

The Magnetic Entropy Change of $\text{La}_{0.7-x}\text{Ga}_x\text{Ca}_{0.3}\text{MnO}_3$ Compounds

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1. Introduction

The magnetic caloric effect (MCE) is intrinsic to magnetic solids and is induced via the coupling of the magnetic sub-lattice with the magnetic field, which alters the magnetic part of the total entropy due to a corresponding change in the magnetic field. It can be measured and calculated as the adiabatic temperature change $\Delta T_{\text{ad}}(T, \Delta H)$ or as the isothermal magnetic entropy change $\Delta S_M(T, \Delta H)$. Traditionally, diluted paramagnetic slats and rare earth intermetallic compounds that display significant MCE have been considered as attractive materials for cryogenic applications. Especially, perovskite $\text{La}_{0.7}\text{Ca}_{0.3}\text{MnO}_3$ (LCMO) shows room temperature magnetoresistance and a ferrimagnetic phase transition with a Curie temperature of 260~270K. Therefore, it would be very interesting to study the magnetocaloric effect for this kind of materials because of the Curie temperature being near room temperature. The magnetic entropy change can be tuned by suitable sintering process. In this work, the magnetocaloric effect of $\text{La}_{0.7-x}\text{Ga}_x\text{Ca}_{0.3}\text{MnO}_3$ compound was investigated. Materials with proper Curie temperature and large spontaneous magnetization have many peculiar properties that are attractive for applications as magnetic refrigerants.

2. Experiments

Polycrystalline $\text{La}_{0.7-x}\text{Ga}_x\text{Ca}_{0.3}\text{MnO}_3$ ($x=0.0, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3$) samples were prepared by standard solid-state reaction in a stream of 5% H_2/Ar gas at sintering temperatures of 1273K for 12h. A stoichiometric mixture of high purity La_2O_3 (99.99%), Ga_2O_3 (99.99%), Ba_2CO_3 (99.99%) and MnCO_3 (99.999%) powders were fired in an Al_2O_3 crucible at 1573K in an electric furnace. X-ray diffraction patterns were taken with a Phillips diffractometer using $\text{Cu K}\alpha$ radiation. The temperature dependence of the magnetization was measured with a commercial vibrating sample magnetometer (VSM) at various temperatures from 80K to 500K in fields up to 10kOe.

3. Results and discussion

$\text{La}_{0.7-x}\text{Ga}_x\text{Ca}_{0.3}\text{MnO}_3$ compound measured at 100 Oe from 80 K. The magnetic transition temperature, T_c defined as the minimum temperature of the dM/dT vs. T curve. The sharp decrease in magnetization implies the occurrence of magnetic ordering. The Curie temperature decreased from 274K to 164K with increasing Ga concentration.

We measured the temperature dependence of the magnetic entropy change for $\text{La}_{0.7-x}\text{Ga}_x\text{Ca}_{0.3}\text{MnO}_3$ compound with an external field of 10kOe. The magnetic entropy change, a function of temperature and magnetic field,

produced by the variation of the magnetic field from 0 to Hmax is calculated by
$$|\Delta S_M| = \sum_i \frac{M_i - M_{i+1}}{T_{i+1} - T_i} \Delta H$$
.

As the magnetic field increase varying from 0 to 10 kOe, ΔS_M is about 0.82 J/kg K(x=0.3) - 2.28 J/kg K(x=0.0). The magnetocaloric effect is taken place around room temperature, especially. The superior features of this compound make it a competitive candidate for a working material in room temperature magnetic refrigeration because of proper substitution of Ga. This opens promising applications in magnetic cooling systems, probably.

4. Conclusion

The magneto-caloric effect and magnetization behavior have been analyzed in the perovskite $\text{La}_{0.7-x}\text{Ga}_x\text{Ca}_{0.3}\text{MnO}_3$ compound with the sintering temperature at 1273K. Samples were fabricated by conventional solid-state reaction method. X-ray diffraction measurements revealed that all the samples are single phase in cubic structure. The TC decreased with increasing Fe content. The magnetic entropy changes, ΔS_M of about 0.82 ~ 2.28 J/kg K were obtained in the temperature range of 164 K ~ 274 K. The maximum values of ΔS_M obtained at x=0.0 compound with Curie temperature of 274 K.

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