Magnetic Properties of $Sr_{0.2}Ca_{0.8}Mno_3$ Ceramics

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Abstract

This paper reports the magnetic properties of strontium calcium Manganite synthesized by chemical Co precipitation method. $Sr_{0.2}Ca_{0.8}MnO_3$ shows orthorhombic crystal structure and it is confirmed by XRD pattern. Scanning electron microscopy is used to study the surface morphology of the sample. The $Sr_{0.2}Ca_{0.8}MnO_3$ ceramic shows negative magnetization below ~42 K, above this temperature it shows paramagnetic nature and below this it shows antiferromagnetic nature. Negative magnetization in this oxide is due to single-ion magneto crystalline anisotropy and antisymmetric Dzyaloshinsky-Moriya interactions.

Keywords. X ray diffraction, Antiferromagnetics, Magnetization reversal

Introduction

In recent years, negative magnetization has been reported for various perovskite structures [1-3]. The negative magnetization effect can develop a remarkable technological perspective for device applications, for example, thermally assisted magnetic random access memories, thermo magnetic switches and other multifunctional devices, in a preselected and convenient manner. The negative magnetization is usually achieved by applying a large magnetic field in a direction opposite to the aligned moments or by changing the temperature in moderate fields [4]. In this paper we report the negative magnetization in the $Sr_{0.2}Ca_{0.8}MnO_3$ ceramic synthesized using chemical Co precipitation method.

Material and Methods

$Sr_{0.2}Ca_{0.8}MnO_3$ ceramic is prepared by simple cost effective chemical co- precipitation method using strontium nitrate, calcium nitrate, manganese nitrate and oxalic acid as a starting material. The chemicals were weighed according to the required proportion by varying concentrations of Ca. 0.5 M solution of strontium, manganese and calcium nitrates were dissolved in double distilled water with constant heating and stirring. After complete dissolving, the above prepared solution was added drop wise in 2 M hot ($75^{O}C$) oxalic acid solution with constant stirring, till complete precipitation occurred. After cooling at room temperature the precipitate was filtered, washed with distilled water and dried. The dried powder was pre-

sintered at 350^0C for 3hr and finally sintered at temperature 1000^0C in a muffle furnace for 8 hours followed by cooling.

Results and Discussion

X ray diffraction studies:

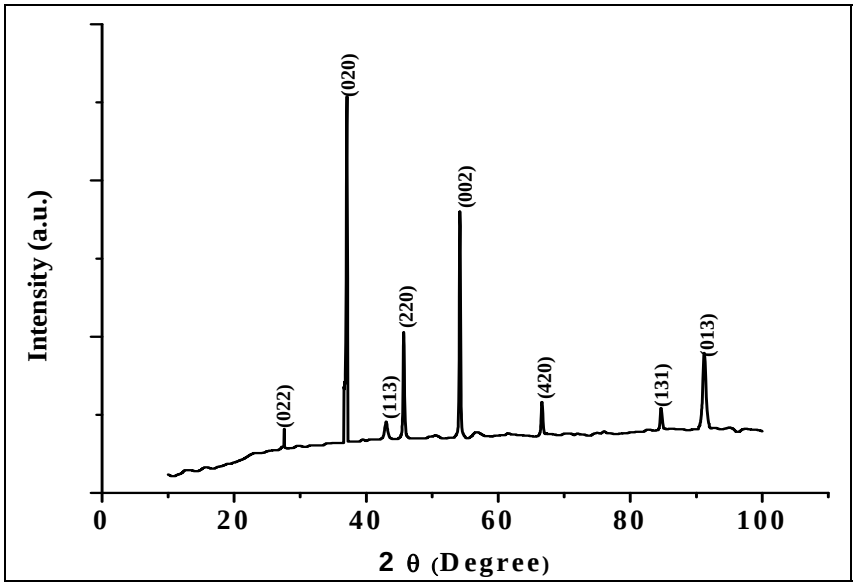

Figure 1. X ray diffraction pattern of $(Sr_{0.2}Ca_{0.8})$ MnO_3 ceramic

Figure 1 shows the perovskite structure of $Sr_{0.2}Ca_{0.8}MnO_3$ ceramic which is obtained by X-ray diffraction pattern. Analysis of X ray diffraction pattern is done by X Pert High Score software. It shows the orthorhombic crystal structure with a lattice parameter a=5. 23Å, b=7. 57 Å and c=5.31 Å.

Scanning Electron Microscope Studies:

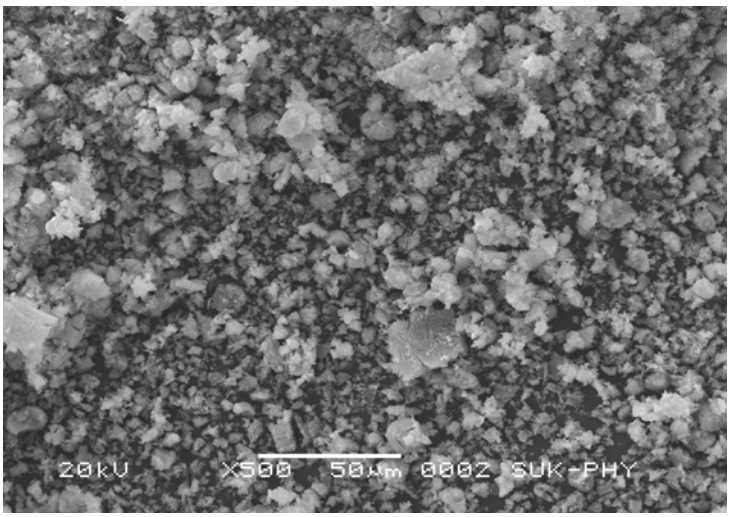

Figure 2. SEM image of $(Sr_{0.2}Ca_{0.8})$ MnO_3 ceramic

Figure 2 shows the scanning electron microscope image for $(Sr_{0.2}Ca_{0.8})$ MnO_3 ceramic. It is seen that the grains are uniformly distributed, forming a cluster with an average grain size is about ~0.2 μm.

Magnetic Studies:

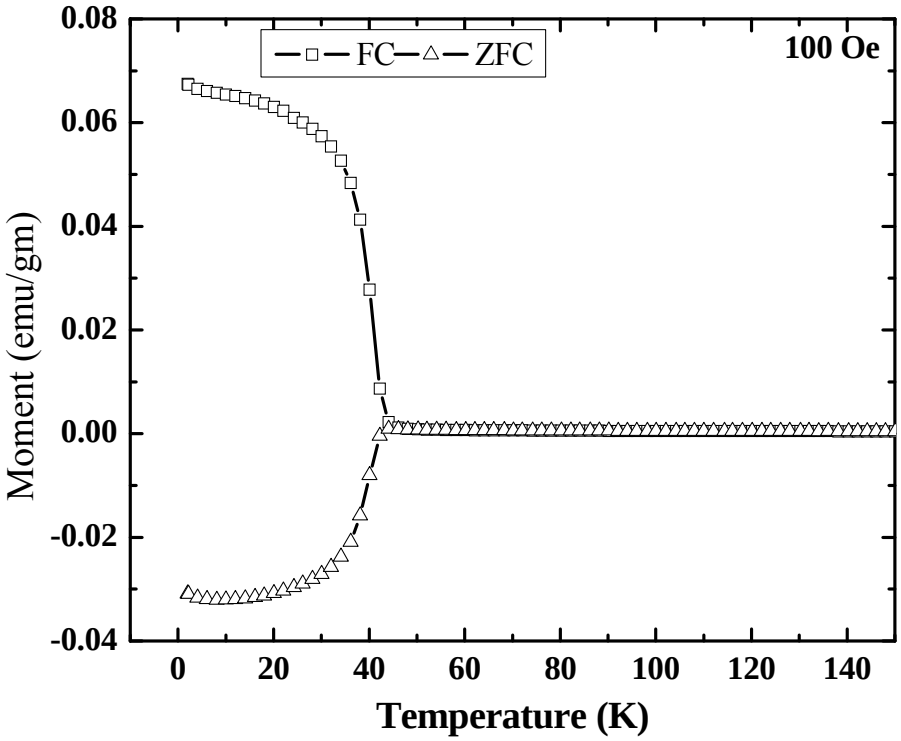

Figure 3. Zero field and field cooled magnetization as a function of temperature for $(Sr_{1-x}Ca_x)$ MnO_3 for x= 0.8 have been measured in a magnetic field, H=100 Oe

The temperature dependence of zero-field-cooled (ZFC) and field-cooled (FC) magnetization has been measured at 100 Oe fields for x=0.8 as shown in figure 3. There is a large difference between ZFC and FC magnetization at around ~ 42 K but no difference is observed above this temperature. The bifurcation between them starts maximum at ~42 K and minimum at ~44 K the magnetization curves follow entirely different paths below this temperature, which usually suggests an inhomogeneous mixture of FM and AFM nature rather than a distinct long-range FM or AFM ordering [5]. FC magnetization shows a broad maximum whereas ZFC magnetization shows a minimum due to the stronger decrease of M_{ZFC} as compared to M_{FC}. In such a system, high-energy barriers blocked meta stable magnetic states are observed, with a possible presence of CO-AFM phase at low temperature. In the FC curves, M_{FC} decreases continuously with increase in temperature and becomes constant again by increasing

temperature, which gives a paramagnetic (PM) to antiferromagnetic (AFM) transition at ~ 42K. However in ZFC curves, M_{ZFC} increases to the maximum value, and then becomes constant with increasing temperature. Paramagnetism in materials arises due to the interactions of unpaired electrons in partially filled orbitals. Due to these interactions, ferromagnetic materials have a net magnetic moment due to the partial alignment of the magnetic moments in the direction of the applied field [6].

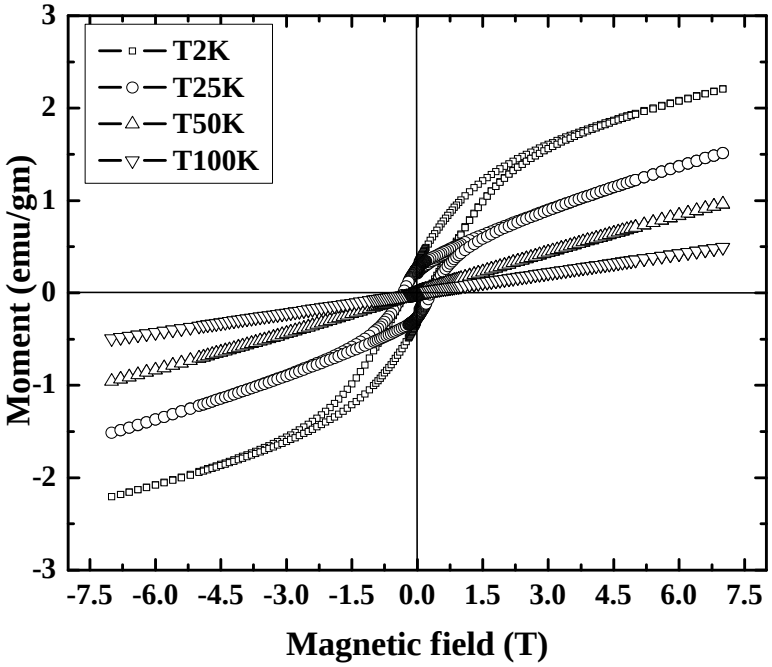

Figure 4. Magnetic-field dependence of magnetization at different temperature for x=0.8.

In order to gain a deeper understanding of magnetic properties and to confirm the AFM behavior at low temperature we carried out field dependent magnetization measurements up to 7.0 T. The field dependence of magnetization at different temperatures is shown in figure 4. The field dependence of virgin magnetization curves M (H) is measured after the sample was cooled from 300K to the target temperature in zero field magnetization measurements. We also check the signal of the sample holder. Figure 4 shows the applied fields and the resultant magnetization of $Sr_{0.2}$ $Ca_{0.8}MnO_3$ for the various temperatures. When a lower field is applied, the magnetization increases rapidly with the field, and the increase follows a curved path. This suggests the existence of an antiferromagnetic component in the sample. The magnetization increases with increasing magnetic field at all temperatures and does not saturate even at high field (7.0 T) and shows a linear relation with magnetic fields as expected for an antiferromagnet. As calcium

concentration increases in strontium Manganite then magnetization goes on increasing. Magnetization decreases with increasing temperature and the maximum magnetization appears at 2 K. At a temperature below 42 K the sample shows the hysteresis loop but above 42 K hysteresis loop gets vanishes. It means that below 42 K sample show antiferromagnetic behavior and above 42 K it shows paramagnetic nature which is also seen from FC and ZFC curve. From the figure it is also observed that the coercive field decreases with increase in temperature. In single particle, domain coercivity decreases due to increase in the intensity of thermally activated processes that alter the directions of the magnetic moments of the particles which are blocked by anisotropy fields and also due to decrease of the value of the anisotropy field of the particles on account of a decrease of the spontaneous magnetization. The observed antiferromagnetic component is attributed to the cation vacancies and positive holes of the magnetic center arising from the excess oxygen. And paramagnetic component is attributed to the nonlocalized holes. When a strong magnetic field is applied at low temperatures, it is easier to switch the direction of the magnetization of the particle to the applied magnetic field. The M (T) curves taken at applied magnetic field of H_a=100 Oe show paramagnetic characteristics above 50 K.

Conclusions

$Sr_{0.2}Ca_{0.8}MnO_3$ is successfully synthesized by chemical Co precipitation method. It shows the orthorhombic crystal structure having Pbnm space group. The magnetization reversal is observed for $Sr_{0.2}Ca_{0.8}MnO_3$. The maximum magnetization appears at 2 K. Below 42K the samples show antiferromagnetic behavior and above 42 K it shows paramagnetic nature which is also seen from FC and ZFC curve.

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