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### Stress Effects of $\text{CoCr}_2\text{O}_4$ Film on $\text{MgO}$ and $\text{MgAl}_2\text{O}_4$ Grown by RF-Sputtering Process

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In multiferroic thin films, ferromagnetic and ferroelectricity coexist[1,2].  $\text{CoCr}_2\text{O}_4$  film was deposited on  $\text{MgO}$  and  $\text{MgAl}_2\text{O}_4$  substrates by rf-sputtering process. The films were prepared at rf-magnetron sputtering power of 50W and a pressure of 10 mtorr (20 sccm in Ar), substrate temperatures of 550°C. The crystal structure was determined to be spinel ( $Fd\bar{3}m$ ) structure by means of X-ray diffraction (XRD) with  $\text{K}\alpha$  Cu radiation. The thickness and morphology of films were measured by scanning electron microscopy (SEM) and atomic force microscopy (AFM). The magnetic properties were measured using a Superconducting Quantum Interference Device(SQUID). The ferrimagnetic transitions were observed about 82 K, which was determined as Néel temperature, but magnetic behavior shows different. The results of each other magnetic property can be explained by stress effects between  $\text{CoCr}_2\text{O}_4$  and substrates of  $\text{MgO}$  and  $\text{MgAl}_2\text{O}_4$ .

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### Magnetic Refrigeration Properties of $\text{La}_{0.8}\text{Ca}_{0.2}\text{Mn}_{0.99}\text{Fe}_{0.01}\text{O}_3$

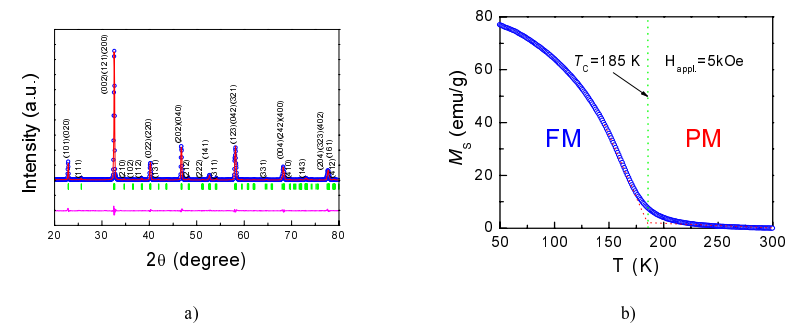
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The crystallographic and magnetic properties of  $\text{La}_{0.8}\text{Ca}_{0.2}\text{Mn}_{0.99}\text{Fe}_{0.01}\text{O}_3$  have been studied using x-ray diffraction (XRD), vibrating sample magnetometer (VSM) and Mössbauer spectroscopy measurements. The  $\text{La}_{0.8}\text{Ca}_{0.2}\text{Mn}_{0.99}\text{Fe}_{0.01}\text{O}_3$  sample was prepared by sol-gel method with starting materials La-nitrate, Ca-nitrate, Mn-acetate and  $^{57}\text{Fe}$ -powder. The sample was annealed at 1000°C under  $\text{O}_2$  atmosphere. Fig. 1 a) and b) show the x-ray refinement and temperature dependence of magnetization, respectively.



**Fig. 1.** a) Rietveld refinement of XRD pattern, b) temperature dependence of magnetization  $M(T)$  measured at 5 kOe for  $\text{La}_{0.8}\text{Ca}_{0.2}\text{Mn}_{0.99}\text{Fe}_{0.01}\text{O}_3$ .

The crystal structure of  $\text{La}_{0.8}\text{Ca}_{0.2}\text{Mn}_{0.99}\text{Fe}_{0.01}\text{O}_3$  was found to be orthorhombic ( $Pnma$ ) structure with lattice constants  $a_0 = 5.486$  Å,  $b_0 = 7.761$  Å, and  $c_0 = 5.510$  Å at room temperature. The Curie temperature ( $T_c$ ) is determined to be 185 K by zero field cooled (ZFC) magnetization curve under 5 kOe applied field. Mössbauer spectrum at 4.2 K was fitted with two independent magnetic components of the magnetic hyperfine fields  $H_{f1} = 526$  kOe and  $H_{f2} = 501$  kOe. Mössbauer spectra shows that the linebroadening and the ratio of the absorption areas is changed below  $T_c$ . The maximum value of magnetic entropy changes,  $|\Delta S_{m,\text{max}}|$  is 0.54 J/kg·K at 155 K, under 5 kOe applied field [1]-[2].

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