Coupling of XPS and GD-OES Profiling as an Advanced Characterization for Perovskite Systems

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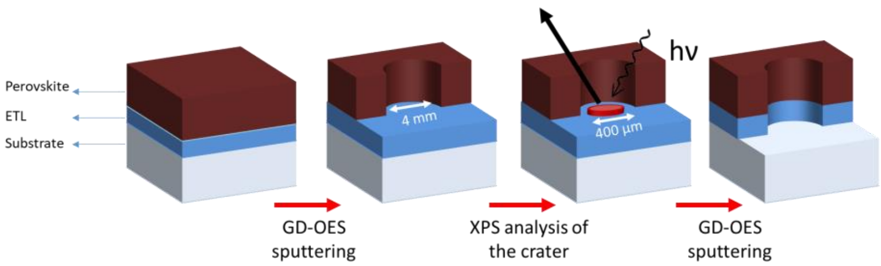
Despite the outstanding rapid evolution of perovskite-based solar cells efficiencies, the main drawbacks of this technology remain their intrinsic and extrinsic stabilities. During past years, several characterizations have been performed on perovskite layers in order to access crystallographic, optical, electrical and chemical information. Researches nowadays are focusing on enhancing the device architecture where interfaces properties play a crucial role on the final performances and stability [1]. This work aims to get further insight into the critical role of perovskite / Electron Transport Layer (ETL) interface on device behavior by probing the chemical composition from the surface to the interfaces. Specific in-depth profiling methodology based on an innovative coupling of two chemical characterization techniques, X- Ray Photoelectron Spectroscopy (XPS) and Glow Discharge Optical Emission Spectroscopy (GD-OES) is applied on half-cell constituted of glass/FTO/c-TiO_2/m-TiO_2/triple cation Perovskites ($Cs_{0.05}(MA_{0.14}$, $FA_{0.86})_{0.95}$ Pb ($I_{0.84}$, $Br_{0.16})_3$). The GD-OES, semi-quantitative technique, assures a fast depth profiling to quickly reach specific areas of interest, which makes it interesting to perform profiling on complete cells and quickly reach the perovskite layer. On the other hand, the XPS allows to precisely probe the composition of the extreme surface and to have access to the atomic composition and the chemical environments. It is important to highlight that the sequences of GD-OES and XPS was successfully applied on photovoltaic absorbers such as CIGS or III-V materials [2][3]. First, an optimization of the operating conditions was carried out in order to minimize the degradation of the perovskite layers. In the case of GD-OES not only the Radio Frequency power and the plasma gas pressure are changed, but also the nature of this gas (Ar, Ar/O, Ne). Secondly, the craters resulting from profiling by GD-OES were chemically studied by XPS in order to determine the chemical composition at different level of the layer as well as in the interface area. We observed that all the conditions employed for GD-OES profiling lead to a systematic reduction or oxidation of lead as well as the degradation of the organic part and iodine loss, more or less pronounced depending on the plasma gas. A comparison of AFM (Atomic Force Microscopy) and SEM (Secondary Electron Imaging) images inside and outside the craters clearly showed a remarkable change in the surface morphology between a bombarded surface by Ar or Ar / O. Results of this coupling will be presented and discussed showing as well its potential to be applied for the study of a complete solar cell.



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