagnetic metallic clusters are embedded in antiferromagnetic insulating matrix. The fraction of these magnetic phases may vary from the nano- to micro-scale [3]. With higher dopant concentration, the percolation of these magnetic metallic clusters leads to the apparent CMR effect. In this study we focus our attention to the low doped $La_{0.8}Sr_{0.2}MnO_3$ (LSMO) manganite and investigate the possible magnetic phase separation and effect of variation in grain size on the magnetic domain size. $La_{0.8}Sr_{0.2}MnO_3$ possesses Curie temperature (T_C) higher than room temperature, therefore the material is supposed to be in the magnetic state at room temperature [4].

Samples have been prepared by the conventional solid-state reaction of precursors, powder pressing and sintering between 1400-1500ºC, for 5h. Structural and microstructural studies (including elemental analysis) have been carried out using X-ray diffraction (XRD) and scanning electron microscopy (SEM) techniques, respectively. Magnetic force microscopy (MFM) technique (Veeco Nanoscope Multimode) has been employed to characterize the magnetic domain structure at room temperature. We utilized a commercial tip of silicon magnetically coated with Co/Cr of nominal spring constant ~5 N/m. H = 1 T was applied perpendicular to sample surface prior to MFM measurement.

Figure 1 shows the scanning electron micrographs of the samples sintered at different temperatures. The samples are quite dense with relative density ~97% which remains unaffected by the change in sintering temperatures between 1400-1500ºC (Table 1). The grain size increases with increasing sintering temperature which can be related to the increase in diffusion rate. Figs. 1 and 2 comparison shows that magnetic domain size is quite smaller than the grain size which means that a grain is composed of several magnetic domains. The other which is worthwhile noticing that the domain size does not vary significantly as is the case with grain size on increasing the sintering temperature. This can be understood from the fact the sample is magnetically phase separated and the interactions among various magnetic and non-magnetic phases decides the size of the magnetic domains. This is also clear from the observation of different contrast of domains in a single grain. Measurements on thin films of such materials will further shed light on the possible correlation among the grain size and the domain structure. Thin film preparation is in progress and the results will be published in future.

References

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Table 1. Sintering temperature, relative density, space group and grain size of LSMO samples.

Sintering temperature (ºC)	Relative Density (%)	Space Group	Grain Size (µm)
1400	97	R-3c	15.9
1430	97	R-3c	18.8
1500	97	R-3c	29.2

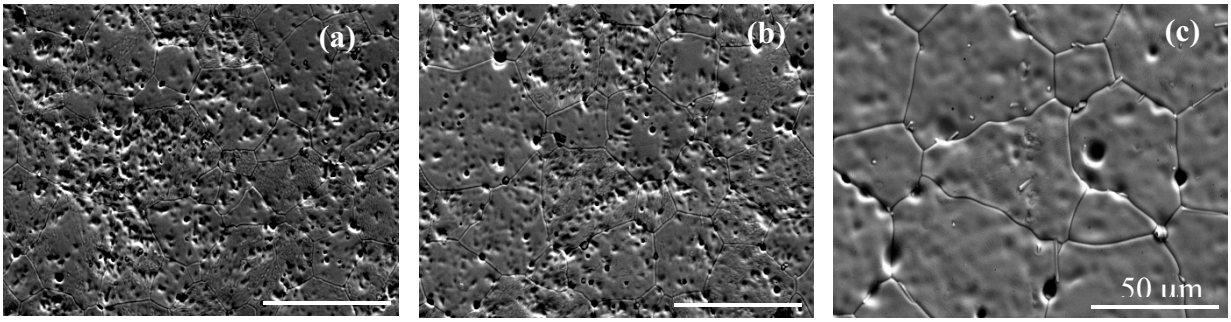

Figure 1. Scanning electron micrographs of LSMO sample sintered at (a) 1400ºC, (b) 1430ºC and (c) 1500ºC, respectively.

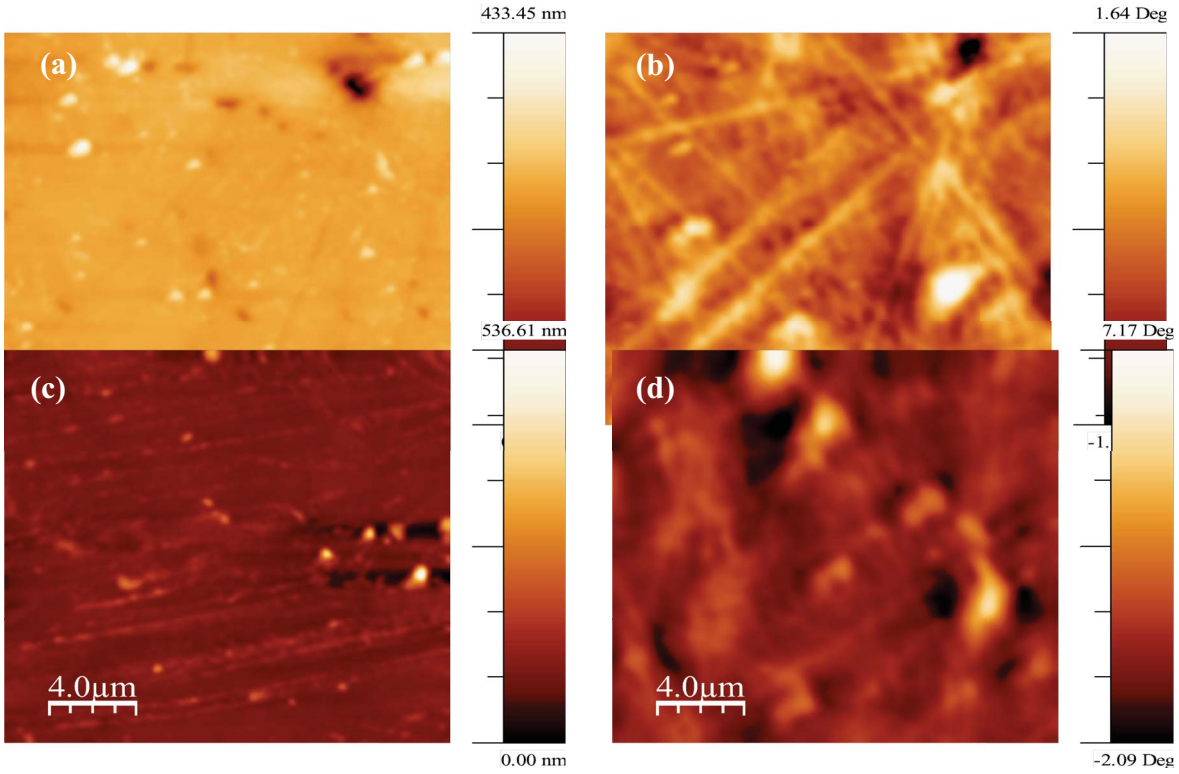

Figure 2. (a), (c) surface topography and (b), (d) magnetic domain structure the LSMO sample sintered at 1400 and 1500ºC, respectively.

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