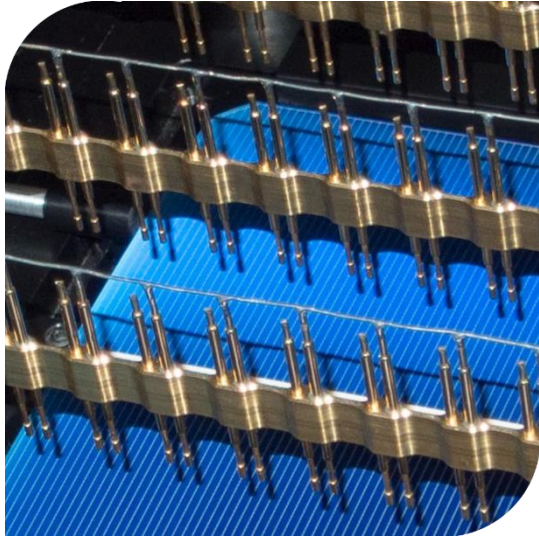




ZEBRA IBC and beyond

Radovan Kopecek

ISC Konstanz

International Solar Energy Research Center Konstanz

- Nonprofit association based in Germany, founded in 2005
- Team of 60 employees from 20 different nations
- Focus **R&D on c-Si solar cells, modules and energy systems** with academic and industry partners in publicly funded and bi-lateral projects
- **Technology Transfer** of TOPCon (TOUCAN) and n-IBC (ZEBRA)



References, technology transfer

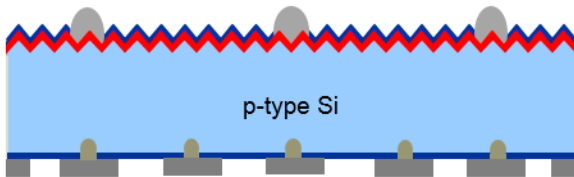


New 2022-2023

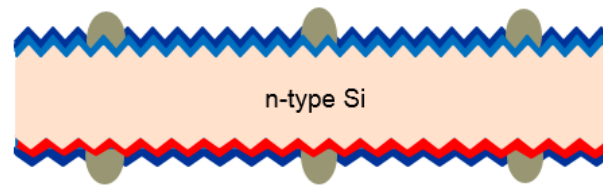


ISC Konstanz: solar cell technologies

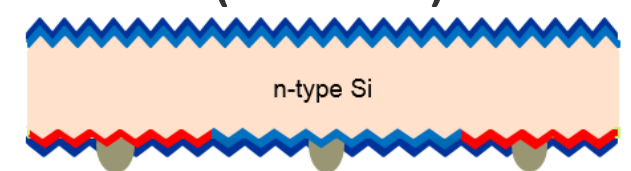
PERC 22.5%+



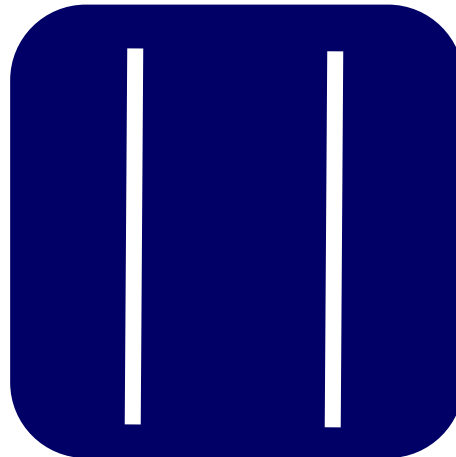
TOPCon (TOUCAN) 24%+



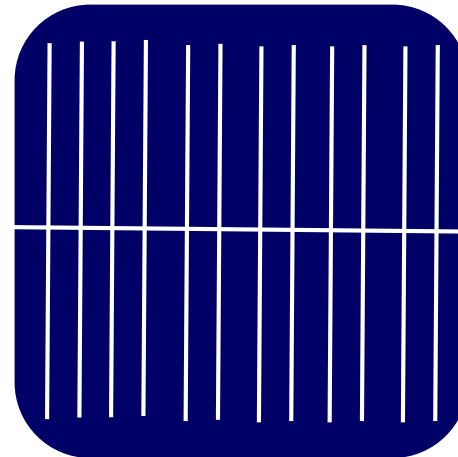
IBC (ZEBRA) 24%+



past

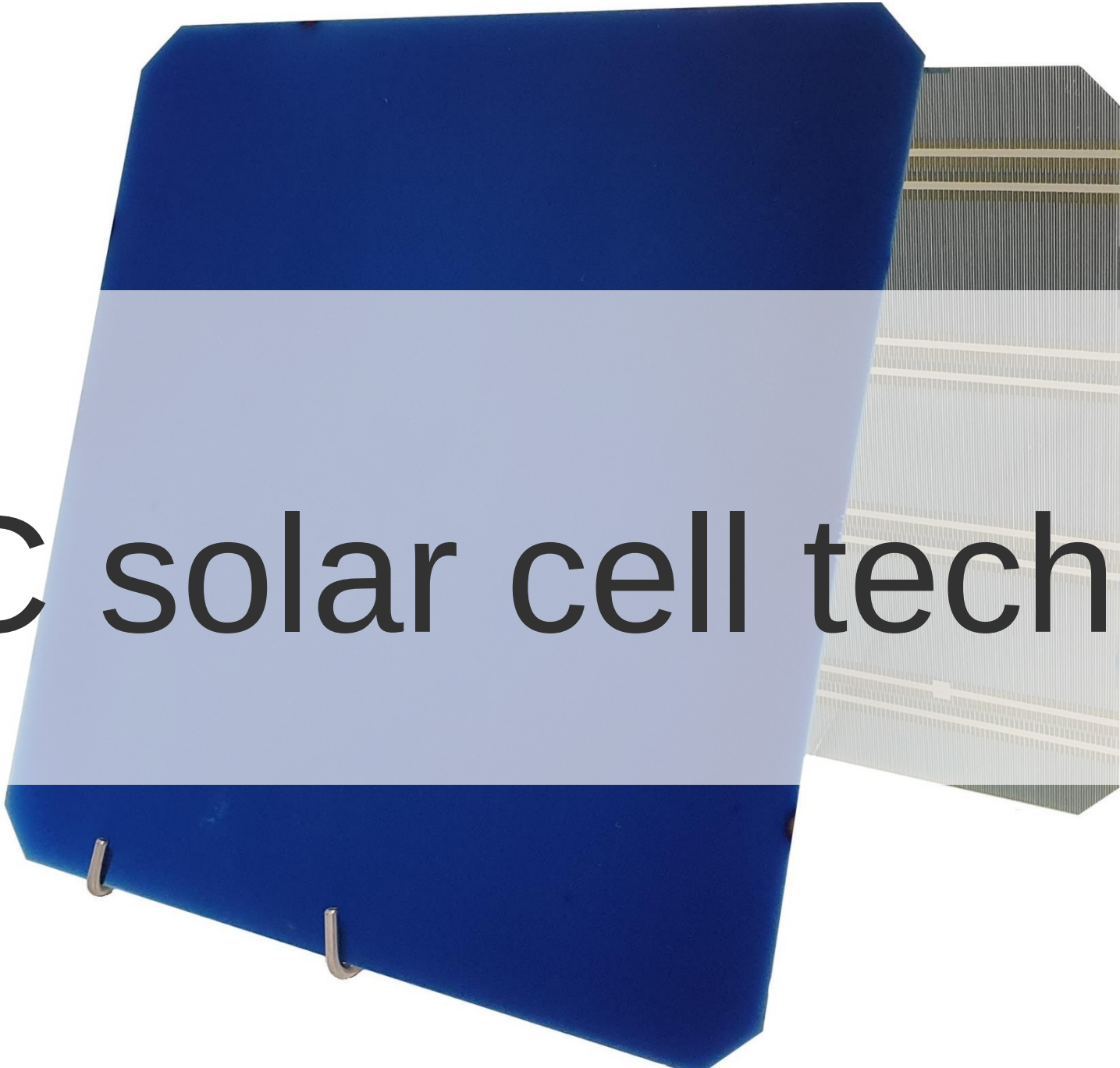


present

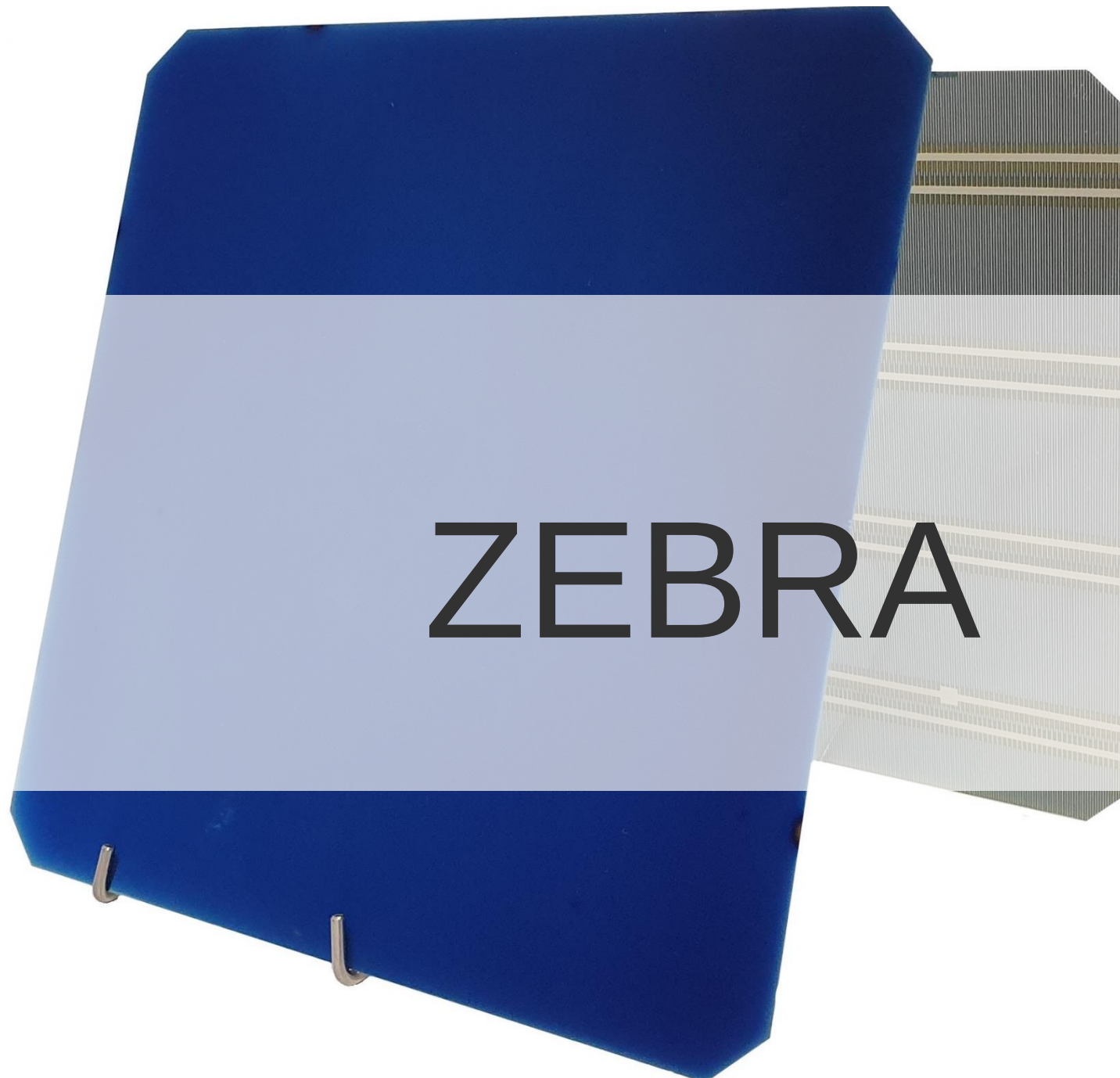


future



The image features two square solar cells. The foreground cell is blue with a light blue horizontal band across its center. The background cell is silver with a grid of fine lines and horizontal gold-colored busbars. The text 'IBC solar cell technology' is overlaid on the blue cell.

IBC solar cell technology



ZEBRA for roof-top PV



ZEBRA for flat roof-top PV



ZEBRA for building integration PV



ZEBRA for building integration PV



Radovan Kopecek
Co-founder and director of ISC
Konstanz

[View full profile](#)

Radovan Kopecek
Co-founder and director of ISC Konstanz
13h • Edited •

Impressive "ZEBRA skyscraper" at SPIC's headquarters in Beijing with ZEBRA technology!! 🌞 Glass between windows is currently being replaced by ZEBRA modules. Congrats. Well done!! BIPV at its best. I look forward to seeing it when it is finished.

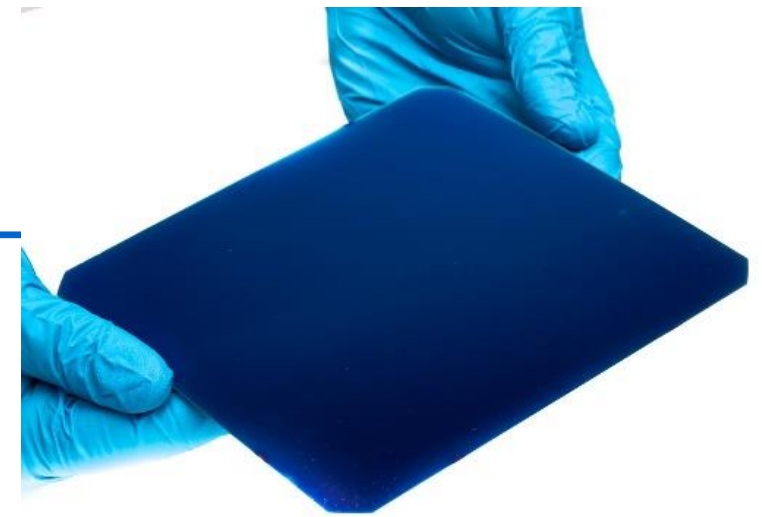
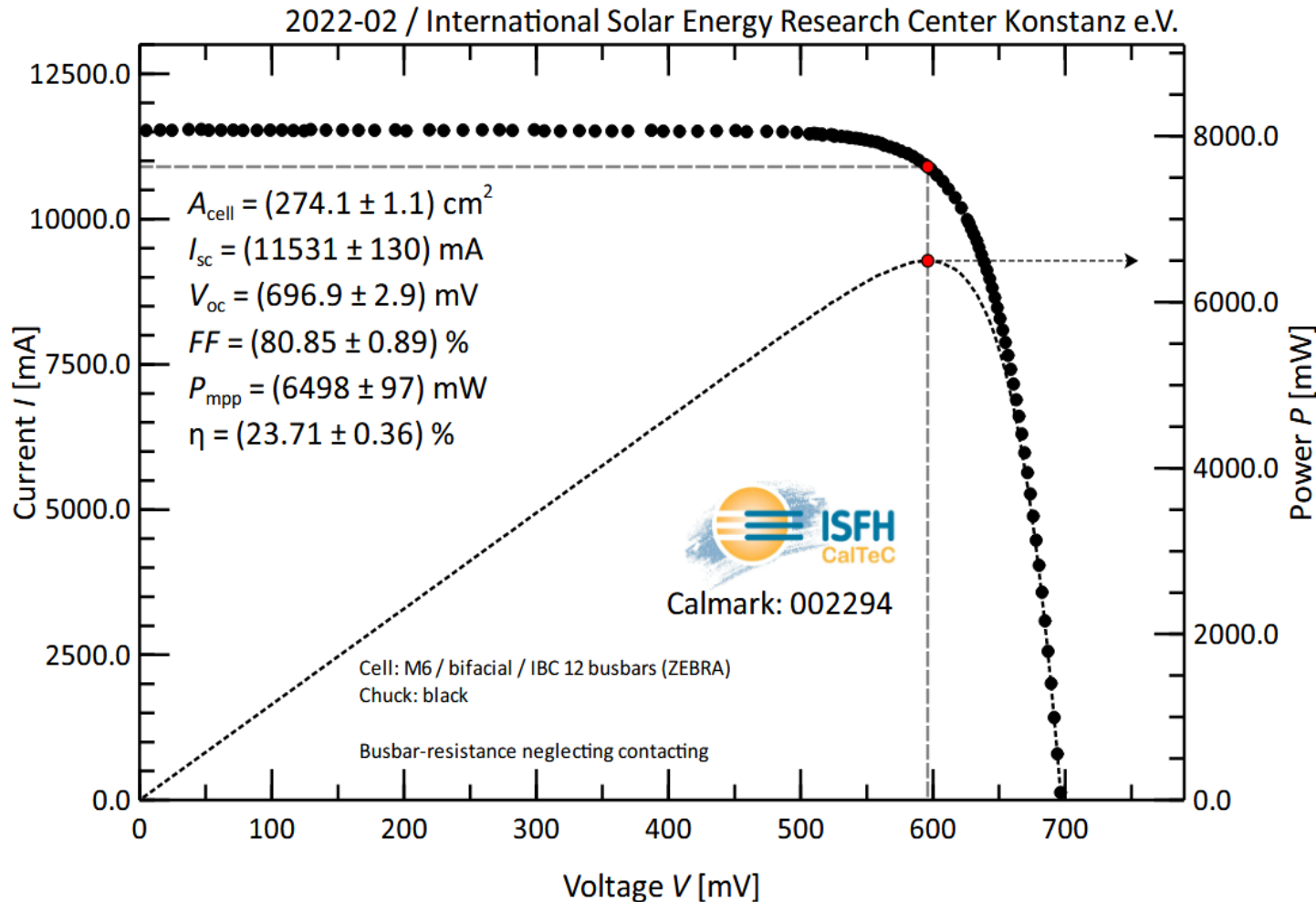




ZEBRA for vehicle integrated PV



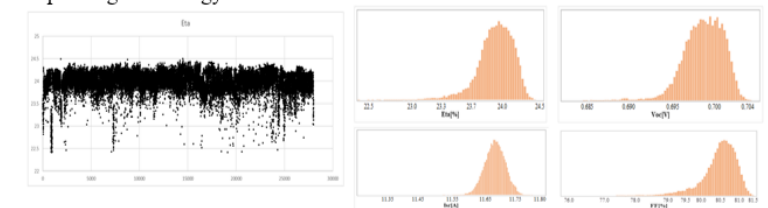
Certified measurement



ZEBRA IBC: 24% efficient solar cells in mass production without passivating contacts

SUMMARY OF THE ABSTRACT

PERC technology is coming to its efficiency limits at about 23% average efficiency and 685mV in production. n-type technology is on its upswing, as TOPCon with passivating contacts and HJT can reach voltages above 700mV. ISC Konstanz with SPIC is following a classical route without the need of passivating contacts yet, reaching open circuit voltages above 700mV with efficiencies above 24% in mass production. This is to our knowledge the highest efficiency in production with classical approach of high temperature diffusion and screen printing technology.

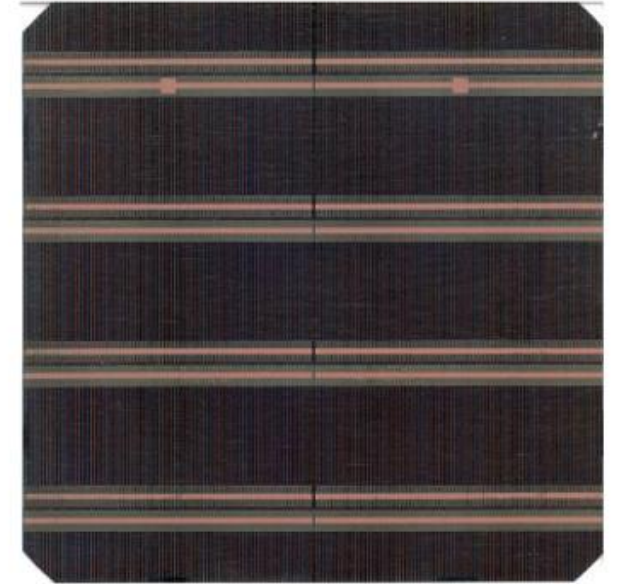


	Isc (A)	Voc (mv)	FF (%)	Eta (%)
average	11.69	697.46	80.57	23.97%
Best cell	11.78	701.31	81.31	24.50%

Reducing Ag

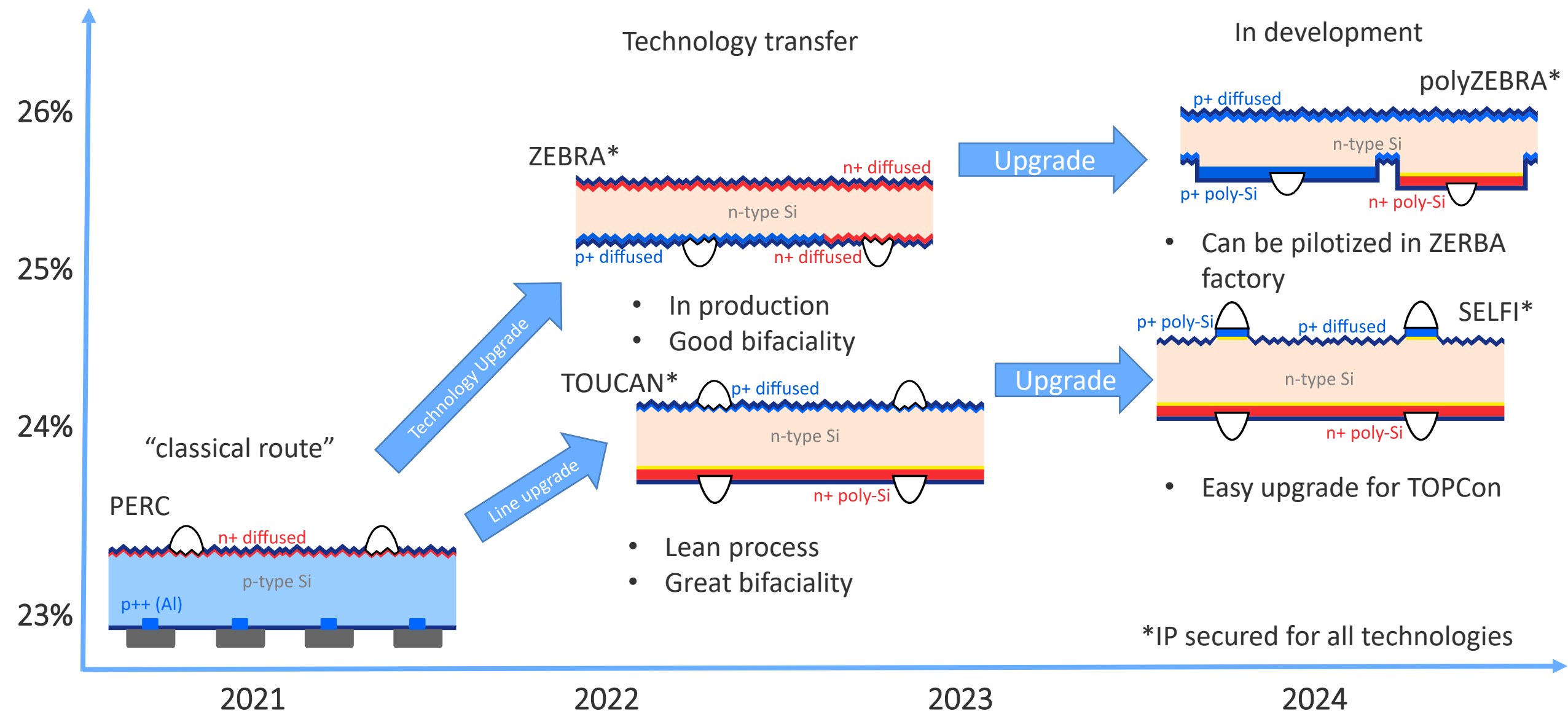
- First cells with only **25 mg silver** per cell were made
- Cu pastes and used screens are not yet optimized!
- Very promising results with high V_{OC} and pFF values

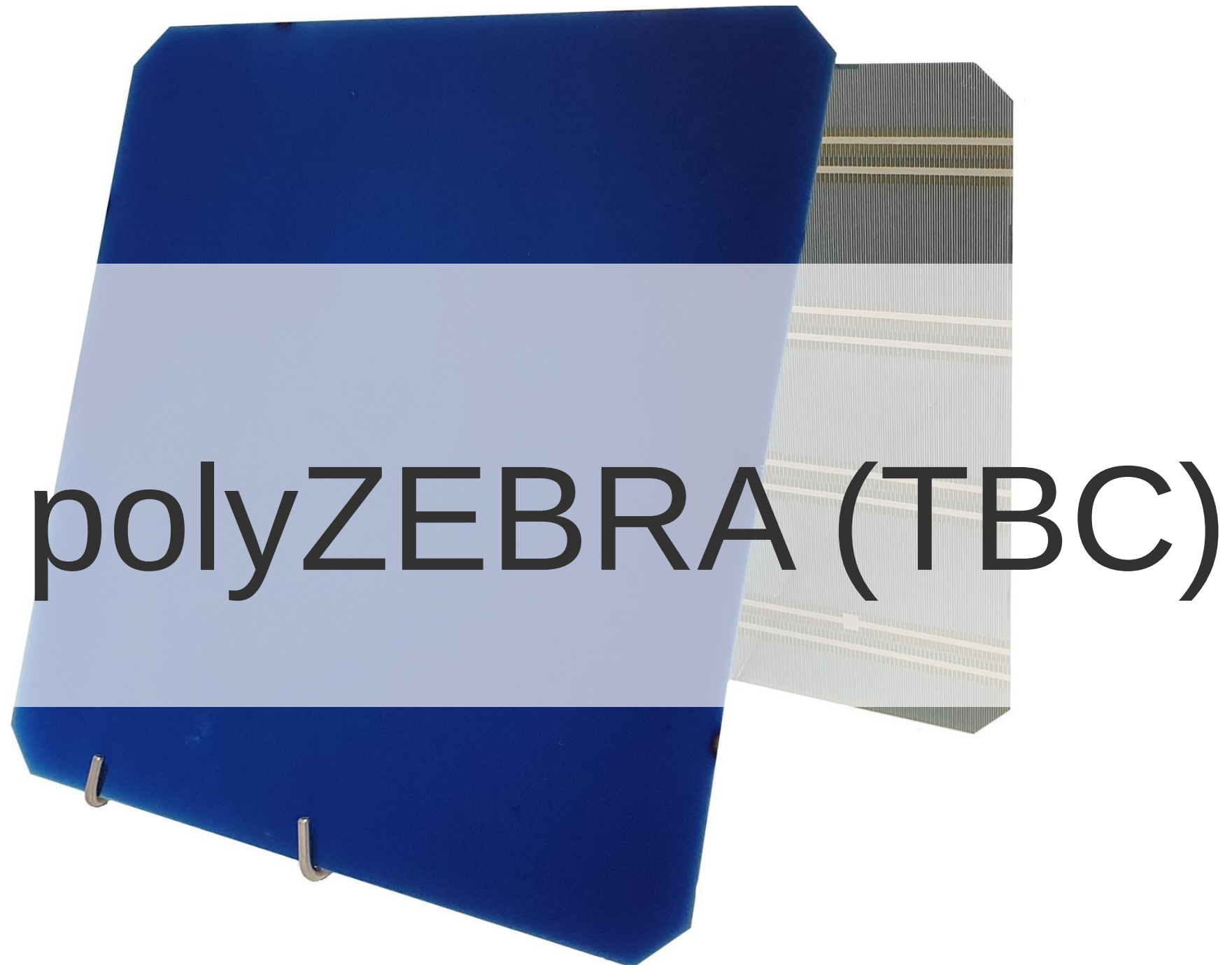
		Jsc	Voc	FF	Eta	SunsVoc	pFF
Cu finger&BB	Best cell	41.24	0.6894	78.37	22.28	0.6892	82.63
	Average	41.18	0.6891	77.75	22.06	0.6889	82.65
	Std. dev.	0.04	0.0004	1.04	0.31	0.0005	0.16
Reference_ Ag finger&BB	Best cell	41.30	0.6892	79.99	22.77	0.6889	83.37
	Average	41.27	0.6881	78.70	22.35	0.6878	82.62
	Std. dev.	0.05	0.0011	1.49	0.46	0.0011	0.44




Copprint

ISC Roadmap





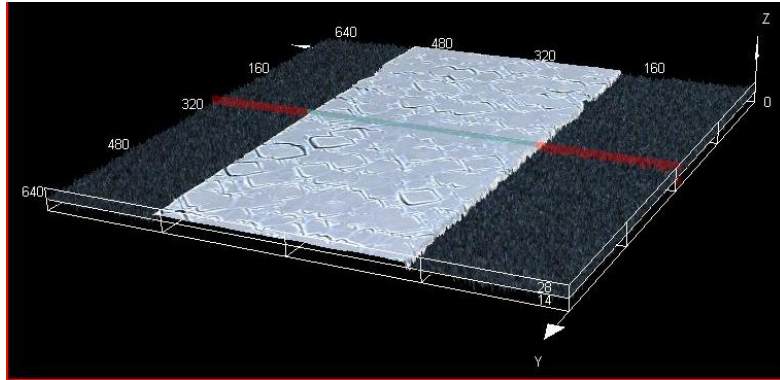
CARBON: TOPCon (TOUCAN) and IBC (polyZEBRA)



CARBON AND ISC KONSTANZ VALIDATE THEIR TECHNOLOGY PARTNERSHIP

Shortly after the announcement of an industrial partnership with the midcap ACI Group, the start-up CARBON, undertaking a solar PV gigafactory project in France, confirms its technology agreement with the International Solar Energy Research Center (ISC) Konstanz on solar energy, recognized developer of TOPCon and IBC technologies.

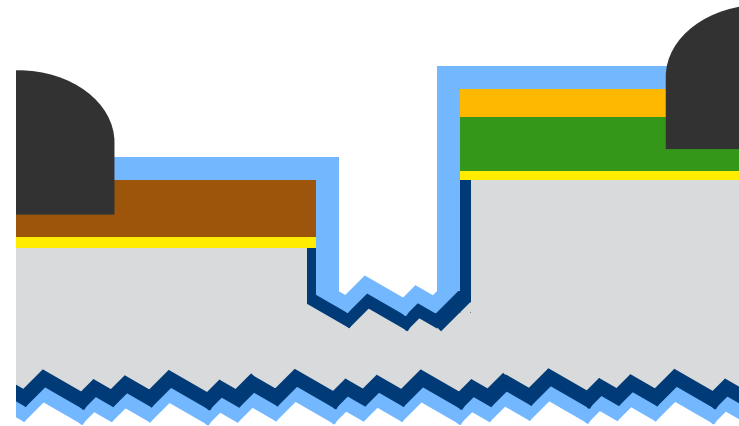
polyZEBRA development update 04/22



- Applicable as upgrade of existing ZERBA (n-type)
- Lean process, based on maskless laser structuring
- Applied for patent

Acknowledgement:

This project has received funding from the European Union's Horizon2020 Programme for research, technological development and demonstration under Grant Agreement no. 857793.



	n c-Si		p-diffused
	SiO _x		SiN _x mask
	n ⁺ poly-Si		AlO _x /SiN _y
	p ⁺ poly-Si		Metal

Etching + Cleaning

TO + n-type poly

Masking + Laser pattern
ablation

Etching + cleaning

TO + i/p-type poly stack

Laser patterning

Etching + cleaning

ARC deposition
(front+back)

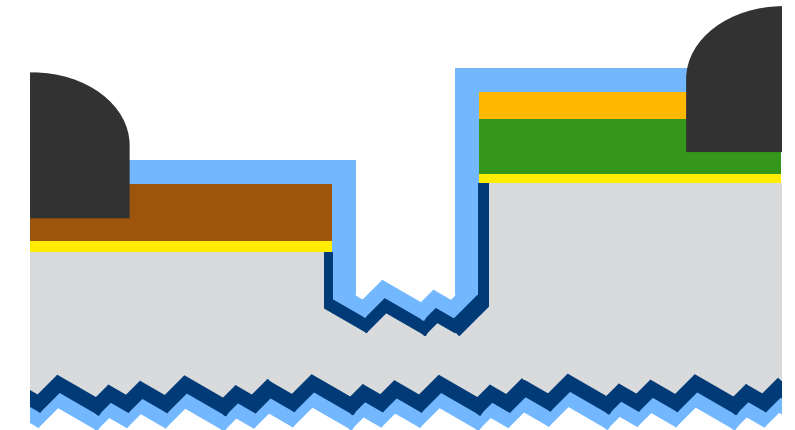
Screen Printing + Sintering



polyZEBRA development update 04/22

	η (%)	V_{oc} (mV)	J_{sc} (mA/cm ²)	FF (%)	pFF (%)
Best cell	22.37	691	41.40	78.19	81.46
Median	22.19	689	41.36	77.98	81.23

- Both polarities with poly-Si passivating contact
- Best precursor $iV_{oc} = 696\text{mV}$
- $iV_{oc} - V_{oc}$ loss $< 5\text{mV}$
- Previous batch best precursor $iV_{oc} = 712\text{mV}$



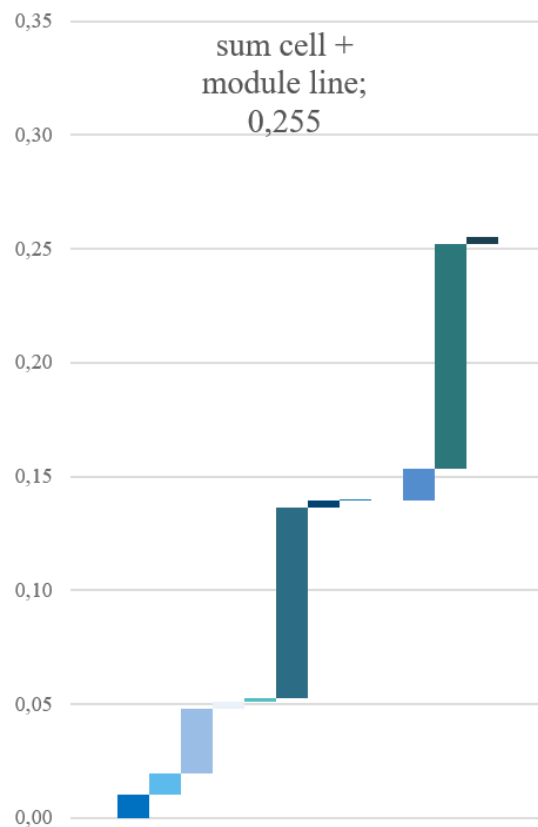
Light gray	n c-Si	Dark blue	p-diffused
Yellow	SiO _x	Orange	SiN _x mask
Green	n ⁺ poly-Si	Light blue	AlO _x /SiN _y
Brown	p ⁺ poly-Si	Dark gray	Metal

Temporary efficiency potential of 24% calculated with best cell's pFF and 712mV

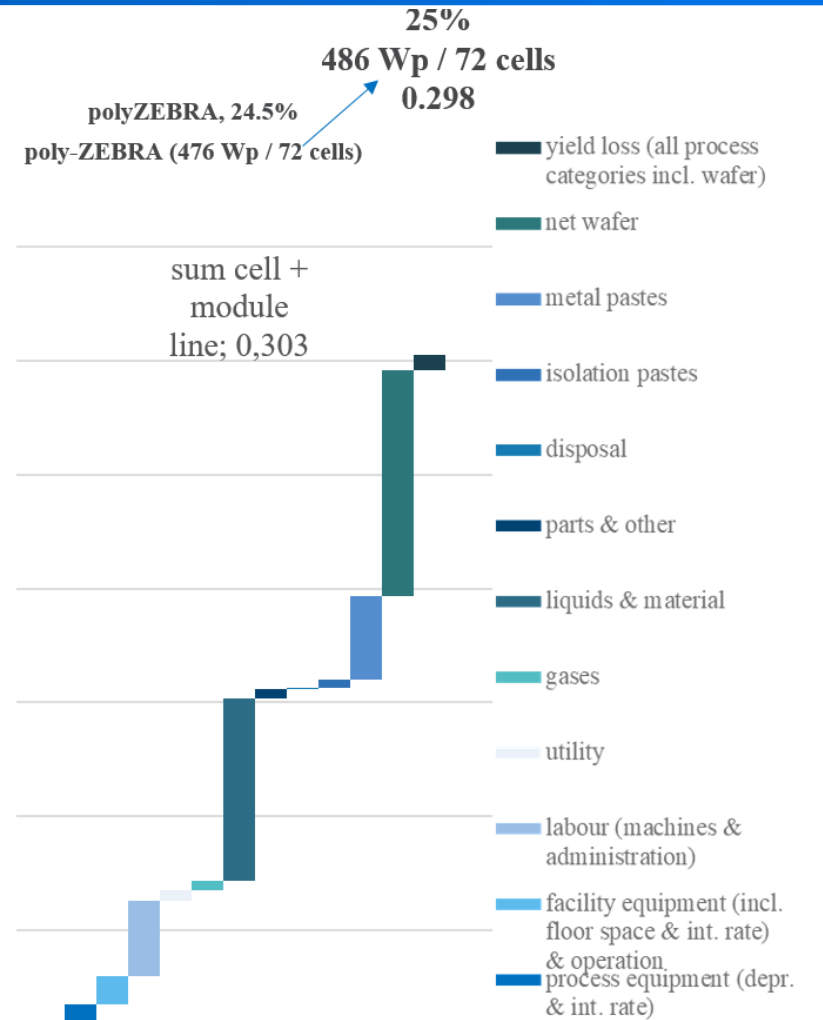
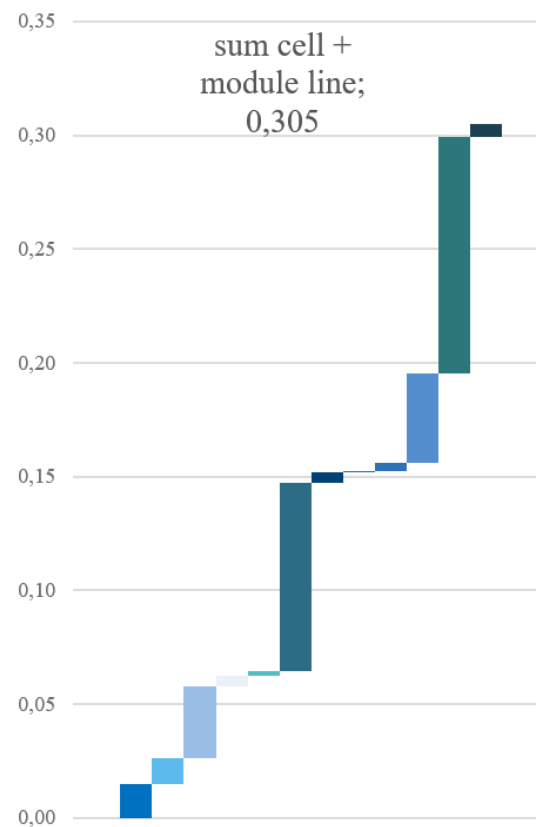
COO of PERC, ZEBRA and polyZEBRA

COO solar module production (USDct)

PERC+, 22.5%
PERC module (442 Wp / 72 cells)



ZEBRA, 23.5%
ZEBRA module (457 Wp / 72 cells)



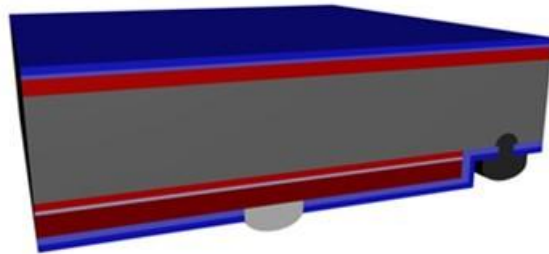
POPEI : POLO IBC



Bundesministerium
für Wirtschaft
und Energie



centrotherm



Voc : 707 mV

Industrial feasible screen printed p-type IBC solar cell based on PECVD a-Si (n)

Wafer : p-type (Ga)

Texturing + Cleaning + TO

PECVD polySi + Anneal

Laser pattern ablation

Laser damage removal +
Cleaning

Passivation + ARC SiN
stacks (RS + FS)

Laser contact opening
(Base)

Screen Printing + Sintering

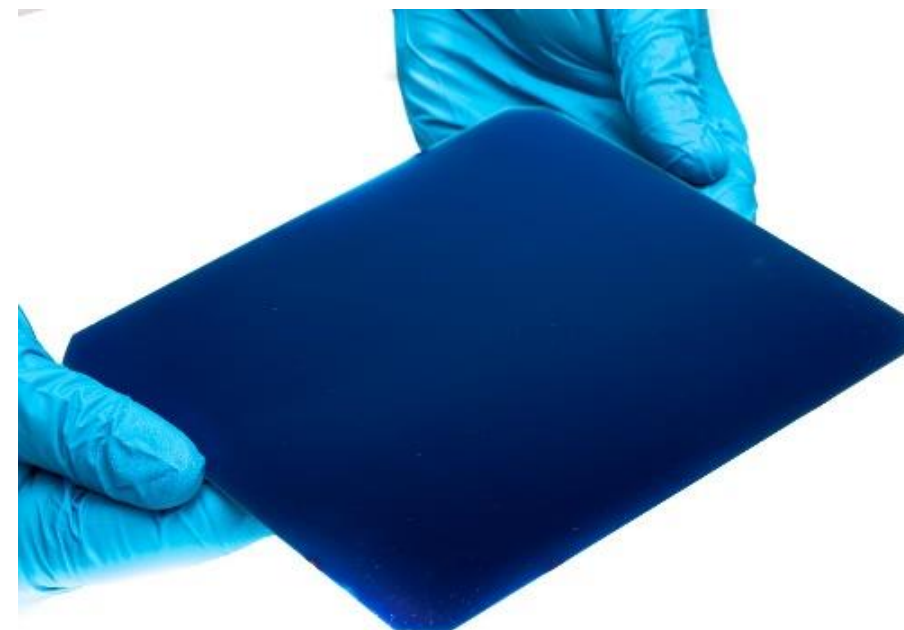
Summary

PERC is king and is still needed to stimulate the supply chain in EU

nPV will become emperor

IBC (ZEBRA) intermediate step

TBC (polyZEBRA) will dominate





© ISC Konstanz e.V. ZEBRA IBC and beyond



WHATEVER
IT TAKES
Thank you

More information: www.isc-konstanz.de