Synthesis and magnetic properties of $La_{0.7}A_{0.3}MnO_3$ (A = Ca and Sr) nanotubes array

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Abstract

Mixed-valent manganites, $La_{1-x}A_xMnO_3$ (A = Ca, Sr or Ba) exhibit a wide variety of physical phenomena such as colossal magnetoresistance (CMR), charge ordering, orbital ordering and magnetic phase separation [1]. These behaviors arise out of strongly competing charge, spin and orbital ordering interactions [2]. When the size of a material is reduced to nanometers, the surface-to-volume ratio becomes increasingly important and various finite size effects come into play. Since, the CMR property of manganites is strongly dependent on the dimension of the manganese oxide lattice, the one dimensional nanotubes will be highly interesting to study. Moreover, manganite nanotubes with ferromagnetic states are also promising nanostructures for technological applications in spintronics and cancer therapy [3,4]. In this-way, we have synthesized $La_{0.7}Ca_{0.3}MnO_3$ and $La_{0.7}Sr_{0.3}MnO_3$ nanotubes by nanoporous alumina template assisted sol-gel method and compared its low temperature magnetic behaviors with its bulk counterpart.

The porous anodic alumina (PAA) templates were prepared by a standard two steps anodization process using high-purity (>99.997%) aluminum foils. The aluminum substrates were cleaned with acetone and ethanol and then electrochemically polished before the first anodization. The first anodization was done in 0.1 M phosphoric acid by applying a constant potential of 195 V at a temperature of 1^0C during 24 hours. Subsequently, the resulting PAA was dissolved by chemical etching and then the second anodization was performed using the same conditions as the first one, but for about 40 hours, allowing one to achieve self-organized PAA with 200 nm pore diameter and 100 μm thickness. To prepare the $La_{0.7}A_{0.3}MnO_3$ sol-gel, the stoichiometric La_2O_3, CaO (or SrO), $Mn(NO_3)_2$ were dissolved in pure water and nitric acid. A small amount of ethylene glycol was added with continuous stirring. The pH of the solution was adjusted to a stable value of 4 pH by adding ammonia solution. The whole solution was then heated to 80^0C until a clear sol was obtained. Finally the sol-gels were adjusted to a molarity of 0.6 M and a viscosity value of 27 mPa.s.

To obtain the nanotubes array, the PAA templates were immersed into the sol-gel at room temperature for about 2 hours. Then both sides of the templates were carefully cleaned and the filled templates were placed in a furnace for the heat treatment. During this process, the temperature was raised to 400 ^{0}C and then to 900 ^{0}C where the templates were kept for 5 hours in a controlled oxygen atmosphere. A small amount of its bulk counterpart was also prepared to compare the characterization results.

The phase purity of the final samples was verified by room temperature X-ray diffraction patterns. The scanning electron microscopy micrographs were also recorded to verify the formation of $La_{0.7}Ca_{0.3}MnO_3$ and $La_{0.7}Sr_{0.3}MnO_3$ nanotubes array. The magnetic properties of the as-prepared nanotubes were characterized as a function of temperature and magnetic field, using a SQUID magnetometer. In the presentation, the synthesis method of manganite nanotubes array and its magnetic behavior will be discussed in detail.

References

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