

## Towards a photoelectrochemical tool for comprehensive quality assessment of solar cell absorber layers

Diego Colombara<sup>a</sup>, Alexandre Crossay<sup>a</sup>, Valérie Depredurand<sup>b</sup> and Phillip Dale<sup>a</sup>

<sup>a</sup>Laboratory for Energy Materials

<sup>b</sup>Laboratory for Photovoltaics

Université du Luxembourg

41, rue du Brill L-4422 Belvaux

The aim of this work is to identify photoelectrochemical parameters for the reliable assessment of the optoelectronic properties of thin absorber films for photovoltaic applications. The ultimate goal is to develop an on-line testing tool capable of evaluating the suitability of solar cell absorbers such as Cu(In,Ga)(S,Se)<sub>2</sub> or Cu<sub>2</sub>ZnSn(S,Se)<sub>4</sub> before these are processed further into complete devices by addition of n-type, window and front contact layers. This would allow monitoring the stability of part of the production plant process with inherent advantages in terms of material usage, energy and time.

By formation of virtually reversible electrolyte (Schottky) junctions [1] it is possible to interrogate semiconductor thin films and extract information about properties such as majority carrier type [2, 3], band-gap and flat-band potential [4], doping density [5], as well as insights on the presence of optically absorbing phases on the film surface [6].

In solid state devices the short circuit current density is related to the generation of carriers, their transport and their subsequent collection at the interface. This is also true for a Schottky junction.

The parallel resistance of solar cells is associated to the presence of conducting (shorting) paths; the dark current measured in solution under reversed bias should give an estimate of such paths.

The voltage of a device measured under open circuit conditions is proportional to the quasi-Fermi level splitting within the absorber. The consequence of this statement applies also to the semiconductor/electrolyte case [7].

In this work we investigate if a sound correlation between the solid state device properties (short circuit current, parallel resistance and open circuit voltage) and the corresponding parameters accessible through a transparent electrolyte junction can be established. To this end three Cu(In,Ga)Se<sub>2</sub> absorber layers obtained by physical vapour deposition were split into two. Half were completed into solar cell devices and the other half were tested photoelectrochemically. The chosen absorber layers gave solid state device power conversion efficiencies of 6, 9 and 12.5% [8]. The photoelectrochemical experiments were performed with a three electrode setup in an equimolar solution of Eu<sup>3+/2+</sup> and consisted of chronoamperometric and voltammetric analyses under pulsed illumination, as well as photocurrent spectroscopy.

The theoretical correlations are complicated by experimental issues including the non-ideality of surface structures and of the current collection [9]. In fact, in agreement with the literature [5, 10, 11], our work shows that photoelectrochemical assessments can also be performed in the absence of active electrolyte redox species. Nevertheless, we highlight their importance if reversibility and longtime reproducibility of the measurements are a strict requirement.

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