PSI-process on 6” Si substrates

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Re-use of Si growth substrate

10-fold use

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R. Brendel, 14th EU-PVSEC, Barcelona 1997, p.1354
R. Horbelt et al., 31st IEEE PVSC, Orlando 2005
Efficiency potential of thin-film Si wafers

Assumptions:
- Good optics 90% of Lambertian ✓
- \( \tau = 1 \, \mu s \) 16 \( \mu s \) measured ✓
- \( S = 100 \, \text{cm/s} \) 120 cm/s measured ✓

Simulated efficiency:
- \( \eta = 18 \% \)
- \( W = 2.5 \, \mu m \)

Porous double layer

Closure of porous surface

First report on surface closure:
V. Labunov et al., Thin Solid Films 137, 123 (1986)

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Building separation layer

First report on separation layer formation:
Utilize out-diffusion from growth substrate!


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Boron autodiffusion: cell result

$V_{OC} = 588 \text{ mV}$
$J_{SC} = 33.3 \text{ mA/cm}^2$
$FF = 74.2 \%$

$\eta = 14.5 \%$

Independently confirmed @ ISE CalLab

Cell area: 4 cm$^2$, thickness 24 µm
FS: a-Si/SiN  RS: B-BSF

$V_{OC} = 616 \text{ mV}$
$J_{SC} = 29.0 \text{ mA/cm}^2$
$FF = 78.8\%$
$\eta = 14.1\%$

Cell area : 95.5 cm$^2$
Si film thickness : 26 $\mu$m

Textured on the illuminated side

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Rear contact - rear junction
PSI-module

Glass
SiN/a-Si:H
Al
Emitter
Base
a-Si:H
SiN
4S interconnection

- 2 µm deep trenches to contact p-type base (etched from the front)
- Short circuit prior to trench etching from the back
- Trenches separating the cells (etched from the back)

Top view, rear side

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FS & RS: a-Si/SiN

Textured on the non-illuminated side

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\[ V_{OC} = 3754 \text{ mV} \]

\((V_{OC} = 626 \text{ mV/cell})\)

\[ I_{SC} = 388 \text{ mA} \]

\((J_{SC} = 28.4 \text{ mA/cm}^2)\)

\[ FF = 67.3\% \]

\[ \eta = 12.0\% \]

Area: 9 x 9.1 cm\(^2\)

Si film thickness: 24 µm
COSIMA contact formation

COSIMA: Contacts to a-Si:H passivated wafers by Means of Annealing

- a-Si:H deposition: PECVD, 225 °C
- Al deposition
- Annealing: 300 °C, 5 min

H. Plagwitz, M. Nerding, N. Ott, H. Strunk, and R. Brendel
“Low-temperature formation of local Al contacts to a-Si:H-passivated Si wafers,” Prog. Photovolt. 12, 47 (2004)

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Summary

- Efficiency of large area PSI solar cell as high as 14.1 %
- Utilization of porous Si as dopant source: $\eta = 14.5$ %
- Surface passivation by a-Si:H
  - Interface defect density lower than $10^9$ cm$^{-2}$
  - Enhanced open-circuit voltage
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