Magnetic properties of nanostructured $Ca_{1-x}Gd_xMnO_3$ obtained by glycine-nitrate procedure

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$Ca_{1-x}Gd_xMnO_3$ nanopowders (x=0.05, 0.10, 0.15, 0.20) with perovskite type crystal structure were synthesized by the glycine nitrate procedure [1]. Starting powders were prepared by combustion of solutions containing mixture of glycine with metal nitrates in their appropriate stoichiometric ratios. The so-obtained powders were annealed at the temperature of 850 °C for 10 minutes to produce final nanostructured samples with the average nanoparticle size of about 20 nm. Magnetic measurements show that electron doping by Gd^{3+} ions substantially changes $CaMnO_3$ antiferromagnetic (AFM) behaviour. After introduction of Gd^{3+} ions, significant ferromagnetic (FM) component appears due to an emergence of double exchange interaction between Mn^{3+}-Mn^{4+} ions. This resulted in appearance of a low temperature plateau in field cooled (FC) magnetization as well as in emergence of hysteresis loop with the relatively high coercivity up to 2300 Oe. Presence of competing long-range AFM and short-range FM interactions and their randomness lead to a frustration of manganese magnetic moments, and appearance of the spin-glass state at low temperature of about $T_{SG}\approx 65$ K (Fig.1, Inset). Concentration dependence of effective magnetic moments $\mu_{eff}(x)$ is linear, while Curie-Weiss temperature $\theta(x)$ changes its sign from negative to positive for concentrations above x=0.05 (Fig. 2) which points to the formation of FM clusters in AFM matrix [2]. The same picture is supported by low temperature M(H) measurements were maximums in $H_c(x)$ and M(x) curves at certain concentration x is a consequence of the balance between FM-cluster/AF-matrix interactions (Fig. 3). Recorded large field-cooled hysteresis shift H_{shift} (Fig.4.) can be also considered as a consequence of exchange bias that emerges at the borderline of FM-AFM regions. We assume that these interactions are also responsible for the unusual $H_c(T)$ plateau at the temperatures below spin-glass transitions (Fig. 4).

References

[1] D. Markovic, V. Kusigerski, M. Tadic, J. Blanusa, V. Antisari, V. Spasojevic, Scr. Mater. **59** (2008) 35.
[2] I. Sudheendra, A. R. Raju and C. N. Rao, J. Phys.: Condens. Matter **15** (2003) 895.

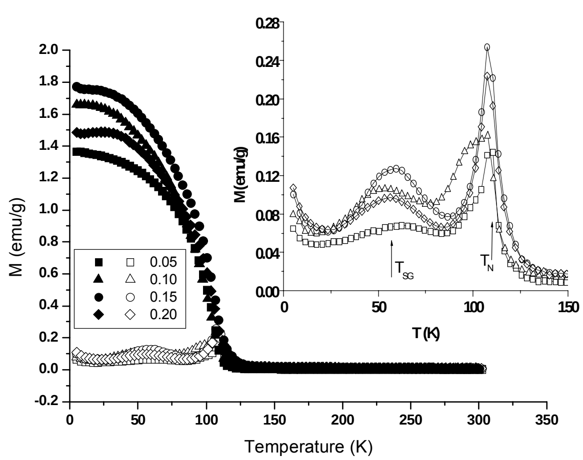

Fig. 1.

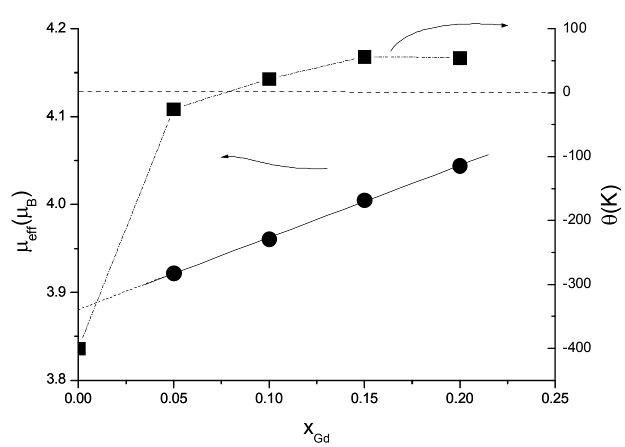

Fig. 2.

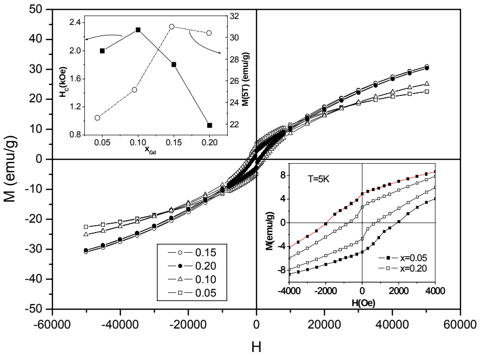
M (emu/g)
H
0.15
0.20
0.10
0.05
H_C(kOe)
M(5T) (emu/g)
x_{Gd}
T=5K
M(emu/g)
H(Oe)
x=0.05
x=0.20

Fig. 3.

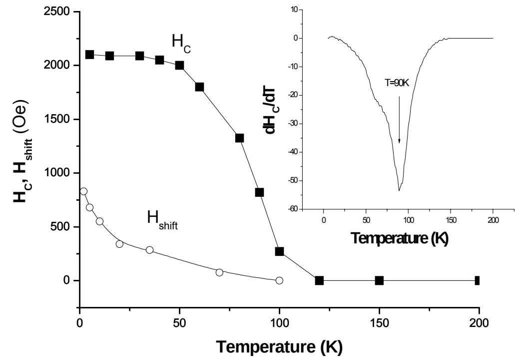
H_C, H_{shift} (Oe)
Temperature (K)
H_C
H_{shift}
dH_C/dT
T=90K
Temperature (K)

Fig. 4.