Structural, magnetic and transport behavior of $SrRu_{0.7}Fe_{0.3}O_3$ epitaxial thin film

Umasankar Dash*, Chang Uk Jung†
Department of Physics and Oxide Research Centre,
Hankuk University of Foreign Studies, Yongin 17035, South Korea
*Corresponding author: cu-jung@hufs.ac.kr; Fax: +82-31-330-4566

1. Introduction

The perovskite oxide $SrRuO_3$ (SRO) has been in the light of many researchers due to its strong correlated properties with other materials and its metallicity. Much fundamental research focused on the growth of single crystalline SRO epitaxial thin film on $SrTiO_3$(001) substrates to study the under line behavior in both physical as well as magnetic properties[1,2]. In contrast, more fascinating properties were observed in thin film form than the bulk sample like thickness dependent metal to insulator transition, antiferromagnetism in ultra-thin films, spin glass behavior and spin transitions[3-5]. As we know SRO is aferromagnetic metallic material whose ferromagnetism originates from a narrow t_{2g} band. The band width can be drastically changed doping at Bsites which might give some interesting physical as well as magnetic properties. Different 3d elements were introduced at B sites of SRO and their physical properties were examined. Li Pi *et. al*. studied transport as well as magnetic properties of doped SRO [6]. They showed that, doping Zn^{2+}, Ni^{2+}, Co^{2+}, Cr^{3+}, and Mn^{3+} into Ru sites might help to know the lattice distortion, variation in ferromagnetic T_C, metal to insulator transition and other intriguing properties. In our previous repot we had shown that, doping Fe into Ru site significantly changes the ferromagnetic T_C as well as resistivity of the thin film.[7]. In thisr eport, we studied the doping effect of Fe on Structural, magnetic and transport behavior of $SrRu_{0.7}Fe_{0.3}O_3$ epitaxial thin film.

2. Experimental

Fe doped SRO polycrystalline target was prepared by conventional method. The target was put inside the high vacuum chamber for laser ablation. Fe doped SRO epitaxial thin film was grown on $SrTiO_3$(001) substrates by KrF excimer laser. The substrate temperature was maintained at 750℃. The oxygen partial pressure was kept around 175 mTorr. The thickness of the as deposited thin film was measured by using Field emission scanning electron microscope (FESEM) and was found to be 60nm. Crystal structure and surface morphology of the thin film was characterized by X-ray diffraction (XRD) and atomic force microscope (AFM). The magnetic property of the thin film was measured by superconducting quantum interface device-vibrating sample magnetometer (SQUID-VSM). Hall bar pattern was made on the thin film by photolithography technique in order to measure the magneto-transport behavior.The resistivity and magnetoresistance measurement was carried out using a cryogen free cryostat (T = 2-300 K, Field sweep, H = -9 T to +9 T) (CMag Vari9, Cryomagnetics Inc.) with a dual channel source-measure unit (Keithley 2612A Standard Measurement Unit).

3. Results and Discussion

High resolution X-ray diffraction (HRXRD) studies showed that the as deposited thin film showed excellent

c axis orientation. As reported previously, we had stabilized the single crystalline by using epitaxial strain without co-doping at Sr site [7]. The calculated lattice constant of the thin film was found to be 3.955 Å. The reciprocal space mapping showed the coherently growth of thin film with that of STO substrate [8]. Excellent step in terrace observed from the atomic force microscope measurement. The surface roughness of the thin film was as low as 0.24nm. We have shown that by doping higher concentration of Fe at Ru site, the resistivity of the thin film can be dramatically enhanced. As reported previously, [7] we had shown that with increasing Fe doping concentration (from x = 0.05 to 0.20), the film resistivity at low temperature (at 2 K) increased from metallic to semiconducting state. The disorder induced by Fe doping at Ru site might be responsible for the increase of zero filed resistivity at low temperature [9]. We had also performed field dependent resistivity study for Fe doped (x = 0.30) SRO thin film. It can be noted that, with application of external magnetic field, the film resistance decreased and Tmin shifts towards left side. Magnetoresistance (MR) measurement of the thin film was carried out and a large MR (~ 20%) was observed for the thin film. The field was sweep from -9 T to +9 T. The observed high MR in our thin film might be comes from the spin fluctuation of mobile electronic carriers. It should be emphasized that MR of our coherently grown epitaxial thin film has much less contribution from grain boundary compared to MR of poly-crystal. The higher value of MR in the polycrystalline sample for x = 0.30 may be attributed to the grain boundary and defects which are absent in our epitaxial thin films [10]. The temperature dependence MR at 9 T also showed similar value of MR (~ 20%) down to 10K. The saturation of magnetization (M_{Sat}) value of $SrRu_{0.7}Fe_{0.3}O_3$ was found to be 0.6μB/Ru.

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