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Interfacial Characterization of PZT/LSMO/PT/Ti/Si/SiO_2 Thin Film by Pulsed Laser and Sol-Gel Deposition

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Introduction

This paper is concerned with the synthesis and analysis of heterostructures of lead zirconate titanate (PZT) with strontium-substituted lanthanum manganites (LSMO) for the observation of magnetoelectric (ME) effects [1] or multiferroic effects. The ferromagnetic manganite LSMO is magnetostrictive and the ferroelectric PZT is piezoelectric. Furthermore, the role of interface between LSMO and PZT thin film is very important. Composites with magnetostrictive and piezoelectric phases are expected to be magnetoelectric because of mechanical stress-mediated electromagnetic coupling. We report properties of interface and their magnetic-field dependence in composites of PZT/LSMO/Pt/Ti/Si/SiO_2. The aim of the this work is to present the interfacial characterization between PZT layer and LSMO layer of PZT/LSMO/Pt/Ti/Si/SiO_2 as a function of annealing temperature by using X-ray diffractometer(XRD), atomic force microscope (AFM), field-emission SEM (FE-SEM), vibrating sample magnetometer (VSM), and Transmission Electron Microscope (TEM).

Experiment and Result

LSMO thin film grown by KrF (248 nm) excimer lasers are used in pulsed laser deposition(PLD). The system consists of a vacuum chamber which is evacuated by a turbo pump to 10^{-6} Torr. The laser beam incident at an angle of 45° to the target surface is focused on to the rotating target, which has an 2 inch diameter pellet made by sol-gel method [2]. Laser beams of energy 190 to 200 mJ are focused to a size such that energy density is maintained between 1 and 2 J/cm^2. The substrate on which the film is to be grown is placed opposite to the target at a distance of 4 cm. Substrate can be heated to 650 °C. Gas inlet facility is provided so that films can be grown in oxygen 125 mTorr gas pressure is employed during the growth of the film. Finally, PZT composites thin films were deposited on the commercially available LSMO/Pt/Ti/Si/SiO_2 by spin coating using a commercial resist spinner. The films were deposited at 4000 rpm for 30 s at sixth times and the final thin films were crystallized in the temperature 650 °C for 30 min in air. Crystallographic structures were examined by XRD using CuKα radiation. The PZT/LSMO/Pt/Ti/Si/SiO_2 showed a rhombohedral structure. The crystal structure of the LSMO, at room temperature(RT), was determined to be rhombohedral of $R\bar{3}c$ space group with its lattice constants $a_0 = b_0 = 5.507$ Å, and $c_0 = 13.370$ Å, respectively. The crystal structure of PZT was determind to be *R3mh* space group with its lattice constant $a_0 = b_0 = 5.765$ Å, and $c_0 = 14.184$ Å, respectively. Film thickness, surface morphology and microstructures were observed by FE-SEM and AFM. The thickness of the LSMO and PZT layer were about 1700 Å and 2300 Å, respectively. The root mean square (rms) and average values of the surface roughness of LSMO film were 36.5 Å and 28.8 Å, respectively. While it has shown that rms and average values of the surface roughness of film were 14.8 Å and 11.5 Å, respectively. The magnetic properties were measured using a vibrating sample magnetometer (VSM). For the magnetization measurements on PZT/LSMO/ Pt/Ti/Si/SiO_2, an ordered magnetization was 150 emu/cc and coecivity was 32.76 Oe, at RT, as shown in Fig 1. Electric properties have typical polarization values. We report that the lattice mismatch between the PZT/LSMO thin film and the substrate plays a very important role and may control the mechanical stress-mediated electromagnetic coupling.

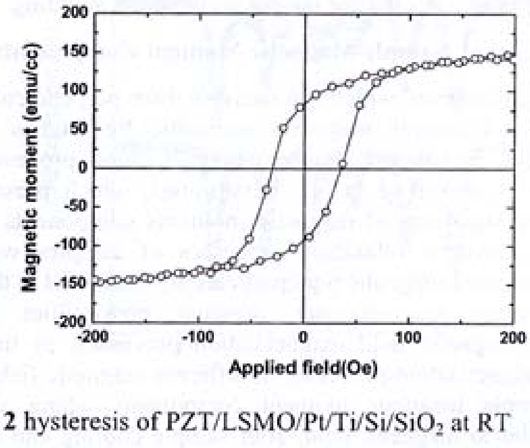

Fig. 2 hysteresis of PZT/LSMO/Pt/Ti/Si/SiO_2 at RT

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