PV4FACADES
Photovoltaics for High-Performance Building-Integrated Electricity Production Using High-Efficiency Back-Contact Silicon Modules

Project duration: 09.2014 to 08.2017
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Publishable Summary

The PV4FACADES project aimed at the development of low-cost and high-efficiency back-contact cell- and module technology and building-integrated PV (BIPV) products based on back-contact technology. These result in higher efficiency PV modules which are perfectly suited for BIPV: much more appealing aesthetics and more suitable electrical, thermal and mechanical characteristics.

Back-contact module technology is the accepted route to higher efficiency PV modules (see e.g. the SEMI PV roadmap). At the same time, back-contact module technology is also perfectly suited for BIPV in which PV elements are integrated into buildings and often have dual functions (serving as electricity generator and construction element) which reduces the balance-of-system costs. For residential rooftop and building integration, the current typical modules are aesthetically unattractive. The much more appealing aesthetics of back-contact modules make them much better suited for BIPV and for residential rooftops. Thus, there are commercial opportunities for PV systems other than the current typical flat plate modules mounted on frames or supports.

The PV4FACADES project ran for three years with the following main objectives:

- The development of low-cost, high-efficiency back-contact cell technologies for industrial take-up.
- The development of back-contact interconnection and lamination technologies, for 156mm x 156mm MWT (metal wrap through) and IBC (interdigitated back contact) cells, with improved integrated cell and module architecture and resulting in a lower cell-to-module loss and a lower cost than current industrial back-contact technology.
- The development of back-contact PV technology specifically designed for building integration, with improved aesthetics and resulting in a higher yearly energy yield.
- The development of module technology with thinner glass, improved reliability and lifetime.

The project included partners from the complete manufacturing chain: from research institutes and producers of cell and module manufacturing equipment, via module producers, to producers of building integrated PV elements.

In WP1, Tempress, imec, ECN and Soltech worked on the development of low-cost MWT and IBC cells, aiming at efficiency over 22%, suitable and optimised for the module technologies of the later WPs. For this aim, imec and Soltech developed MWT technology, where imec developed an MWT version of its back junction n-PERT cell with plated front contacts and screen-printed Al back contact. A cell process was successfully developed, achieving an efficiency of near 21%. Tempress developed a new LPCVD polysilicon deposition tool for the PV industry, initially by placing an LPCVD furnace in an existing equipment at ECN. With this tool, we have been able to do all experiments in

this project, leading to several world record passivation quality results and several papers at conferences and publications. After the process was fine, Tempress started to work on the furnace integration into a version for production platform 'Spectrum' which can handle higher through-puts. After several design iterations, a completely new LPCVD furnace based on latest technology platform was placed at ECN. ECN and Tempress focused on integration of novel LPCVD polySi passivated contact technology in nPERT and IBC cell processes, with innovative use of industrial fire-through metallization for the metal contact to the polySi layer. This resulted in near 20% nPERT efficiency, and in preliminary tests 18% IBC cell efficiency (with significant gain in Voc over conventional FT-metallized IBC cells, but low FF due to limited optimization of paste and firing parameters). Additionally, conventional FT-metallized IBC cells without polySi passivated contacts, with efficiency between 20% and 20.5%, were supplied for module development and test.

In WP2, two innovative back contact interconnection techniques were tested and optimised, aiming for a cell-to-module power loss of 0%. Here, Soltech, Eurotron, and ECN provided the interconnection techniques and pilot scale manufacturing equipment. With MWT cells, for BIPV modules of 22 cells, a cell to module power gain of +0.7% was achieved. With IBC cells, due to the need to distribute the limited quantity of available cells over many different tests (several types of degradation tests; and outdoor tests), only small size modules were made. As a result with IBC cells the cell to module power loss was about -3% for single cell and 4-cell laminates, which is expected to lead to between -1% and 0% for full size modules.

In WP3, lamination materials and technologies were developed and optimised, leading to thinner glass, new encapsulants, shorter process time, and lower cost. Şişecam developed strengthened and AR-coated glass, with low Fe2O3 content, with thickness of 2 mm for glass-glass, and 3.2mm for glass-foil modules. Sunlego, Eurotron, Soltech, and ECN tested and used this glass, and optimised lamination technology using also new encapsulants and edge sealants.

In WP4, product integration into high-performance building elements (roof elements) was performed by end users Wienerberger and Eternit in collaboration with Soltech. Integration of microinverters, for better shadow performance, was developed and tested by Sunlego and Soltech. Market studies and market feedback was collected for the roof elements, and a life cycle analysis of one exemplary roof element was performed.

In WP5, analysis and reliability testing was performed by Eliosys, GUNAM, imec, and ECN. This included development of test methods and setups for partial shading. Performance variations depending on different climates were monitored in outdoor tests at GUNAM and ECN.

Project consortium

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Participating countries and financing:

Country	Number of organisations involved	Project costs in EUR	Public funding in EUR
The Netherlands	3	1'317'365	684'601
Belgium-Flanders	4	688'657	531'902
Belgium-Wallonia	1	229'410	160'587
Turkey	2	502'836	334'884
Total	***10***	***2'738'268***	***1'377'090***

Funding agencies involved and contracts

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RVO	TEMW140009 / PV4Facades
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Service Public de Wallonie – DG06	PV4FACADES n°1318084
TUBITAK	Project no : 913008
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