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The growth and properties of p-type transparent conducting thin films of the perovskite type

Oualyd El Khaloufi[a*], Aymane Cheikh[a], Moussa Mezhoud[a], Adrian David[a], Christophe Labbé[b], et Ulrike Lüders[a]

a. CRISMAT (UMR6508 CNRS-ENSICAEN-Normandie Université-Université de Caen Normandie), Caen
b. CIMAP (UMR6252 CNRS-ENSICAEN-Normandie Université-Université de Caen Normandie-CEA), Caen

* email : oualyd.elkhaloufi@ensicaen.fr

The aim of our project is to grow solid solution thin films of (La,Sr)VO_3 (LSVO) and (La,Sr)CrO_3 (LSCO) by pulsed laser deposition (PLD). These materials have been recently identified as new p-type transparent conducting oxides (TCO) [1], with a high potential for the development of transparent p-type electrodes for a more efficient holes collection in photovoltaic cells or transparent electronics. We will explore different compositions to understand the impact of doping on the electrical and optical properties, and to evaluate the p-type conduction in this type of materials in order to constitute a p-n junction with the n-type TCO $SrVO_3$ (SVO).

All samples were grown on a $SrTiO_3$ (001) monocrystalline substrates. In order to gain a high flexibility concerning the composition of the solid solution, the deposition of the thin films is made from two targets of the respective parent compounds. By choosing a number of pulses on each target allowing the growth of less than one unit cell, the solid solution can be formed in the thin film by successive depositions from each target. Several optimizations were performed in order to evaluate the impact of the different deposition parameters (temperature, energy, distance…) on the quality of the thin films, and to gain an overview on the phase diagram of the solid solutions in the thin film form.

Concerning the LSVO films, we show that doping SVO with La improves the electrical n-type properties, with a resistivity of pure SVO of 270 μΩcm at 300K to 159 μΩcm for the composition $La_{1/2}Sr_{1/2}VO_3$. The samples were confirmed to be transparent, making LSVO a TCO with improved electrical behaviors compared to SVO. The metal-insulator transition for about 80% of La doping [2] is observed, but nevertheless, no p-type behavior was found within the realized vanadate thin film solid solutions.

Similar studies were carried out for the LSCO solid solution. In this system, we show that a certain amount of oxygen background pressure during the deposition is necessary to generate p-type conduction in this solid solution, ranging in the area of 30 mΩcm, which is an excellent value for p-type TCO [2]. The relations between the deposition parameters, the structural and chemical changes of the thin films and the resulting properties will be discussed on the basis of these two, closely related solid solutions, showing however a quite different evolution of the properties with the growth parameters.

[1] K. H. L. Zhang *et al.*, "Perovskite Sr-Doped LaCrO3 as a New p-Type Transparent Conducting Oxide," *Adv. Mater.*, vol. 27, no. 35, pp. 5191–5195, 2015, doi: 10.1002/adma.201501959.

[2] K. H. L. Zhang *et al.*, "Hole-induced insulator-to-metal transition in L a1-x S rxCr O3 epitaxial films," *Phys. Rev. B - Condens. Matter Mater. Phys.*, vol. 91, no. 15, pp. 1–9, 2015, doi: 10.1103/PhysRevB.91.155129.