Thickness-dependent magnetic structure of ferromagnetic/antiferromagnetic all-manganite multilayers

Niebieskikwiat, Darío,[1] Hueso, L.E.,[2]
Borchers, J.,[3] Mathur, N.D.,[2] and Salamon, M.B.[1]

[1]*Department of Physics, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA*
[2]*Department of Materials Science, University of Cambridge, Pembroke Street, Cambridge CB2 3QZ, UK*
[3]*NIST Center for Neutron Research, National Institute of Standards and Technology, Gaithersburg, MD 20899, USA*

Polarized Neutron Reflectometry (PNR) and magnetometry measurements have been used to obtain a comprehensive picture of the magnetic structure of a series of $La_{2/3}Sr_{1/3}MnO_3/Pr_{2/3}Ca_{1/3}MnO_3$ (LSMO/PCMO) superlattices. Five repetitions of the ferromagnetic (FM) LSMO (thickness 11.8 nm) and the antiferromagnetic (AFM) PCMO layers (thickness t_A between 0 and 7.6 nm) were grown by pulsed laser deposition on atomically flat $SrTiO_3$ substrates. All our multilayers exhibit the FM transition of the LSMO layers at $T_C \sim 340$ K. However, the presence of the LSMO-PCMO interfaces produces a reduction of the magnetic moment of the LSMO layers as compared to the pure LSMO film. This effect is related to the existence of a magnetically disordered layer on the LSMO side of the FM-AFM interfaces. As shown by the magnetic profiles obtained from PNR, the magnetization of the first few Mn-O monolayers on the LSMO is reduced as compared to the inner FM volume of LSMO. In the PCMO layers a FM contribution is also observed related to the presence of FM nanodomains embedded within the predominant AFM matrix. This FM contribution was found to be maximized at intermediate thicknesses $t_A \sim 3$ nm. We ascribe this behavior to the accommodation of the FM droplets at the matching condition between layer thickness and domain size, where the FM nanodomains would find the optimal strain conditions within the PCMO layers. This evolution of the magnetic structure has important implications for the transport properties of these superlattices, where the metallization of the nominally insulating AFM layers was shown to play a fundamental role in the magnetoresistance response of this kind of tunneling devices.