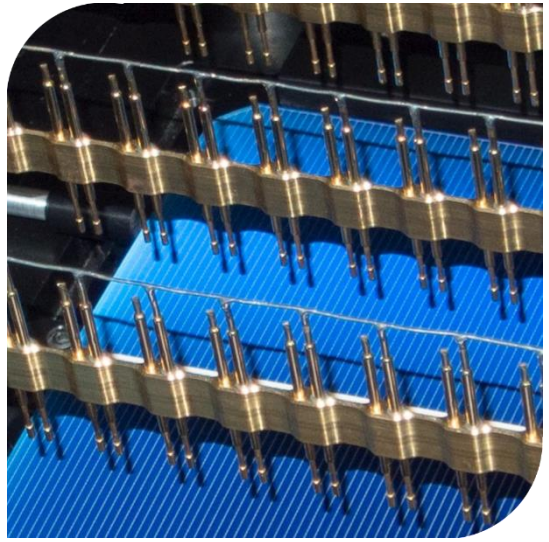



The polyZEBRA concept – upgrade of low cost IBC solar cell production

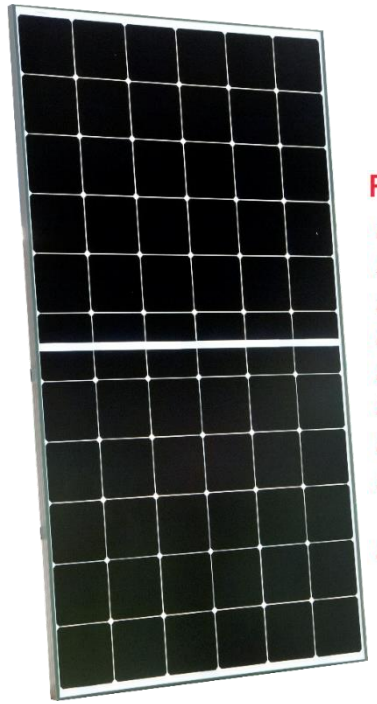
Dr. Florian Buchholz

ISC research for a sunny future

Status of IBC production

Status of IBC production

- Cell efficiency vs. module efficiency



ANDROMEDA 2.0

High Efficiency Series

FEATURES

- Up to 22.3% Efficiency
- Bigger dimension, More power generation
- IBC-No electrode to block sunlight
- N-Type cell has ZERO LID
- Excellent Temperature Coefficient
- Anti-PID
- Low mismatch loss
- Minimal power degradation (93% of initial after 25years)
- Double 25 Years Warranty

Mechanical Parameters

Cell Type	NIBC 166x83mm(Half-Cell)
No. of Cells	132(6x22)
Junction Box	Ip68 with three bypass diodes
Output Cable	4mm², 1400mm with MC4 (Length can be customed)
Glass	3.2mm coated tempered glass
Frame	Anodized aluminum alloy frame
Dimension	1895x1039x30mm
Weight	21.0kg

TOP PERFORMER 2021 PVEL PV MODULE RELIABILITY SCORECARD

TOP PERFORMER 2022 PVEL PV MODULE RELIABILITY SCORECARD

Most Efficient Solar Panels 2023 * V3.6 Jan 2023

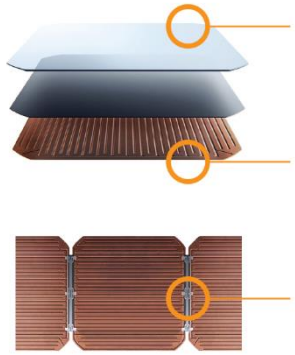
CLEAN ENERGY REVIEWS

Manufacturer	Model	Max power (W)	Cell Type	Efficiency
SUNPOWER	Maxeon 6	440W	N-Type **IBC**	22.8 %
LONGi Solar	Hi-MO 6 Scientist	440W	P-Type HPBC Half-cut	New 22.8 %
CanadianSolar	HiHero CS6R-H-AG	440W	N-Type **HJT** Half-cut	22.5 %
REC Solar	Alpha Pure R	430W	N-Type **HJT** Half-cut	22.3 %
SPIC	Andromeda 2.0	440W	N-Type **IBC** Half-cut	22.3 %
Q CELLS	Q.TRON-G1+	400W	N-Type TOPcon Half-cut	22.3 %
JA SOLAR	Deep Blue 4.0 X	435W	N-Type TOPcon Half-cut	New 22.3 %
Panasonic	EverVolt H	410W	N-Type **HJT** Half-cut	22.2 %
JinKO Solar	Tiger NEO	480W	N-Type TOPcon Half-cut	22.2 %
中来股份 JOLYWOOD	Niwa Light	430W	N-Type TOPcon Half-cut	22.0 %

Status of IBC production

- Sunpower
  - Long years of experience
  - Passivating contacts
  - Silver-free
  - High costs
- SPIC
  - ZEBRA cell
  - Half-cut, bifacial option
  - Standard technology, screen printing
  - Low costs
- Longi (p-type)
- Other activities (MB, Trina, etc.)

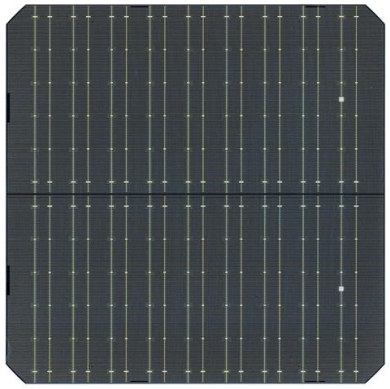
SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES

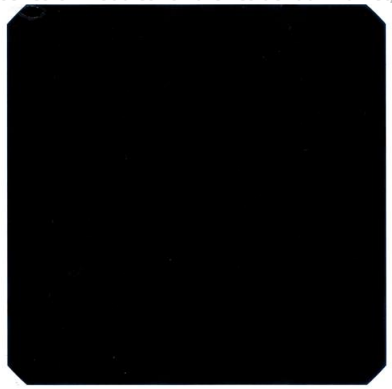


https://sunpower.maxeon.com/de/solarmodul-produkte/maxeon-solarmodule

https://www.solarpowerworldonline.com/2019/03/sunpower-increases-solar-cell-size-with-new-400-w-a-series-of-modules-for-the-residential-market/

SPIC

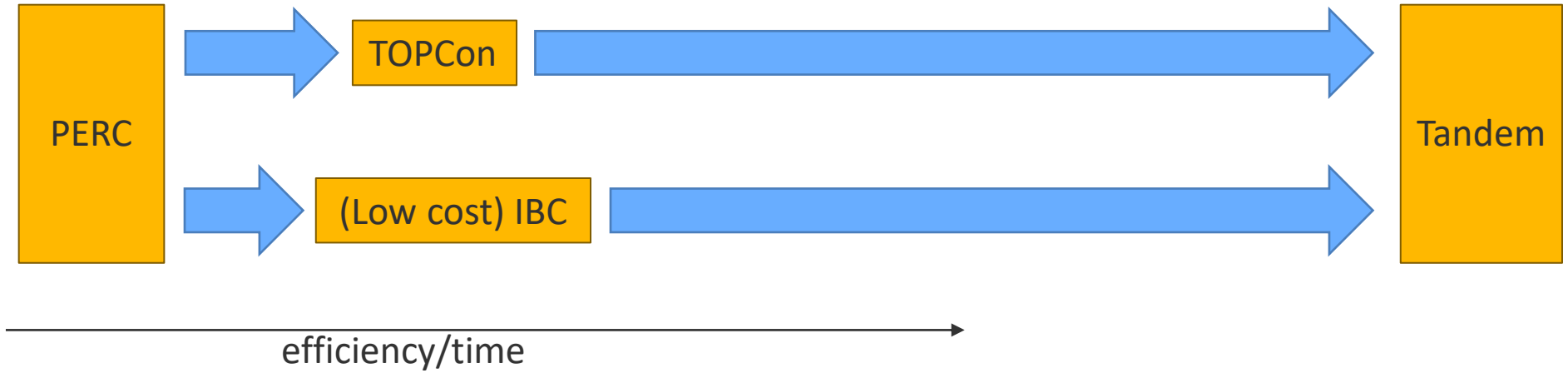




http://en.spicsolar.com/default/single/430.html

Motivation

- Technology evolution



→ How to bridge the time gap until tandem?

Motivation

- Silver consumption
  - 2022 estimate of **15.5-16.9%** of global silver supply
  - Even with learning rate of 20%, future silver demand will increase
  - 60 TW of PERC by 2050 could use **60%** of global Ag reserves

→ How to reduce the silver consumption?

Brett Hallam, Yuchao Zhang, Moonyong Kim, Pablo Dias, Robert Underwood, Challenges and Opportunities for Terawatt-Scale Deploymentof n-type Solar Cell Technologies N-type PV Workshop March 30-31, 2022

Content

Low cost IBC

TOPCon IBC

Screen printed Cu-IBC

Cost calculations

Conclusions

IBC4EU Project

Start: 1.11.2022
Funding: Horizon Europe
Duration: 36 months
Project budget: 16.7 M€
17 members, 4 associated partners
Coordinator: ISC Konstanz

- Goals: bring **high efficiency**, **low cost**, **low silver-content IBC** to the market
- Strenghten/Rebuild EU-based PV value chain

Project Partners

ISC, PROTECH, NorSun, ENERGYRA, FuturaSun, imec, CEA, TNO innovation for life, ISFH, Copprint, LuxChemtech, WIP RENEWABLE ENERGIES, VALOE Lithuania, VALOE Finland, HIGHLINE TECHNOLOGY, kalyon, BECQUEREL INSTITUTE

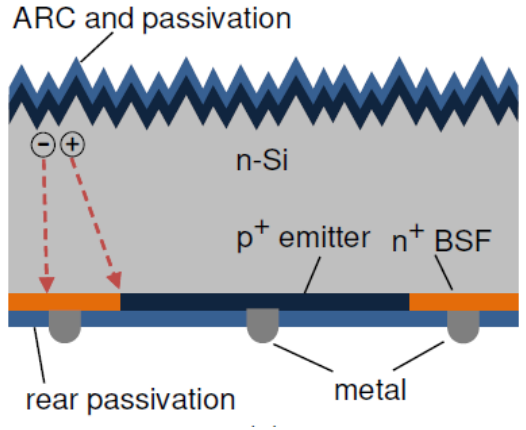
Associated Partners

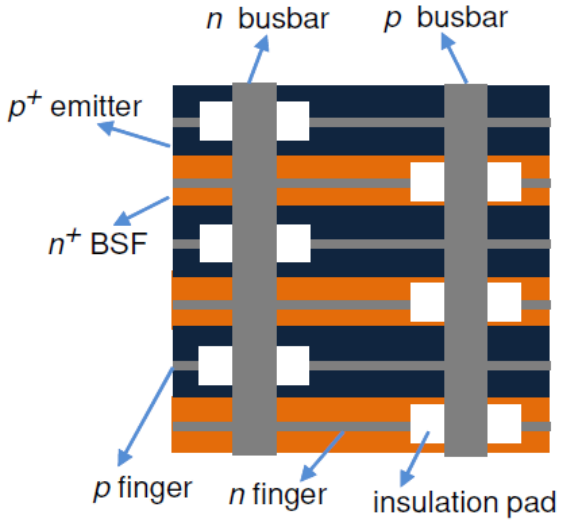
C, LPKF Laser & Electronics, Toyal 東洋アルミ, R|E|N|A|

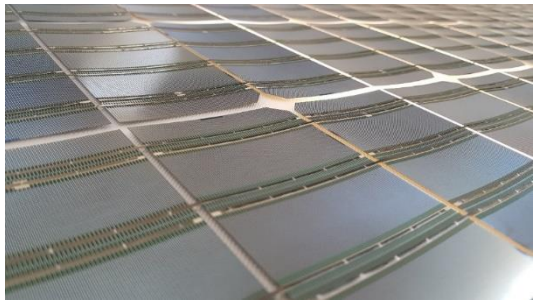
This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No.101084259

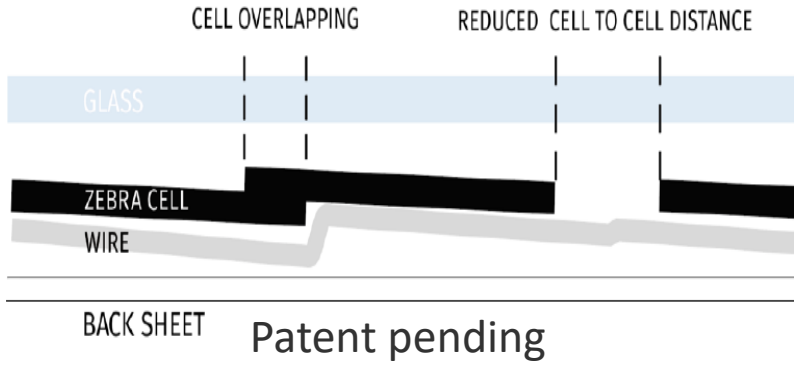
Low cost IBC – ZEBRA™

- PERC-like process equipment, V_{oc}~ 700mV
- Screen printed
- Flexible design rear side
- Stringable (by soldering)
- Bifacial (BF up to 0.8)



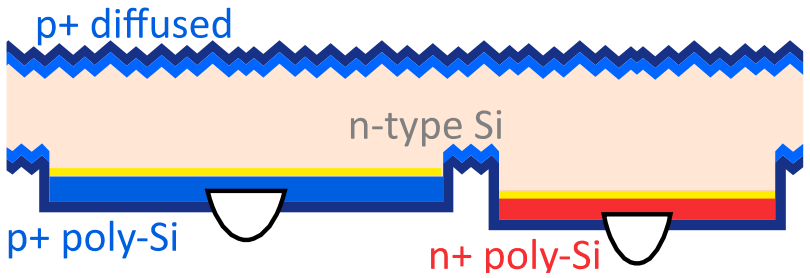




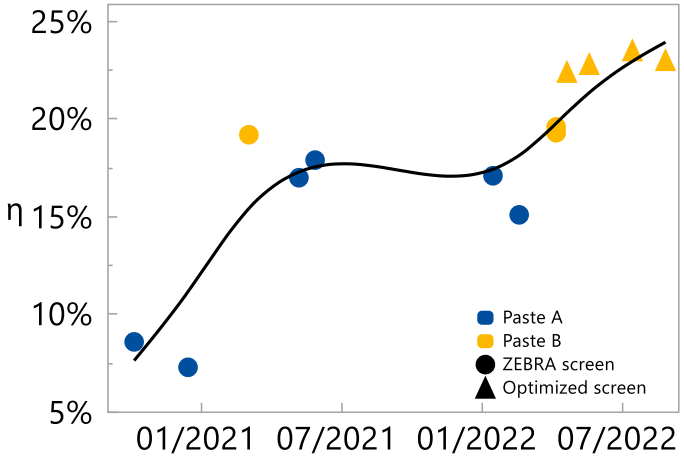


Patent pending

TOPCon IBC – polyZEBRA



- IP secured
- 2 patent applications pending



Status Q1/2023:
baseline+0.5%

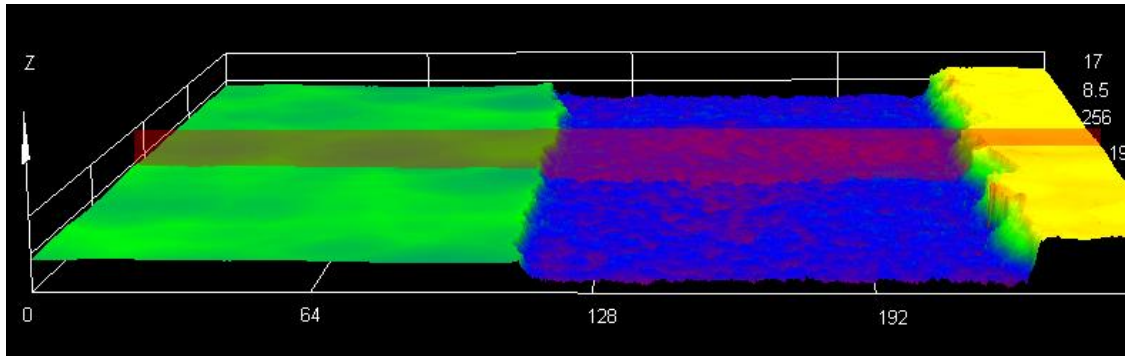
	ZEBRA		poly ZEBRA	
1	wetbench		wetbench	1
			SiO2+a-Si(n)	2
2	B-diff		SiNx	3
3	wetbench		Laser (abl)	4
			wetbench	5
			SiO2+a-Si(i)	6
4	SiNx		B-diff	7
5	Laser (abl)		wetbench	8
			Laser (SE)	9
6	wetbench		TEX	10
7	P-diff		B-diff	11
8	wetbench		wetbench	12
9	SiNx front		AlOx+SiNx front	13
10	SiNx rear		AlOx+SiNx rear	14
11	SP + FF		SP + FF	15
12	IV+sorting		IV+sorting	16

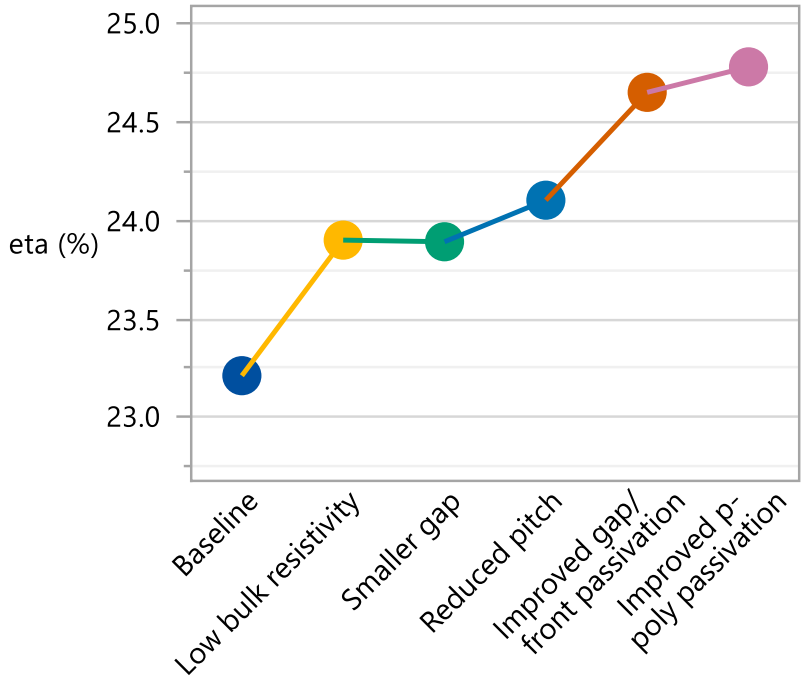
Linke et al. Fully Passivating Contact IBC Solar Cells Using Laser Processing. WCPEC 2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857793

TOPCon IBC – polyZEBRA

- Summary
  - True upgrade
  - Proven process technology
  - Variable in cell size (up to M12)
  - Cut cell, bifacial
  - Back-end 100% compatible with ZEBRA technology





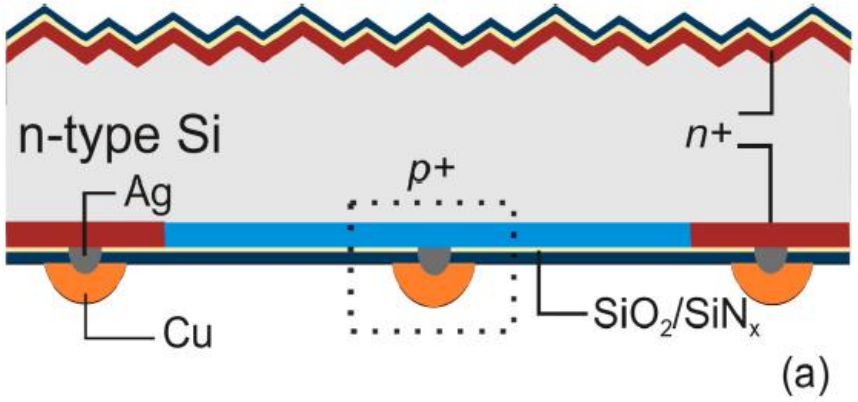
Efficiency potential: >24.5%

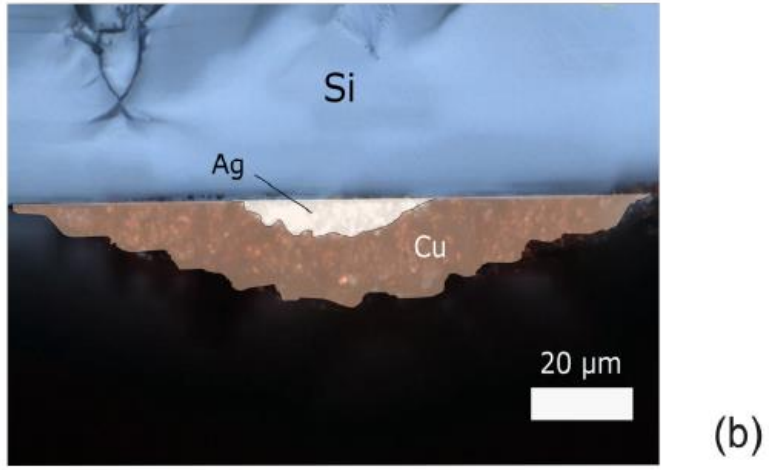
Screen printed Cu-IBC

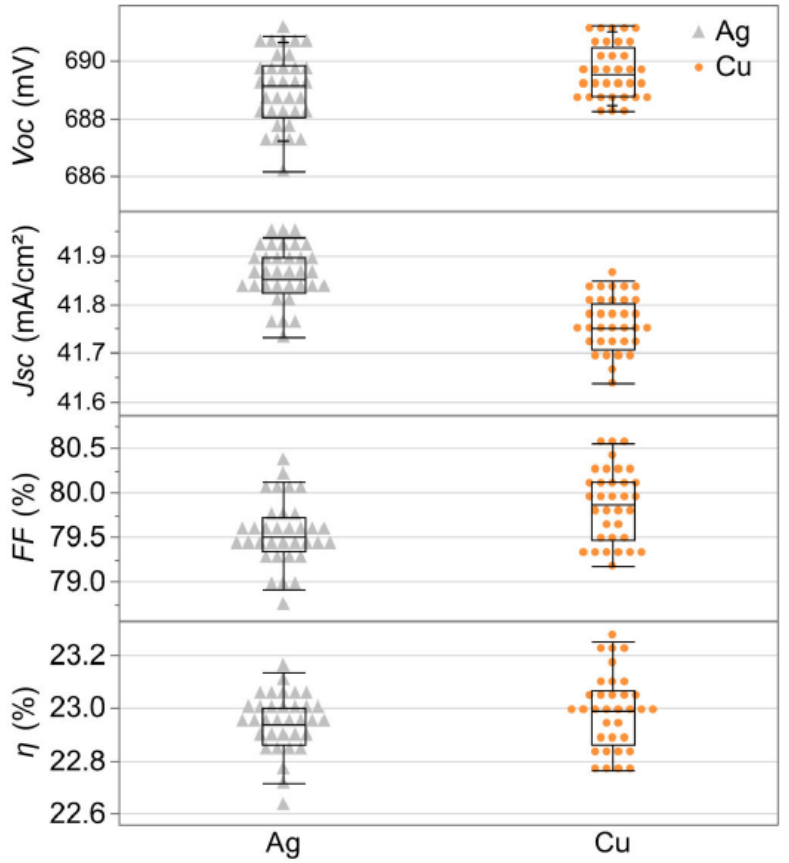
- IBC ideal for Cu screen printing
- Technology well-known from PCB
- 100% compatible with standard PV equipment
- Curing fast and at low temperature
  - Standard drying
  - “Snap curing” (300°C, few seconds with direct solid-to-solid heat transfer)

How to avoid direct contact with Si?

Screen printed Cu-IBC



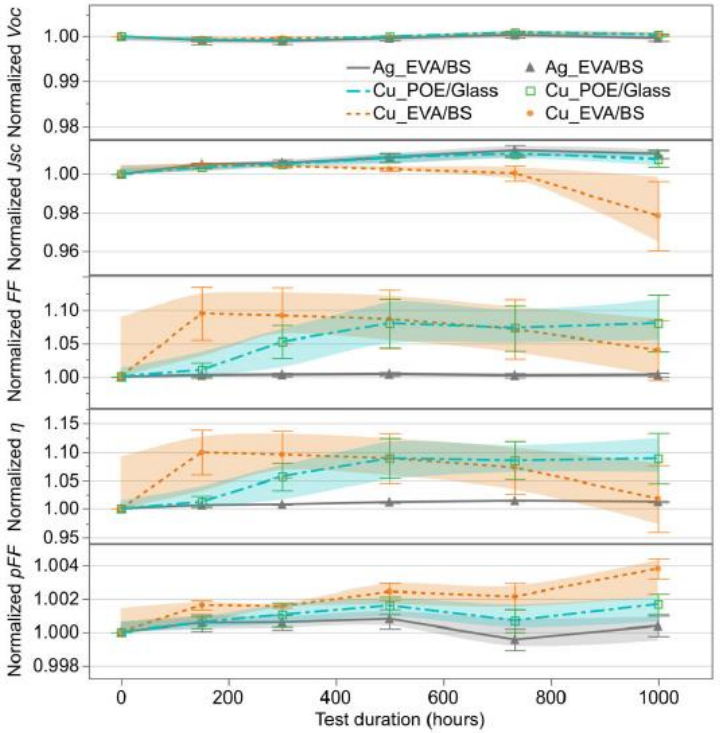




Chen, Ning, et al. "Thermal Stable High-Efficiency Copper Screen Printed Back Contact Solar Cells." Solar RRL 7.2 (2023):2200874

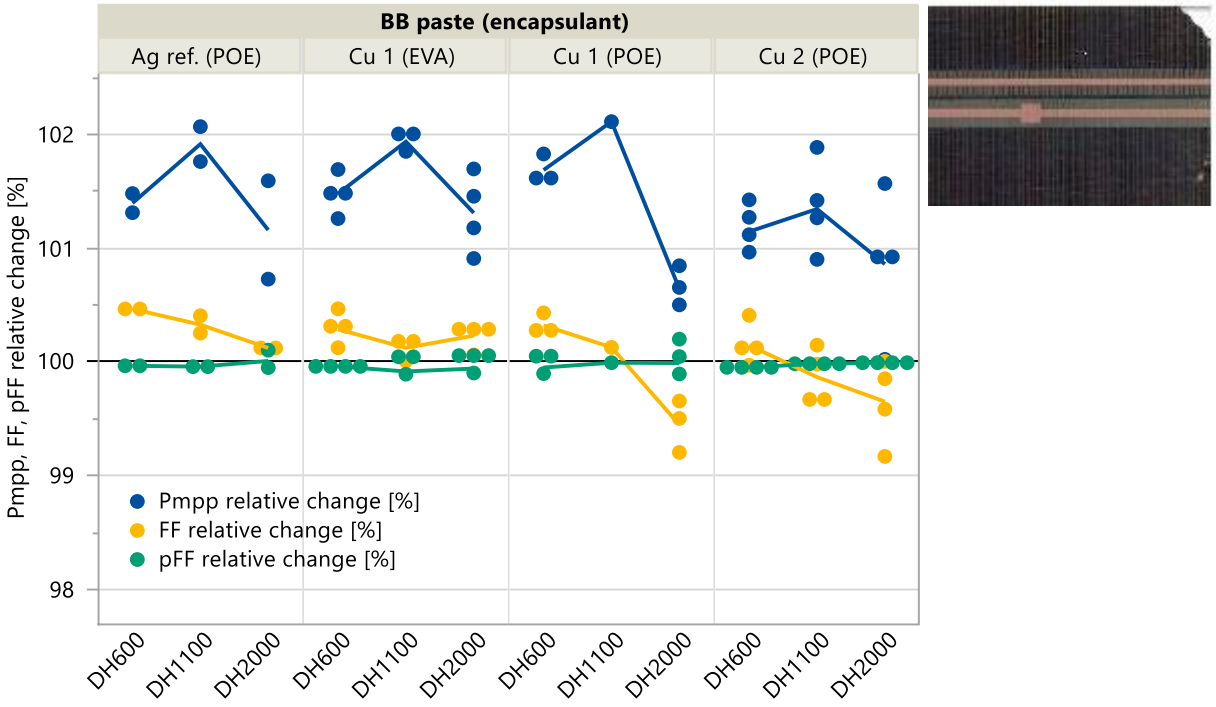
Screen printed Cu-IBC

Module performance (DH) with Cu fingers



Chen, Ning, et al. "Thermal Stable High-Efficiency Copper Screen Printed Back Contact Solar Cells." Solar RRL 7.2 (2023):2200874

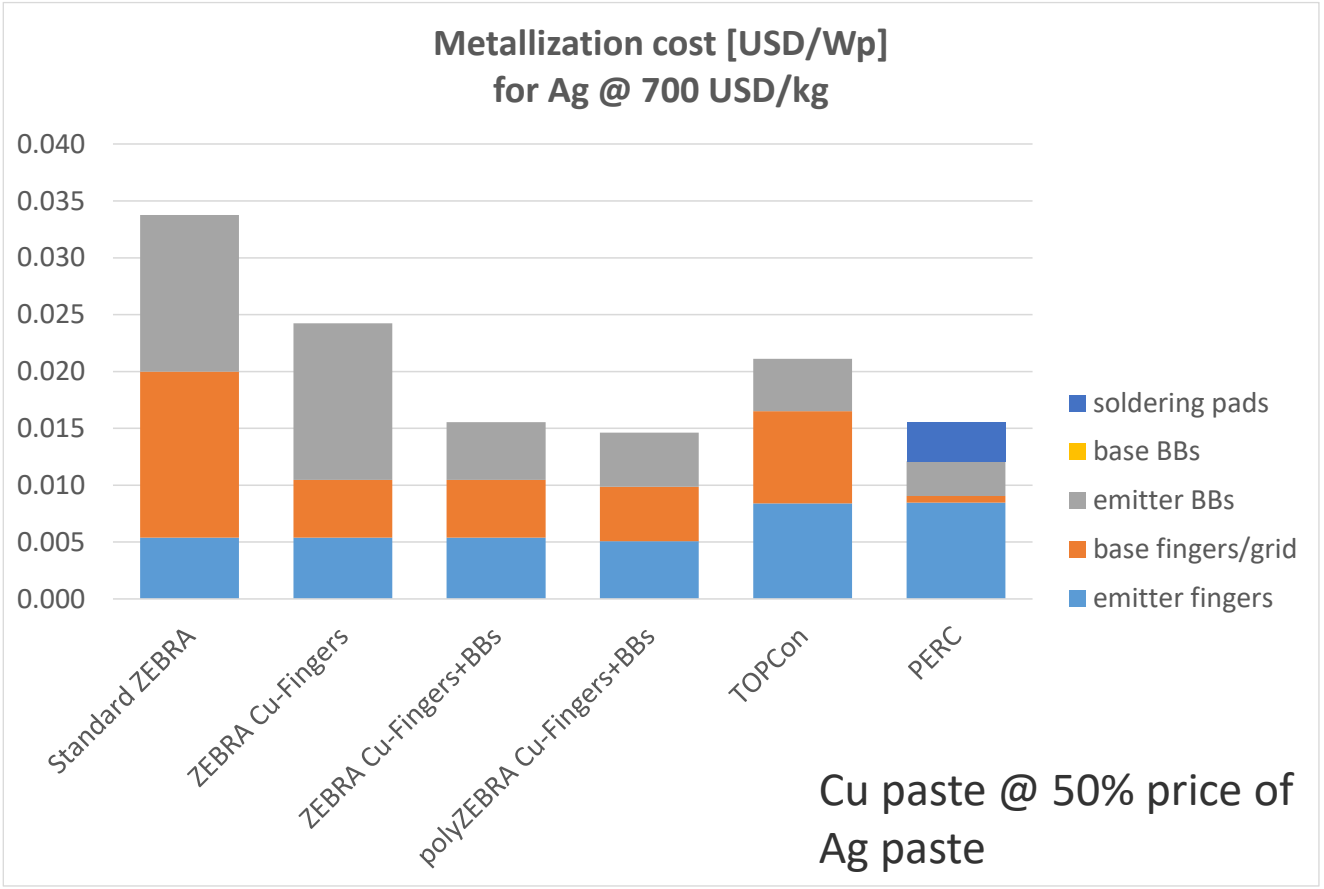
Module performance (DH) with Cu busbars



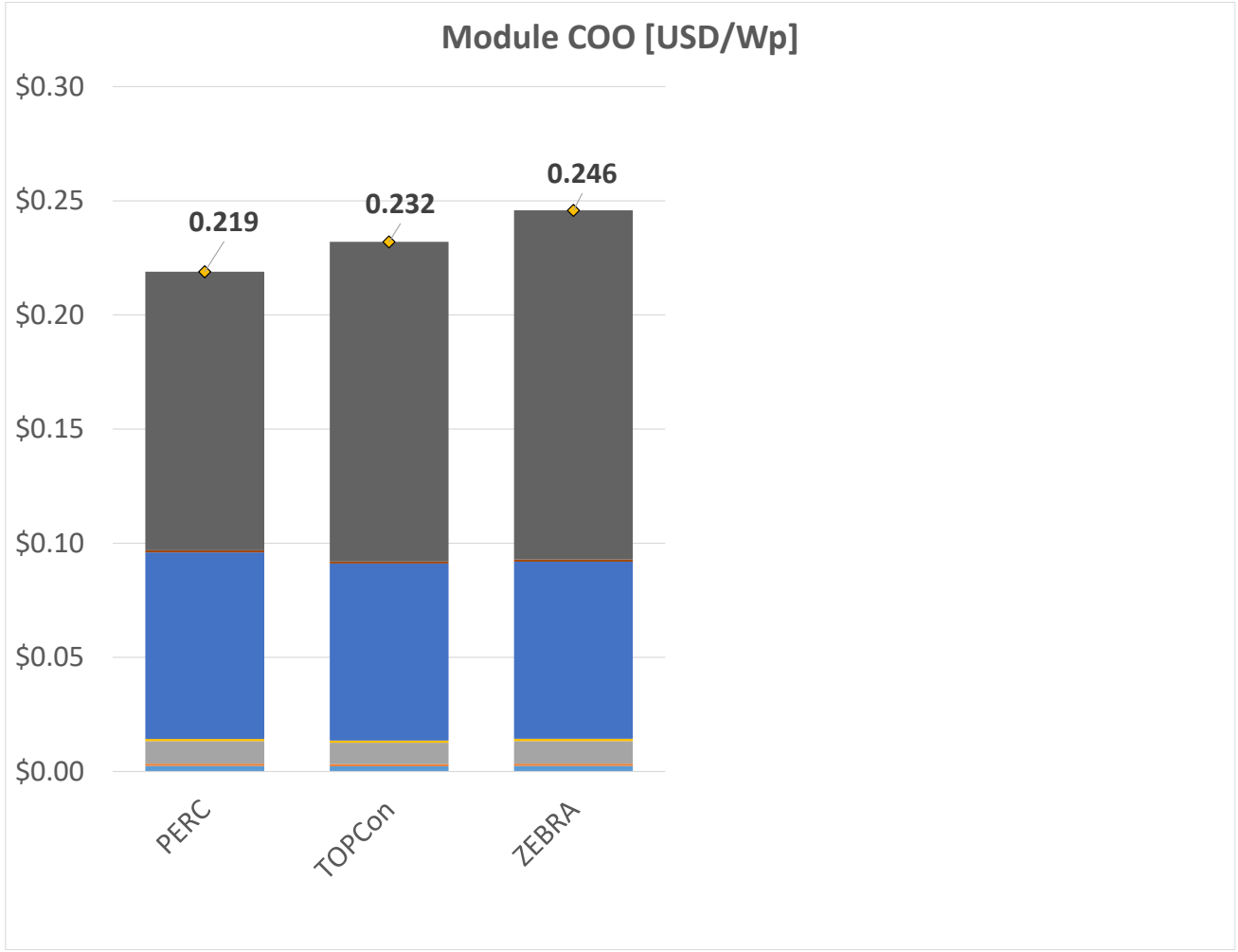
To be presented at the MIWS 2023 (Neuchâtel) by Rudolph et al.

Screen printed Cu-IBC

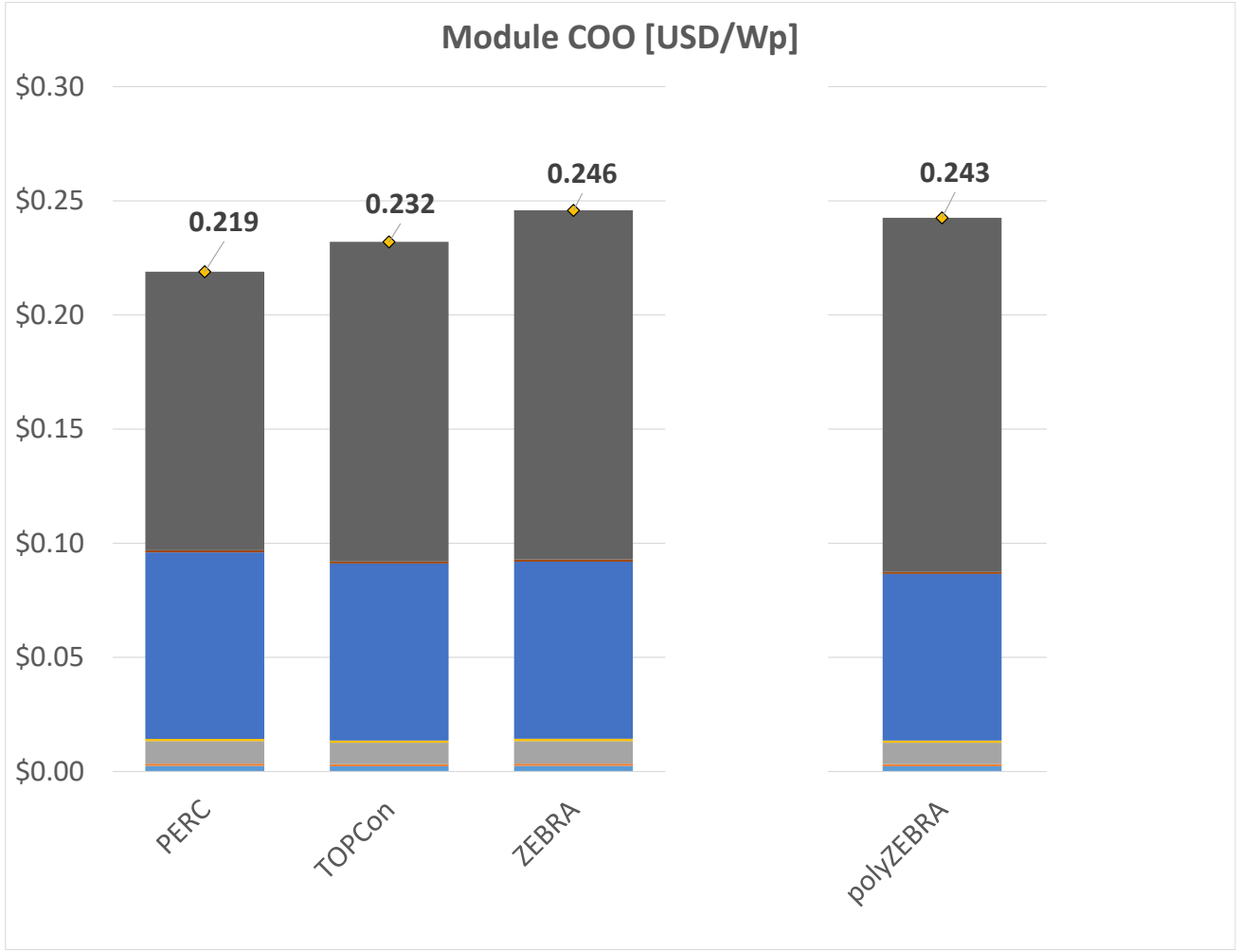
- Summary
  - Simple curing
  - No direct contact with unprotected Si → no source for Cu contamination
  - Solderable
  - Stable in module



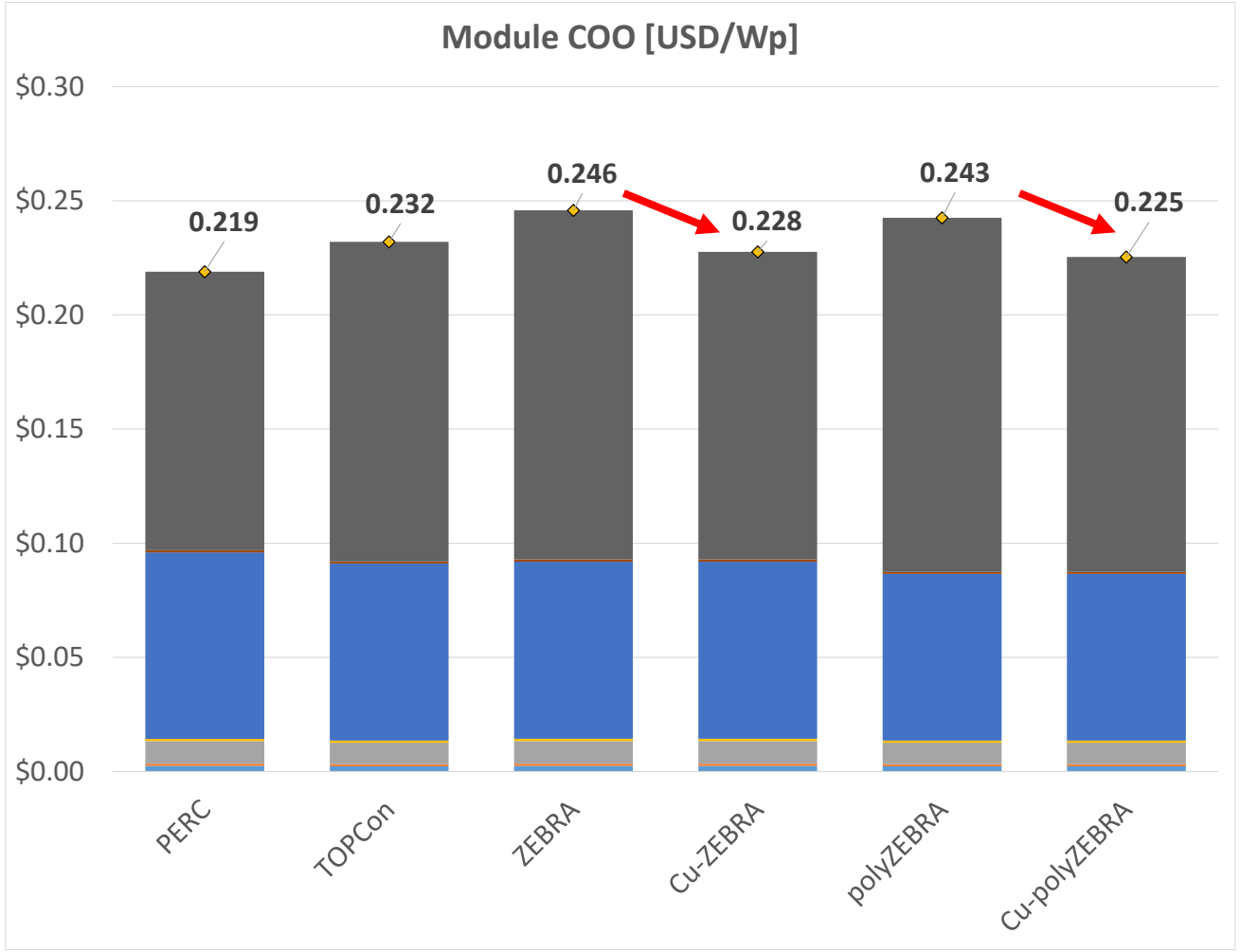
Cost calculations



Cost calculations

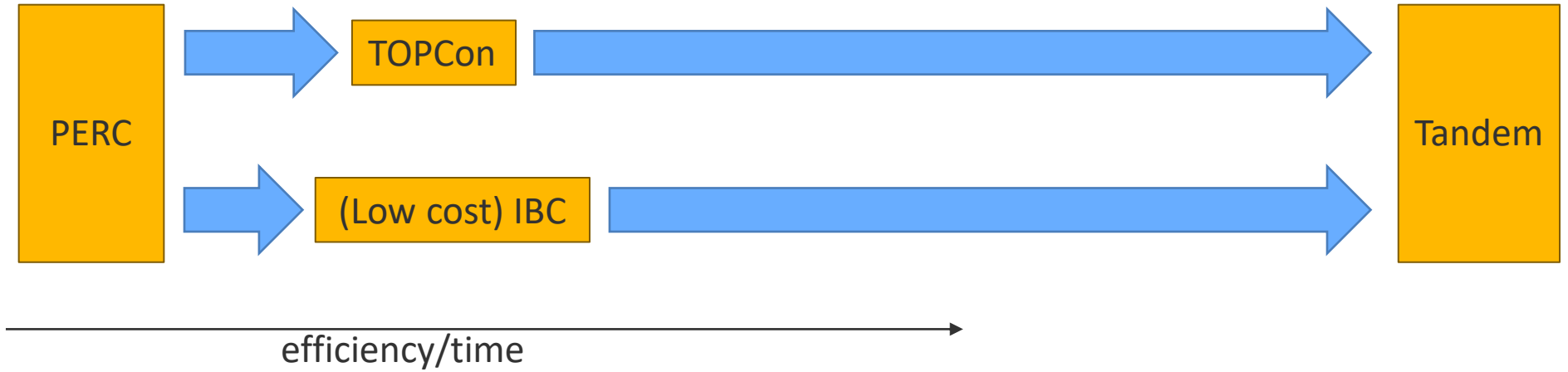


Cost calculations



Conclusion

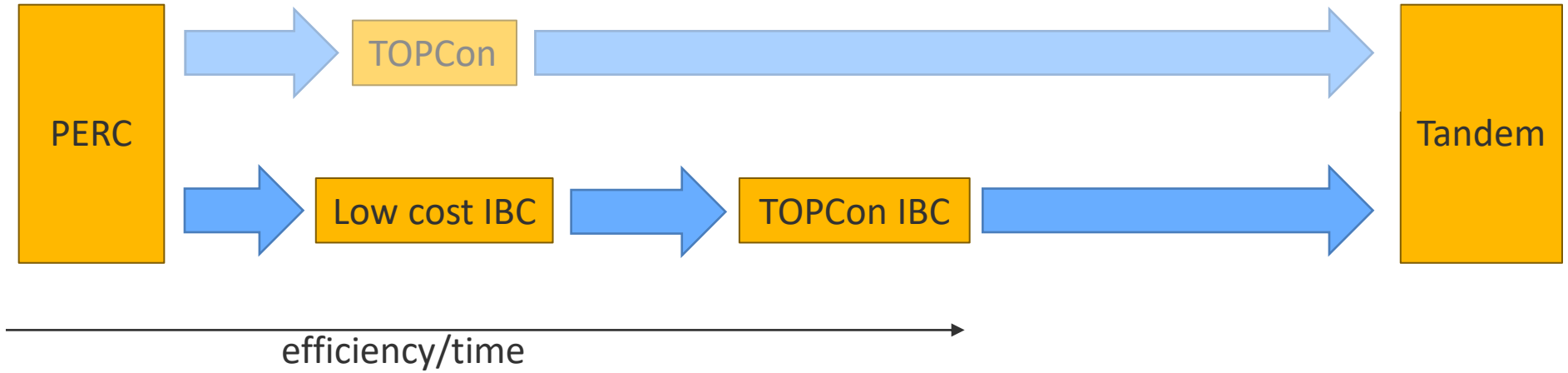
- Technology evolution



→ How to bridge the time gap until tandem?

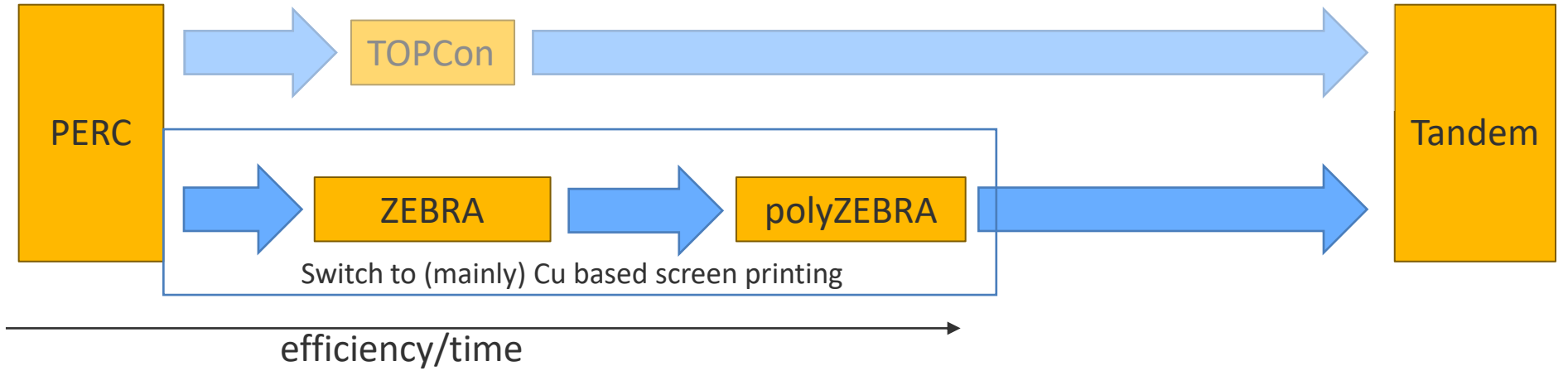
Conclusion

- Technology evolution



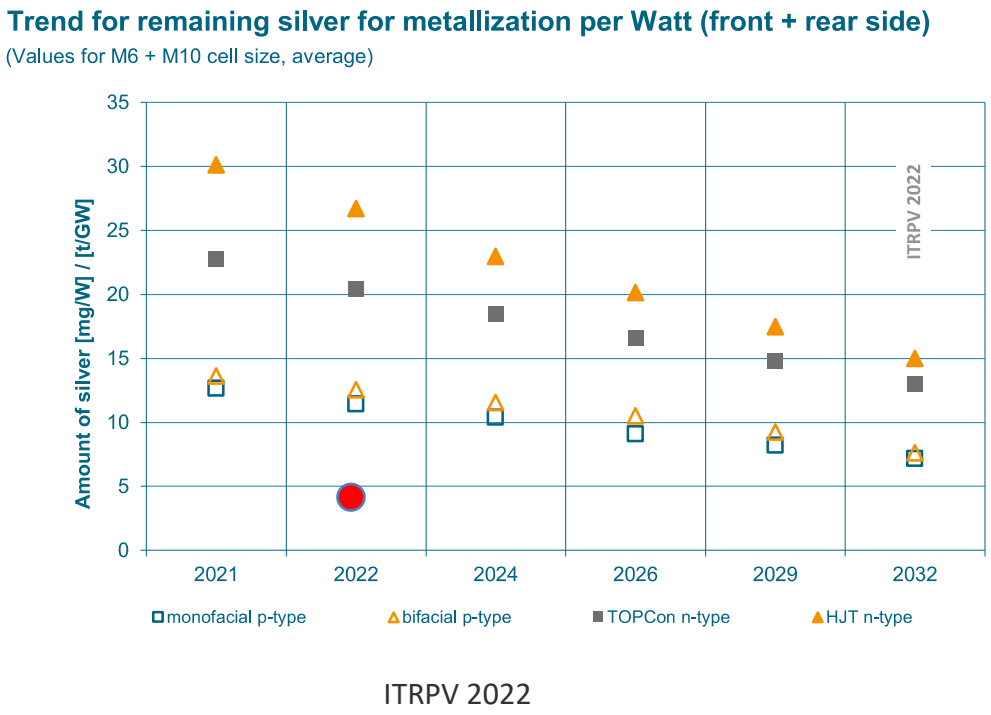
Conclusion

- Technology evolution (revisited)

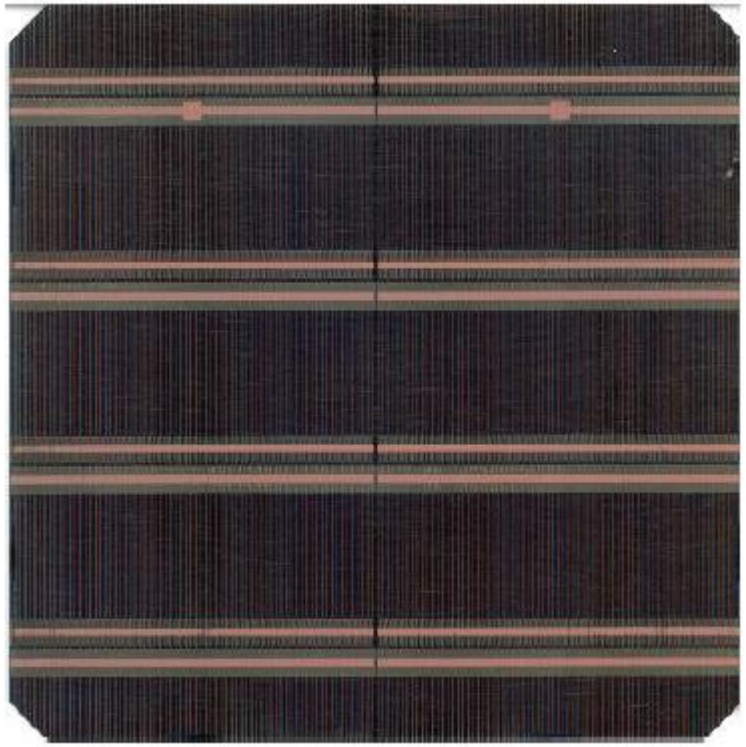


Conclusion

- Cu-ZEBRA

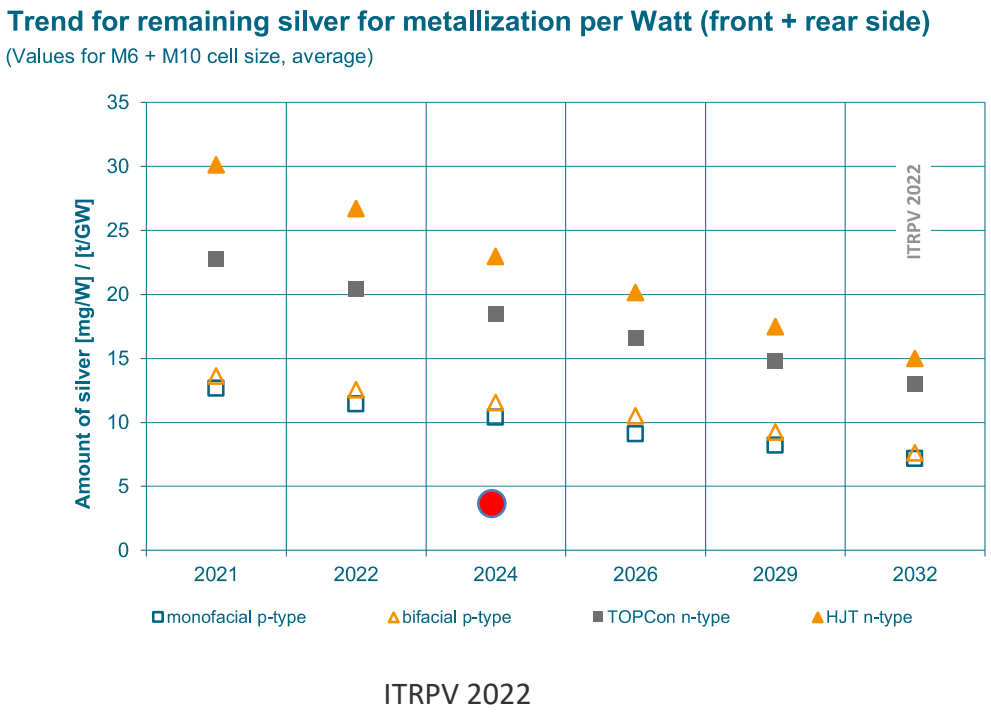


ITRPV 2022

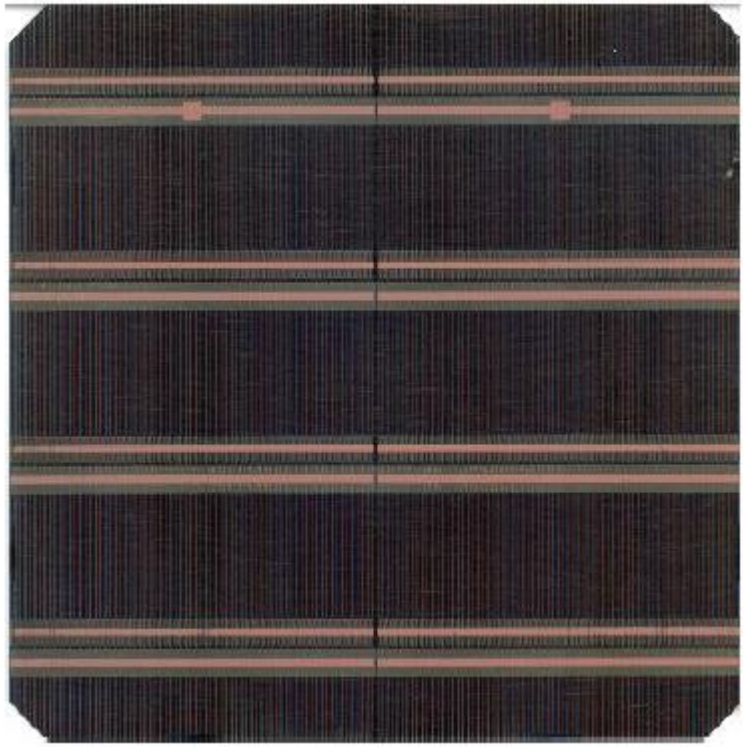


Conclusion

- Cu-polyZEBRA



ITRPV 2022



→ Screen-printed Cu-polyZEBRA→ high efficiency at low cost

© ISC Konstanz e.V.

The polyZEBRA concept - upgrade of low cost IBC solar cell production – PV CellTech 2023

ISC research for a sunny future

Thank you for your attention

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No.101084259

SiliconPV 2023

13th International Conference on Crystalline Silicon Photovoltaics

npworkshop Delft 2023

Advanced technologies, materials and concepts for crystalline Si solar cells and modules

April 11 – 14, 2023 | Delft, The Netherlands

Both ***on-site*** and ***online***

ISC