Journal of Magnetism and Magnetic Materials 440 (2017) 179–180

Contents lists available at ScienceDirect

Journal of Magnetism and Magnetic Materials

journal homepage: www.elsevier.com/locate/jmmm

Magnetization of manganite thin films on ferroelectric substrates

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A R T I C L E I N F O

Keywords:
Thin film
Multiferroic
Ferroelectric
Magnetization

A B S T R A C T

Here we report the magnetic susceptibility measurements of magnetron sputtered orthorhombic manganite $RMnO_3$ (R=Yb, Gd) thin films deposited on dielectric $LaAlO_3$ and ferroelectric $SrTiO_3$, $LiNbO_3$ substrates. We observed that all of investigated o-$RMnO_3$ films show a splitting in the temperature dependence of ZFC and FC magnetization curves. We found that the substrate can impact on the splitting temperature ZFC-FC curves and absolute value of the magnetization of thin films.

1. Introduction

The physical properties of multiferroics can be changed in thin films, where magnetic, electric properties and lattice parameters of substrates and also topology of thin films became important. Previously Li et al. reported exotic multiferroic behaviors, including high-T_C ferroelectric state, a large spontaneous polarization and relatively strong ferromagnetism emerging in orthorhombic $GdMnO_3/SrTiO_3$ (001) thin films of thickness 10–110 nm with self-assembled nano-scale twin-like domains [1,2]. Moreover, both the onset temperatures of the weak FM phase $T \sim 105$ K and the ferroelectric phase $T_C \sim 75$ K of the film are much higher than that of the bulk. Rubi et al. also showed that strain effects alone cannot account for the difference between the magnetic properties of the bulk material and thin films, and that the film morphology plays, instead, a crucial role in h-$YbMnO_3/SrTiO_3$ [2,3]. But in contrast with $GdMnO_3/SrTiO_3$ authors observed that the magnetic properties depart from the bulk behavior only in the case of ultrathin films ($d < 30$ nm) without domain structure of the surface.

The aim of this work is to study the influence of ferroelectric substrate $SrTiO_3$(STO), $LiNbO_3$(LNO) and dielectric $LaAlO_3$(LAO) on magnetic properties of multiferroic thin films $GdMnO_3$(GMO) and $YbMnO_3$(YbMO).

2. Experimental details

o-GMO and o-YbMO thin films were deposited on (001)-oriented STO, LAO and (014)-oriented LNO substrates by radio frequency magnetron sputtering. Detailed deposition conditions and crystallographic characterizations were reported in [4]. The magnetization was measured on the PPMS-9 device in the temperature range from 4 to 300 K and in in-plane magnetic field up to 1 T zero-field-cooled (ZFC) and field-cooled (FC) regimes. Diamagnetic glue was used to hold the samples. For simplicity presentation we subtracted a diamagnetic contribution of a substrate. The molar diamagnetic susceptibility of substrates can be estimated using diamagnetic susceptibilities of single ions (J. of Chem. Educ. **85**, 532(2008)). The number of moles of substrate was estimated using the mass of the sample, neglecting the mass of the thin film.

3. Results and discussion

The temperature dependences of the magnetic susceptibility of o-GMO measured in magnetic fields of 1000 Oe on two substrates STO and LNO are equivalent in temperature range from 300 to 50 K and don't coincide below 50 K (Fig. 1). The absolute value of the magnetic moment and temperature of the splitting of the FC and ZFC curves strong depends on the type of the substrate. The magnetic moment for GMO/STO is two times more then for GMO/LNO at 4 K. The splitting temperature is 12–17 K in GMO/STO and 50 K in GMO/LNO, that is

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http://dx.doi.org/10.1016/j.jmmm.2016.12.108
Received 13 August 2016; Accepted 21 December 2016
Available online 23 December 2016
0304-8853/