Black silicon solar cells with black bus-bar strings

Davidsen, Rasmus Schmidt; Tang, Peter Torben; Mizushima, Io; Thorsteinsson, Sune; Poulsen, Peter Behrensdorff; Frausig, Jesper; Nordseth, Ørnulf; Hansen, Ole

Publication date: 2016

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Black silicon solar cells with black bus-bar strings
Rasmus Schmidt Davidsen*,a, Peter Torben Tangb, Io Mizushimab, Sune Thorsteinssonc, Peter Behrensdorff Poulsen,c, Jesper Frausigd, Ørnulf Nordsethe, Ole Hansena

*a Department of Micro- and Nanotechnology, Technical University of Denmark (DTU), 2800-Lyngby, Denmark, bIIPU, 2800-Lyngby, Denmark, cDepartment of Photonics Technical University of Denmark (DTU), 4000-Roskilde, Denmark, dGaia Solar A/S, 2650-Hvidovre, Denmark, eInstitute for Energy Technology (IFE), Norway

*rasda@nanotech.dtu.dk, Ørsteds Plads building 345East, 2800 Lyngby, Denmark

Concept
Black bus-bar strings are realized by four different wet-chemical, inorganic surface treatments:
- CuO on Cu without solder
- Etched solder on Cu
- NiZnS on solder
- NiCuCo on solder

Reflectance, black bus-bar strings
Measured reflectance as function of wavelength of bus-bar strings without (bare Cu, and Cu with solder) and with (NiCuCo, NiZnS, etched solder, and CuO) black coatings.

First test panel
Photograph of a 4-cell panel based on screen-printed black Si solar cells and interconnected with black CuO-coated bus-bar strings.

Reflectance, black Si
Measured total (diffuse + specular) reflectance of RIE-textured Si with SiN:H averaged over the wavelength range 300-1000 nm as function of the distance from the center of a 156x156 mm2 CZ wafer.

CuO + adhesive glue
Current-voltage (I-V) and power measurement of two 9-cell test panels based on 100x100 mm2 p-type CZ screen-printed black Si solar cells interconnected with (left) glued CuO coated strings and (right) soldered etched bus-bar strings.

I-V Results

Etched string + soldering

FF ~ 0.74

FF ~ 0.77

Industrial Application:
Inorganic, blackened bus-bar strings proposed for interconnection

All-black panels from conventional, front-contacted Si solar cells

Conclusion
We present black silicon texturing and blackened bus-bar strings as a potential method for obtaining all-black solar panels. Black silicon results in total, average reflectance below 0.5% in the wavelength range 300-1000 nm across a 156x156 mm2 silicon wafer. Black bus-bar strings were realized by various inorganic methods e.g. oxidized copper resulting in reflectance below 3% in the entire visible wavelength range. The combination of these two technologies results in aesthetic, all-black panels based on conventional, front-contacted silicon solar cells without compromising efficiency.