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## On-the-fly alterable thin-film modules for design driven applications

The SolarDesign consortium is delighted to bring to your attention the latest news about SolarDesign Project and Photovoltaics.

### NUMERICAL SIMULATION OF ULTRAFAST EXPANSION AS THE DRIVING MECHANISM FOR CONFINED LASER ABLATION WITH ULTRA-SHORT LASER PULSES.

**Jürgen Sotrop · Alfred Kersch · Matthias Domke · Gerhard Heise · Heinz P. Huber**

Recently, a so-called “directly induced” laser ablation effect has been reported, where an ultra-short laser pulse (660 fs and 1053 nm) irradiates a thin Mo film through a glass substrate, resulting in a “lift-off” of the irradiated layer in form of a thin, solid, cylindrical fragment. This effect provides a new and very energy-efficient selective structuring process for the Mo back electrode thin-film solar cell production. To understand the underlying physical mechanisms, a 3D axisymmetric finite element model was created and numerically solved. The model is verified by a direct comparison of experimental and numerical results. It includes volume absorption of the laser pulse, heat diffusion in the electron gas, and

the lattice, thermal expansion of the solid phase and further volume expansion from phase transition to fluid and gas, and finally the mechanical motion of the layer caused by the resulting stress wave and the interaction with the substrate. The simulation revealed that irradiation of the molybdenum layer with an ultra-short pulse causes a rapid acceleration in the direction of the surface normal within a time frame of a hundred picoseconds to a peak velocity about 100m/s. The molybdenum layer continues to move as an oscillating membrane, and finally forms a dome after about 100 ns. The calculated strain at the edges of the dome exceeds the tensile stress limit at fluencies that initiate the “lift-off” in experimental investigations. In addition, the simulation reveals that the driving mechanism of the “lift-off” is the ultrafast expansion of the interface layer and not the generated gas pressure.

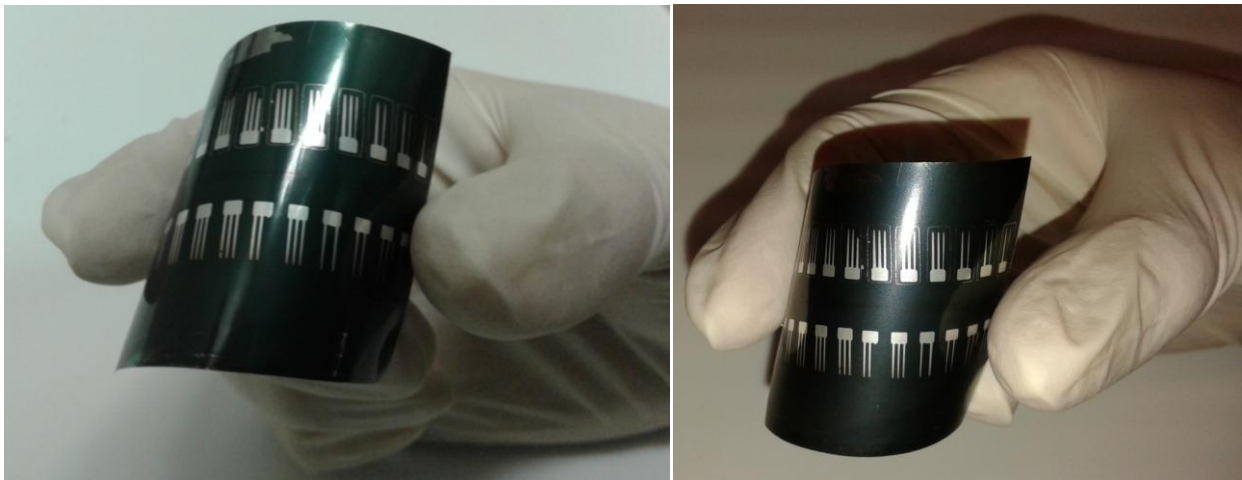
### UNIMIB NEW RESEARCH LINE

The group of Professor Maurizio Acciarri and Professor Simona Binetti from the University of Milano Bicocca focuses on the research on conventional photovoltaic. Such emerging technology in fact allows improving

.the efficiency to cost ratio, since the amount of material, required for the realization of thin film solar cells is at least two order of magnitude lower than in the case of first generation PV devices. Among these second generation thin film devices the alloy  $\text{Cu}(\text{In,Ga})\text{Se}_2$  (CIGS) is the most promising material due to the high efficiencies recently obtained (20.8 % lab record).

A new research line on the alternative buffer layer for chalcogenide photovoltaics is developed by UNIMIB through the FP7 NMP Project SolarDesign: On-the-fly Alterable Thin-film Solar Modules for Design Driven Applications project. Thereby, one main thrust in the CIGS solar cells is to replace the cadmium sulfide, CdS buffer layer with other material. Currently, a CdS thin film deposited by Chemical Solution Deposition (CSD) technique is utilized as a buffer layer in CIGS solar cells. The further process is not manufacturing-friendly due to the use of cadmium and the liquid waste. Thereby, the cell production is limited by the window materials, and there is need to develop wider band gap buffer layers alternative to CdS. The UNIMIB material candidates as alternative buffer layers in CIGS solar cells include zinc tin oxides ( $\text{Zn}_x\text{Sn}_y\text{O}_2$ ), indium sulfide ( $\text{In}_x\text{S}_y$ ) and zinc sulfide (ZnS) deposited by r.f. sputtering technique which can be easily integrated into a roll to roll system.

Recently, a special attention is on the deposition of the CIGS absorber layer on flexible substrates.

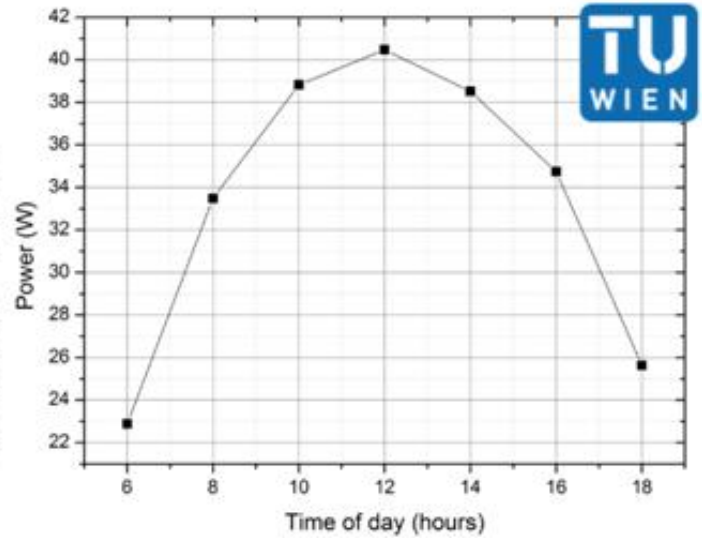
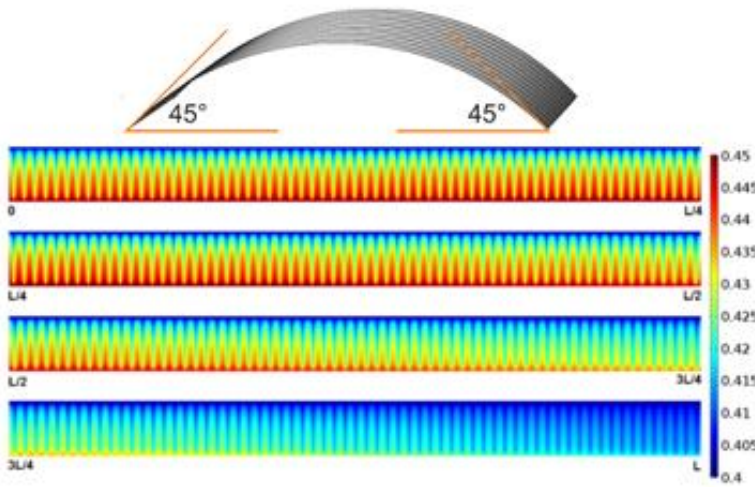


Example of alternative buffer layers and flexible substrates.

### **VIENNA UNIVERSITY OF TECHNOLOGY DEVELOPS THE NUMERICAL MODEL TO DESCRIBE CIGS SOLAR MODULES**

Vienna University of Technology (TUW) has finished development of the numerical model that describes solar modules made using CIGS technology developed within SolarDesign project. The developed model has two important aspects. Firstly, it is used to optimize the current fabrication technology, by exploring the impact of physical parameters of the solar cells. The simulation of the technology process is indispensable, as it saves both time and recourses by reducing the needed number of technological experiments. Thus, the needed technology push is provided which leads to lower cost of the produced photovoltaic modules.

Secondly, the developed model is used to explore the possibilities to meet the demands of the designers/architects, defined by the market pull. Specific user defined shapes of modules can be easily achieved, while maintaining the defined electrical needs. The design of metallization lines with varying thickness or shape, as well as arbitrary banding profiles is enabled. The simulations of the solar modules under different illumination levels has been taken into account, thus enabling the calculation of the daily or yearly energy performance of the considered modules.



Example of the simulation of an arbitrary curved module: a) module geometry, b) voltage distribution along one cell, b) calculated power yield during a day (Performed at Vienna University of Technology)

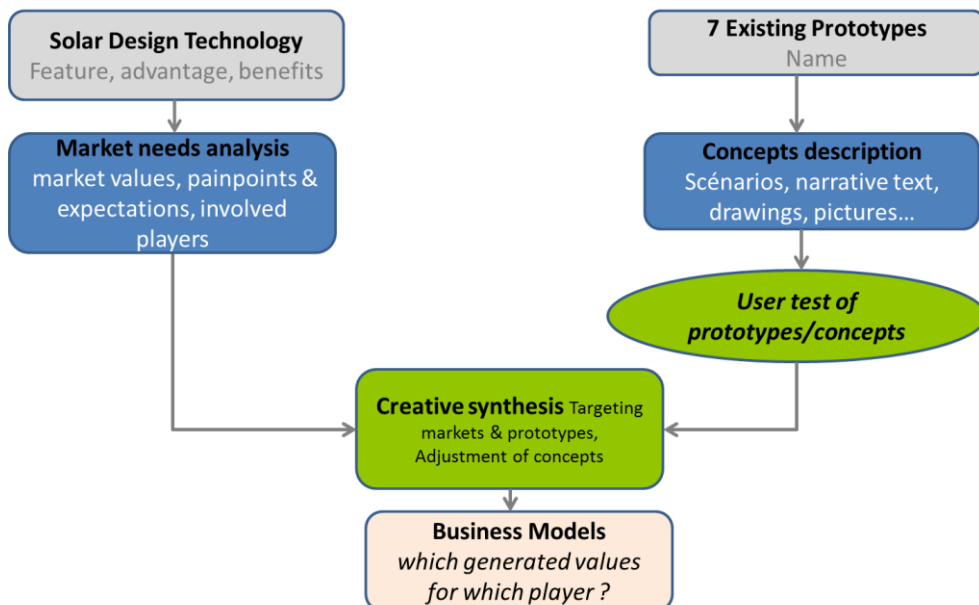
### CEA DEVELOPS A MULTI TOOLS MARKETING METHODOLOGY

CEA has defined and applied a multi tools marketing methodology in the framework of SolarDesign which could be used in other projects which have several potential key results.

The methodology will be presented in a BIPV workshop in the framework of SOPHIA Project that will take place from the 15<sup>th</sup> to the 16<sup>th</sup> of September 2014 at INES (Le Bourget du Lac, France).

The presentation will concentrate on the market survey method defined and applied so as to get the potential attractiveness on the technology concept and in parallel to get the maximum of signals on several possibilities of applications.

The methodology aimed to prioritize 4 markets (outdoor lighting, BIPV, consumer products and textile) by considering their attractiveness vs. Solar Design technology assets. Four different actions were lead: a documentary research based on patents and economic data's analysis, a "field analysis" with qualitative interviews of well-chosen actors, a "quantitative analysis" inspired by Kano approach and a long-term news watch disseminated to the members through a share point dedicated to the project.



## FIRST SOLARDESIGN IDEAS PRESENTED AT THE INTERSOLAR 2014

First SolarDesign ideas were presented by Andreas Zimmermann, Managing Director at Sunplugged, at the Intersolar 2014 event in Munich. The Intersolar exhibition and conference is Europe's biggest PV event, and during the three day event first prototypes and 3D renderings were shown on a joint stand of the Region of Tyrol and Baden Württemberg to a public audience.



## SOLARDESIGN PROJECT PARTICIPATED IN E-MRS SPRING MEETING

Prof. Simona Binetti and PhD Raluca Mereu (UNIMIB) participated in the E-MRS Spring Meeting from the 27<sup>th</sup> to 29<sup>th</sup> of May 2014 in Lille (France). The main objective of the E-MRS Meeting provides the opportunity to exchange ideas, discuss new developments and expand one's concepts of materials science engineering. The conference included 30 parallel symposia, one plenary session, one exhibition and much more. The UNIMIB delegates attended the *Thin film chalcogenide photovoltaic materials* symposia with the oral presentation "**Cu(In, Ga) Se<sub>2</sub> solar cells on flexible substrate fabricated by an innovative roll to roll hybrid sputtering an evaporation process**" supported by Prof. Binetti and the poster presentation of the PhD Raluca Mereu "**Zinc Tin Oxide (ZTO) thin films deposited via r.f. sputtering as alternative buffer layer for Cu(In,Ga)Se<sub>2</sub> solar cells**".

## SOLARDESIGN PROJECT PARTICIPATED IN STATO E PROSPETTIVE DEL FOTOVOLTAICO IN ITALY

Prof. Maurizio Acciarri participated with an oral presentation to the conference STATO E PROSPETTIVE DEL FOTOVOLTAICO IN ITALIA in 26<sup>th</sup> of June 2014 Rome (Italy). The conference program was the about the development of the research of the photovoltaics, which is a total relapse benefit of users of the national electricity system. Starting from the presented presentations of the results achieved, the conference aimed to open a debate between the research done by the most important national groups working on photovoltaics and expectations of the realities of the national productive sector.

## SOCIALLY SUSTAINABLE MANUFACTURING ECOSYSTEMS WORKSHOP

Prof. Maurizio Acciarri as delegate of University of Milano Bicocca (UNIMIB) participated in the Socially Sustainable Manufacturing Ecosystems Workshop in 30<sup>th</sup> of June 2014, Milan (Italy).

Organised by Politecnico di Milano, Fondazione Politecnico di Milano and Chalmers University, within the context of the SO SMART Coordination and Support Action ([www.sosmarteu.eu](http://www.sosmarteu.eu)), the Workshop aimed at bringing together industrial players, policy makers, and key societal stakeholders in order to discuss technological and societal trends, elaborate future scenarios, and define research agendas on Socially Sustainable Manufacturing Ecosystems in which manufacturing enterprises, employees and the society enact new ways of interaction, socially and economically sustainable in the medium and long term. The Workshop was a pre-World Manufacturing Forum event and it is supported by the European Commission.

## NEWS and EVENTS

Finally, we are pleased to inform you about other latest news and events related to SolarDesign Project and Photovoltaic:

- [Fourth consortium and steering board meeting](#) took place from the 18<sup>th</sup> to the 20<sup>th</sup> of June at EURAC Research in Bolzano (Italy).
- SolarDesign was presented to the participants of [euspen's 14<sup>th</sup> International Conference and Exhibition 2014](#), in Dubrovnik.
- Mr. W. Brenner, from TUWien, attended the 37<sup>th</sup> [International Convention MIPRO](#) in Croatia and presented the standardization tasks of SolarDesign.
- TUW has presented results of the [modeling of CIGS cells and modules in Photovoltaic Technical Conference PVTC 2014](#) in the form of oral presentation entitled "Front Grid Optimization of CIGS Solar Cells Using Hybrid Modelling Approach" by Nikola Bednar, Noemi Severino and Nadja Adamovic.
- **Ludwig Kronthaler** and **Laura Maturi** (EURAC) participated in the [Energy Forum-Advanced building skins 2013](#) from the 5th to the 6th of November 2013 in Bressanone (Italy).

You can find more information related to the project news at [www.solar-design.eu](http://www.solar-design.eu)

## UPCOMING EVENTS

- **29<sup>th</sup> European Photovoltaic Solar Energy Conference and Exhibition in Amsterdam.** Prof. Maurizio Acciarri and PhD Raluca A. Mereu, as delegates of University of Milano Bicocca (UNIMIB) will attend the 29<sup>th</sup> European Photovoltaic Solar Energy Conference and Exhibition which takes place in 22-26 September 2014 in Amsterdam, the Netherlands. The EU PVSEC is the largest International Conference for Photovoltaic research, technologies and applications, and at the same time a top international PV Industry Exhibitions.

During the conference PhD Raluca A. Mereu will present the papers "**Studies of the ZnSnO<sub>x</sub> and In<sub>x</sub>S<sub>y</sub> as Alternative Buffer Layers Deposited via R.F. Sputtering for Chalcogenide Photovoltaics**". Prof. Maurizio Acciarri will present the paper "**Cu(In,Ga)Se<sub>2</sub> Solar Cells on Flexible Substrate Fabricated by an Innovative Roll to Roll Hybrid Sputtering an Evaporation Process**".

- **SolarDesign 4<sup>th</sup> Project Meeting** will take place in December 2014.

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