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NEXTBASE
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NextBase - Deliverable report

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

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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 (µc-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 µc-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).