Large magnetic entropy change in $La_{1-x}Ca_xMnO_3$ synthesized from nanoparticles

P. Zhang[1], K. Tarigan[1], T. D. Thanh[2], T. L. Phan[1], S. C. Yu[1,*]

[1]BK21 Physics Program and Department of Physics, Chungbuk National University, Cheongju 361-763, South Korea
[2]Institute of Materials Science, Vietnam Academy of Science and Technology, Hoang Quoc Viet street, Hanoi, Vietnam

Introduction

Recently, many works about the magnetocaloric property of $La_{1-x}Ca_xMnO_3$, a typical perovskite manganite, show that this kind of material exhibit a considerable magnetic entropy change, and when the Ca doping content is near x = 0.3, the magnetic entropy change reaches the highest value [8].

W. Tang *et al.*[10] studied about the particle size effects on $La_{0.7}Ca_{0.3}MnO_3$, found that the particle size influence the type of magnetic phase transition which changes from first-order to second-order with decrease in the particle size.

In order to get more information about the relation between the type of magnetic phase transition, the particle size and the Ca content, we investigated the structure and magnetic property of $La_{1-x}Ca_xMnO_3$ ($0.2 \le x \le 0.4$) compounds prepared from $La_{1-x}Ca_xMnO_3$ nanoparticles.

Experiment

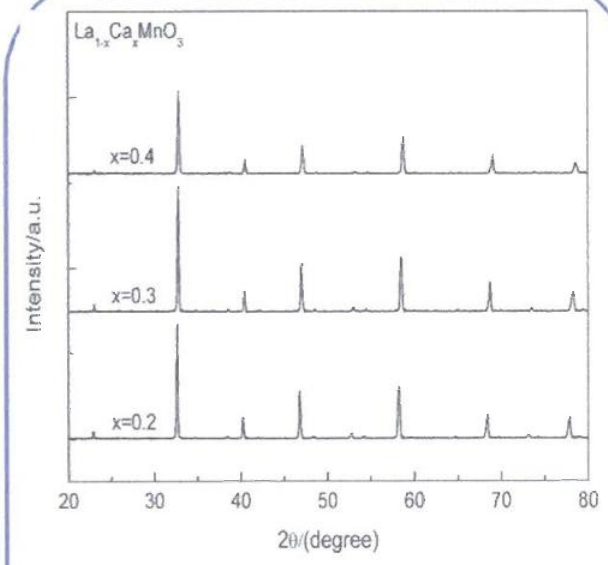
High-purity precursors of La_2O_3, CaO, and MnO_2 combined with stoichiometrical masses were firstly mixed by the ball-milling process for 12 hrs.

The mixtures were then calcined at 1200 °C for 12 hrs for reaction. After this step, the mixtures were ball-milled again for 24 hrs to refine particle sizes of about 15 nm.

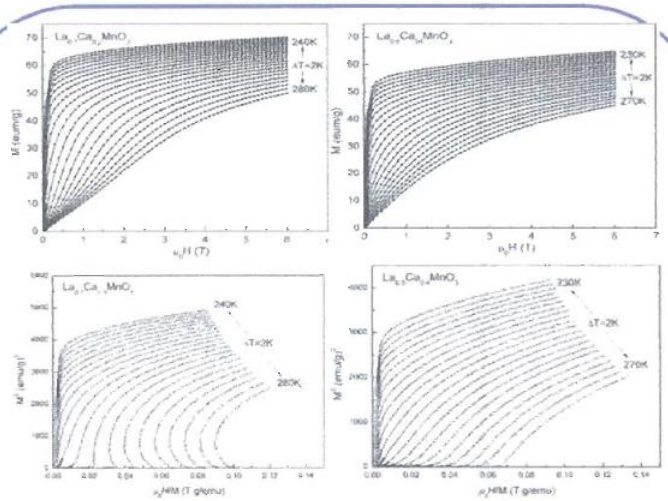
Finally, they were pressed into pellets, and annealed at 1300 °C for 24 hrs.

The crystal structures were investigated by X-ray diffraction (XRD). Magnetic measurements were performed on a magnetic property measurement system (MPMS) with the applied magnetic field range of 0 - 6 T.

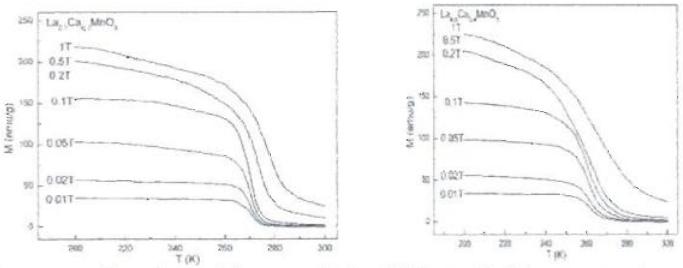
Results and discussions



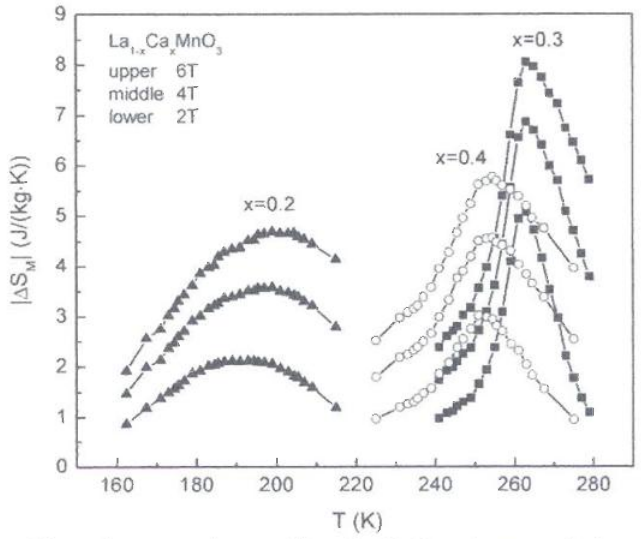
XRD patterns of $La_{1-x}Ca_xMnO_3$ at room temperature



Isothermal magnetization curves (M-H curves) and its Arrott plots of the representative sample of $La_{0.7}Ca_{0.3}MnO_3$ and $La_{0.6}Ca_{0.4}MnO_3$



Temperature dependence of the magnetization (M-T curves) of the representative sample of $La_{0.7}Ca_{0.3}MnO_3$ and $La_{0.6}Ca_{0.4}MnO_3$ measured with varying magnetic field from 0.01 T to 1T.



Magnetic entropy change of $La_{1-x}Ca_xMnO_3$ under an applied magnetic field of 2, 4, 6 T.

Conclusions

The magnetocaloric effect around the ferromagnetic-paramagnetic transition temperature was studied for $La_{1-x}Ca_xMnO_3$. It was revealed that ΔS_M of the $La_{0.7}Ca_{0.3}MnO_3$ under an applied field of 6 T reached a maximum value of 8.1 J/(kg.K). From the Arrott plots and the M-T curves with different magnetic field, the first-order magnetic phase transition existing in $La_{0.7}C_{0.3}MnO_3$ around T_C, it could explain the large ΔS_M appear only in $La_{0.7}Ca_{0.3}MnO_3$. The types of the magnetic phase transition result from a combination of things. In general, with relatively high magnetic entropy change obtained, these types of perovskite material become a series of promising candidate of magnetic refrigeration.

E-mail : scyu@chungbuk.ac.kr
Applied Physics Laboratory