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ELECTRODEPOSITION AND SURFACE ANALYSIS FOR NEW MATERIALS FOR ENERGY APPLICATIONS

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The global environmental concerns and the escalating demand for energy, coupled with a steady progress in renewable energy technologies, are opening up new opportunities for the utilization of renewable energy resources. A fundamental aim of material sciences is to reckon the relationship between the properties of a device, and the morphological and structural characteristics of the surface. Combining basic electrochemical techniques with spectroscopic, microscopic and structural techniques is crucial for characterizing the structure-activity relationship for many different technological devices. We consider this approach even more interesting, if these electrochemical and structural characterizations, are performed simultaneously under the control of the electrical potential. In this context during the last two decades, several interesting combined techniques emerged. These combined experiments have recently been widely used for the study of new-generation solar cells and low-precious-content fuel cells up to the preparation of sensors for Industry4.0. In the field of thin-film solar cells electrodeposition is well known for depositing metals and metallic alloys at the industrial level, with a wide range of applications from large area surface treatments to most advanced electronic industries. Electrodeposition of semiconducting materials represents a new challenge, not only from the academic point of view, but also from the economic point of view, since this method presents interesting characteristics for large area, low cost and generally low temperature and soft processing of materials.

In this presentation, we provide an overview of different cases of study where basic electrochemical techniques have been combined with spectroscopic, microscopic and structural techniques is crucial for characterizing the structure-activity relationship for many different Materials for Energy Applications [1].

In one case of study, we exploited alternated metal electrodepositions by E-ALD (Electrochemical Atomic Layer Deposition) to obtain multilayered thin films. E-ALD provided a tight control over the materials' growth, at the nanometer level, even when an entire p-n junction was deposited. We performed a thorough structural study of these composite ultra-thin films by means of electrochemical operando SXRD (Surface X-Ray Diffraction) and FEXRAV [2](Fixed Energy X-Ray Absorption Voltammetry) experiments performed at ID03 in Grenoble [3].

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In the field of fuel cells, we aimed at reducing the quantity of catalytic material in order to meet the industrial demand for alternative catalysts be used in place of Platinum-group metals[4]. To remove and replace platinum with less expensive materials, we exploited a synergistic mechanism involving one metal able to break the O-O bond of molecular oxygen and second metal species capable to reduce the resulting adsorbed atomic oxygen. The presence of specific metals together with a high carbon content are essential requirements for catalysts for Oxygen Reduction Reaction (ORR [5]).

Furthermore, we developed and characterized new catalyst for fuel cells, based on automotive tires recycling [6]. There are several technologies for tires recycling, including pyrolysis: a thermal decomposition process performed at higher temperature in an inert atmosphere which allows the transformation of complex substances in simple molecules. We worked at modified surfaces implementing novel electrodeposited catalysts obtained from the microwave assisted pyrolysis (MAP) of waste tires, and we proposed them for direct alcohol fuel cells [7].

In conclusion, we believe that one the fundamental aims of analytical chemistry applied to surface sciences is to reckon the relationship between the properties of a device, and the morphological and structural characteristics of the surface itself.

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