»ROCK-STAR« – HIGH-SPEED ROTARY PRINTING FOR SOLAR CELL METALLIZATION: FROM VISION TO REALITY


9th Metallization & Interconnection Workshop
High-Speed Rotary Printing for Solar Cell Metallization: From Vision to Reality
Fraunhofer Institut für Solare Energiesysteme

Freiburg, 06.10.2020
1. Rotary Printing for Solar Cell Metallization
   Background and Motivation

2. Technology
   Flexography and Rotary Screen Printing

3. Projects »Rock’n’Roll«
   »Rock-Star« and »Rock-It«
   A Brief Review

4. Project »Rock-Star«
   Main Results and Achievements of the Project

5. The »Rock-Star« Demonstrator
   Concept and Highlights

6. Summary and Outlook
   Next Steps - Project »Rock-It«
Rotary Printing for Solar Cell Metallization

Background and Motivation

- Globally installed PV capacity rapidly approaches **terawatt-scale**:  
  → Decrease costs of cell and module production  
  → Increase throughput of production lines

Cumulative installed global PV capacity from 2010 to 2019 (Source: PSE Projects GmbH, taken from Fraunhofer ISE Photovoltaics Reports 2020)

Rotary Printing for Solar Cell Metallization

Background and Motivation

- Globally installed PV capacity rapidly approaches terawatt-scale:
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  - Increase throughput of production lines
  - Backend: Metallization & Classification: ITRPV Prediction 2026: **8,500 – 13,000 Wafer/h**[1]

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Rotary Printing for Solar Cell Metallization
Background and Motivation

- Globally installed PV capacity rapidly approaches **terawatt-scale**:
  - Decrease costs of cell and module production
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  - Backend: Metallization & Classification:
    - ITRPV Prediction 2026: **8.500 – 13.000 Wafer/h**[^1]
- Flatbed screen printing:
  - Reduction of cycle time below $t \approx 1 \text{ s}$
  - difficult or impossible

The Challenge: «Boosting throughput of metallization by maintaining the same quality level»
Rotary Printing for Solar Cell Metallization
»Rock-Star« Approach

Approach of »Rock-Star«: »Rotary and continuous instead of flat and sequential printing«
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Rotary Printing for Solar Cell Metallization
Technical Background – Rotary Screen Printing and Flexographic Printing

Rotary Screen Printing:
- Cylinder Screen
- Shuttle
- Squeegee

Flexography:
- Ink chamber
- Flexo plate/sleeve
- Anilox roller
- Elevated areas
- Recessed areas
- Shuttle

Emulsion
- Open mesh
  - Printing
  - Non-printing
- Flexo Sleeve
  - Elevated areas
    - Printing
  - Recessed areas
    - non-printing

Source: Gallus Ferd. Rüesch AG
„Rock-Star“

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Joint Projects „Rock-Star“ and „Rock-It“  
Projects „Rock’n’Roll“, „Rock-Star“ and „Rock-It“ – A Review

2010: First results on small-size Si samples using IGT test device\cite{1,2}

\cite{1} Frey, Master Thesis (2010) \quad \cite{2} Frey et al., Energy Proc. 8 (2011)
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2014  “Rock’n’Roll”
→ Upscaling of tests on full wafer size\cite{3}

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2015 Start of funded joint project “Rock-Star” with 9 industry partners
→ Comprehensive evaluation of flexo and rotary screen printing\[5-7\]

2016 – Concept, fabrication and testing/hook-up
2019 of the “Rock-Star” demonstrator machine
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2020 Demonstrator launched at ISE PVTEC\[8\]

„Rock-Star“

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Project »Rock-Star«
Technological Highlights and Achievements

Rotary Screen Printing:
- Rear side metallization of Cz-Si PERC solar cells successfully shown\(^1\)

\(^1\) Lorenz et al., Energy Proc. 124 (2017)
Project »Rock-Star«
Technological Highlights and Achievements

Rotary Screen Printing:

- Rear side metallization of Cz-Si PERC solar cells successfully shown\(^1\)
- Front side metallization with finger width down to \(w_f \approx 40 \, \mu\text{m}\)\(^2\)

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Technological Highlights and Achievements

Rotary Screen Printing:

- Rear side metallization of Cz-Si PERC solar cells successfully shown\[1\]
- Front side metallization with finger width down to $w_f \approx 40 \, \mu m$\[2\]
- Demonstrator module (9 mc-Si PERC cells, SWCT interconnection):
  - RSP rear side metallization
  - Module efficiency: $\eta_{\text{mod,n}} = 17.7 \%$\[3\] ($\eta_{\text{mod,n}}$ normalized on total cell area)

\[1\] Lorenz et al., Energy Proc. 124 (2017)
\[3\] Lorenz et al., Proc. 37th EUPVSEC (2020)

Demonstrator module: 9 mc-Si PERC solar cells with rotary screen printed rear side metallization and SWCT interconnection
Flexo Printing:

- Flexo printed front side metallization successfully demonstrated using
  - Seed and Plate approach with Ni/Cu/Ag Plating (Fig. C)[1,2]
  - Direct metallization down to $w_f \approx 30 \, \mu m$ finger width[3]
- Mini module with flexo printed Al BSF solar cells and SmartWire interconnection[4]

Flexo printed contact finger with A,B) direct metallization, C) seed layer and Ni/Cu/Ag plating, D) interconnected cells with SmartWire
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Concept and Innovation of the »Rock-Star« Demonstrator

- Autonomous Shuttles
- High-Speed Camera
- Rotary Screen Unit
- Flexo Printing Unit

Highlights:
- Inline capable
- Modular Printing Units
- Printing Speed: Up to 600 mm/s
- Cycle time: down to 0.45 s/cell
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Summary and Outlook
Next Steps – Project „Rock-It“

Summary:
- Successfull demonstration of front and rear side metallization using flexography / rotary screen printing
- Development and launch of high-throughput demonstrator platform

Outlook „Rock-It“:
- Evaluation of demonstrator platform
- Optimization of rotary printed metallization
- Fabrication of fully rotary printed PERC and HJT solar cells
- Feasibility studies for other applications (fuel cells, sensors, PCB...)
Thank you for your attention!

Fraunhofer-Institut for Solar Energy Systems ISE

Dr. Andreas Lorenz
Andreas.Lorenz@ise.fraunhofer.de
www.ise.fraunhofer.de