Tuning Curie temperature of $La_{1-x}Sr_xMnO_{3-\delta}$ films by oxygen defect induced lattice strain

Nagoya Univ.[1], ◦ Satya Prakash Pati[1] and Tomoyasu Taniyama[1]
Email: pati.satya.prakash@b.mbox.nagoya-u.ac.jp

Recently, numerous efforts have been given in controlling the magnetic phase transition temperature by external parameters such as strain, pressure, voltage etc. to escalate researches for the realization of room temperature spintronic devices [1,2]. In this regard, $La_{1-x}Sr_xMnO_{3-\delta}$ (LSMO) has potential for room temperature spintronic applications due to its high Curie temperature (T_C), high spin polarization, and half metallicity [3]. Herein, we investigate the effect of oxygen content on the lattice strain and T_C of LSMO thin films on (001) oriented $SrTiO_3$ (STO) substrates.

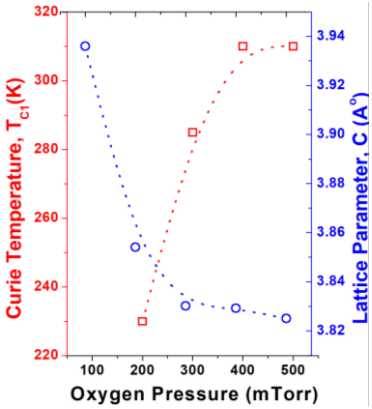

Fig. 1: Oxygen pressure dependent out-of-plane lattice parameter and Curie temperature of LSMO films.

Pulsed laser deposition (PLD) having an Nd:YAG laser of a wavelength of 266 nm with an energy of ~40 mJ and a repetition frequency of 10 Hz was used for the growth of LSMO films. The films were grown in varying O_2 pressures atmosphere from 100 to 500 mTorr while maintaining the substrate temperature at 650ºC. In-situ post-annealing of all the films were performed at 850ºC for 30 min in an O_2 pressure of 200 Torr. The rate of growth is found to decrease with increasing O_2 pressure and remains constant ≈3.33nm/min above an O_2 pressure of 300 mTorr. XRD measurements (2θ/χ and φ-scan) confirm (001) oriented epitaxial growth of the samples without having any other phases. The out-of-plane lattice parameters are found to vary from 3.936 to 3.825 Å with increasing O_2 pressure from 100 to 500 mTorr. That implies, with increasing O_2 content, out-of-plane compression and in-plane expansion occur. Magnetization measurements show that the magnetic easy axis lies in-plane while it is isotropic in all directions in the in-plane at room temperature. The saturation magnetization (M_S) is found to increase (≈0 to 250 emu/cc) with increasing O_2 pressure and remains constant above 400 mTorr. Interestingly, the films show in-plane biaxial anisotropy at 100 K. In-plane temperature dependent magnetization measurement at 100 Oe shows two type of transition temperatures (T_{C1}) and (T_{C2}) for all the samples. Fig. 1 represents the variation of lattice parameter and T_{C1} with O_2 pressure. T_{C2} remains almost constant at 355 K for all the films while T_{C1} varies from 230 to 310 K with increasing O_2 pressure from 200 mTorr to 500 mTorr, meaning that the Curie temperature can be enhanced with out-of-plane contraction. These results will pave a way to control the Curie temperature by oxygen defect induced lattice strain for possible room temperature spintronic applications.

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References

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