Superparamagnetic Clusters in $La_{1-x}Sr_xCoO_3(x \leq 0.2)$

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1. Introduction

The substitution of Sr^{2+} ions on La^{3+} sites in $La_{1-x}Sr_xCoO_3$ (LSCO) results that the Co^{4+} ions co-exist with Co3+ ions in LSCO. It is generally accepted that the interaction between Co^{4+}-Co^{3+} is ferromagnetic (FM) double exchange, whereas the Co^{3+}-Co^{3+} and Co^{4+}-Co^{4+} interactions are antiferromagnetic (AF) superexchange[1]. Frustration appears as a result of the coexistence of FM and AF orderings. This condition is adequate for the system to have the glass behavior at low temperature if FM and AF interactions are comparable. Based on earlier results, the LSCO system is reported as a spin glass state at low doping concentration($x<0.18$)[1].

In the other hand, superparamagnetic system also has similar characteristics with spin glass system (e.g. irreversibility magnetization, and time dependent magnetization)[2]. Comparison between superparamagnetic system ($Cu_{97}Co_3$) and canonical spin glass system ($Au_{96}Fe_4$) revealed the differences between two systems in detail[3]. In $Cu_{97}Co_3$, the bifurcation between zero-field-cooled magnetization (ZFCM) and field cooled magnetization (FCM) is far above the blocking temperature (T_b); whereas that of in $Au_{96}Fe_4$ is near the freezing temperature (T_f). The FCM of $Cu_{97}Co_3$ increases monotonically with decreasing temperature, however the FCM in Au96Fe4 is nearly independent of temperature. With increase of applied field, T_b in superparamagnetic system decreases considerably but T_f in spin glass system just slightly decreases.

2. Experimental Details

The polycrystalline samples of $La_{1-x}Sr_xCoO_3$ were prepared by solid state reaction. X-ray diffraction was carried out using Rigaku diffractometer with Cu-Kα radiation. The magnetization (M) was measured by a vibration sample magnetometer over the temperature range, 15-300 K, in various fields up to 5 kOe under ZFC and FC sequence.

3. Results and Discussion

Comparing our results with those of $Cu_{97}Co_3$ and $Au_{96}Fe_4$, it is found that the magnetic behaviors of LSCO are very similar to those of $Cu_{97}Co_3$ rather than those of $Au_{96}Fe_4$. In Fig. 1, the FCM of $La_{0.9}Sr_{0.1}CoO_3$ is nearly temperature independent at low temperature whereas the FCM of $La_{0.85}Sr_{0.15}CoO_3$ increases monotonically. As the doping amount decreases, the FCM behavior resembles that of superparamagnetic system. And in the Fig. 1 the position of Tf and the bifurcation point are similar to those of superparamagnetic system in all range of synthesized samples. These behaviors may be due to the existence of superparamagnetic clusters in LSCO. With increase of doping amount, the superparamagnetic clusters decrease and ferromagnetic clusters increase and grain size becomes bigger. Thus, at higher doping concentration the FCM resembles a ferromagnetic behavior and the superparamagnetic behavior is surpressed.

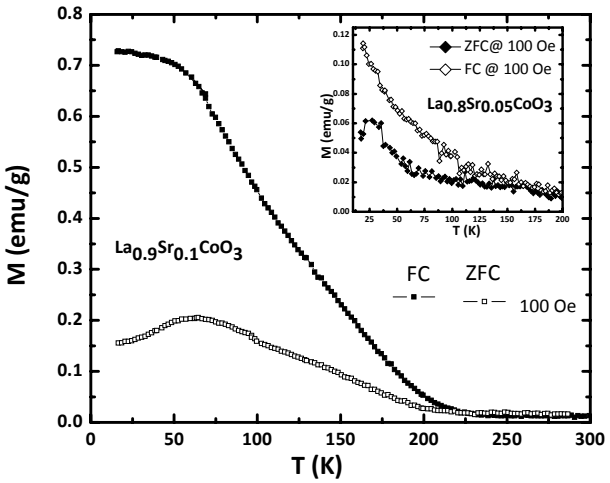

Fig. 1. Temperature dependent magnetization for x =0.05 and x =0.1.

4. References

[1] M. Itoh. I. Natori, S. Kubota, and K. Motoya, J. Phys. Soc. Jpn., **63**, 1486 (1994).

[2] K. Binder, A.P. Young, Rev. Mod. Phys., **58**, 801 (1986).

[3] T. Bitoh, K. Ohba, M. Takamatsu, T. Shirane, S. Chikazawa, J. Phys. Soc. Jan., **64**, 1305 (1995).