

26.1 %-efficient back contacted solar cells with passivating POLO contacts

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Project 26+: Options for industrial realization of Si-solar cells with efficiencies over 26%

Motivation

Why?

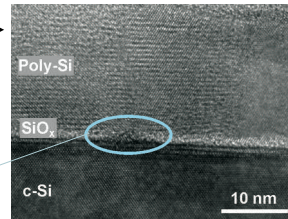
- High efficiencies to compensate balance of system costs and to reduce leveled cost of electricity
- Highest efficiencies for vehicle integrated photovoltaics (VIPV)

How?

- Poly-Si on oxide (POLO) passivating contacts reduce recombination losses
- High temperature stability allows for standard metallization techniques

Method and approach

- Development of baseline cell process with an efficiency potential > 26 %
- Simplification of process by substitution of lab-processes by industrial relevant ones



Hole in interfacial oxide

Transmission electron microscope image of a hole in the interfacial silicon oxide of the passivating contact.

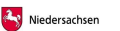
Partner and Funding

- Institute of Electronic Materials and Devices, Leibniz Universität Hannover
- Fraunhofer-Institut für Solare Energiesysteme

Associated industrial partners:

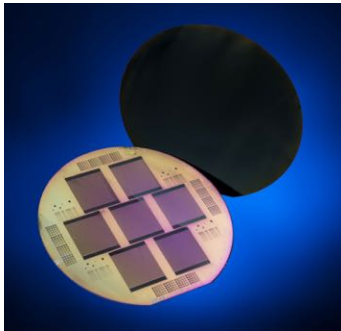
- Centrotherm Photovoltaics
- Wacker
- Singulus

Funded by the state of lower saxony and the German Federal Ministry for Economic Affairs and Energy (BMWi) under grant number- 0325827A

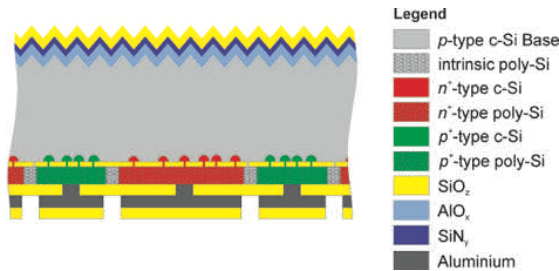


on the basis of a decision by the German Bundestag

Solar cell results



Photograph of the 26.1%-efficient solar cell. 7 cells are processed on one wafer.



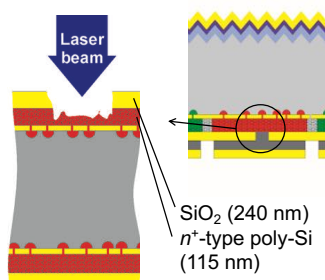
Schematic of the cross section of the 26.1%-efficient back contacted solar cell.

European record efficiency of c-Si cells
World record efficiency on p-type c-Si cells

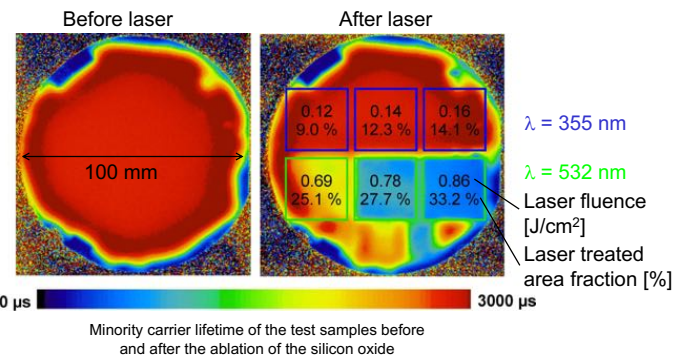
- $\eta = 26.1 \%$
- $V_{OC} = 727 \text{ mV}$
- $J_{SC} = 42.6 \text{ mA/cm}^2$
- $FF = 84.3 \%$
- $A = 3.97 \text{ cm}^2 \text{ (d.a.)}$

All parameters independently confirmed at CalTeC (@ ISFH)

Laser contact openings on POLO



Schematic of the cross section of the laser contact openings on test samples.



Minority carrier lifetime of the test samples before and after the ablation of the silicon oxide

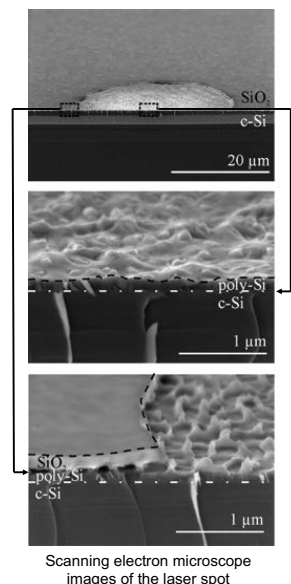
Layer selective ablation of the SiO₂ layer

- Recombination current density at contact of 2 fA cm^{-2}
- Laser pulse length 9 ps
- Laser wavelength of $\lambda = 355 \text{ nm}$: stable lifetime
- Laser wavelength of $\lambda = 532 \text{ nm}$: decrease in lifetime

Conclusions

- Damage free laser contact openings using a wavelength of 355 nm and a pulse length of 9 ps
- World record 26.1 %-efficient p-type solar cells

F. Haase, C. Klamt, S. Schäfer, A. Merkle, M. Rienäcker, J. Krügener, R. Brendel, and R. Peibst, "Laser contact openings for local poly-Si-metal contacts enabling 26.1 %-efficient POLO-IBC solar cells", Solar Energy Materials and Solar Cells, 186 (2018), p. 184-193.



Scanning electron microscope images of the laser spot