Effect of lattice mismatch induced strain on dynamic magnetic properties of $La_{1-x}Sr_xMnO_3$ films

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

Current research interest on low power consumption and high speed spintronic devices demands the development of interfacial multiferroics comprising of an oxide ferromagnet (FM) and a ferroelectric (FE) material [1,2]. Among oxide FMs, perovskite manganites, in particular, $La_{1-x}Sr_xMnO_3$ (LSMO) with x=0.3-0.4 have potential for different applications due to the unique properties such as half metallicity, i.e., high spin polarization, and high Curie temperature. In this work, we report on the effect of strain due to lattice mismatch on the static and dynamic magnetic properties of LSMO thin films. We use two different substrates having different lattice parameters to induce distinct lattice mismatch strains in LSMO thin films.

LSMO films with a thickness of 100-nm were grown either on (001) oriented $SrTiO_3$ (STO) or ferroelectric $(1-x)Pb(Mg_{1/3}Nb_{2/3})O_3$-$xPbTiO_3$ (001) (PMN-PT, with x=0.3) substrate at 650ºC using pulsed laser deposition equipped with a Nd:YAG laser of wavelength 266 nm. Growth was done in an oxygen atmosphere at a pressure of 0.5 Torr. The energy of the laser was ~40 mJ and the repetition frequency was 10 Hz. In-situ post-annealing were performed for all films at 850ºC for 30 min in a O_2 pressure of 200 Torr. A vector network analyzer with a co-planer waveguide was used to measure ferromagnetic resonance (FMR) in in-plane magnetic fields at room temperature. In case of LSMO on PMN-PT, a clear single dispersion of the FMR is seen, whereas a double dispersion structure appears for the films on STO. The difference is attributed to the presence of two different microstructural phases in the films on STO substrate. Temperature dependent magnetization measurement shows a single transition temperature (≈355 K) for the film on PMN-PT, while double transition temperatures (≈ 310 K and 355 K) are found for films on STO, in agreement with the FMR data. Figure 1 depicts possible lattice mismatch between LSMO films and (a) PMN-PT and (b) STO substrates, where the lattice parameters were calculated from the XRD data; the lattice constants of LSMO, STO and PMN-PT in bulk are 3.876, 3.895, and 4.003 Å, respectively. We consider that immediate lattice relaxation occurs at LSMO/PMN-PT interface due to large lattice mismatch between LSMO and PMN-PT substrate. On the other hand, a strained LSMO layer is formed before it is fully relaxed associated with the small lattice mismatch between LSMO and STO. This scenario is also supported by the XRD data, in which the XRD peak is decomposed into two components arising from separate strained and relaxed regions.

This work was supported in part by JST CREST Grant Number JPMJCR18J1, JSPS KAKENHI Grant Numbers JP17H03377, JP18F18353, the Asahi Glass Foundation, and the Kato foundation for Promotion of Science.

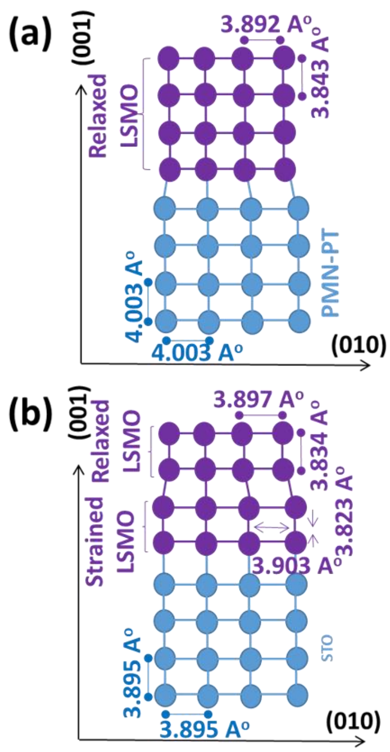

Fig. 1: Schematic illustrations of lattice mismatch between LSMO films and (a) PMN-PT and (b) STO substrates.

References:

[1] Y. Shirahata et al., *NPG Asia Mater.* **7**, e198 (2015).
[2] J. Okabayashi et al., *npj Quantum Mater.* **4**, 21 (2019).