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Critical thickness for ferromagnetism in insulating $LaMnO_3$ films
X. RENSHAW WANG, N. POCCIA, D.P. LEUSINK, MESA+ Institute for Nanotechnology, University of Twente, The Netherlands, TURA R. PAUDEL, E.Y. TSYMBAL, Department of Physics and Astronomy, Nebraska Center for Materials and Nanoscience, University of Nebraska, United States, C.J. LI, W.M. LV, T. VENKATESAN, ARIANDO ARIANDO, NUSNNI-Nanocore, National University of Singapore, Singapore, H. HILGENKAMP, MESA+ Institute for Nanotechnology, University of Twente, The Netherlands — The interplay between exchange interactions, interfacial charges, and confinement effects controls the electronic, magnetic, and transport properties of complex oxide thin films. Here we report the emergence of ferromagnetism in insulating $LaMnO_3$ thin films grown on $SrTiO_3$ substrates beyond a critical thickness. $LaMnO_3$ (001) films are deposited by a pulsed laser deposition technique with thicknesses varying from 1 unit cell to 24 unit cells. The position dependent local magnetization is then mapped with micrometer resolution using scanning superconducting quantum interference device microscopy. We find that the magnetic ground state switches from non-ferromagnetic to ferromagnetic within a change of one unit cell above the critical thickness of 5 unit cells with characteristic domain size of about 20 μm. Further increase of film thickness up to 24 unit cells leads to reduction of the domain size to about 10 μm. The critical thickness is qualitatively explained in terms of the charge transfer in polar $LaMnO_3$ (001) thin films based on results of additional experimental data, density-functional calculations, and the electrostatic modeling.

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