

Asymmetry and rotation of the in-plane magnetic easy axis in $\text{La}_{0.67}\text{Sr}_{0.33}\text{MnO}_3$ thin film grown on $\text{NdGaO}_3(112)$

Hiroaki Nishikawa^{1,2}, Evert Houwman^{2*}, Hans Boschker², Mercy Mathews², Guus Rijnders²,
Dave H. A. Blank²

¹ *School of Biology-Oriented Science and Technology, Kinki University, Kinokawa 649-6493, Japan*

² *MESA⁺ Institute for Nanotechnology, University of Twente, 7500 AE Enschede, The Netherlands*

**E-mail of the corresponding author: e.p.houwman@utwente.nl*

The manganite $\text{La}_{0.67}\text{Sr}_{0.33}\text{MnO}_3$ (LSMO), is of great interest because of its colossal magnetoresistance and the predicted full spin polarization. These properties make it an interesting material for a number of spintronic device applications, especially tunneling magnetoresistance (TMR) junctions. For achieving very high TMR ratios, some of the issues to be resolved are the magnetization properties and magnetic domain structure of the LSMO electrodes. To this end we are investigating the relationships between the strain state, the structure change and the magnetic anisotropy of the LSMO grown on various substrates. In this study, we have investigated the thickness dependence of the in-plane magnetic anisotropy of LSMO thin films grown on NdGaO_3 (NGO), with a $(112)_o$ surface (we will use subindex “o” for the NGO orthorhombic and “pc” for the LSMO pseudo-cubic crystal structure). The $\text{NGO}(112)_o$ plane has a similar structure as the perovskite pseudo-cubic $(011)_{pc}$ plane. Therefore the orientation of LSMO grown on $\text{NGO}(112)_o$ is $\{011\}_{pc}$.

LSMO thin films were grown on atomically smooth $\text{NGO}(112)_o$ by the pulsed laser deposition technique. In-plane magnetization loops were measured as a function of the angle of the in-plane field by a vibrating sample magnetometer. It is shown that with increasing film thickness the in-plane magnetic anisotropy changes from uniaxial to biaxial. The surface unit of the $\text{NGO}(112)_o$ is not a rectangle but a parallelogram with 89.5° and 90.5° angles. Due to this asymmetry the easy axes of the LSMO thin films are not along any low index (in-plane) crystal vectors of NGO or LSMO. Moreover, the total value and the rotation angle of the in-plane remanence as function of the field angle with increasing film thickness is measured directly for the first time on LSMO thin films.