Advancements in Fine Line Metallization: Latest Achievements at Fraunhofer ISE

A. Lorenz, J. Schube, A. Brand, S. Pingel, A. Nair, M. Singler, M. Linse, L. Folcarelli, F. Maarouf, M. Salimi, M. Retzlaff, N. Wengenmeyer, O. Mhirsi, R. Haberstroh, B. Singh Goraya, S. Nold, J. De Rose, F. Clement, R. Preu

Special thanks to: Dr. Weiming Zhang[1], Dr. Ning Chen[2], Dr. Xinpeng Zhang[3]
[1]Zhejiang Gonda Electronic Technology Co., Ltd. [2]Wuxi Autowell Technology
[3]Hangzhou Jingbao New Energy Technology Co., Ltd (KinPa New Energy)

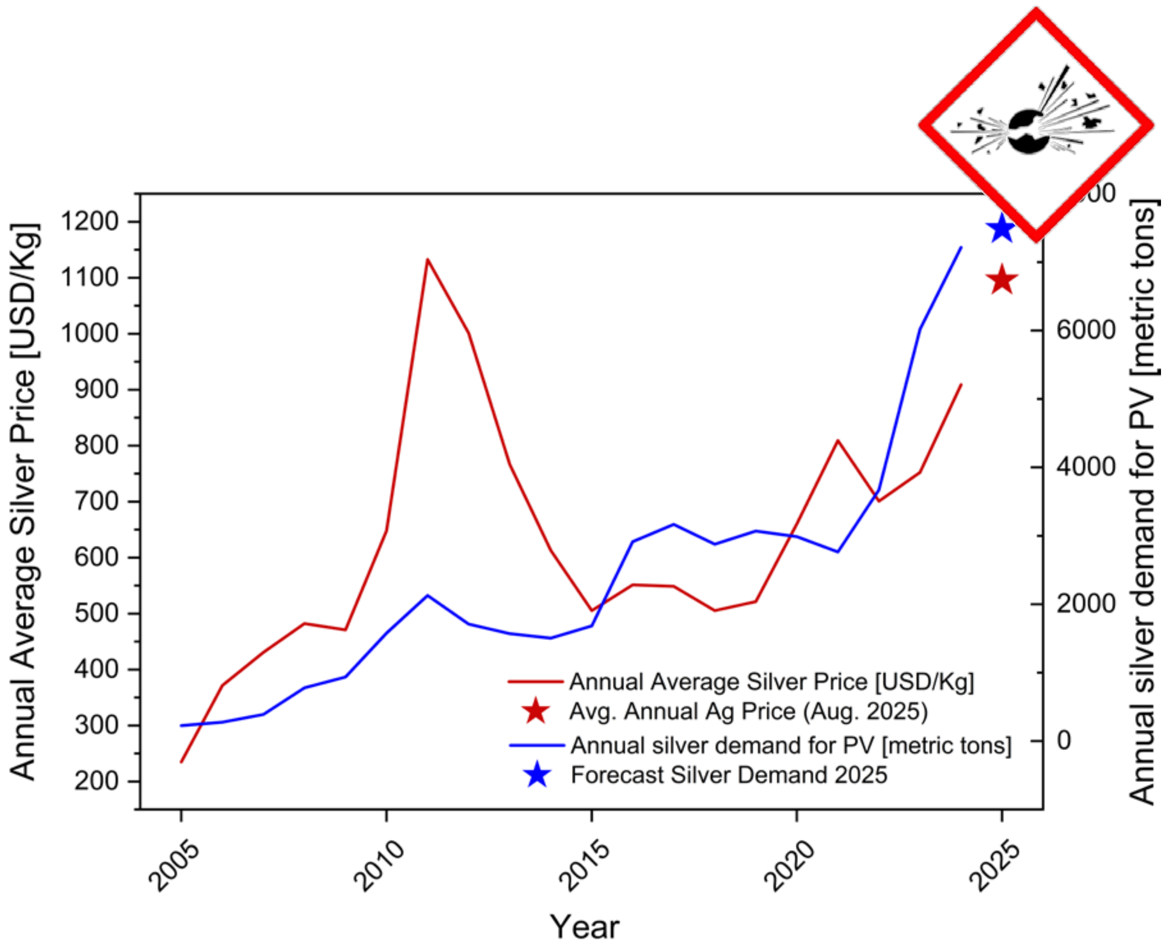
13th Metallization and Interconnection Workshop
October 21st 2025, Berlin

Motivation

There is no alternative to drastic silver reduction

Silver demand for the PV industry 2025:

- Silver price reaches new record highs (> 52 $/Oz)
- PV silver demand of PV expected to reach > 7,5 kt [1]
- **„Explosive mix“ for PV industry**



Evolution of silver price [$/Kg] and yearly total silver demand [Tons] from 2005 to 2025 (forecast). Source: The Silver Institute [2]

[1] V. Cattaneo et al., Resources, Conservation and Recycling 224, S. 108562. DOI: 10.1016/j.resconrec.2025.108562 (2025)
[2] The Silver Institute: World Silver Survey 2015 / 2020 / 2024

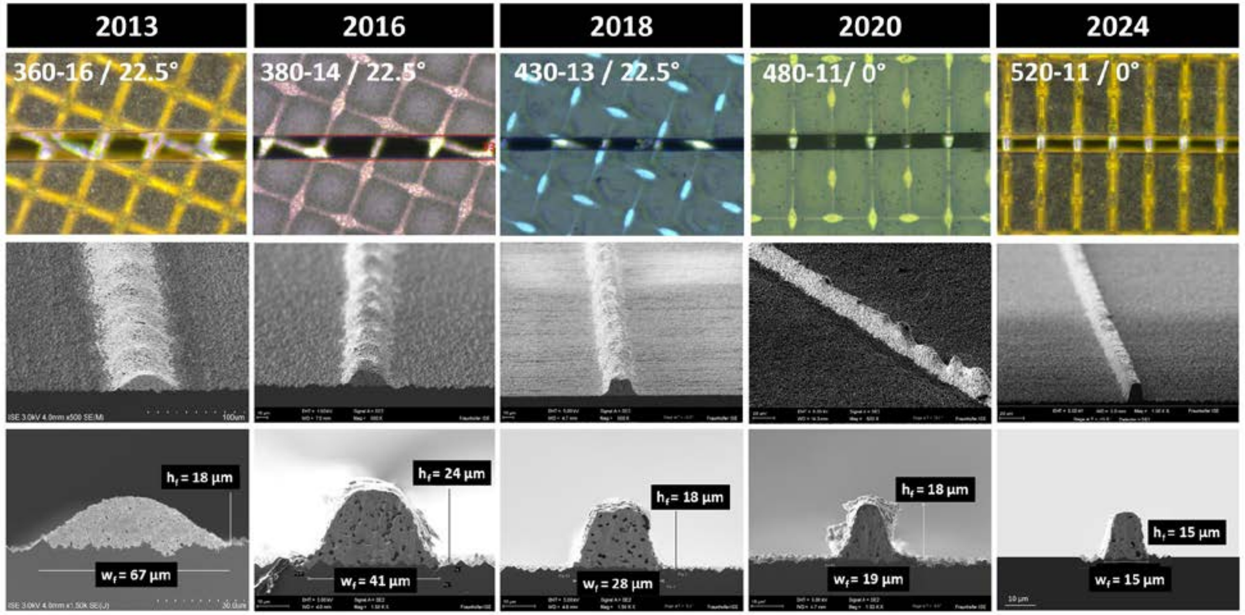
Fraunhofer ISE

Motivation

There is no alternative to drastic silver reduction

Impact on PV industry:

- Strong pressure to drastically reduce/replace Ag
- Possible solutions:
  - ➢ Silver reduction by fine line printing,
    Rapid development of new screens & pastes [1]
    → Approaching 10 µm in industrial mass production [2,3]



Evolution of fine line screen printing at Fraunhofer ISE: Microscopic images of different screen types and SEM images of selected front side contacts (Al BSF and PERC) from 2013 to 2024. Source: Fraunhofer ISE

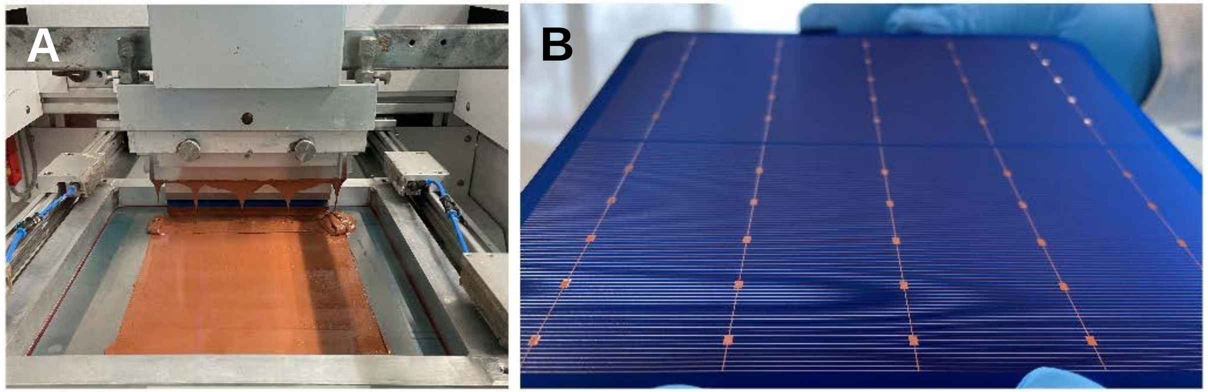
[1] N. Chen et al., Sol. Energy Mater. Sol. Cells 290 (2025)   [2] N. Chen, this workshop   [3] W. Zhang, this workshop

Motivation

There is no alternative to drastic silver reduction

Impact on PV industry:

- Strong pressure to drastically reduce/replace Ag
- Possible solutions:
  - ➢ Silver reduction by fine line printing,
    Rapid development of new screens & pastes [1]
    → Approaching 10 µm in industrial mass production [2,3]
  - ➢ Replacement of silver (i.e. AgCu [1,2], Copper [2] or Nickel [3] paste),



A) Screen printing of copper paste B) SHJ solar cells with Cu front side metallization (Source: Fraunhofer ISE)

[1] J. Cao, this workshop
[2] S. Pingel et al., 15th SiliconPV, Oxford, UK (2025)
[3] T. Druffel et al., 15th SiliconPV, Oxford, UK (2025)
[4] V. Unsur et al., Solar Energy Materials and Solar Cells 287 (2025)

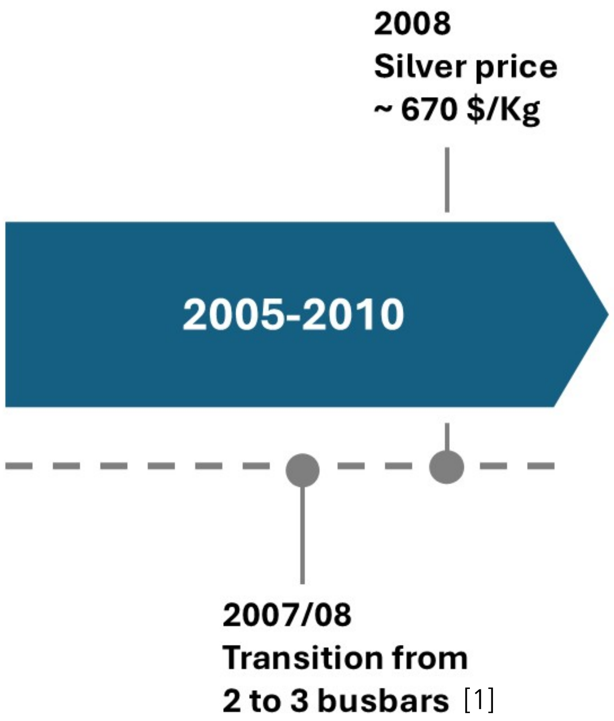
Fraunhofer ISE

A brief historic excursion: Review of 25 years of screen printed solar cell metallization

AI generated

Evolution of Screen Printing for PV

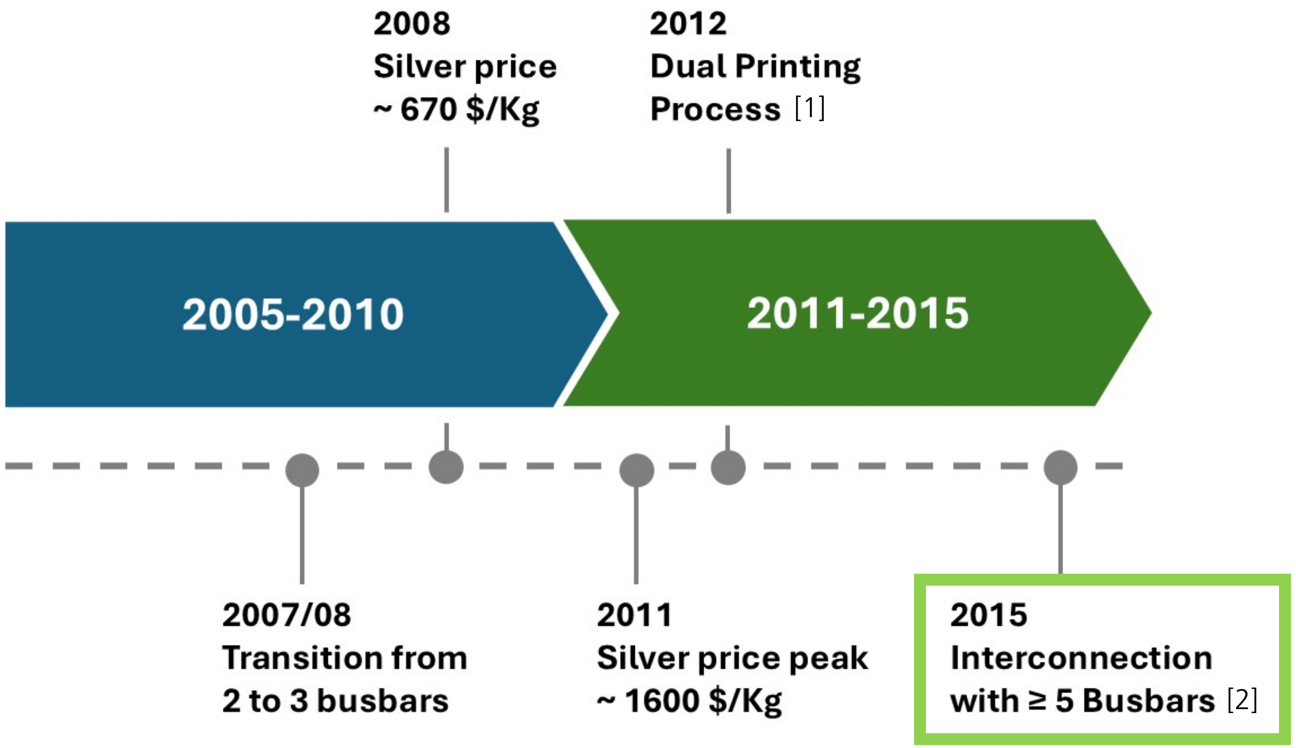
A whirlwind journey through history

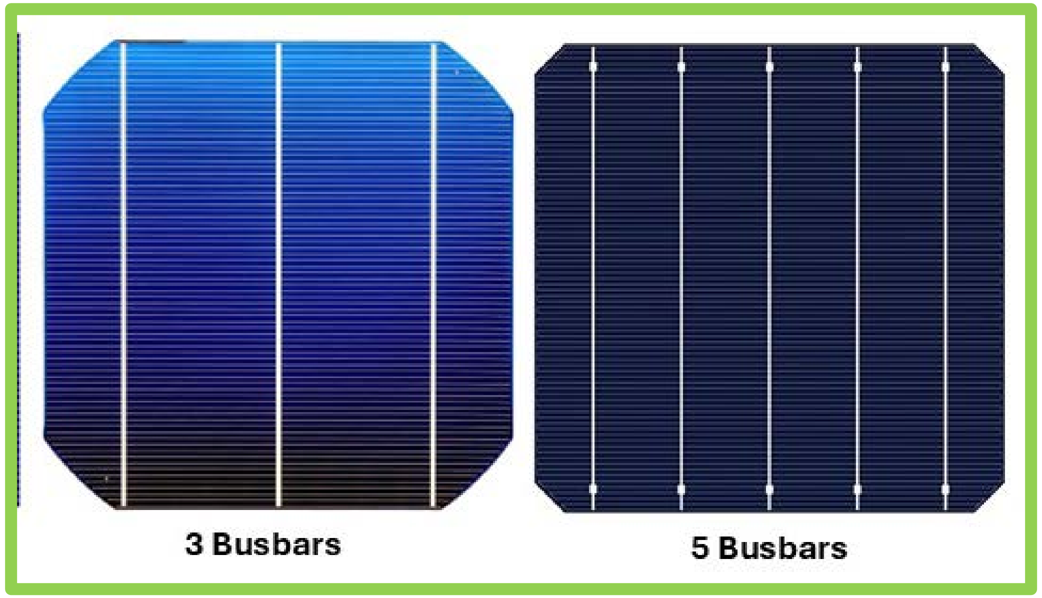


[1] L.J. Caballero et al., 33rd IEEE PVSC) San Diego, CA, USA (2008)

Evolution of Screen Printing for PV

A whirlwind journey through history



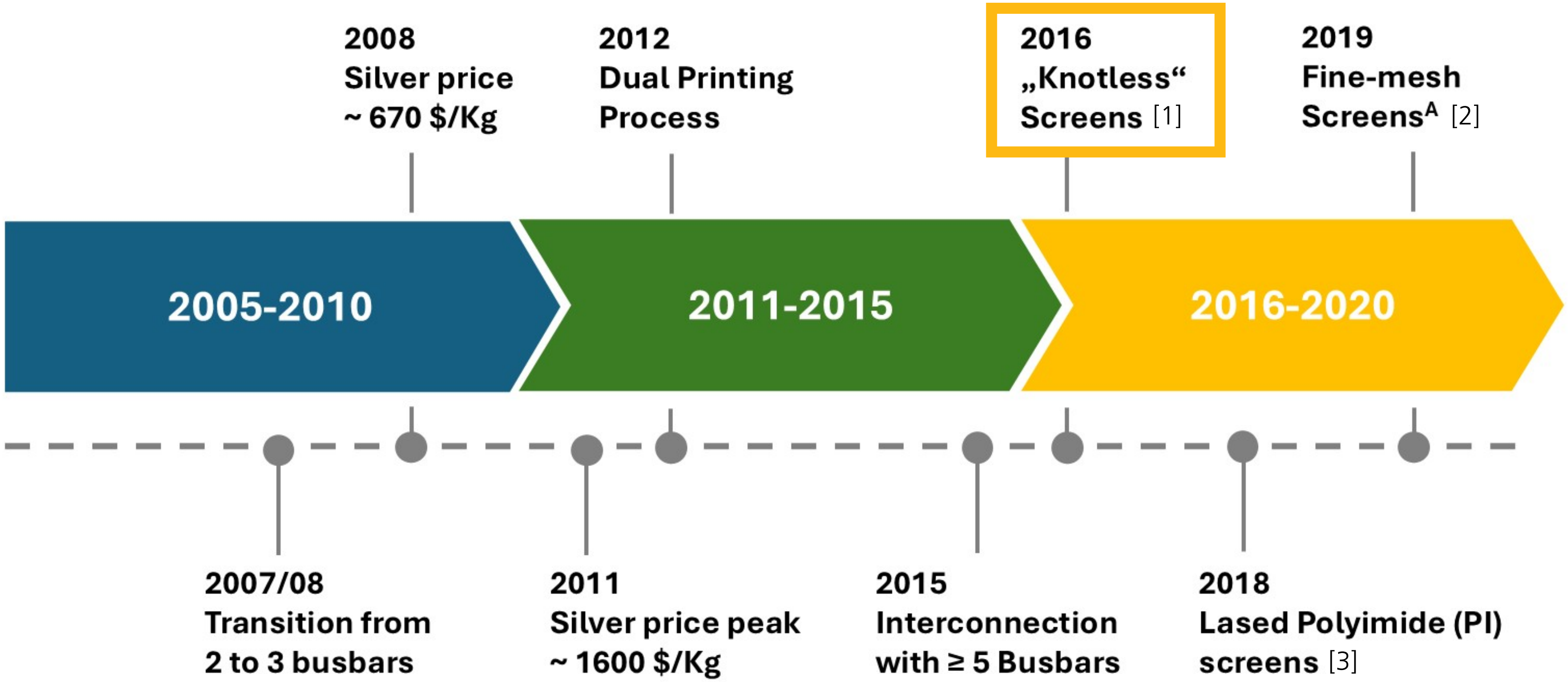


Silicon solar cells with 3 and 5 busbars for interconnection

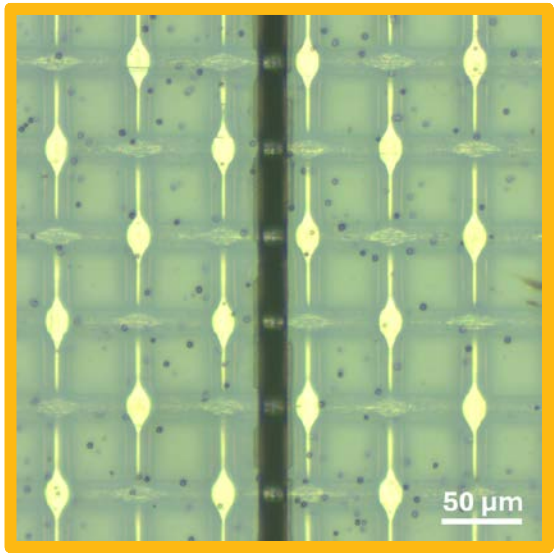
[1] M. König et al., Energy Procedia 27 (2012)
[2] https://www.solarserver.de/2015/05/04/photovoltaik-technologie-solarworld-ag-setzt-auf-5-busbars-und-meldet-perc-solarzellen-rekordwirkungsgrad-von-2151/, 2015 (accessed 28 May 2025).

Evolution of Screen Printing for PV

A whirlwind journey through history



^A Fine mesh screens ≥ 480 wires/mesh

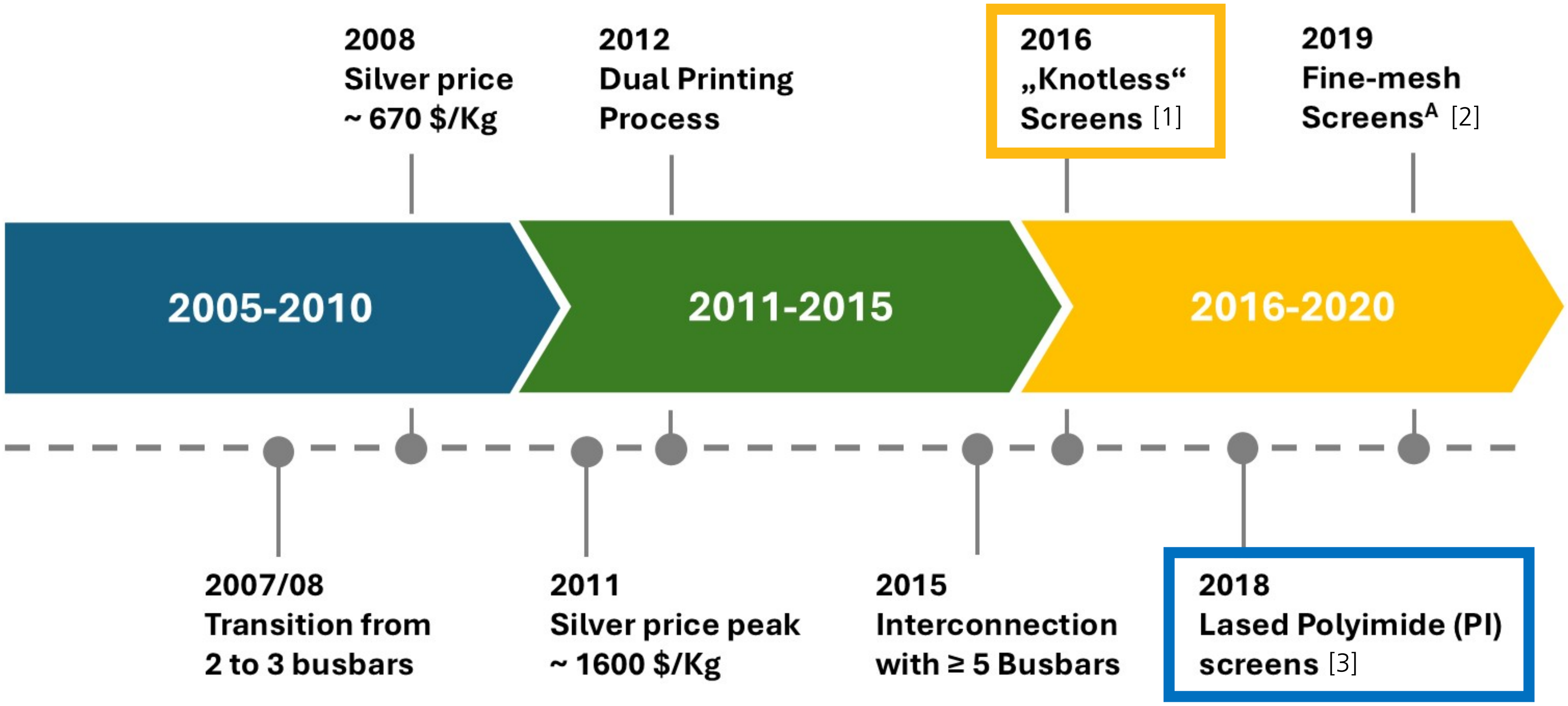


Microscopic image of knotless screen (500-05 / 0° mesh)

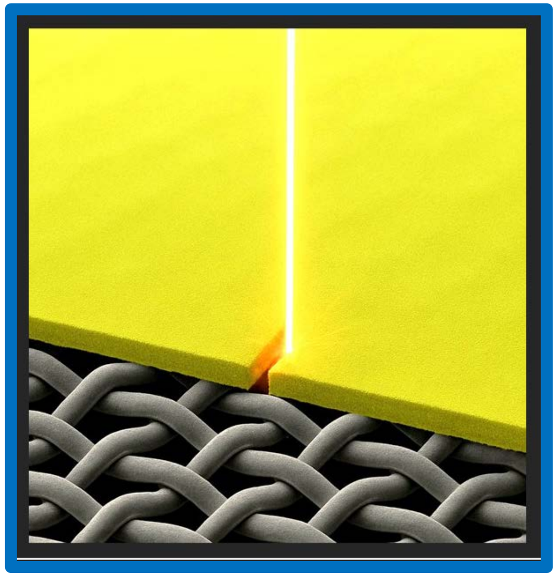
[1] Y. Zhang, 7th Workshop on Metallization, Constance (2017) [2] T. Wenzel et al., Solar Energy Energy Materials and Solar Cells 244 (2022)
[3] https://www.eqmagpro.com/f9900-series-from-brave-ch-gains-widespread-praise-in-solar-industry-for-successfully-revolutionizing-screen-printing-process/ (accessed 29 May 2025).

Evolution of Screen Printing for PV

A whirlwind journey through history



^A Fine mesh screens ≥ 480 wires/mesh



AI-created visualization of lasing process for Polyimide screens (Source: A. Lorenz, ISE)

[1] Y. Zhang, 7th Workshop on Metallization, Constance (2017) [2] T. Wenzel et al., Solar Energy Energy Materials and Solar Cells 244 (2022)
[3] https://www.eqmagpro.com/f9900-series-from-brave-ch-gains-widespread-praise-in-solar-industry-for-successfully-revolutionizing-screen-printing-process/ (accessed 29 May 2025).

Fraunhofer ISE

Evolution of Screen Printing for PV

A whirlwind journey through history

2008
Silver price
~ 670 $/Kg

2012
Dual Printing
Process

2016
„Knotl
Screen

2023[1]
LECO[C]

2025 [2]
Ultra-fine mixed
woven mesh screens

2005-2010 | **2011-2015** | **2016-2020** | **2021-2025**

2007/08
Transition from
2 to 3 busbars

2011
Silver price peak
~ 1600 $/Kg

2015
Interconnection
with ≥ 5 Busbars

2018
Lased Polyimide (PI)
screens

2022/23
Super Multi-Busbar
Interconnection[D] [3]

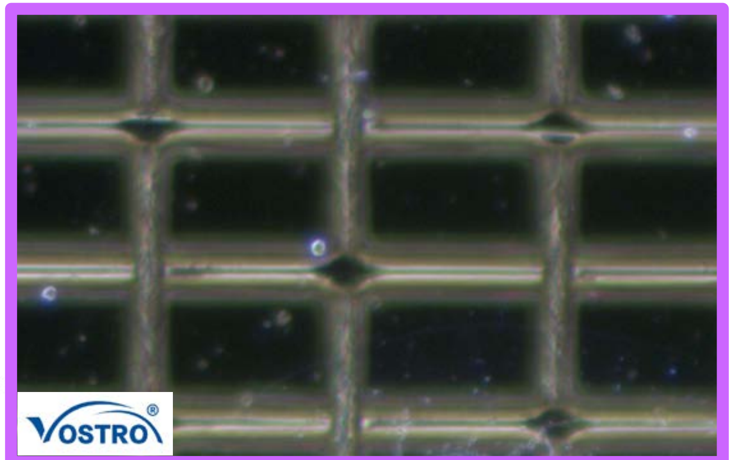
2025
Fine line
dual-layer stencils [4]

[A] Fine mesh screens ≥ 480 wires/mesh
[B] Mesh back-etching to reduce wire thickness
[C] Laser Enhanced Contact Optimization
[D] SMBB ≥ 13 Wires

[1] Höffler, H. et al., AIP Conf. Proc. 2826, 040002 (2023)
[2] Product information, Vostro Electronic Technology Co. Ltd. (2025)
[3] JA Solar, 20th China SoG Silicon and PV Power Conference (2024)
[4] N. Chen et al., Sol. Energy Mater. Sol. Cells 290 (2025)
[5] Source: With courtesy of CE Cell Engineering GmbH

Evolution of Screen Printing for PV

A whirlwind journey through history



2005-2010 | 2011-2015 | 2016-2020 | 2021-2025

2007/08 Transition from 2 to 3 busbars

2008 Silver price ~ 670 $/Kg

2011 Silver price peak ~ 1600 $/Kg

2012 Dual Printing Process

2015 Interconnection with ≥ 5 Busbars

2016 „Knotless“ Screens

2018 Lased Polyimide (PI) screens

2022/23 Super Multi-Busbar Interconnection[D] [3]

2025 [2] Ultra-fine mixed woven mesh screens

2025 Fine line dual-layer stencils [4]

[A] Fine mesh screens ≥ 480 wires/mesh

[B] Mesh back-etching to reduce wire thickness

[C] Laser Enhanced Contact Optimization

[D] SMBB ≥ 13 Wires

[1] Höffler, H. et al., AIP Conf. Proc. 2826, 040002 (2023)
[2] Product information, Vostro Electronic Technology Co. Ltd. (2025)
[3] JA Solar, 20th China SoG Silicon and PV Power Conference (2024)
[4] N. Chen et al., Sol. Energy Mater. Sol. Cells 290 (2025)

Fraunhofer ISE

Evolution of Screen Printing for PV

A whirlwind journey through history

2005-2010 | **2011-2015** | **2016-2020**

2007/08
Transition from 2 to 3 busbars

2008
Silver price ~ 670 $/Kg

2011
Silver price peak ~ 1600 $/Kg

2012
Dual Printing Process

2015
Interconnection with ≥ 5 Busbars

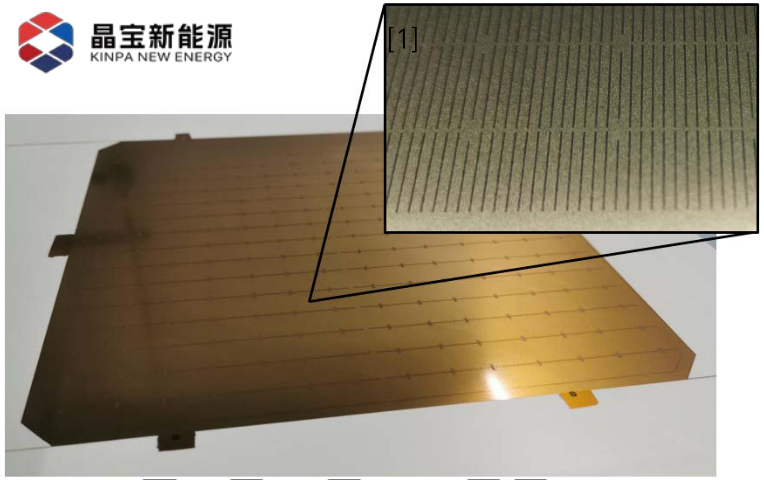
2016
„Knotless“ Screens

2018
Lased Polyimide (PI) screens

2019
Fine-mesh Screens[A]

2022/23
Super Multi-Busbar Interconnection[D] [3]

2025
Fine line dual-layer stencils [4]

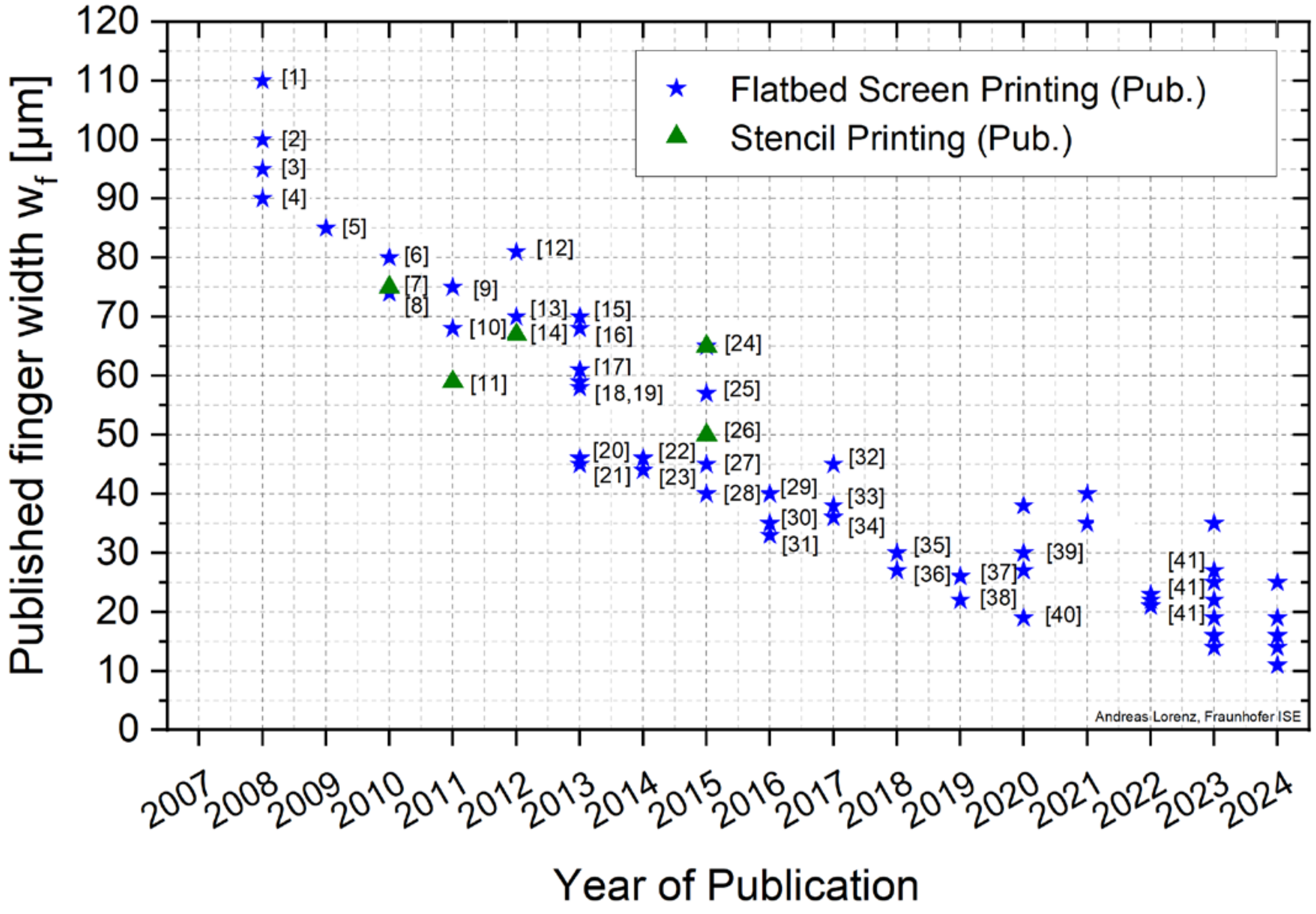


[A] Fine mesh screens ≥ 480 wires/mesh
[B] Mesh back-etching to reduce wire thickness
[C] Laser Enhanced Contact Optimization
[D] SMBB ≥ 13 Wires

[1] Höffler, H. et al., AIP Conf. Proc. 2826, 040002 (2023)
[2] Product information, Vostro Electronic Technology Co. Ltd. (2025)
[3] JA Solar, 20th China SoG Silicon and PV Power Conference (2024)
[4] N. Chen et al., Sol. Energy Mater. Sol. Cells 290 (2025)

Evolution of Screen Printing for PV

A whirlwind journey through history



Linear learning curve of screen printed finger width evolution from 2008 to 2025. Updated version based on [1,2], References see [2],

[1] Lorenz, A. et al., Proc. of the 35th Photovoltaic Solar Energy Conference (EUPVSEC) (2018)

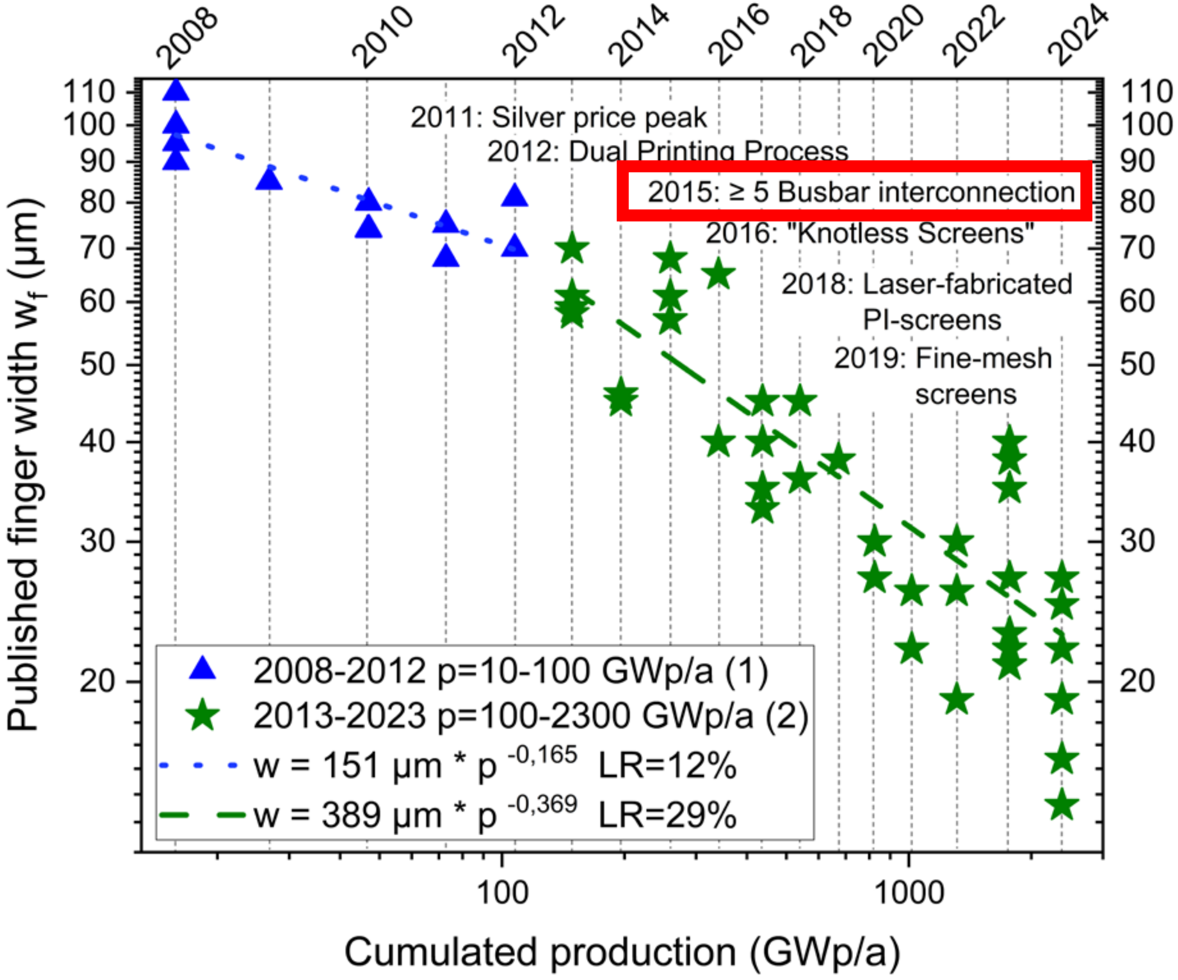
[2] Tepner & Lorenz, Progr. Photovolt Res Appl 31 (6), (2023) DOI: 10.1002/pip.3674.

Evolution of Screen Printing for PV

A whirlwind journey through history

New learning curve model:

- Two-phase logarithmic learning curve based on published finger widths [1]
- Linked to the annual growth of the cumulated PV production volume
- Key Findings:
  - ➢ Fine line screen printing accelerated drastically from around 2014/2015 on
  - ➢ Game changer: Transition from 3 to ≥ 5 busbars for interconnection



[1] Lorenz et al. [Submitted for publication]

Fraunhofer ISE

Fraunhofer ISE

Progress in fine line screen printing for TOPCon at Fraunhofer ISE

TOPCon – Latest results with high-end screens and stencils

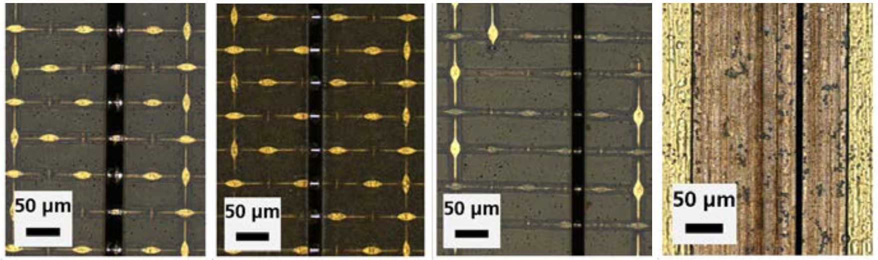
Aim and experimental setup

Aim and motivation:

- Reduction of silver by fine line printing
- Evaluation of new screen & stencil technology

Experimental setup:

- Screen/paste variation:
  - ➢ Fraunhofer ISE TOPCon precursors (M10)
  - ➢ 3 different fine mesh screen configurations
  - ➢ Varying nominal finger width / # fingers
  - ➢ High-end dual layer stencil
  - ➢ 2 high-performance Ag pastes (partly diluted)



	Screen 1 (Ref)	Screen 2	Screen 3	Stencil
Mesh/Stencil configuration	520-11 (0°)	520-09 (0°)	500-05 (0°)	Dual layer
Nom. Finger width w_n [µm]	24	20	17/15/13	9
Paste	A/B	A/B	A/B	A/B

Experimental setup – Overview of screen/stencil variations for the conducted TOPCon fine line test batch.

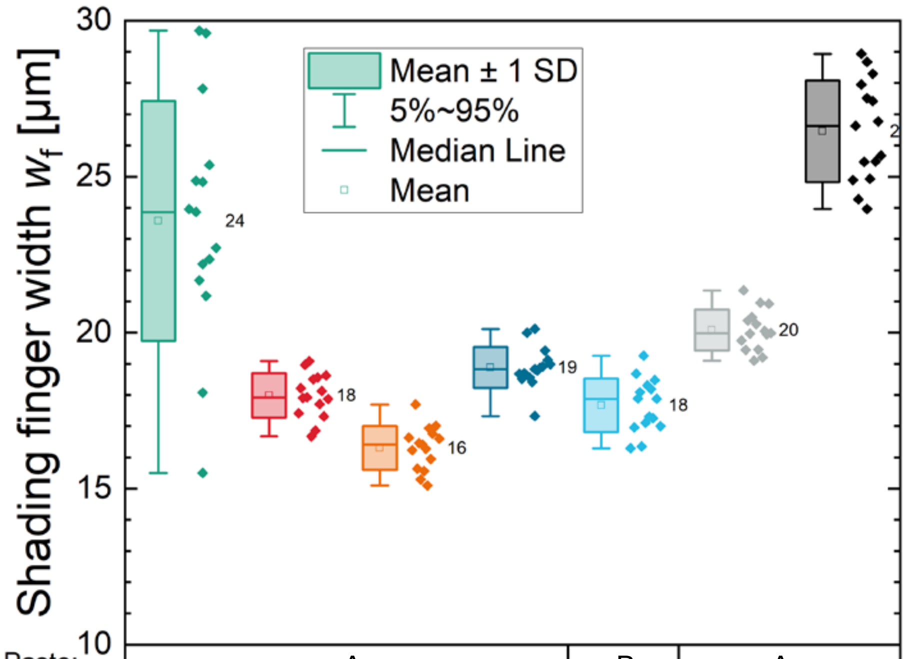
GONDA 晶宝新能源 KINPA NEW ENERGY Fraunhofer ISE

TOPCon – Latest results with high-end screens and stencils

Screen / stencil printing results

Printing results:

- Substantial finger width reduction possible with screens 500-09 and 500-05
- Best results for 500-05 (0°) mesh with w_n = 17 µm: ∅ finger width w_f ~ 18 µm, uniform printing quality
- Stencil: improved finger uniformity, yet strong variation of finger width



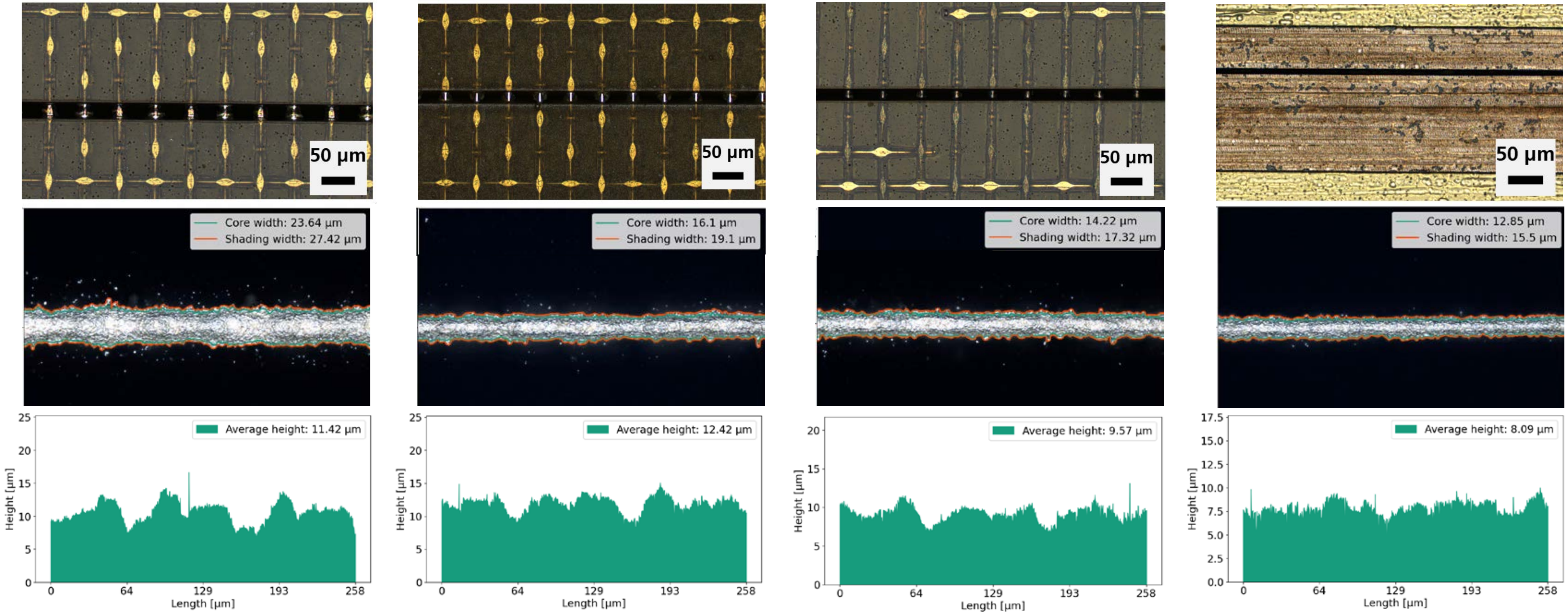
Paste:	A				B	A	
Mesh:	-	500x05				520x09	520x11
$\#_f$ [a.u.]:	168	200	190	180		168	154
w_n [µm]:	9	13	15	17		20	24

晶宝新能源 KINPA NEW ENERGY Fraunhofer ISE

TOPCon – Latest results with high-end screens and stencils

Screen / stencil printing results

Gr. 1 | 520-11 / 0°	Gr. 2 | 520-09 / 0°	Gr. 3 | 505-05 / 0°	Gr. 4 | Stencil



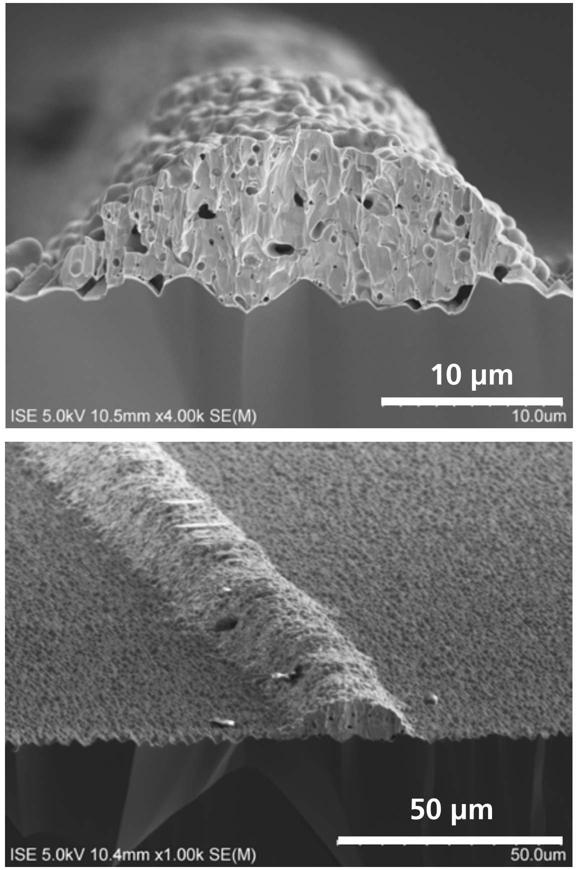
晶宝新能源 KINPA NEW ENERGY

Fraunhofer ISE

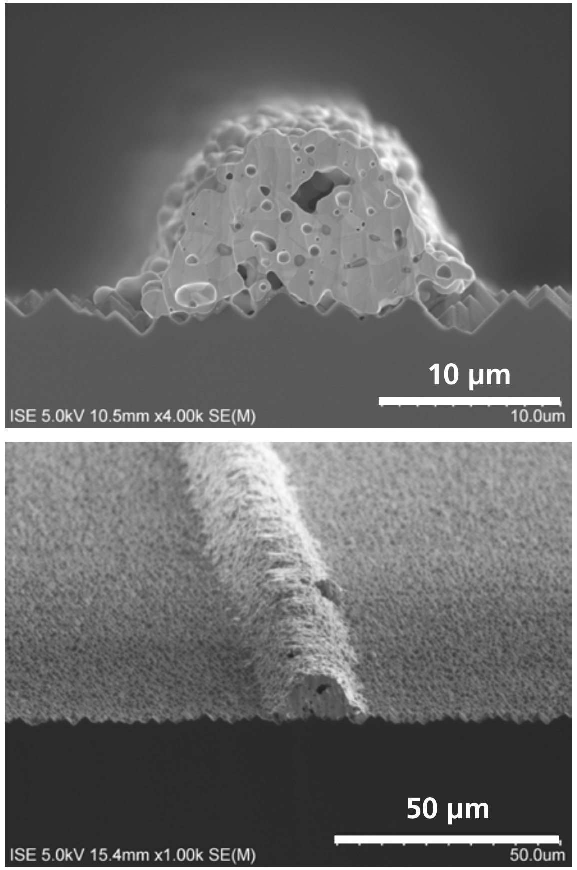
TOPCon – Latest results with high-end screens and stencils

Screen / stencil printing results

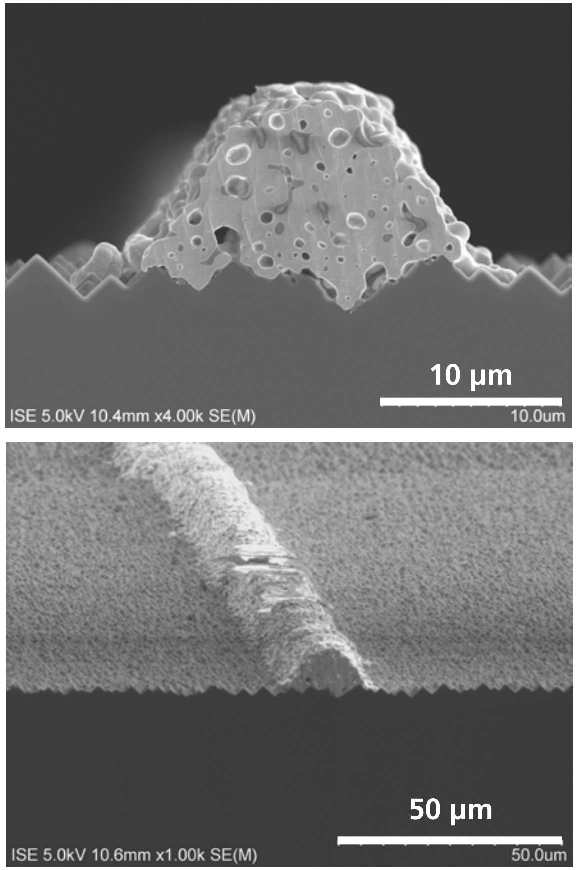
Gr. 1 | 520-11 / 0°



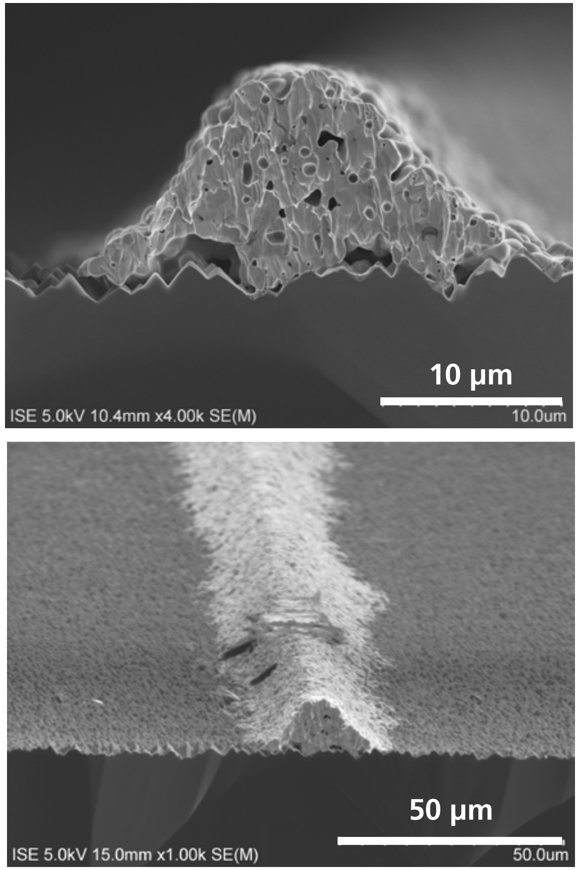
Gr. 2 | 520-09 / 0°



Gr. 3 | 505-05 / 0°



Gr. 4 | Stencil



晶宝新能源 KINPA NEW ENERGY
Fraunhofer ISE

TOPCon – Latest results with high-end screens and stencils

Screen / stencil printing results

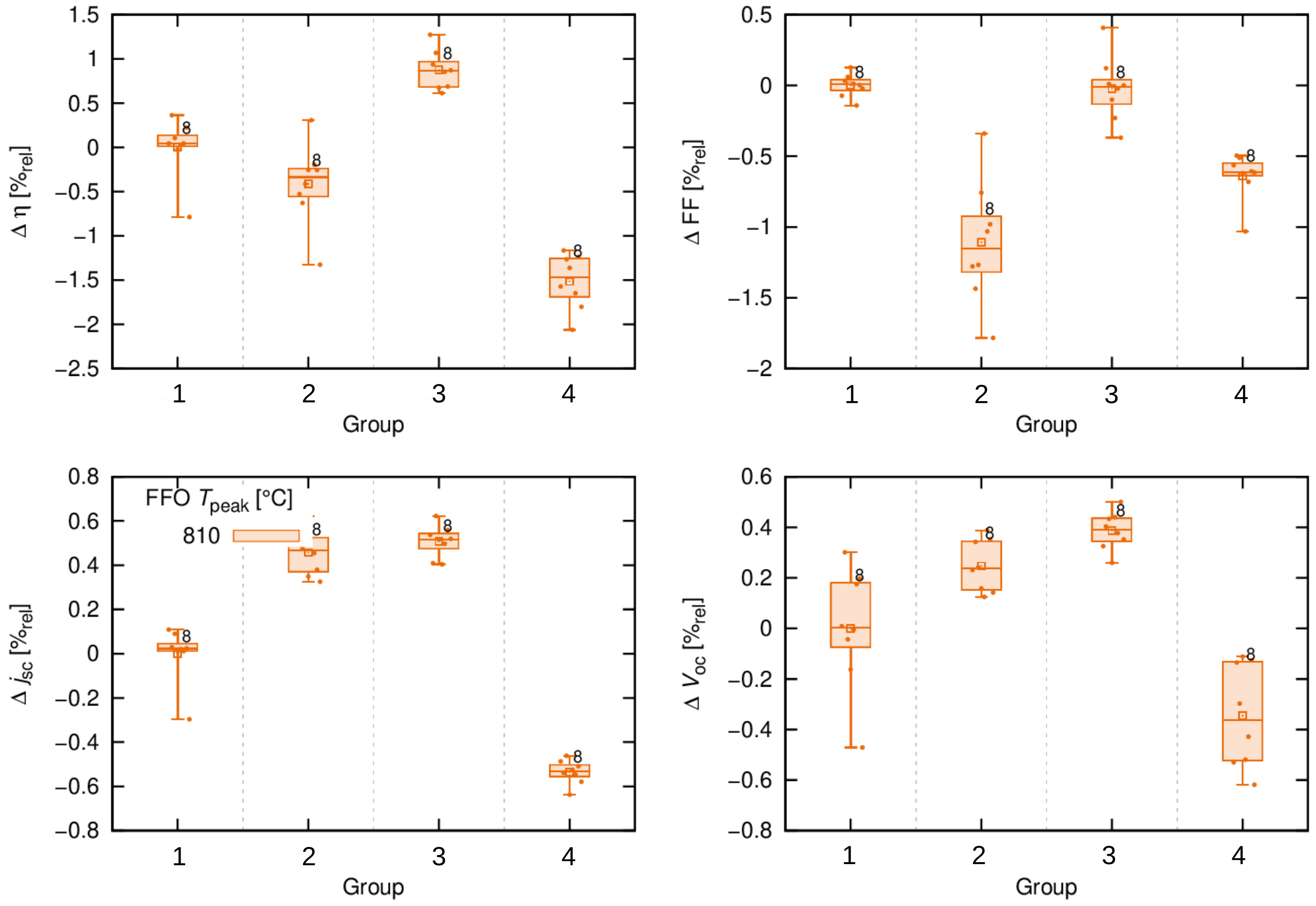
Group	Screen/Stencil
1	520/11 0° - w_n =24 µm
2	520-09 0° - w_n = 20 µm
3	500-05 0° - w_n = 17 µm
4	Stencil - w_n = 9 µm

Results on cell level:

- J_{sc} gain up to ~ **0.55 %rel.** (group 3)
  → smaller fingers, reduced shading
- V_{oc} gain of up to ~ **0.4 %rel.** (group 3)
  → smaller fingers, reduced metal-related recombination
- FF roughly on same level as reference (gr. 3)
- Total efficiency gain: ~ **0.9 %rel.** (group 3)

Silver consumption:

- Group 3: Silver reduction **Δm_{Ag} = 19 mg (- 34%)** compared to reference group 1

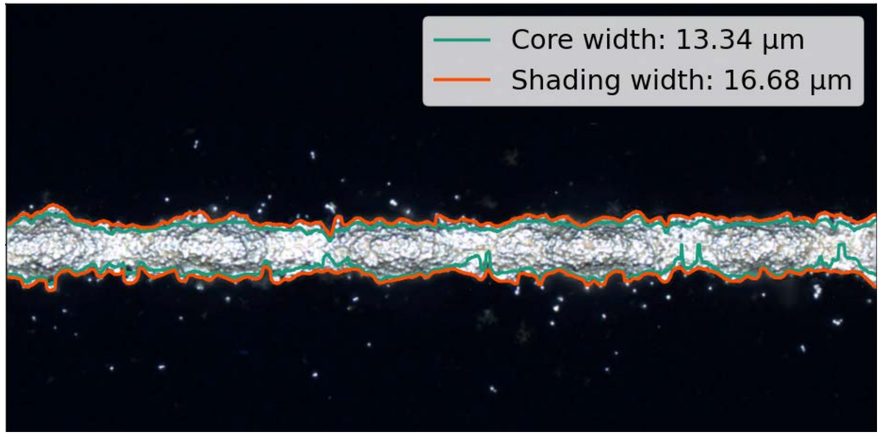


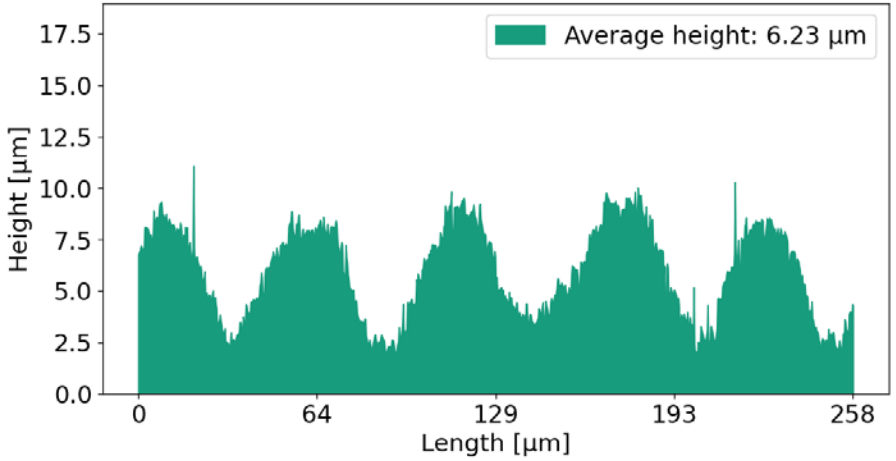
TOPCon – Latest results with high-end screens and stencils

Screen / stencil printing results

Printing results:

- 500-05 Screens with finger openings (wn = 13 and 15 µm) were printable
- Finger geometry was inconsistent (interruptions and strong height variation), result did not match „ISE quality standard“



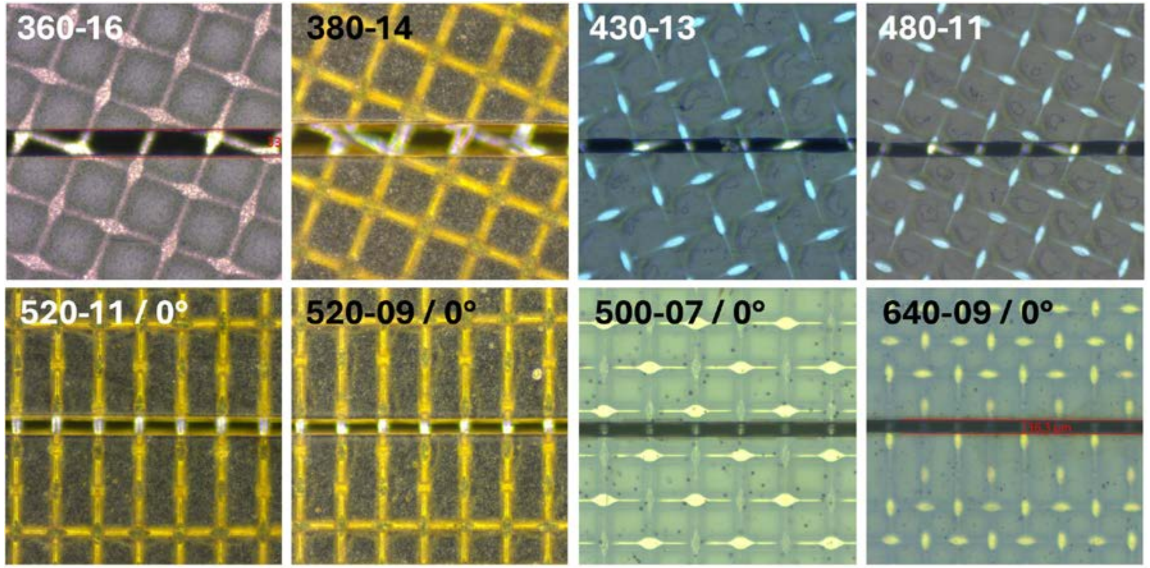


Fine line screen printing for TOPCon and SHJ

Challenges for ultra fine line printing (≤ 10 µm)

Important influencing factors:

- Screen / Stencil properties [1-6]:
  - ➢Mesh count, wire thickness, PI-layer (EOM), channel width, knotless/angled…



Variants of fine line screens with varying mesh count, wire thickness and mesh angle [Source: ISE]

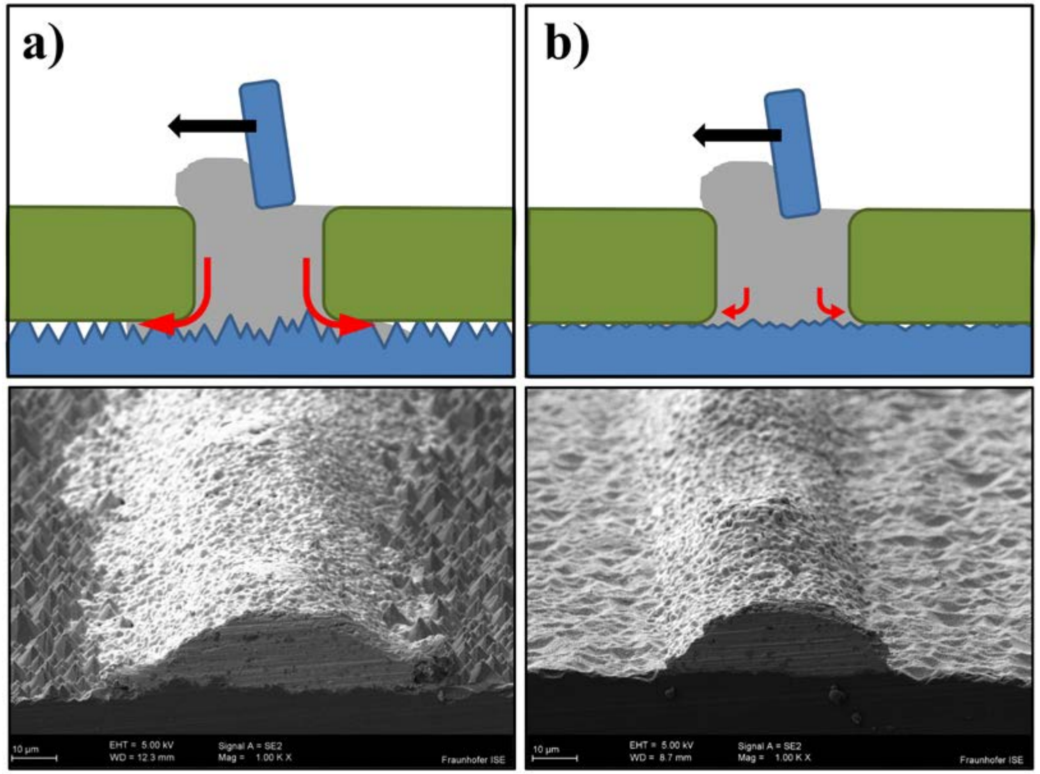
[1] Y. Zhang, 7th Workshop on Metallization, Constance (2017)
[2] Lorenz, A. et al., 35th EUPVSEC (2018)
[3] Tepner et al., IEEE J. Photovolt. 10 (2) (2020)
[4] Wenzel et al., Solar Energy Materials and Solar Cells 244 (2022)
[5] Tepner & Lorenz, Progr. Photovolt Res Appl 31 (6), (2023)
[6] N. Chen et al., Sol. Energy Mater. Sol. Cells 290 (2025)

Fine line screen printing for TOPCon and SHJ

Challenges for ultra fine line printing (≤ 10 µm)

Important influencing factors:

- Screen / Stencil properties:
  - ➢Mesh count, wire thickness, PI-layer (EOM), channel width, knotless/angled…
- Surface properties and edge sealing:
  - ➢ Crticial for spreading: Edge seeling between texture and PI-barrier layer [1]
  - ➢Influenced by texture size and PI properties [2,3]



Impact of wafer surface texture and PI barrier layer properties on uniformity and spreading of printed contacts [Source: ISE [3]

[1] Aoki, M. et al., 40th IEEE Photovoltaic Specialists Conference (PVSC) (2014)
[2] Lorenz, A. et al., IEEE J. Photovoltaics 5 (4) (2015) [3] Tepner & Lorenz, Progr. Photovolt Res Appl 31 (6), (2023)

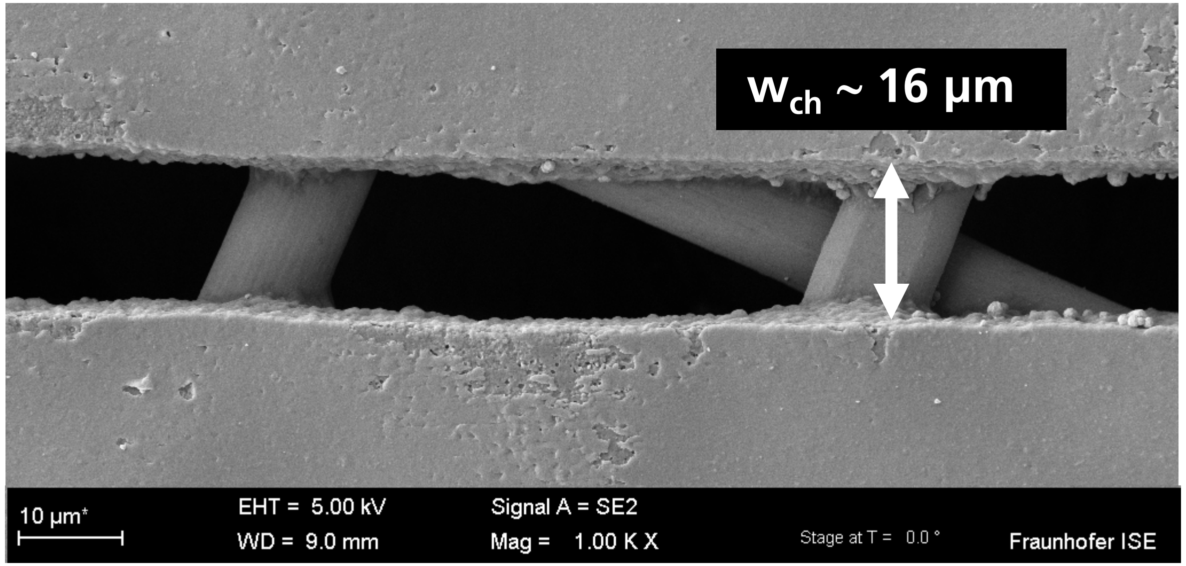
Fraunhofer ISE

Fine line screen printing for TOPCon and SHJ

Challenges for ultra fine line printing (≤ 10 µm)

Important influencing factors:

- Screen / Stencil properties:
  - ➢Mesh count, wire thickness, PI-layer (EOM), channel width, knotless/angled…
- Surface properties and edge sealing:
  - ➢ Crticial for spreading: Edge seeling between texture and PI-barrier layer [1]
  - ➢Influenced by texture size and PI properties [2,3]
- Paste properties & Printing conditions:
  - ➢Rheology (i.e. dilution) [4] and particle size [5]



True-to-scale SEM image overlay of a fine-line channel in a fine mesh screen (480-11/22.5°)

[1] Aoki, M. et al., 40th IEEE Photovoltaic Specialists Conference (PVSC) (2014)
[2] Lorenz, A. et al., IEEE J. Photovoltaics 5 (4) (2015)
[3] Tepner & Lorenz, Progr. Photovolt Res Appl 31 (6), (2023)
[4] Tepner, S. et al., Adv. Mater. Technol. 5 (10), (2020)
[5] Tsai, J.T. Et al. Journal of Alloys and Compounds 548 (2013)

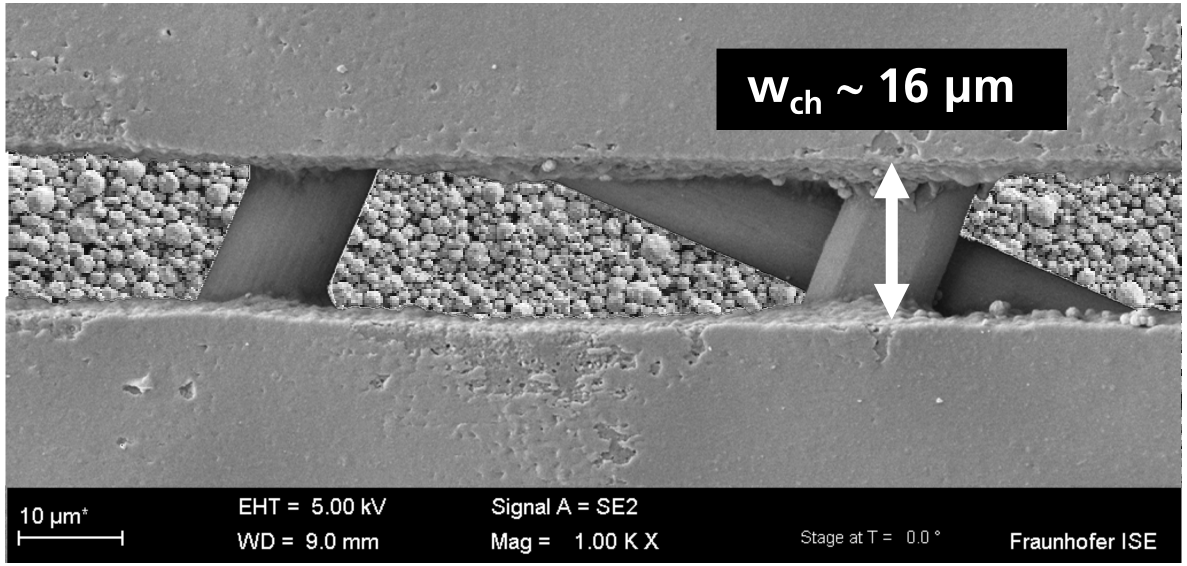
Fraunhofer ISE

Fine line screen printing for TOPCon and SHJ

Challenges for ultra fine line printing (≤ 10 µm)

Important influencing factors:

- Screen / Stencil properties:
  - ➢Mesh count, wire thickness, PI-layer (EOM), channel width, knotless/angled…
- Surface properties and edge sealing:
  - ➢ Crticial for spreading: Edge seeling between texture and PI-barrier layer [1]
  - ➢Influenced by texture size and PI properties [2,3]
- Paste properties & Printing conditions:
  - ➢Rheology (i.e. dilution) [4] and particle size [5]



True-to-scale SEM image overlay of a fine-line channel in a fine mesh screen (480-11/22.5°) with SEM image of a PERC Paste (particle size ~ 2-5 µm)

[1] Aoki, M. et al., 40th IEEE Photovoltaic Specialists Conference (PVSC) (2014)
[2] Lorenz, A. et al., IEEE J. Photovoltaics 5 (4) (2015)
[3] Tepner & Lorenz, Progr. Photovolt Res Appl 31 (6), (2023)
[4] Tepner, S. et al., Adv. Mater. Technol. 5 (10), (2020)
[5] Tsai, J.T. Et al. Journal of Alloys and Compounds 548 (2013)

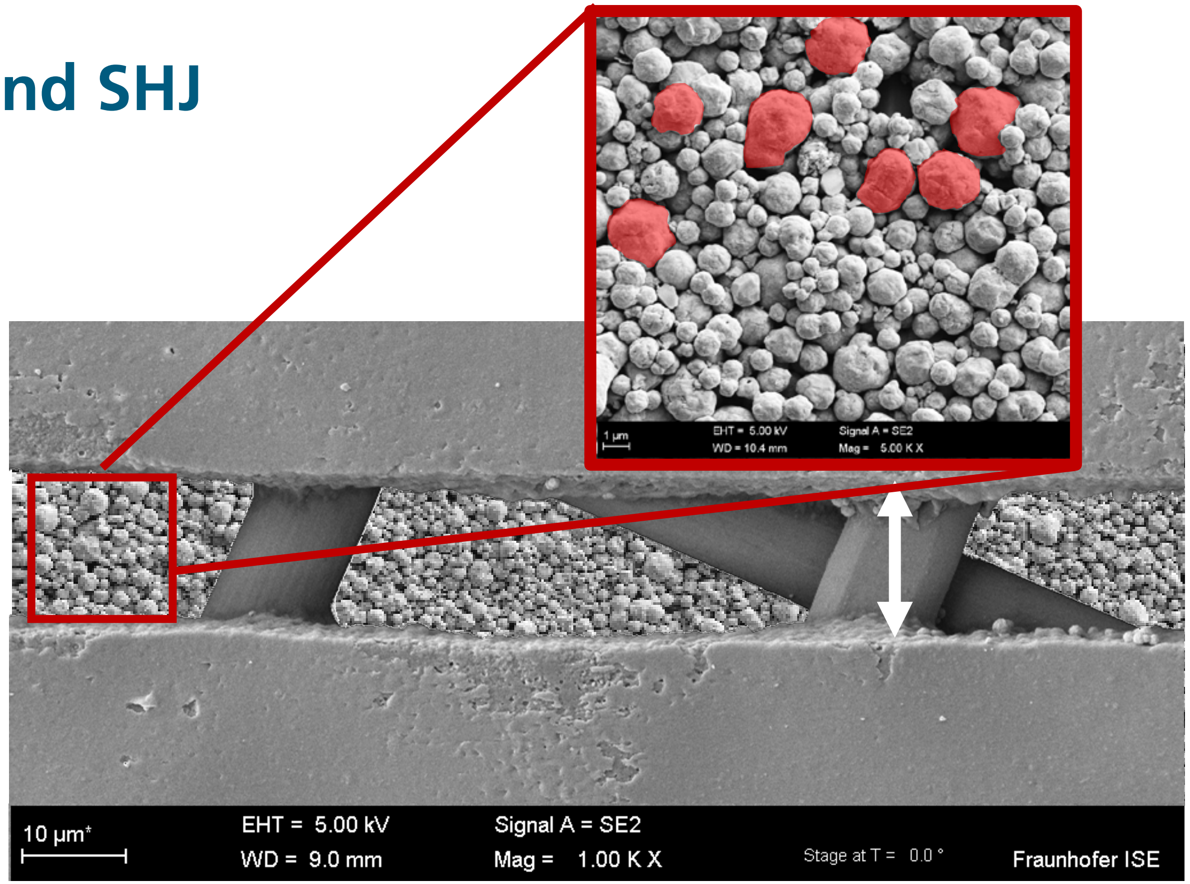
Fraunhofer ISE

Fine line screen printing for TOPCon and SHJ

Challenges for ultra fine line printing (≤ 10 µm)

Important influencing factors:

- Screen / Stencil properties:
  - Mesh count, wire thickness, PI-layer (EOM), channel width, knotless/angled…
- Surface properties and edge sealing:
  - Crticial for spreading: Edge seeling between texture and PI-barrier layer [1]
  - Influenced by texture size and PI properties [2,3]
- Paste properties & Printing conditions:
  - Rheology (i.e. dilution) [4] and particle size [5]



True-to-scale SEM image overlay of a fine-line channel in a fine mesh screen (480-11/22.5°) with SEM image of a PERC Paste (particle size ~ 2-5 µm)

[1] Aoki, M. et al., 40th IEEE Photovoltaic Specialists Conference (PVSC) (2014)
[2] Lorenz, A. et al., IEEE J. Photovoltaics 5 (4) (2015)
[3] Tepner & Lorenz, Progr. Photovolt Res Appl 31 (6), (2023)
[4] Tepner, S. et al., Adv. Mater. Technol. 5 (10), (2020)
[5] Tsai, J.T. Et al. Journal of Alloys and Compounds 548 (2013)

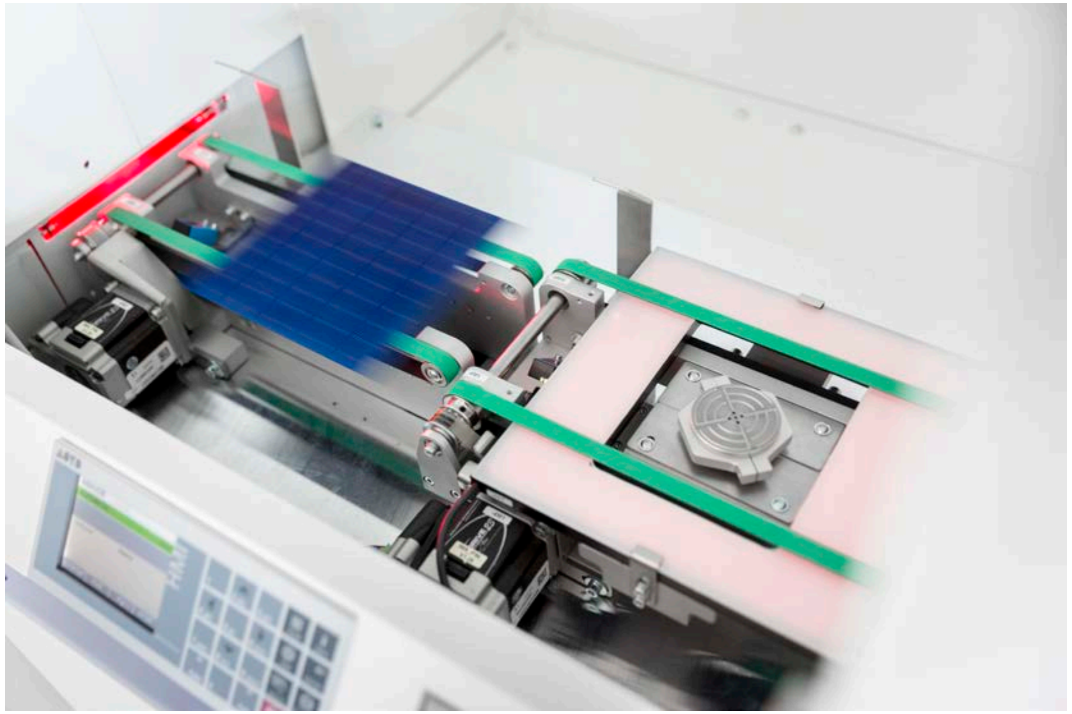
Fraunhofer ISE

Fine line screen printing for TOPCon and SHJ

Challenges for ultra fine line printing (≤ 10 µm)

Important influencing factors:

- Screen / Stencil properties:
  - ➢Mesh count, wire thickness, PI-layer (EOM), channel width, knotless/angled…
- Surface properties and edge sealing:
  - ➢ Crticial for spreading: Edge seeling between texture and PI-barrier layer [1]
  - ➢Influenced by texture size and PI properties [2,3]
- Paste properties & Printing conditions:
  - ➢Rheology (i.e. dilution) [4] and particle size [5]
  - ➢Printing/flooding speed, cycle time of machine



Screen printing line at Fraunhofer ISE

[1] Aoki, M. et al., 40th IEEE Photovoltaic Specialists Conference (PVSC) (2014)
[2] Lorenz, A. et al., IEEE J. Photovoltaics 5 (4) (2015)
[3] Tepner & Lorenz, Progr. Photovolt Res Appl 31 (6), (2023)
[4] Tepner, S. et al., Adv. Mater. Technol. 5 (10), (2020)
[5] Tsai, J.T. Et al. Journal of Alloys and Compounds 548 (2013)

Fraunhofer ISE

Copper paste metallization

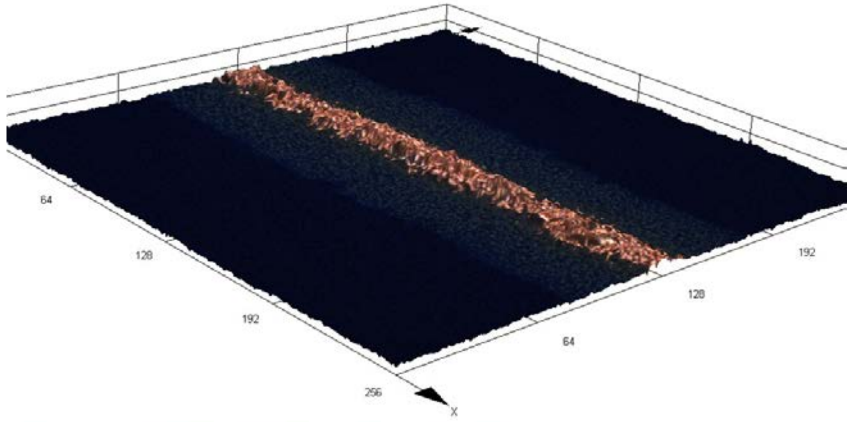
Update: Fine line screen printing of copper pastes

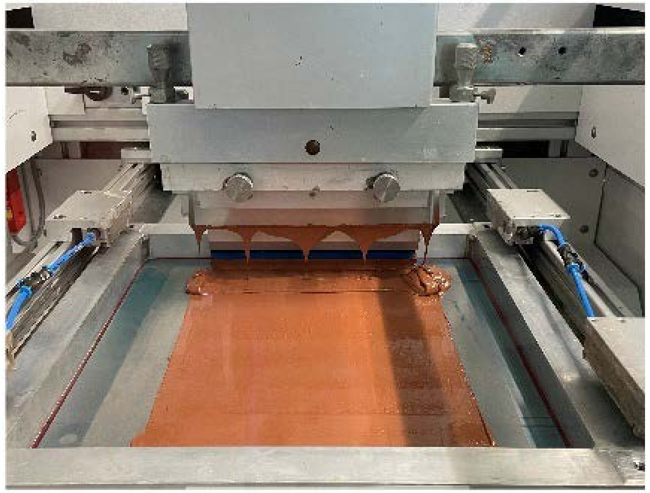
Aim and motivation:

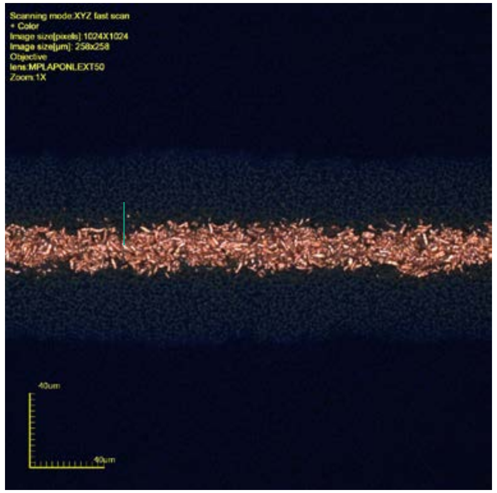
- Evaulation of pure copper pastes (LT and HT) for SHJ and TOPCon

Screen printing results:

- Strong progress regarding development of copper paste printability
- LT copper pastes can be printed down to **~20-25 µm width** with **5-7 µm height**
- Rear side metallization on SHJ [1,2] and TOPCon [3,4] successfully demonstrated width good cell results







[1] Pingel et al., 15th SiliconPV, Oxford (2025) [2] Pingel et al., 13th Metallization & Interconnection Workshop, Berlin (2025)
[3] Druffel et al., 15th SiliconPV, Oxford (2025) [4] Druffel et al., this workshop

Fraunhofer ISE

Outlook – Can screen printing challenge photo-lithography?

Screen Printing beyond PV

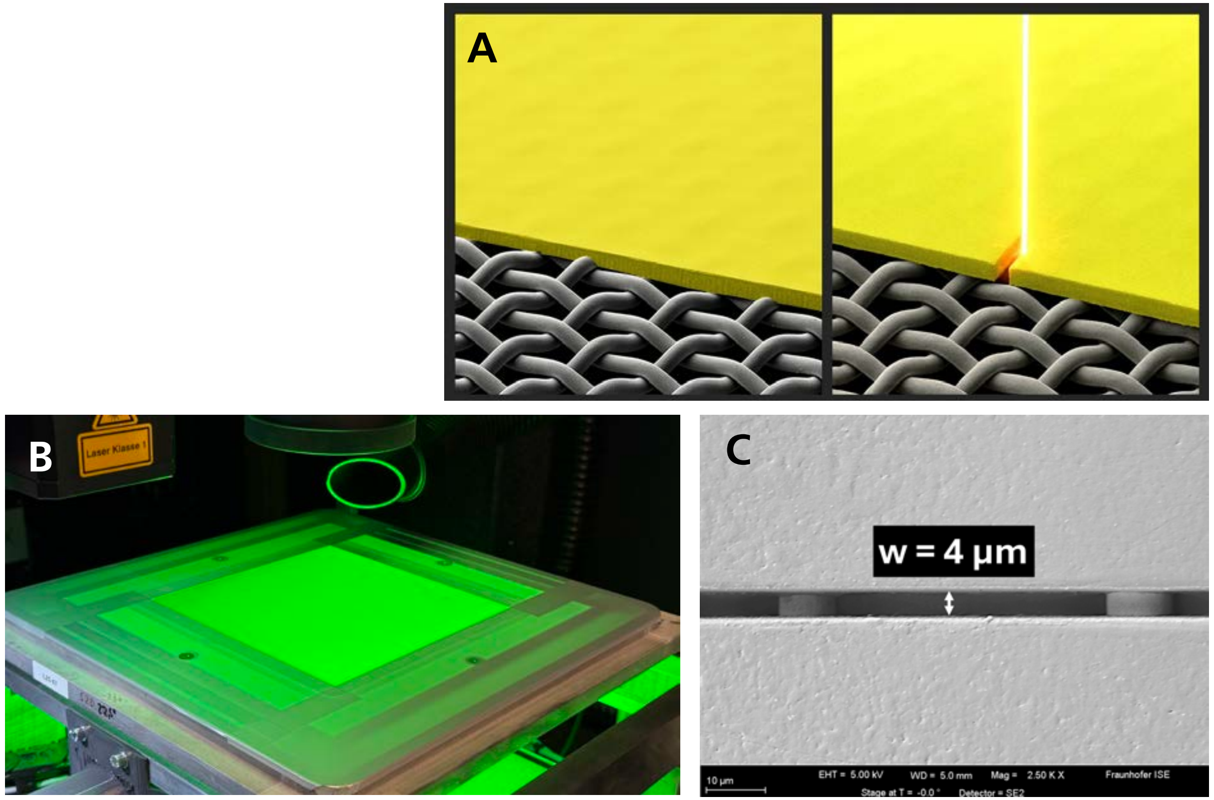
How fine can we print with screen and stencil printing?

Motivation and Background:

- „Laser2Screen“ device at Fraunhofer ISE enables laser opening of very fine lines on PI screens and stencils [1,2]

Hypothesis:

- Can screen printing challenge **simple photolithography applications?**

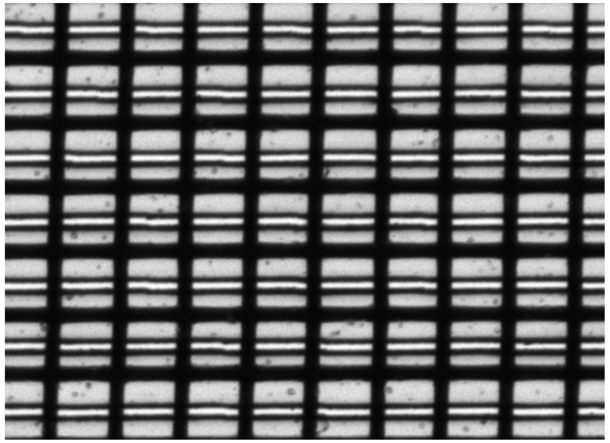


A) AI-created visualization of laser structuring process for PI-screens; B) „Laser2Screen“ lasing machine at Fraunhofer ISE; C) 4 µm channel on PI-screen realized at Fraunhofer ISE (Source: ISE)

[1] [Laser Structuring of High-Precision Printing Forms - Fraunhofer ISE]()
[2] Nair, A. et al., Sol. Energy Mater. Sol. Cells 290, S. 113732. DOI: 10.1016/j.solmat.2025.113732.

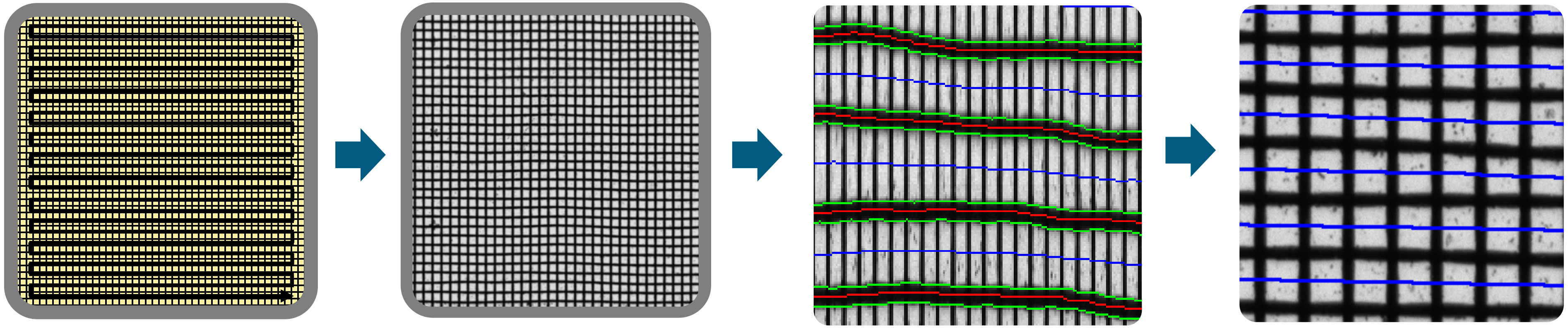
Screen Printing beyond PV

Lasing of knotless screens at Fraunhofer ISE



Lasing of 0° screens at ISE:

- Development of a processing pipeline for lasing of 0°-Screens (Knotless) at Fraunhofer ISE
- Screen mesh analysis using OSIF full screen inspector
- Digital clone („digital mesh“) → laser coordinate extraction



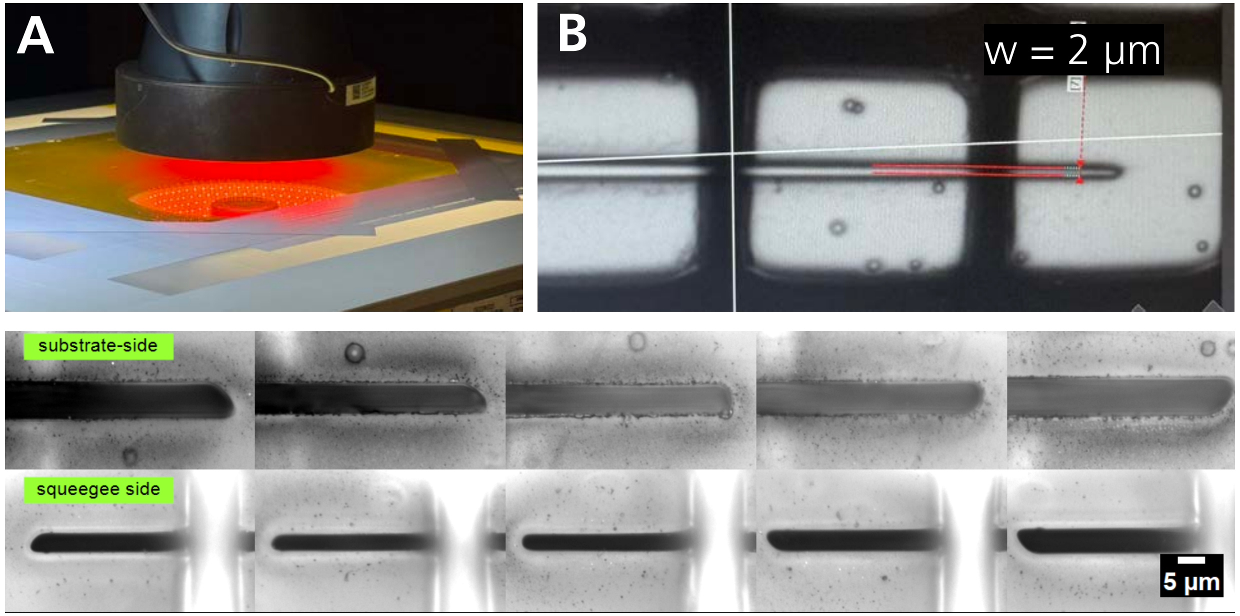
Full-Format Screen-Scan → **Digital Clone** → **Image Processing** → **Coordinate Extraction**

Screen Printing beyond PV

How fine can we print with screen and stencil printing?

Experimental setup:

- Laser opening of ultra fine channels using „Laser2Screen“ device at Fraunhofer ISE [1,2]
  - Screen type: 500-05 (0°) with PI layer
  - Laser opening: Test patches with 1 – 10 µm tapered line-shaped channels
  - Screen printing with Ag-Nano Paste on ISE TOPCon precursors (rear side)



A) Laser2Screen device for fine line structuring of screens and stencils
B) Ultra narrow tapered channel in between two wires (500-05 mesh)
C) Microscopic images of lased fine line channels in PI layer (Source: ISE)

[1] Laser Structuring of High-Precision Printing Forms - Fraunhofer ISE
[2] Nair, A. et al., Sol. Energy Mater. Sol. Cells 290, S. 113732. DOI: 10.1016/j.solmat.2025.113732.

PULSAR PHOTONICS Fraunhofer ISE

Screen Printing beyond PV

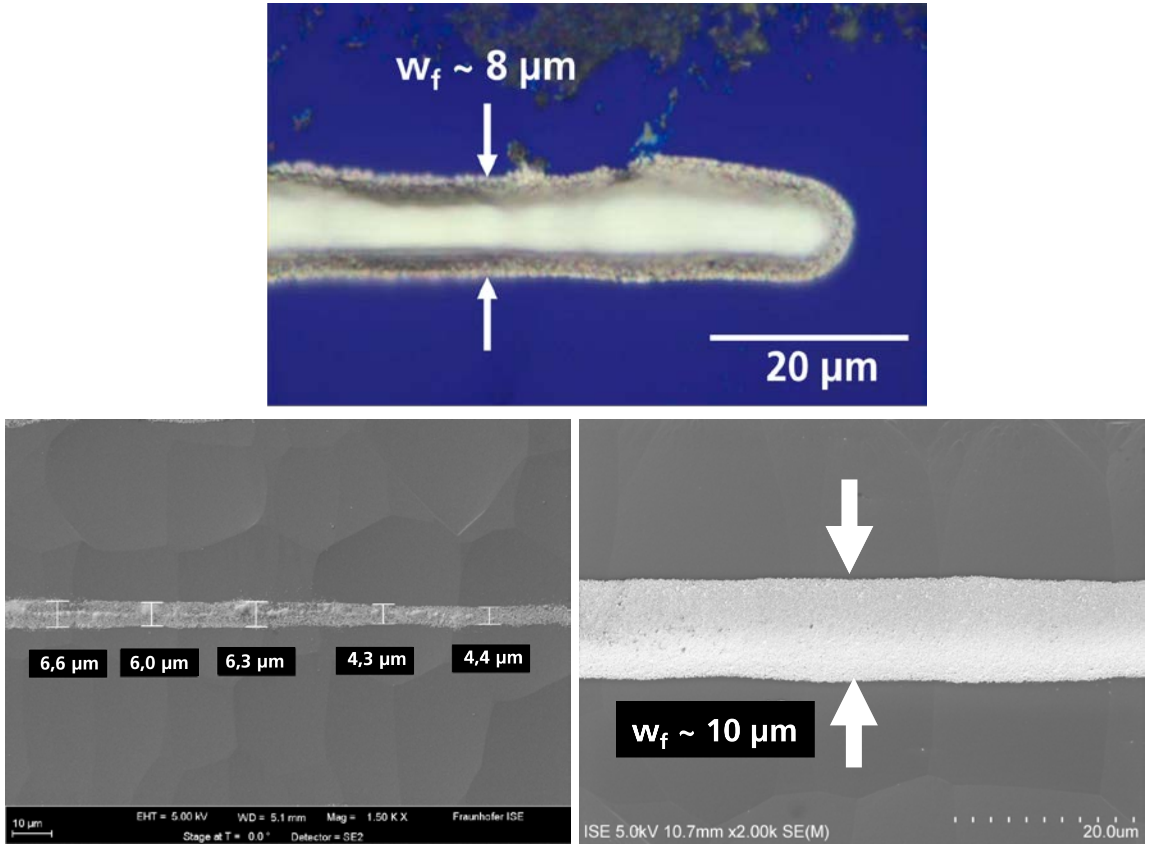
How fine can we print with screen and stencil printing?

Results::

- Ultra narrow channels down to ~ 1 µm realized on PI screen
- Screen printed line width:
  w_f ~ 8-10 µm (with measurable finger height)
  w_f ~ 4-6 µm (Seed layer)

Conclusion:

- Screen printing is able to realize ultra fine lines below 10 µm
- Ultra fine line printing require intense fine tuning of paste property, wafer surface and screen configuation



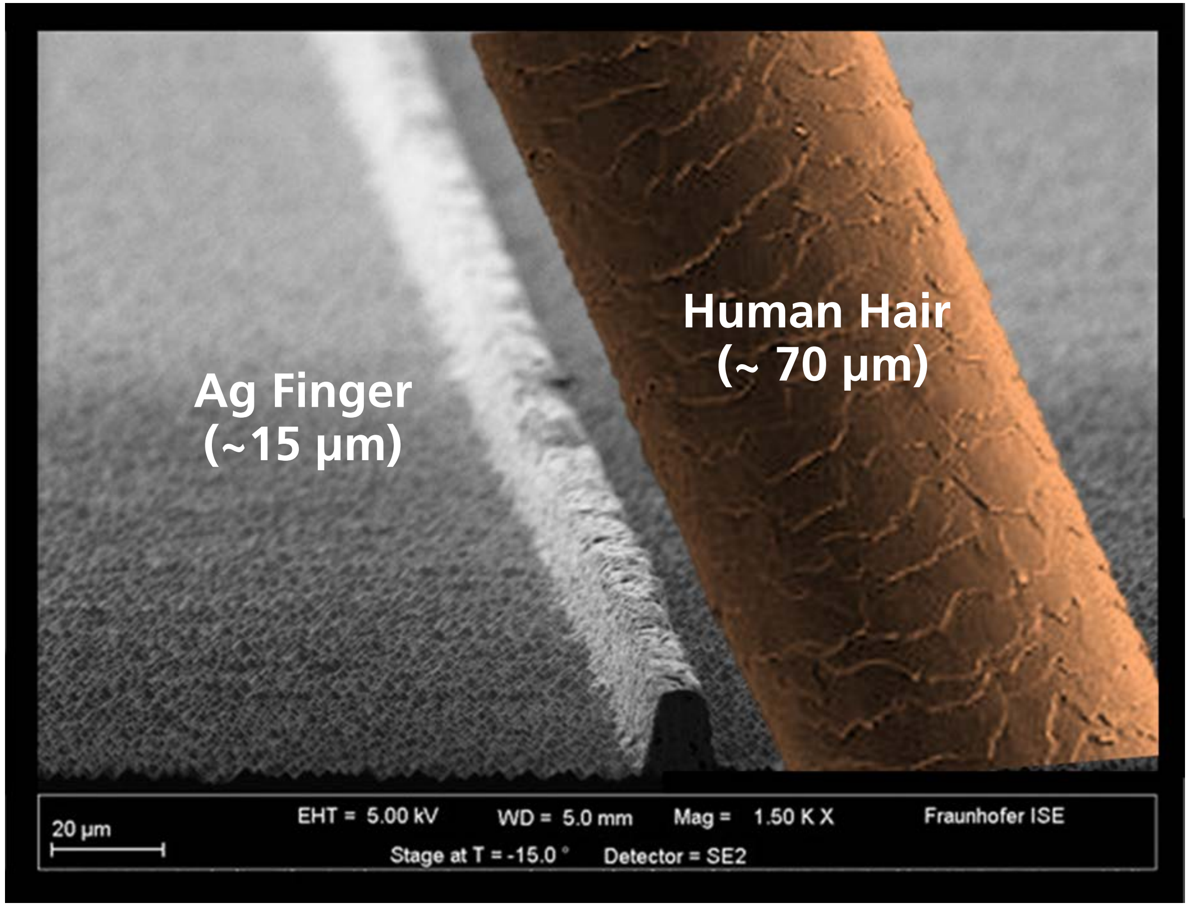
Screen printed ultra fine contacts using a fine line test layout lased at Fraunhofer ISE with Ag nano paste

Summary and Outlook

Screen printing – Achievements and Trends

Summary:

- New learning curve model illustrates impact of disruptive innovations on evolution of fine line screen printing
- Finger width down to **~18 µm** and **-34% silver reduction** on TOPCon obtained using high-end screens and stencils
- Printing of finer fingers possible, major challenge: printing conditions / cycle time
- Ultra fine fingers demonstrated:
  w_f ~ 8-10 µm (width measurable height)
  w_f ~ 4-6 µm (seed layer)



Summary and Outlook

Screen printing – Achievements and Trends

Trends for metallization:

- Screen printing has not reached the resolution limit
  → Finger width < 10 µm in mass production will come
- High-end stencils will increasingly gain importance
- Screen printable AgCu, Cu and Ni pastes will likely replace silver pastes in the mid future
- Assumption: Sustainability target of < 2 mg/W_p in mass production is possible with screen printing

[1] W. Zhang, this workshop [2] N. Chen, this workshop

*Image AI generated

Fraunhofer ISE

Thank you for your attention!

Dr. Andreas Lorenz
Head of Group »Printing Technology«
Fraunhofer ISE
Phone: +49 761 4588 2229
andreas.lorenz@ise.fraunhofer.de

This work has been funded by the Federal Ministry for Economic Affairs and Climate Action within the project "RE-PV" (No. 03EE1174A)

Special Thanks to:

GONDA
VOSTRO®
晶宝新能源 KINPA NEW ENERGY
OSIF GmbH
PULSAR PHOTONICS

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag