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졸-겔법에 의한 $La_{2/3}Sr_{1/3}Mn_{0.99}Fe_{0.01}O_3$ 입상 다결정 박막의 제조 및 전도특성

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Sol-Gel synthesis and transport properties of $La_{2/3}Sr_{1/3}Mn_{0.99}Fe_{0.01}O_3$ granular thin films.

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1. INTRODUCTION

The doping of the Mn ions by other transition metal ions in perovskites of composition $Ln_{1-x}A_xMn_{1-y}TR^{3+}{}_yO_3$ (TR=transition metal), which shows ferromagnetism and colossal magnetoresistance (CMR) for the y=0 composition sample, gives rise also to changes in the Mn^{3+}/Mn^{4+} proportion. Up to date, some authors have investigated the Fe doping effects on the structural, transport and magnetic properties of $La_{1-x}Ca_xMn_{1-y}Fe_yO_3$, $La_{1-x}Pb_xMn_{1-y}Fe_yO_3$ and $La_{1-x}Sr_xMn_{1-y}Fe_yO_3$ bulk samples and found that the dopant Fe causes no structure change, but suppresses condition and ferromagnetism and modifies magnetoresistance. As we know, there are many different properties in bulk and thin films, such as crystal growth and microstructure etc. However, the thin film properties of Fe doped manganite has not been reported on a systematic study. So we report structural, magnetic, and transport properties of $La_{2/3}Sr_{1/3}Mn_{0.99}Fe_{0.01}O_3$ (LSMFO) thin films, which have been prepared by novel water-based sol-gel process.

2. EXPERIMENTAL

LSMFO thin films were prepared by spin-coating on Si(100) with thermally oxidized SiO_2(2000 Å) substrates with a precursor prepared by a water-based sol-gel processing. Thermal gravity (TG) and differential temperature analysis (DTA) were conducted on the powdered xerogel up to 800℃ at a heating rate of 5℃/min. LSMFO films were deposited by spin-coating at 4000 rpm for 30 s and the films were pyrolized on a hot plate at 80℃, 200℃, and 300℃, respectively, for 3 min between each coating. The LSMFO-coated films were placed in a alumina boat and annealed in O_2 at temperatures in the range of 500 – 850℃. Crystallographic structures were examined using thin-film X-ray diffractometer using CuKα radiation. The surface morphology was observed by using atomic-force microscope. Magnetic properties measurements were carried out with a VSM in fields up to 1 .0 Tesla at room temperature. High-field magnetotransport properties were measured from 77 K to 310 K in fields up to 1.0 Tesla using a standard four-probe technique. In the transport -property measurements, the field was applied parallel to the film surface.

3. RESULTS AND DISCUSSIONS

The weight loss of the bulk gels obtained from the precursor solutions takes place in two distinct steps defined by two temperature intervals. The DTA curves indicated a series of exothermic peaks. For all systems, an exothermic peak is observed at ~290℃, which has been associated with decomposition of organic and crystallization of manganese perovskite.

The pure perovskite peaks of LSMFO begins to appear in the sample annealed at 300℃ and the phase is fully developed at temperatures above 500℃. The lattice constants were found to be 3.8747 and 3.8724 Å for x=0.0 and x=0.01, respectively. The LSMO thin films were composed of uniformly distributed grains, and the grains grew with increasing annealing temperature. The surface roughness was ~135Å in the film annealed at 500℃ and 117Å in the film annealed at 800℃. To explore the effect of the annealing temperature on the magnetic properties in detail, here we studied the magnetic hysteresis loops of $La_{2/3}Sr_{1/3}Mn_{0.99}Fe_{0.01}O_3/SiO_2/Si(100)$ thin films as a function of annealing temperature. Both coercivity (H_c) and magnetization (M) are strongly dependent of annealing temperature.

In the zero-field temperature dependence of normalized [R(T)/R(300K)] resistance for the LSMFO thin films with different annealing temperature, all samples show a metal-semiconductor (insulator) transition temperature (T_{MS}) and T_{MS} is much lower than the Curie temperature (T_C). Transition temperature is found to be strongly dependent of the annealing temperature. The nonlinear [R(H)-R(max)/R(max)] response remains very similar to that for polycrystalline sample where spin-dependent tunneling and/or spin-dependent scattering are responsible for the nonlinearity. These results provide us evidence that the underlying mechanism responsible for the MR effect may be the spin-dependent sequence like spin-dependent tunneling and/or scattering.

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