# Back-contacted Silicon Heterojunction Solar Cells with a Simplified Photolithography-free Processing

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*In collaboration with EPFL and Meyer Burger Research, CSEM is developing the next generation of back-contacted silicon heterojunction solar cells, aiming at demonstrating top-level conversion efficiencies with a cost-effective process flow.*

Crystalline silicon solar cells implementing passivating contacts based on hydrogenated amorphous silicon (a-Si:H) and transparent conductive oxide (TCO) layers demonstrate the key advantage of increased operating voltages, as demonstrated in CSEM silicon heterojunction solar cell (SHJ) platform. In addition, maximum optical performance can be achieved using an all back-contacted solar cell architecture, providing no metallization shadowing at the cell sunny-side. The back-contacted silicon heterojunction (BC-SHJ) architecture therefore represents one of the silicon solar cell approach with the highest efficiency potential, combining optimum electrical and optical performance. This was demonstrated in 2016 with the achievement by Kaneka, Japan, of a conversion efficiency up to 26.33% using such BC-SHJ architecture, establishing the world-record efficiency for single junction crystalline silicon solar cells. However, the successful industrial spread of BC-SHJ devices is impeded by their complex and delicate process flow, usually involving several costly photolithography steps, to realize the patterned rear contacts. In the frame of the CTI project "PUNCH", CSEM, in close collaboration with EPFL and Meyer Burger Research, is developing the next generation of BC-SHJ devices, targeting high conversion efficiency along with a cost effective process flow.

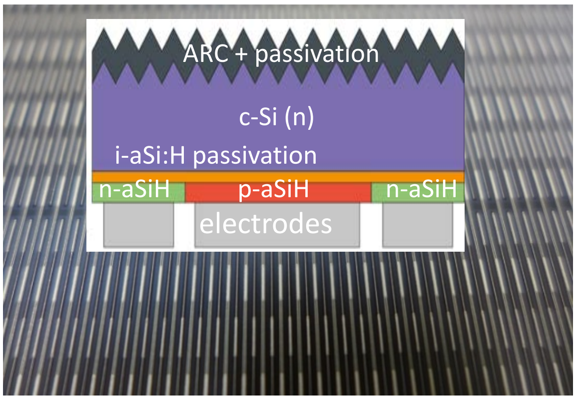


*Figure 1: Schematic cross-section of the BC-SHJ devices developed, on top of a close-up view of the back side of a full 6-in BC-SHJ device.*

CSEM developed and patented an innovative back side architecture[1], based on shadow-masking and on advanced thin film layers stacks, enabling to accurately pattern the rear electrodes of BC-SHJ devices without the use of any photolithography step. The CSEM approach drastically reduces the number of process steps to only 8, compared to at least 14 steps for a photolithography-based process flow. This results in a potential cost-effective process flow for the mass production of BC-SHJ devices. In addition, the developed rear side design features a lower contact resistance of the hetero-contact, hence yielding a reduced series resistance in the final device.

As a major achievement, CSEM together with EPFL and Meyer Burger Research fabricated in 2016 a 22.9%-efficient lab-scale BC-SHJ solar cell (9 cm²), using the developed simplified fabrication steps and architecture. The current-voltage curve of this record device is plotted in Figure 2. This result demonstrates the high efficiency potential of the BC-SHJ technology developed at CSEM.

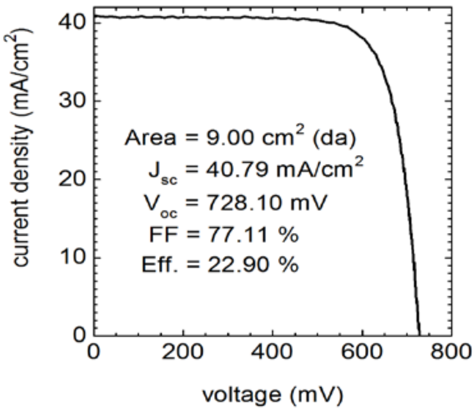


*Figure 2: Current-voltage curve of the 22.9%-efficient record BC-HJT device jointly developed by CSEM, EPFL, and Meyer Burger Research.*

The upscaling of this process flow was first conducted towards 25 cm² cells, with efficiency up to 22.8% demonstrated using the developed architecture. Then, upscaling to full 6-in wafers was initiated at the Meyer Burger Research facilities. The first large area BC-SHJ cells prototypes – obtained using mass production tools – demonstrated that the photolithography-free process flow developed has the potential for producing industrial BC-SHJ devices in a cost-effective way in the coming years. Strong focus is now set to achieve higher performance by further reducing series resistance of the devices.

Future work also focuses on the metrology and on the integration of the developed solar cells. Dedicated contacting units are being developed, while a module architecture specifically designed for BC-SHJ devices, based on the Meyer Burger SmartWire® technology, is being developed to efficiently integrate the cell developments into the final product.

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• EPFL, IMT, PV-Lab
•• Meyer Burger Research

[1] B. Paviet-Salomon, A. Tomasi, M. Despeisse, C. Ballif, "Photovoltaic device and method for manufacturing the same", patent EP 15 19 2655 (2015).