

EUROPEAN COMMISSION

HORIZON 2020 PROGRAMME
TOPIC H2020-LCE-07-2016-2017

Developing the next generation technologies of renewable electricity and
heating/cooling

GA No. 727523

**Next – generation interdigitated back-contacted silicon
heterojunction solar cells and modules by design and
process innovations**



NextBase - Deliverable report

**D4.3 – Optimized front-side with ultimate transparency
and passivation quality for IBC-SHJ with $J_{sc} > 42 \text{ mA/cm}^2$**

Deliverable No.	NextBase D4.3	
Related WP	WP4	
Deliverable Title	Optimized front-side with ultimate transparency and passivation quality for IBC-SHJ with $J_{sc} > 42 \text{ mA/cm}^2$	
Deliverable Date		
Deliverable Type	Report	
Dissemination level	Confidential (CO)	
Author(s)	Hariharsudan Sivaramakrishnan Radhakrishnan (imec), Mathieu Boccard (EPFL), Alaaeldin Gad (Jülich), Paul Procel (TUD)	22-09-2018
Checked by	EB members	24-09-2018
Reviewed by (if applicable)	Ivan Gordon (imec), Lars Korte (HZB)	26-09-2018
Approved by	Kaining Ding (Jülich) - Coordinator	28-09-2018
Status	Final	

Disclaimer/ Acknowledgment



Copyright ©, all rights reserved. This document or any part thereof may not be made public or disclosed, copied or otherwise reproduced or used in any form or by any means, without prior permission in writing from the NextBase Consortium. Neither the NextBase Consortium nor any of its members, their officers, employees or agents shall be liable or responsible, in negligence or otherwise, for any loss, damage or expense whatever sustained by any person as a result of the use, in any manner or form, of any knowledge, information or data contained in this document, or due to any inaccuracy, omission or error therein contained.

All Intellectual Property Rights, know-how and information provided by and/or arising from this document, such as designs, documentation, as well as preparatory material in that regard, is and shall remain the exclusive property of the NextBase Consortium and any of its members or its licensors. Nothing contained in this document shall give, or shall be construed as giving, any right, title, ownership, interest, license or any other right in or to any IP, know-how and information.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727523. The information and views set out in this publication does not necessarily reflect the official opinion of the European Commission. Neither the European Union institutions and bodies nor any person acting on their behalf, may be held responsible for the use which may be made of the information contained therein.

Publishable summary

In this deliverable report, the front-side of the IBC-SHJ cell was scrutinised to assess the potential improvements that can be made to increase the short-circuit current density, J_{SC} to values above 42 mA/cm^2 . The standard front-side stack used by most of the NextBase consortium partners consists of an intrinsic hydrogenated amorphous silicon (a-Si:H) and silicon nitride (SiN_x). The a-Si:H layer acts as an excellent passivation layer while the SiN_x acts as an anti-reflection coating (ARC). The main loss mechanisms associated with the front-side are direct reflection loss, front escape loss, front parasitic absorption loss in the front-side thin film stack as well as recombination losses due to imperfect surface passivation.

A J_{SC} loss analysis was performed on an IBC-SHJ cell with the standard a-Si:H/ SiN_x front stack, which revealed that the main loss pathways are front reflection, front escape loss and parasitic absorption and recombination losses at the rear-side. In particular, the front-side absorption or recombination losses were negligible. Using this simple low-temperature front-side stack, HZB and CSEM/EPFL have attained best J_{SC} values of 42.2 mA/cm^2 and 42.7 mA/cm^2 , respectively, while imec has reached a best J_{SC} of 41.9 mA/cm^2 , limited by rear-side losses and front escape losses. With a textured rear surface, a J_{SC} above 42 mA/cm^2 should be attainable. These findings corroborate well with the conclusions in deliverable D5.2.

Alternative stacks based on high-transparency materials such as chemical oxides and microcrystalline silicon carbide ($\mu\text{c-SiC:H}$) in combination with double-layer ARCs have shown promising results in terms of passivation. Simulations using such stacks have shown the potential for these stacks to also enable J_{SC} values above 42 mA/cm^2 . In another approach, the Cat-doping process to post-dope n-type $\mu\text{c-Si:H}$ films has shown an enhancement in lifetime after Cat-doping due to enhanced field effect passivation. In addition, it was shown that a high-temperature front-side using a diffused n^+ front surface field (FSF) with thermal oxide passivation and SiN_x ARC does not have an advantage over the standard low-temperature a-Si:H/ SiN_x stack.

Thus, the optimal front-side stack is indeed the standard low-temperature a-Si:H/ SiN_x stack with an additional MgF_2 coating. In fact, Kaneka has also achieved a J_{SC} of 42.7 mA/cm^2 using a-Si:H passivation and a double-layer ARC. Further increases in J_{SC} can be attained using advanced texturing methods (e.g. modulated surface texturing, see deliverable D3.3).