

RHINO

Realization of High efficiency Industrial N-type solar cells

Project duration: from 01.2018 to 03.2021

Report submitted: 10.2021

Publishable Summary

This project targeted the development of an industrially feasible manufacturing approach for an n-type cell structure that has demonstrated above 25% efficiency in a cleanroom environment. Key elements of the cell structure are an advanced or selective boron-doped emitter and a full area passivated rear contact, fabricated by low-pressure chemical vapour deposition of an in-situ phosphorous doped polysilicon layer on top of a thermally grown interface oxide. For these key elements, production capable processes and high throughput production tools have been developed and implemented in a lean solar cell production process. Both the implementation of the passivating rear contact and reducing the front carrier recombination losses by the development of advanced emitter from BBr₃ diffusion increased the efficiency of the developed industrial solar cell from 21% to 22,3% while using screen printed metallization and established production equipment.

The formation of a selective emitter structure, which is realized by laser-doping from the borosilicate glass, which is present on the wafer surface after thermal diffusion, has been intensively studied. A low contact resistance below 2 mΩcm² and a junction depth of > 1 μm could be demonstrated. However, within the project it was not possible to demonstrate an advantage of the laser-doped selective emitter over advanced homogeneous emitters with increased junction depth. High reflection losses at the laser-treated area was identified as one of the main challenges. Instead, advanced homogeneous emitters were developed. These diffusion processes enable recombination parameters of J_{0e} < 15 fA/cm² (textured, Al₂O₃/SiN_x-passivated) at industrially relevant process times of 2 hours. Further optimization of the BBr₃-process yielded a junction depth > 1 μm, which effectively reduces metallization induced recombination and these processes were successfully implemented in the solar cell process.

Test modules fabricated from these bifacial cells demonstrated high bifaciality factors of ~85%, still outperforming current passivated emitter and rear (PERC) modules in terms of bifacial properties. Modelling of bifacial module operation enabled a reliable prediction of energy yields depending on system configuration and ambient conditions.

The project contained partners from a research institute, a manufacturer of diffusion and polysilicon deposition furnaces, a laser system specialist and a module manufacturer. They all brought into this project their expertise that enabled to reach almost all the project goals. Based on the project results, follow-up projects were able to further push the development of industrial TOPCon solar cells at Fraunhofer ISE and the industry partners leading to current solar cell efficiencies of up to 23,8% at Fraunhofer ISE. Further exploitation is under way at Fraunhofer ISE with planned industry projects to transfer the developments.

Project consortium

Coordinator and all contact details:

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Participating countries and financing:

Country	Number of organisations involved	Project costs in EUR	Public funding in EUR
Germany	2	1'475'857	1'005'111
The Netherlands	1	647'000	313'478
France	1	130'142	58'564
<i>Total</i>	<i>4</i>	<i>2'252'999</i>	<i>1'377'153</i>

Funding agencies involved and contracts

Funding Agency	Contract N° and Title
PTJ	0324224A and 0324224B "Verbundvorhaben: RHINO - Realisierung von hocheffizienten industriellen n-Typ-Solar-Zellen, Teilvorhaben: Selektiver Emitter und Prozessintegration"
RVO	TESOL17007
ADEME	1805C0014

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