Strain analysis on the interface of ferromagnetic/ferroelectric in epitaxial perovskite thin film heterostructures by transmission electron microscopy

Flávia Regina Estrada, Pedro Schio de Noronha Muniz, Thiago José de Almeida Mori, Maíra Dombroski Neme, Julio Criginski Cezar

LNLS/CNPEM

Jefferson Bettini

LNNano/CNPEM

Magnetoelectric composites have been extensively studied, as they are suitable for microelectronic devices such as Magnetoelectric Random-Access Memory (MeRAM) and low cost magnetic field sensors. The strain on the interface between ferromagnetic (FM) and ferroelectric (FE) layers in a heterostructure thin film is, usually, the main responsible for the magnetoelectric coupling between the layers. That coupling may be limited by the layers size, thin film growing conditions and post-annealing temperature, which may result in nanoscale structural variations and distortions. In this work, we investigate the nanostructure and interface of FE/FM bilayers and heterostructure by Transmission Electron Microscopy (TEM), focusing on the analysis of the strain on the FE/FM interface by Geometrical Phase Analysis (GPA) method. The samples are La$_{0.7}$Ca$_{0.3}$MnO$_3$/BaTiO$_3$ (LSMO/BTO) thin films grown onto SrTiO$_3$ (STO) substrates by pulsed laser deposition (PLD) under different conditions. Both of them present a perovskite structure and small difference on the lattice parameters (on the pseudocubic $a_P$ axis: 3.88Å, 3.99Å and 3.9Å respectively). The samples were epitaxially grown by PLD method at U11A-PGM beamline facilities at the Brazilian Synchrotron Light Laboratory and the TEM images were collected at Electron Microscopy Laboratory at Brazilian Nanotechnology National Laboratory. We find that, at specific growing conditions, near the interfaces of LSMO/STO octahedral tilting distortions are present on LSMO layer. By its turn, the thickness designs the ferroelectric domain size and shape on BTO layers. In this sense, the GPA method of analysis could provide us a comparison of the strain gradient of the layers with different thickness and mismatch. Besides, this methodology can be used to correlate the nanostructure and properties of these FM/FE samples, ultimately allowing us to understand at atomic level the conditions that optimize the magnetoelectric coupling in this kind of composite heterostructures.