NOVACOST
Non Vacuum Based Strategies for Cost Efficient Low Weight Chalcogenide Photovoltaics

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Publishable Summary

Chalcogenide (CuInGa(S,Se)2-CIGS, Cu2ZnSn(S,Se)4-CZTS) based technologies have a strong potential for high efficiency low cost photovoltaics (PV) solar cells and modules. Indeed, thin film technologies are well adapted for the use of alternative low weight substrates that are required for the extension of PV towards large area industrial/commercial roofs and architectural facades (BIPV) where less than 4 kg/m2 modules are expected. Among thin film technologies, CIGS prepared by vacuum based methods is the one showing the higher efficiency (with a 20,4% world record on low weight substrate (EMPA, 2013)). This explains the significant growth in the CIGS worldwide industrial production from about 150 MW/y in 2009 up to over 2 GW/y in 2011, even if the struggling market situation is forcing many CIGS based companies to bankrupt. The struggling and competitive future is driven by the fact that electricity generated by PV is becoming increasingly competitive, with an average levelized cost of energy (LCOE) estimated to be between 0,12-0,17 €/kWh in 2011, depending on regional climate conditions. This constant reduction is struggling the European industry towards i) strong reduction of the production and investment costs, that today are at ~ 1,0 €/Wp in Europe versus ~ 0,6 €/Wp in emerging countries like China and Taiwan; and ii) investment in novel “advanced” industrial processes allowing high efficiencies and low-cost device production.
NOVACOST project aims at developing a non-vacuum low cost and up-scalable roll-to-roll manufacturing method with innovative precursors and crystallisation process for the fabrication of cost-efficient low weight CIGS and CZTS-based solar cells and modules. For this purpose, two industrial partners (‘Advanced Coatings & Construction Solutions sàrl’ in Belgium-Wallonia, ‘Francisco Albero S.A’ in Spain) and two research institutions (‘Instituto de Recerca en Energia de Catalunya’ in Spain, and ‘Uppsala University’ in Sweden) will employ their knowledge and know-how on materials, processes and characterization through 8 workpackages: the use of innovative chalcogenide inks formulation and the improved control of coating processes to enhance the film homogeneity will be addressed for CIGS and CZTS respectively in WP1 and WP2, the breakthrough introduction of Intense Pulse Lighting technique for crystallization of the CIGS / CZTS layers will be investigated in WP3, and the set-up of a methodology for quality control of these PV thin films will be addressed in WP4.

All these innovations will be assessed by solar cells and mini-module prototyping (WP5). The project includes lab scale to pre-industrial pilot development of roll-to-roll (R2R) compatible technologies and assessment of economic and environmental benefits (WP6). The global objective is to demonstrate that the developed innovative technologies forecast a 15-50 % cost reduction in the equipment with respect to the state-of-the-art vacuum based CIGS manufacturing processes,

paving the way to achieve 0,6 €/Wp system cost for the production of solar cells. Dissemination and plans for commercialization of the developed eco-friendly products and technology will be finally addressed (WP7), aiming to reinforce the industrial competitiveness of PV European actors.

Main results:
A strong focus has been realized in the project on CZTS absorber, with the successful development of eco-friendly metallic salt-based inks suitable for CZTS deposition by R2R compatible non-vacuum techniques such as inkjet or spray coating. Devices up to 6.6% have been realized, and alkali doping strategies defined to pave the way to devices exhibiting 10% efficiencies. Scalability of the products and associated processes has been demonstrated up to A4 format, and a fully atmospheric process defined for CZTS absorber completion. Cost analysis demonstrated cost cuttings on materials (OPEX) up to a factor of 5 for low volumes production. Moreover, a preparation method for fast turn-around TEM analysis has been successfully developed and used to characterize solar cell devices, with in-depth analysis of doping mechanisms in CZTS absorber.

Project consortium

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Participating countries and financing:

Country	**Number of organisations involved**	**Project costs in EUR**	**Public funding in EUR**
Belgium-Wallonia	1	357'501	143'000
Spain	2	550'633	164'000
Sweden	1	213'000	213'000
Total	*4*	*1'121'134*	*520'000*

Funding agencies involved and contracts

Funding Agency	Contract N° and Title
SPW	1318079 -- NOVACOST
MINECO	PCIN-2013-128-C02-01 -- NOVACOST
MINECO	PCIN-2013-129-C02-02 -- NOVACOST
Energimyndigheten	38351 -- NOVACOST