Growth and Magnetic Properties of $LaCoO_3$ Epitaxial Thin Films

Virat Vasav Mehta[1], M. Liberati[1], R.V. Chopdekar[1, 2], F. Wong[1], E. Arenholz[3], Y, Suzuki[1]
1. Department of Materials Science and Engineering, UC Berkeley and Materials Science Division, Lawrence Berkeley National Laboratory
2. School of Applied Physics, Cornell University
3. Advanced Light Source, Lawrence Berkeley National Laboratory

Complex oxides of the perovskite ABO_3 structure exhibit a wide range of electronic and magnetic properties based on crystal field symmetries and cation exchange behavior**.** One such example is $LaCoO_3$ (LCO) which has been studied in its bulk form over the past 50 years. However, the details of this material's magnetic ground state behavior are still under current debate. Despite the present interest in this material, there has been little work to our knowledge on the synthesis and characterization of LCO thin films [1, 2]. Epitaxial thin films provide model systems in which epitaxial strain and non-equilibrium deposition processes enable us to probe the role of cation valence, cation distribution and lattice strain on the magnetism and transport behavior. In this work, we present a study of the relationship between structure and magnetism in epitaxial LCO thin films grown for a range of thicknesses on (La, Sr)(Al, Ta)O_3 (LSAT), $SrTiO_3$ (STO), and $LaAlO_3$ (LAO) substrates via pulsed laser deposition. Rutherford backscattering spectrometry confirms stoichiometry as well as film thickness. Atomic force microscopy reveals terraced surface microstructure with an rms surface roughness of 0.34 nm for the thinnest films. Standard $2\theta - \theta$ and rocking curve X-ray diffraction shows epitaxial growth and excellent crystalline quality. A closer look at the thickness dependence of the X-ray diffraction spectra shows that thinner films are under the most uniform tensile strain while those which are substantially thicker than the Matthews Blakeslee critical thickness of 7.5 nm (for the LSAT case) are partially relaxed. The dominant contribution to soft X-ray absorption spectra is from Co^{3+} in octahedral symmetry**.** Careful magnetic characterization of LCO films using SQUID magnetometry reveals long range magnetic order at temperatures below 40K. All films have a magnetization of 40-80 emu/cm^3 at 5T, which is equivalent to 0.3-0.6μ_B per formula unit and comparable to 0.4μ_B/f.u. found for other LCO thin films [2]. Oxygen post-annealing produced little to no effect on the properties of the films, thus suggesting that oxygen deficiency is not an issue in our as-grown films.

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[2] D. Fuchs, C. Pinta, T. Schwarz, P. Schweiss, P. Nagel, S. Schuppler, R. Schneider, M. Merz, G. Roth, and H. v. Loehneysen, *Phys. Rev. B* **75** 144402 (2007).