The FP7 NMP project Solardesign: On-the-fly alterable Thin-film solar modules for design driven applications

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Abstract

The vision to use photovoltaics (PV) as a decentralized and sustainable source of energy in their products is shared by many designers, architects and manufacturers world-wide. The demand for aesthetically integrated photovoltaic materials is growing steadily in many industries. The FP7 NMP project SolarDesign addresses this demand by the development of novel solar cell materials, manufacturing processes and supportive actions (design toolbox). One key technology is a laser based monolithic interconnection process for thin-film solar cells.

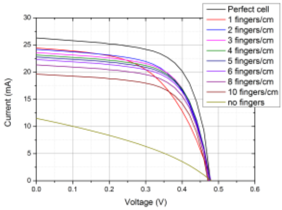
1. Introduction - SolarDesign Vision

The scientific and technical objectives (STOs) of this project are to develop:

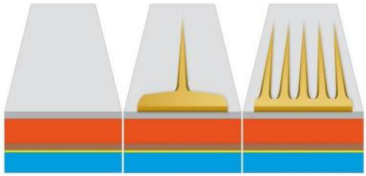
STO1: A flexible scribing and printing technology that allows producing a given photovoltaic module according to specific design requirements "on-the-fly". This flexible interconnection is applied on the solar foil (i.e. an endless solar cell) with a minimum width of 300 mm and allows curved solar cells and interconnection patterns with a minimum radius of 10 mm.

STO2: Novel materials for the underlying flexible solar cell technology to extend the design related degrees of freedom and to optimize the materials used for integrative solar applications.

STO3: Novel materials for satisfying design related requirements on solar module level. Focus is laid on materials for the electrical conducting front grid to allow a high design freedom of patterns.



1a



1b

Figure 1: 1a - Metallization grid optimization, d_{Ag} = 20 µm, this provides good conductivity, therefore the width of the fingers can be a minimum: w_{finger} = 200 µm, 1b - different layouts of the metallic front contacts. The challenge for the design of the front contact lies in optimization of contradicting parameters like high conductivity and minimized losses by shading.

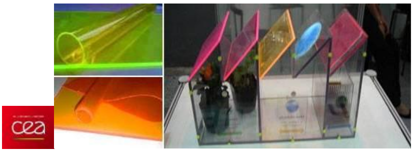


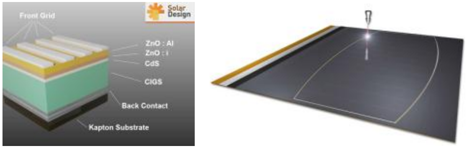
Figure 2: Color variations providing more freedom of PV design, using different novel encapsulants allows custom designed optical appearance

STO4: A methodological toolbox to provide design rules for the best solar cell super-structure and module design layout for a given application by using numerical modelling and simulation.

STO5: The developed technologies will be demonstrated in the following applications: solar charging (cover for tablet PC and solar powered radio), solar powered light, solar powered sensor networks for detection of fire in forest, urban solar lighting (compact solar street lighting system) for Product Integrated Photovoltaics (PIPV), building skins with geodesic curvatures or other related forms for Building Integrated Photovoltaics (BIPV) and integration of PV in textile support.

2. SolarDesign Approach

The basic material, will be an endless thin-film solar cell based on the developed CIGS thin film technology as given below.



3a 3b

Figure 3: 3a - cross section CIGS solar cell, 3b - the key innovation of SolarDesign: An easy adaptable cell interconnection that allows full freedom over the design and electrical voltages of a PV module. For the realization of this idea fundamental RTD in the solar cell stack, short pulse laser scribing and large area printing of micro patterns are necessary. This solar cell can be cut according to the size and shape stipulated by the user and a flexible interconnection can be applied to obtain the required electrical specifications.

The material is based on CIGS (Copper, Indium, Gallium, Diselenide).The absorber layer was deposited by an alternative growth approach based on a sputtering/co-evaporation process for very high-throughput manufacturing [4].For interconnection of solar cells to a final PV module micro-scale grooves are applied by an ultra short-pulse laser process into the solar foil. With the help of this laser process the edges of a given PV module can be isolated and the thin-film layers are ablated selectively so that the rear contact (which is initially covered by several thin functional layers) and the transparent front contact of the solar foil can be electrically interconnected. The electrical interconnection itself can be then printed virtually in the same production step.

3. Important Features for SolarDesign driven PV

No toxic materials: inline with regulations RoHS (Restriction of Hazardous Substances) and WEEE (Waste Electrical and Electronic Equipment Directive); low temperature coefficient: Novel materials for the buffer layer will be developed and the band gap of the absorption layer will be optimized; energy yield in diffuse light conditions: better efficiency at 350 W/m^2 radiation and a blue enhanced spectrum (overcast day) [3]; standardization: the consortium decided proactively to contribute to European standards (CEN/CENELEC) as standards can enhance the economic value of a research and innovation project.

4. SolarDesign Consortium

The consortium formed by eleven partners belonging to six different countries, covers the needed expertise, namely, PV design, materials research, thin-film deposition and characterization, laser processing, interconnection manufacturing, and integration in products (PIPV) and buildings (BIPV). E.g.: company Sunplugged is developing own CIGS thin-film solar cells on flexible substrates production line. Vienna University of Technology (TUW) provides the numerical modelling and simulation tool that allows prediction of energy yields, performance, electrical-, optical-, thermal- and mechanical characteristics during the design process. Munich University of Applied Sciences (MUAS) has been involved in research of laser scribing processes of CIGS thin-film solar cell [2]. Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA) developes encapsulants for modules (new materials, new pigments, upscaling up to large surfaces). CEA has experience in BIPV (integration of modules into tile) and via CEA-INES has the module manufacturing capabilities.

Acknowledgements

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