Magnetic properties and magnetocaloric effect in $La_{0.7}Ca_{0.3-x}Ba_xMnO_3$ exhibiting first-order and second-order magnetic phase transitions

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We have prepared polycrystalline samples $La_{0.7}Ca_{0.3-x}Ba_xMnO_3$ (x = 0, 0.025, 0.05, 0.075 and 0.1) by solid-state reaction, and then studied their magnetic properties and magnetocaloric (MC) effect based on magnetization versus temperature and magnetic-field (M-H-T) measurements. Experimental results reveal the easiness in tuning the Curie temperature (T_C) from 260 to about 300 K by increasing Ba-doping concentration (x) from 0 to 0.1. Under an applied field H = 50 kOe, maximum magnetic-entropy changes around T_C of the samples can tuned in the range between 6 and 11 $J \cdot kg^{-1} \cdot K^{-1}$, corresponding to refrigerant-capacity values ranging from 190 to 250 $J \cdot kg^{-1}$. These values are comparable to those of some conventional MC materials, and reveal the applicability of $La_{0.7}Ca_{0.3-x}Ba_xMnO_3$ materials in magnetic refrigeration. Analyses of the critical behavior based on the Banerjee criteria, Arrott plots and scaling hypothesis for M-H-T data, and scaling laws for the MC effect prove a magnetic-phase separation when Ba-doping concentration increases. In the doping region x = 0.05-0.075, the samples exhibits the crossover of first- and second-order phase transitions with the values of critical exponents β and γ close to those expected for the tricritical mean-field theory. The samples with $x < 0.05$ and $x > 0.075$ exhibit first- and second-order transitions, respectively. More detailed analyses related to the Griffiths singularity, the critical behavior for different magnetic-field intervals started from 10 kOe, and the magnetic-ordering parameter $n = d\mathrm{Ln}|\Delta S_m|/d\mathrm{Ln}H$ (where ΔS_m is the magnetic-entropy change) demonstrate magnetic inhomogeneities and multicritical phenomena existing in the samples.

Keywords: Perovskite manganites, Magnetic properties, Magnetocaloric effect