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Structural, magnetic and electrical properties of oxygen-deficient $\text{La}_{0.6}\text{Sr}_{0.4}\text{CoO}_{3-\delta}$ thin films

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Controlled oxygen release or uptake in complex oxides can induce changes of the crystal structure and simultaneously of the magnetic and electrical properties. Consequently, a systematic control of the oxygen stoichiometry can enable potential applications in spintronics, solid oxide fuel cells and catalysts. In $\text{La}_{0.6}\text{Sr}_{0.4}\text{CoO}_{3-\delta}$ (LSCO) the gradual oxygen release triggers a phase transition from the initial ferromagnetic (FM) perovskite (PV) structure to an oxygen vacancy layered antiferromagnetic (AFM) brownmillerite (BM) structure.

We have studied LSCO thin films fabricated by pulsed laser deposition (PLD). In situ x-ray diffraction during thermal annealing reveals the topotactic phase transition of the LSCO thin films, which can be attributed to the release of oxygen and ultimately the transition to a coherently ordered BM phase. By comparing the magnetic and electronic properties of the sample at different oxygen deficient states, we demonstrate that the magnetic and electronic transitions are apart from the structural phase transition [1].

Using in situ polarized neutron reflectometry (PNR) measured at the MR reflectometer (SNS/Oak Ridge), we explore the nuclear scattering density (nSLD) and quantify the change in oxygen stoichiometry and the magnetization of the LSCO film during annealing. The PNR data shows a significant decrease of nSLD for the annealed film indicating a reduction in oxygen concentration. The oxygen stoichiometry is found to vary from $\text{La}_{0.6}\text{Sr}_{0.4}\text{CoO}_3$ before annealing to about $\text{La}_{0.6}\text{Sr}_{0.4}\text{CoO}_{2.5}$ for annealed films. We find that disordered oxygen vacancies forming in the initial phase of annealing quickly govern the magnetic properties of the film by triggering a FM to AF transition [1].

[1] S. He, O. Petravic, V. Lauter, L. Cao, Y. Zhou, M. L. Weber, J. Schubert, O. Concepción, R. Dittmann, R. Waser, T. Brückel, F. Gunkel, $\text{La}_{0.6}\text{Sr}_{0.4}\text{CoO}_{3-\delta}$ Films Under Deoxygenation: Magnetic And Electronic Transitions Are Apart from The Structural Phase Transition. *Adv. Funct. Mater.* 2024, 34, 2313208.

Hauptautoren: HE, Suqin (Quantum Materials and Collective Phenomena (JCNS-2), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany); PETRACIC, Oleg (Quantum Materials and Collective Phenomena (JCNS-2), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany); CAO, Lei (Quantum Materials and Collective Phenomena (JCNS-2), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany); LAUTER, Valeria (Neutron Scattering Division, Neutron Sciences Directorate, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA); ZHOU, Yunxia (Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, 01328, Dresden); WEBER, Moritz (Peter Gruenberg Institute (PGI-7), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany); SCHUBERT, Jürgen (Semiconductor Nanoelectronics (PGI-9), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany); DITTMANN, Regina (Peter Gruenberg Institute (PGI-7), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany); WASER, Rainer (Peter Gruenberg Institute (PGI-7), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany); BRÜCKEL, Thomas (Quantum Materials and Collective Phenomena (JCNS-2), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany); GUNKEL, Felix (Peter Gruenberg Institute (PGI-7), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany)

Vortragende(r): PETRACIC, Oleg (Quantum Materials and Collective Phenomena (JCNS-2), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany)

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