Innovative way to analyse interfaces of III-V layers based solar cells: GD-OES and XPS coupling

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Nowadays the development of opto-electronic devices and tandem solar cells promote the interest for III-V semiconductor materials. Such architecture evolutions of solar cells require a good characterization strategy to accurately understand the chemical properties at the different interfaces constitutive of the heterojunction based device. Our methodology consists in combining Glow Discharge – Optical Emission Spectroscopy (GD-OES) equipped with a Differential interferometry Profiling (DiP) module and X-ray Photoelectron Spectroscopy (XPS) analyses. This combination provides the advantage of the high etching rate of GD-OES and of the surface chemical diagnostic (composition and chemical environment) obtained by XPS. In this way, interfaces of interest are quickly reached and XPS experiments are directly performed inside the GD-OES crater. However, the GD-OES profiling and the interruption of the plasma sputtering, lead to the degradation of the studied material and to re-deposition processes inside the crater [1, 2]. Therefore, an evaluation of the crater surface state must be performed to ensure the reliability of the chemical information relayed by XPS. Indeed the GD-OES crater bottom is systematically studied to determine the possible perturbation of its surface chemistry and morphology and develop regeneration (chemical or physical) steps. Here we compare the data obtained for the surface (deoxidized or not) inside the crater and outside the crater as reference. In addition, the surface chemical state obtained after GD-OES profiling is compared to the one obtained by profiling using Ar^+ bombardment inside the XPS analysis chamber to get insight on the impact of this phenomenon.

Firstly, the behavior of binary semiconductors (InP, GaAs and GaP) is studied. We characterized the degradation nature by XPS, SEM-EDS and EBSD measurements. The roughness of the crater bottom is increased and, depending on the material, variation of the atomic ratios is shown as well as the presence of oxides and an amorphization. To regenerate the material surface, both chemical and physical solutions are tested and their efficiencies compared. In a second time, the approach is extended to the ternary semiconductors such as InGaP and AlGaAs. As for the previous systems, we note also a superficial degradation of the surface verified by XPS and SEM-EDS. These results will be discussed in more details.

[1] D. Mercier & al. Appl. Surf. Sci. **347** (2015) 799 - 807.
[2] S. Béchu & al, JVST B, (2019) Accepted.