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Thin epitaxial films of complex oxide materials for SOFC applications.

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In this presentation I will first give an overview of the activities around research in the energy-related field in our Institute in Barcelona, Spain. Afterwards, I will describe some of the activities that we carry out in our group related to fundamental characterisation of complex oxide materials for their use as cathode materials in SOFCs working at intermediate temperatures (IT-SOFC). The ultimate performance of IT-SOFCs is mostly limited by the oxygen surface exchange process taking place at the cathode surface involving a number of different steps: oxygen adsorption, dissociation and diffusion. In real cathode materials the intrinsic oxygen surface exchange properties are difficult to analyse in detail because they are often affected by extrinsic effects related to surface morphology, surface active area, porosity, grain connectivity, etc, as well as grain size and orientation (i.e. particularly in layered oxide materials often used in IT-SOFC cathodes). In this context the studies that we carry out try to overcome extrinsic effects by performing fundamental characterisation on "ideal" surfaces of epitaxial thin film materials.

We grow thin epitaxial films of complex oxide materials by controlling as much as possible their crystal quality, orientation, surface morphology, microstructure (distribution of point and extended defects), as well as surface termination and depth profile chemical composition.

Despite some vapour phase deposition techniques, like Pulsed Laser Deposition (PLD) or Molecular Beam Epitaxy (MBE), as well as some chemical techniques like Chemical Vapour Deposition (CVD) or Atomic Layer Deposition (ALD), have been proven to produce the best crystal quality films, still the fact that most of the films are grown at high temperature, and under metastable conditions, makes that film microstructure and composition may evolve with time, temperature and film thickness in order to release the different sources of strain, either elastic or chemical. The presence of local defects at the nanoscale, or surface chemical segregation at atomic scale in depth, is difficult to analyse without the proper tools. In this presentation we will show some examples of epitaxial films of typical IT-SOFC cathode materials deposited by PLD and their characteristics, as well as the techniques that we have been using to analyse their oxygen surface exchange performance.

Some of the oxide films with either perovskite or perovskite-related layered structures are currently under investigation at I2CNER by the Low Energy Ion Scattering technique in order to determine general trends about surface termination and cation segregation which are essential for understanding the physico-chemical response of these materials, not only for SOFC applications, but in a wide range of applications. Some of the preliminary LEIS results already reveal unexpected composition depth profiles.