Area1: Crystalline and thin film silicon PV

Full title:	**Present status and future perspectives of bifacial PERC+ solar cells and modules**
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Abstract:
The photovoltaic industry is currently introducing the "Passivated Emitter and Rear Cell" (PERC) silicon solar cell concept into mass production which applies a full-area rear aluminum layer and is hence monofacial. The ITRPV and other market forecasts predict around 50% market share of PERC solar cells within the next 5 to 10 years. ISFH and SolarWorld started development of a novel bifacial PERC solar cell named PERC+ by screen-printing an Al finger grid on the cell rear side thus enabling absorption of sunlight from the front and rear side of the solar cell [1]. First simulations and outdoor tests demonstrated that bifacial PERC+ modules generate around 5% to 10% [1,2] more electricity compared to monofacial PERC modules due to the additional absorption of diffuse light from the PERC+ rear side. Another potential application is building-integrated PV in glass facades for which the bifacial PERC+ cells provide higher aesthetic appearance on the rear side when compared to solar cells with a full-area Al layer [3].

This paper reviews the present status and future perspectives of bifacial PERC+ solar cells and modules. The highest published efficiencies of bifacial PERC+ solar cells are 21.5% for the front side and 16.7% when illuminated from the rear side [4]. SolarWorld pioneered mass production of bifacial PERC+ cells in 2015 [5]. Since then, several other leading solar cell manufacturers such as Neo Solar Power, LONGi Solar and Trina Solar started production of bifacial PERC+ cells and modules as well [6,7,8]. First outdoor field installations with up to 20 MWp capacity are under construction [8]. Two new analytical models have been published [9,10] describing why PERC+ cells obtain deeper Al back surface fields (BSF) [9] and void-free local Al contacts [10] increasing the open circuit voltage compared to industry-typical PERC cells with full-area Al layer. We demonstrate a novel prototype module where we apply the Smart Wire Connection Technology (SWCT) [11] from Meyer Burger AG, Switzerland, to busbar less PERC+ solar cells soldering 18 wires directly to the front Ag fingers and rear Al fingers without the use of Ag pads thereby reducing the Ag paste consumption. The resulting prototype PERC+ SWCT module exhibits independently confirmed front and rear side efficiencies of 19.8% and 16.4%, respectively.

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