LNO BOTTOM ELECTRODES FOR SPINTRONICS ON Si AND AL_2O_3 SUBSTRATES PREPARED BY SPIN COATING TECHNIQUE USING METAL-ORGANIC PRECURSORS

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Abstract

Lanthanum nickel oxide $LaNiO_3$, (LNO) has a structure similar with perovskite ferroelectrics with metallic conductivity in a wide temperature range. LNO thin film acts as a template layer for growth of ferroelectric layers.

In this paper LNO layers were prepared by a wet chemical method from metal-organic precursors on Si and Al_2O_3 substrates. Films deposited on both substrates were very smooth and crack-free. R (T) curves of the LNO films possessed good metallic character.

1. INTRODUCTION

Conductive oxide layers such as $SrRuO_3$, IrO_2, $LaNiO_3$ (LNO), RuO_2, and $LaAlO_3$ have been studied intensively due to their potential application for bottom electrode or buffer layer in deposition of perovskite thin films. Recent technological interest in the development of highly conductive electrodes for spintronic film devices has focussed attention on LNO. Spintronics, or spin-electronics is a relatively new research field where in addition to the electron charge transport electron spin transport is used.

LNO significantly improves the microstructure and electrical property of ferroelectric thin films, exhibits unique metallic, magnetic and electronic properties due to the strong interplay of structural, electronic and magnetic degrees of freedom. As oriented and textured ferroelectric layers have better properties than polycrystalline ones and as ferroelectric layers can inherit the electrode orientation, it is very important to prepare oriented electrodes with satisfactory microstructural properties.

Homogeneous surface corresponding to smooth and dense interface between electrode and upper film is required for electrical applications. The surface morphology of a thin film often determines the electrical properties that are crucial to the performances of a device. The aim of our research is to achieve smooth and crack free LNO bottom electrodes for spintronics and characterize the thin films.

2. EXPECTED PROPERTIES AND EXPERIMENTAL TECHNOLOGY

Perovskite oxides are represented by the general formula ABO_3 in which A ions can be rare earth, alkaline earth and alkali that fit into dodecahedral site of the framework, and the B ions can be 3d, 4d and 5d transitional metal ions which occupy the octahedral sites. These solids are resistant to high temperatures, are mechanically and chemically stable in the reaction medium and show interesting dielectric and conductor properties.

LNO thin films have a pseudocubic structure and a moderate lattice parameter (3.84 Å), resulting in good lattice match with ferroelectric materials. Meanwhile, LNO films retain good room temperature (RT) metallic properties. Therefore, LNO films can be used not only as bottom electrodes but also as template seed layers in the control of crystalline structure and preferred orientation of the subsequent ferroelectric films.

Many techniques have been used to fabricate LNO films, such as pulsed laser deposition, RF magnetron sputtering, metal-organic chemical vapor deposition (MOCVD), wet chemical processes including the sol–gel method and metallo-organic decomposition (MOD). The wet chemical process generally offers significant advantages in the film fabrication of electronic materials, such as high purity, low cost, ease of composition control, relatively low processing temperature and large deposition area. In the wet chemical process, the preparation of high-quality films depends strongly upon the synthesis of an appropriate precursor, the coating, and the crystallization conditions as well as the substrate used. There are numerous reports on the preparation of LNO films by the wet chemical process using different precursor solutions on various substrates such as Si, SiO2/Si, SrTiO3 and crystalline quartz substrate. However, it is also important to understand the relationships of the growth conditions with the microstructures and the electrical properties of the LNO films fabricated by the wet chemical process.

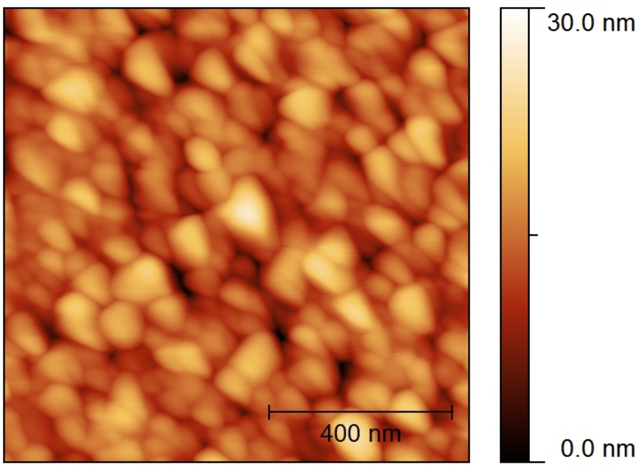
3. EXPERIMENT

In this paper LNO layers were prepared by a wet chemical method from metal-organic precursors. This method has good reproducibility and the process is simple.

The LNO precursor's solution was spin-coated onto Si and Al_2O_3 substrates. The deposited layers were slowly heated in a gradient thermal field and annealed at 750 deg C.

We used metal-organic precursors $La(CH_3COCHCOCH_3)$ and $Ni(CH_3COCHCOCH_3)$ with 1:1 stoichiometric ratio to make the $LaNiO_3$ solution. This solution was spin coated at 2500 RPM onto substrate. The thin films were annealed at 750 deg C for 1 hour in air, with a heating gradient of 10 deg C / min. Other temperatures used in the experiment have ensured worse AFM aspects. We observe that perovskite structure occurs from 600 deg C annealing temperature and epitaxial growth occurs from 700 deg C.

The thin films morphology was investigated using atomic force microscopy. LNO thin films deposited on both Si and saphire substrates had a uniform microstructure, without cracks or pores on the surface. All films were very smooth, with RMS roughness up to 5 nm, which makes them suitable for use as an electrode material.



AFM: Si // $LaNiO_3$

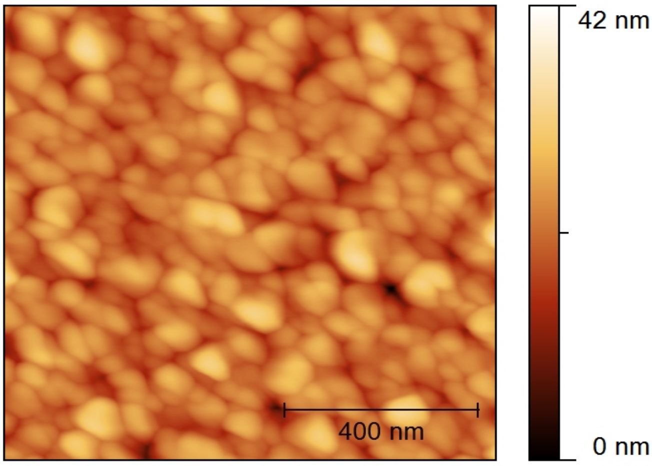
1µm×1µm

Mod: Contact

RMS= 4,4nm

Peak-to-Valley (P-V)= 41,5nm

Fig.1 AFM Image Si// $LaNiO_3$



AFM: Al_2O_3 // $LaNiO_3$

1µm×1µm

Mod: Contact

RMS= 4nm

Peak-to-Valley (P-V)= 36nm

Fig.2 AFM Image Al_3O_3// $LaNiO_3$

Measurement of R(T) was carried out using four point probe method for LNO films on Si and saphire (Al_2O_3) substrates. The thin films were cooled in liquid nitrogen from 300 K to 80 K.The temperature dependece exhibits good metallic behavior. Four point measuremets were carried out with Kheitley 2400 multimeter, remote controled with LabVIEW.

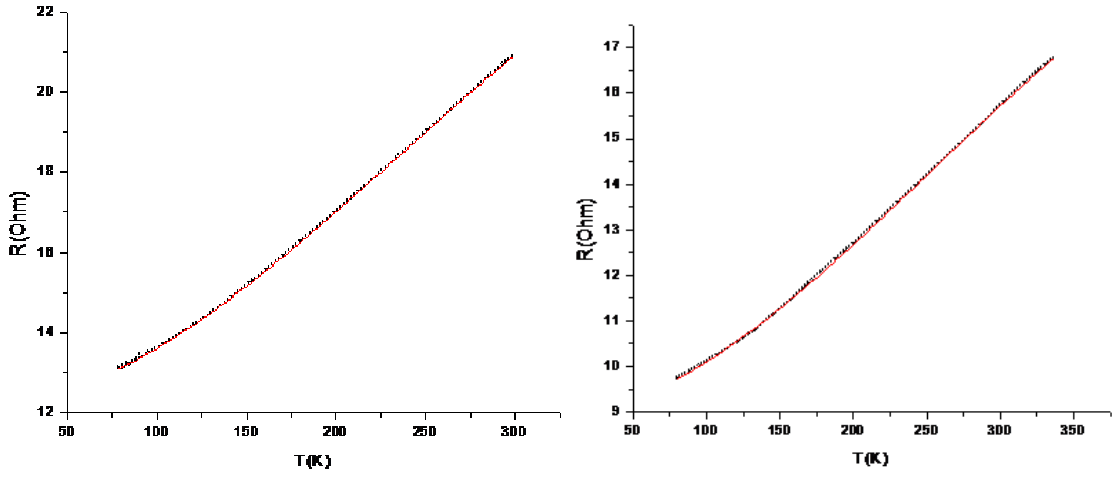


Fig.3 R(T) for LNO on Si (a) and R(T) for LNO on Al_2O_3 (b)

4. CONCLUSIONS

LNO films were deposited by spin-coating technique on substrates using metal-organic precursors and annealed at 750 deg C. This method is suitable for bottom electrodes for spintronics.

The experimental characterisation have shown good reproducibility and uniformity for the thin layers.

AFM images and four point measurements confirm that the thin films are smooth and crack free. LNO exhibits also a good metallic character. This is desired, as the surface morphology of a thin film often determines the electrical properties that are crucial to the performances of a device.

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