

Approaches for Reducing Metallization-Induced Losses and Cost in Industrial TOPCon Solar Cells

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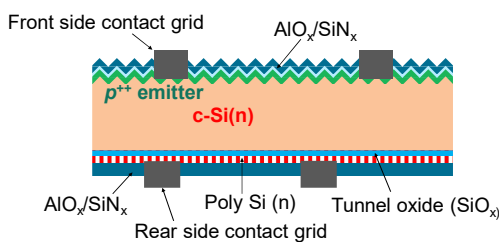
Link to Fraunhofer ISE contribution of the 47th EU PVSEC (available as of Sep 25, 2024)

Introduction

- *i*TOPCon solar cells dominated by recombination at the front side
- Carrier recombination at metal-semiconductor interface needs to be reduced
- Laser-enhanced contact optimization to decouple contact formation and passivation

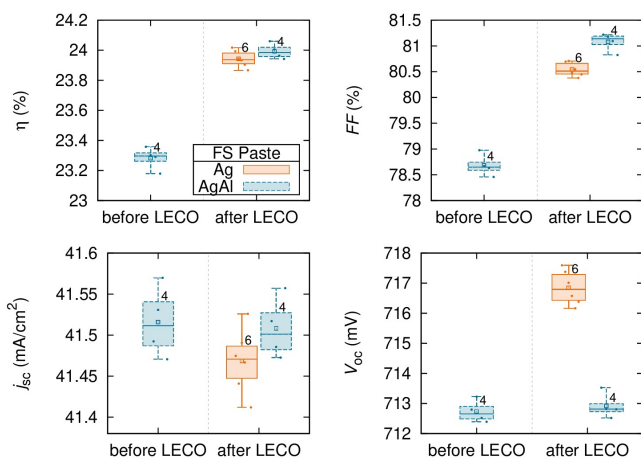
Sample preparation

- Established process flow for fabrication of industrial *i*TOPCon solar cells
- Equipment and processes optimized for M10 wafers
- Metallization using either single step flat-bed screen-printing, or laser ablation and Ni/Cu/Ag plating
- Laser Enhanced Contact Optimization (LECO) [1] for screen printed contacts with pure Ag or AgAl paste



Schematic cross section of fabricated *i*TOPCon solar cells

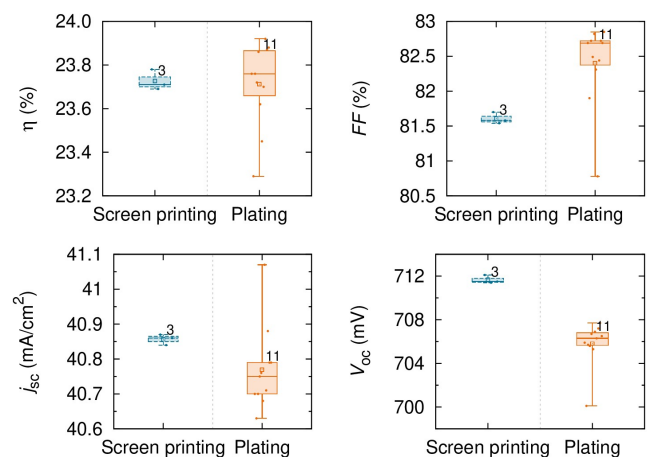
Impact of contact optimization



M2 sized solar cells, industrial cell tester measurement with condition "grn | grn, hrc" [2, 3]

- LECO treatment allows high FF at lower firing set temperature
- Lower firing temperature beneficial for reducing $j_{0,met}$
- LECO enables use of Ag paste that results in higher V_{oc} than conventional AgAl paste

Metallization variation



M10 sized solar cells, lab type cell tester measurement with condition "grn | grn, hrc" [2, 3]

- Screen printed contacts with higher V_{oc} , but lower FF than plated contacts
- Origin lies in metallized area fraction, as laser ablation leads to complete opening of passivated surface, whereas screen printing forms only local contacts
- Plating reduces Ag consumption by >90% (only 1.1 mg/W_p) and cost
- Conversion efficiency similar with respect to distribution and group size
- Lower j_{sc} for plated contacts due to use of layout with busbars

Calibrated IV measurements

Champion *i*TOPCon solar cells. Measurement condition "grn | grn, hrc" [2, 3]

* Calibrated measurement at ISE CalLab PV Cells

** Calibrated measurement at ISFH CalTec

	V_{oc} (mV)	j_{sc} (mA/cm ²)	FF (%)	η (%)
Screen printed contacts				
M2 (156.75 mm)	722	41.6	81.5	24.5*
M10 (182 mm)	712	41.1	82.1	24.0**

Summary

- Baseline process for M10 *i*TOPCon solar cell fabrication developed
- Conversion efficiencies over 24% achieved
- Contact optimization established for use of Ag front side pastes
- Plating for reduced cost at similar efficiency level

[1] R. W. Mayberry, et al., 36th EU-PVSEC, 2019.
[2] grn: grid resistance neglected, hrc: highly reflective chuck
[3] M. Rauer, et al., 40th EU-PVSEC, 2023.

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