In4CIS
New in-line optical methodologies for advanced assessment of high efficiency CIGS industrial processes

Project duration: from 09.2019 to 12.2022
Report submitted: 08.2020

Publishable Summary

In4CIS aims to establish and demonstrate at pre-industrial level optical advanced methodologies for the in-line assessment of advanced processes in Cu(In,Ga)Se2 (CIGS) thin film photovoltaic technologies. These will be applied to the monitoring of innovative postdeposition treatments (PDT) that are developed for the production of very high efficiency CIGS devices, in order to ensure a successful transfer of these CIGS process concepts from cell (lab) level to a pre-industrial module level. PDT processes are based in alkaline postdeposition doping treatments and have allowed achieving solar cells with reproducible efficiency values > 20% (with a record certified value of 22.6%), in the frame of the Sharc25 H2020 European project that was coordinated by the ZSW partner (http://sharc25.eu/). The successful transfer of these process concepts to pre-industrial module level requires for a detailed assessment of the uniformity of the processed layers when the processes are scaled from cell (cm2) to module (m2) device dimensions. Appearance of inhomogeneities in the layers when scaled to module dimensions constitutes one of the main reasons for the decrease of the efficiency of the modules in relation to that from the individual cells. Optimisation of the uniformity of the processes implies the need for high sensitivity tools and methodologies allowing the advanced assessment at in-line monitoring level of the uniformity of the processed layers, detecting at an early stage the appearance of in-homogeneities in the processed surfaces at the process line. This implies the need for non-destructive methodologies –as those based in optical techniques- allowing the fast inspection of the processed surfaces in the process line.

The typical CIGS device architecture includes a Mo back contact (that is deposited on a glass substrate), the CIGS absorber layer (that constitutes the core of the photovoltaic device, absorbing most of the light that is converted into electricity), a nanometric buffer layer (typically CdS or Zn(O,S)) and the window layer that is formed by a transparent conductive oxide (TCO). Fig. 1 shows a schematic representation of the device structure. In these devices, the assessment of the uniformity of the PDT processes implies the need to monitor the uniformity of the surface region of the CIGS absorbers after deposition of the buffer layers in the device structure. Availability of suitable in-line monitoring tools is critical to ensure high throughput/high yield industrial processes as required for competitive CIGS PV production lines.

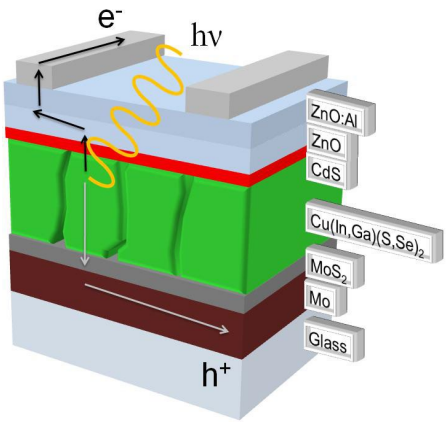

Fig. 1. Typical CIGS device architecture

The optical methodologies proposed in the project are based in the use of multi-wavelength excitation Raman scattering/Photoluminescence (PL) techniques for the advanced non-destructive quantitative assessment of the uniformity of the CIGS surface absorber region at different process steps in the CIGS production line. These methodologies are based in the use of resonant excitation strategies where the excitation light is close to an elemental transition –as the energy of the band gap- of the compound that is analysed by the Raman probe. This determines a strong increase –of orders of magnitude – of the efficiency of the Raman process, and this allows achieving a very high measuring sensitivity with fast measuring times - compatible with their implementation at in-line process monitoring level.

Project consortium

Coordinator and all contact details:

Full name of organisation	Institut de Recerca de l'Energia de Catalunya
First and family name of coordinator:	Marcel Placidi
Full address:	C. Jardins de les Dones de Negre 1, 2a planta 08930 Sant Adrià de Besós (Barcelona), Spain
E-mail:	mplacidi@irec.cat

Participating countries and financing:

Country	**Number of organisations involved**	**Project costs in EUR**	**Public funding in EUR**
Spain	3	406 531	327 918
Germany	2	383 626	360 525
Total	*5*	*790 157*	*688 443*

Funding agencies involved and contracts

Funding Agency	Contract N° and Title
Agencia Estatal de Investigación (AEI)	• PCI2019-111837-2 • PCI2019-111827-2
CDTI	EXP - 00128144 / SERA-20201007
Projektträger Jülich (PtJ)	• 03EE1020A «Verbundvorhaben: In4CIS – Neue in-line Methodik für fortgeschrittene Bewertung von hocheffizienten industriellen CIGS Prozessen; Teilvorhaben: Probenpräparation und Prototyp-Validierung am ZSW» • 03EE1020B «Verbundvorhaben: In4CIS – Neue in-line Methodik für fortgeschrittene Bewertung von hocheffizienten industriellen CIGS Prozessen; Teilvorhaben: Technische und ökonomische Evaluierung der industriellen Anwendung der entwickelten in-line Methodik für fortgeschrittene Bewertung von hoch-effizienten CIGS Prozessen»