

IBC production at SPIC

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A decorative wavy line at the bottom of the slide, transitioning from orange on the left to red in the middle, and then to green on the right.

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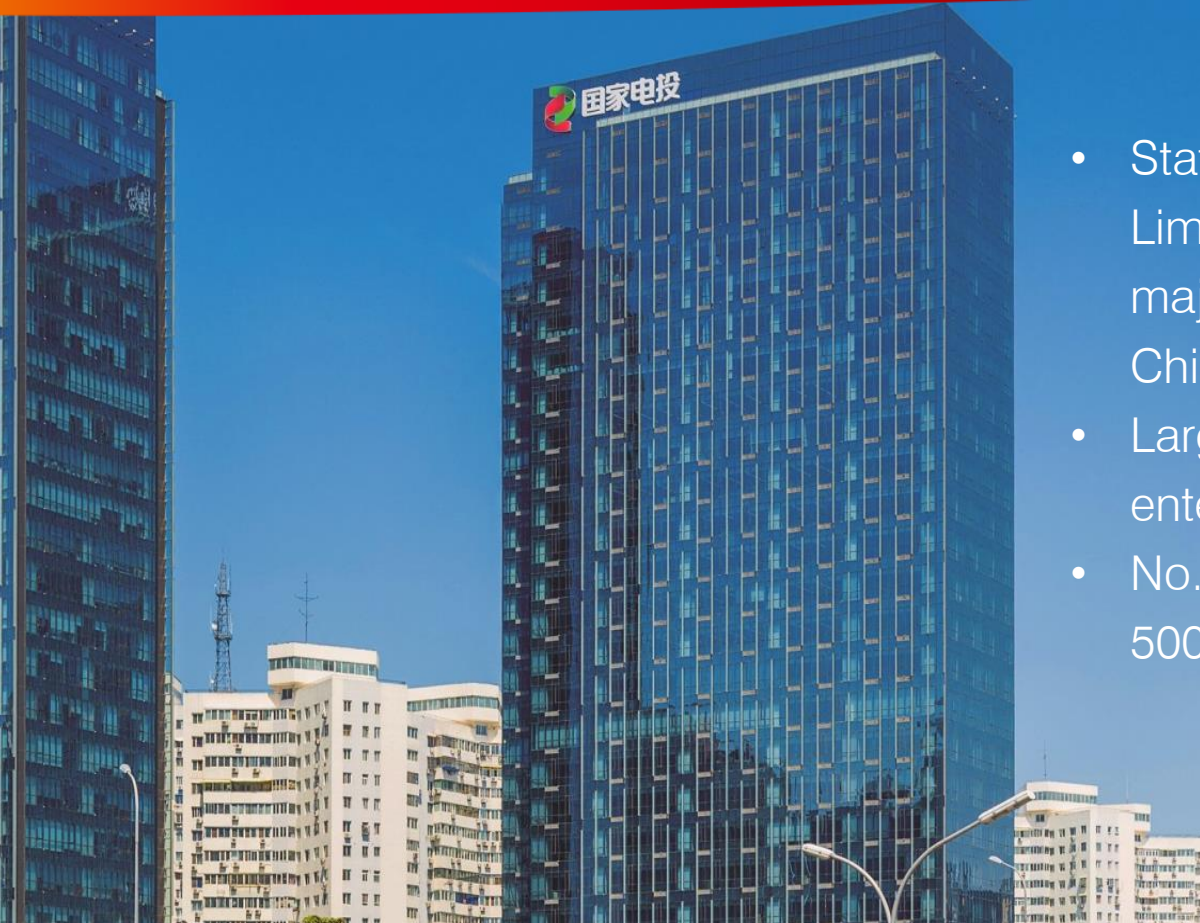
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Introduction of SPIC Solar

国家电投太阳能公司简介

PART 01



- State Power Investment Corporation Limited (SPIC) is one of the five major power generation groups in China
- Largest solar power generation enterprise in the world
- No. 293 among the Fortune Global 500 in 2021

35GW Solar Power Rank 1st



85GW Thermal Power

24GW Hydropower



187GW in total

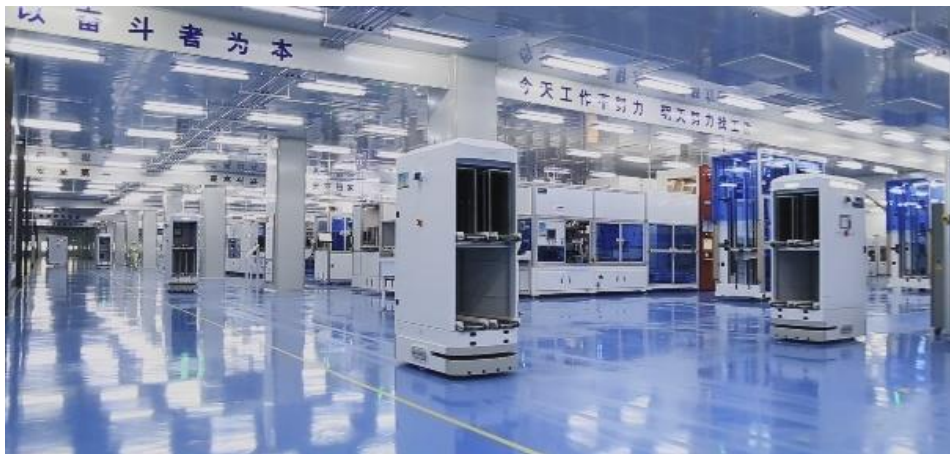


8GW Nuclear Power

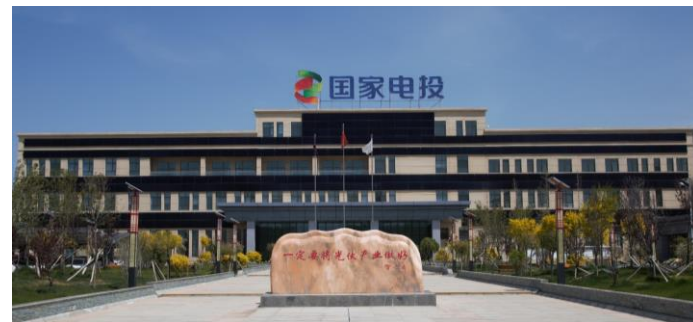
35GW Wind Power



- Qinghai Huanghe Hydropower Development Co., Ltd. Xining Solar Power Branch (SPIC Solar) is a fully owned subsidiary of SPIC
- Annual production capacity of 1.1 GW solar cells
- 200 MW n-type IBC cell and module line is located in Xining city, Qinghai province, northwest China, commissioned at the end of 2019.



n-type IBC Production Xining



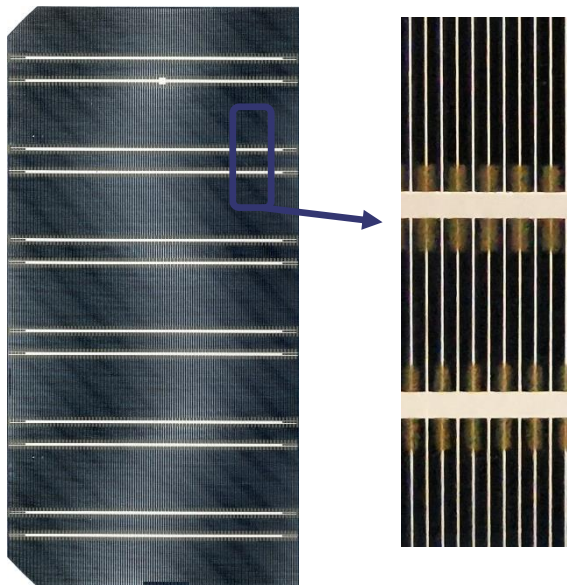
Basic of the cell and manufacturing

电池制造基础介绍

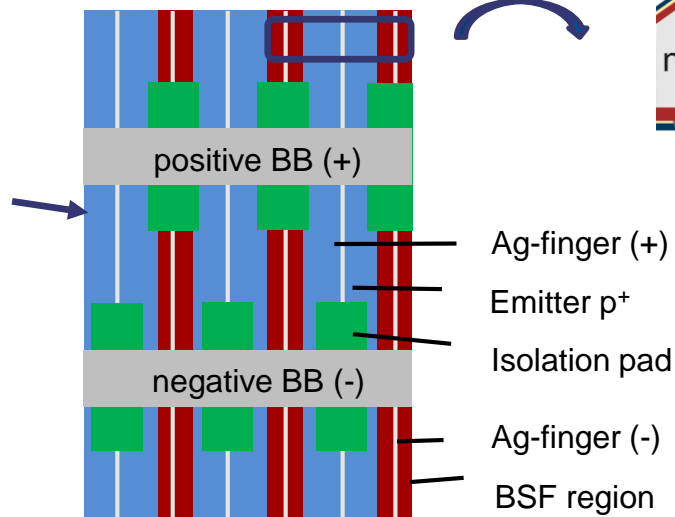
PART 02

The stripes of the ZEBRA

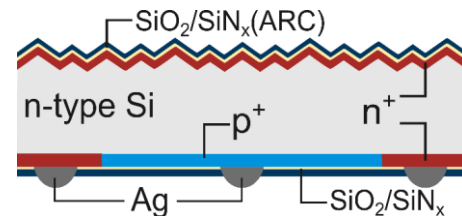
Photo of rear side



Schematic drawing



Drawing cross section



The stripes are p⁺ and n⁺ doped regions of optimum width

PERC process steps

SDE and Texture

POCl₃ Diffusion

PSG and Etching

PECVD Rear side

PECVD Front side

Laser LCO

Screen printing

Additional process steps for ZEBRA

PECVD rear (masking)

Alkaline SDE

BBr₃ Diffusion

BSG etching

Only 4 additional production steps, (Laser is used in different way)

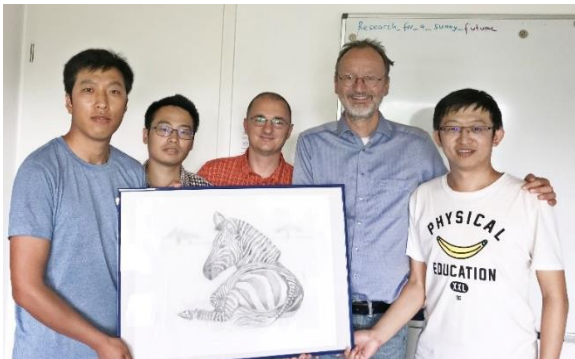
Proven equipment base

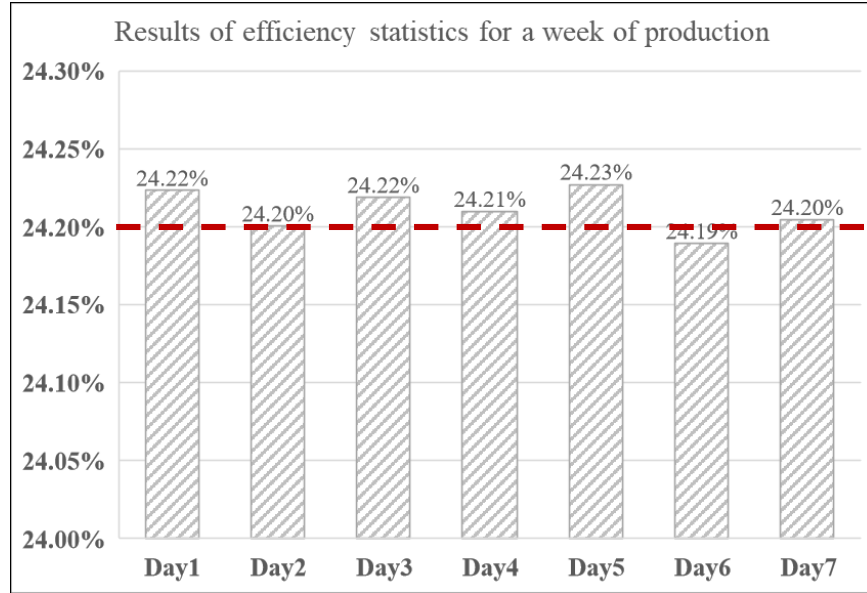
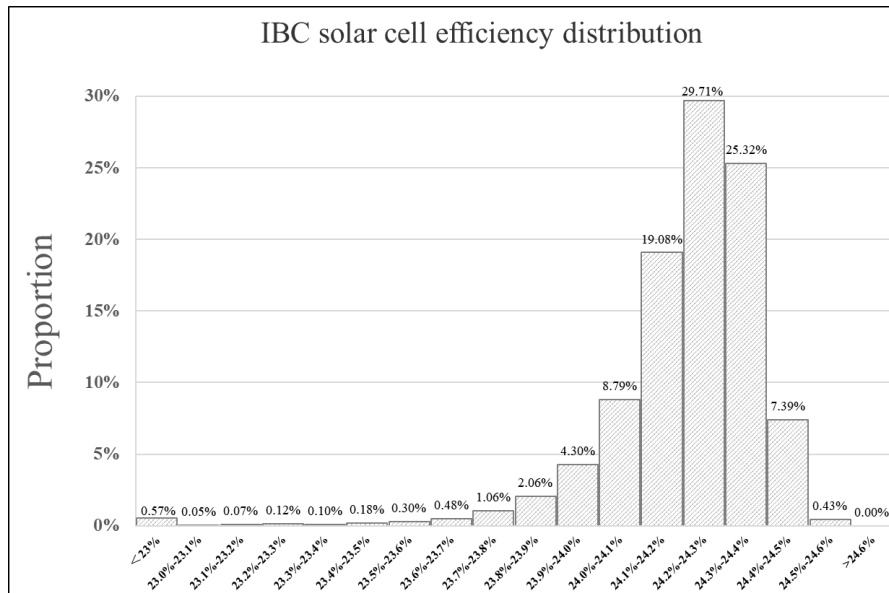
All additional steps can be performed standard equipment, proven in mass production

PECVD tubes
Diffusion furnace
Batch etching
No AlOx needed!

Production line for ZEBRA IBC solar cells was ramped up from Q4-2019 to Q1-2020 by a team of process experts from SPIC and ISC Konstanz

1st mass production of IBC cells in China





	Voc (V)	Isc(A)	FF(%)	Eta(%)
average	0.700	11.83	80.15	24.21
Best cell	0.704	11.86	80.64	24.60

IV data for a week of production, 4/2022

Month*	Aug 22	Sep 22	Oct 22	Nov 22
Unit	MW	MW	MW	MW
Actual monthly capacity	12.13	19.92	19.63	18.2
Calculate annual capacity	146	239	236	218

*monthly reporting from 21th of previous month until 20th of actual month

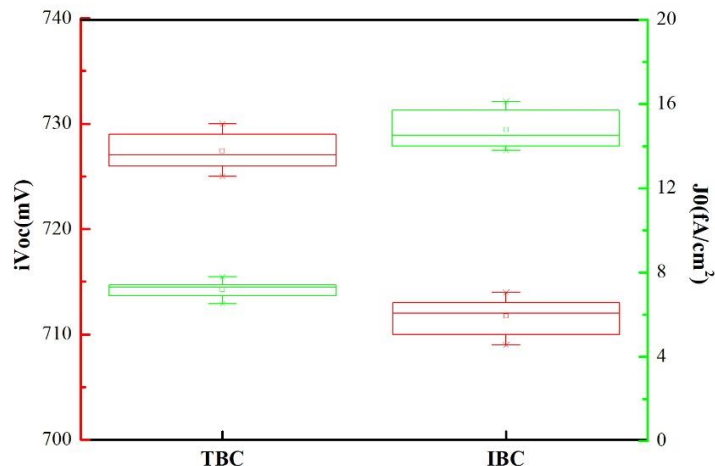
Production is now increased to full capacity fulfill customer orders

TOPCon contacts + IBC cell = TBC cell

We work on the integration of passivating contacts into a cost effective process flow for mass manufacturing.

Cell precursor

Group	Anneal	Lifetime(μ s)	iVoc(mV)	J0(fA/cm ²)
IBC	Y	2845	712	14.5
TBC	Y	4124	727	7.4



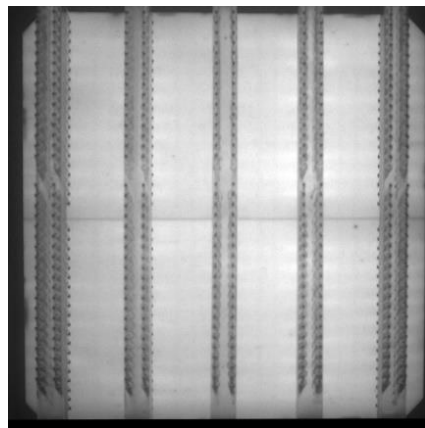
TOPCon contacts + IBC cell = TBC cell

We work on the integration of passivating contacts into a cost effective process flow for mass manufacturing.

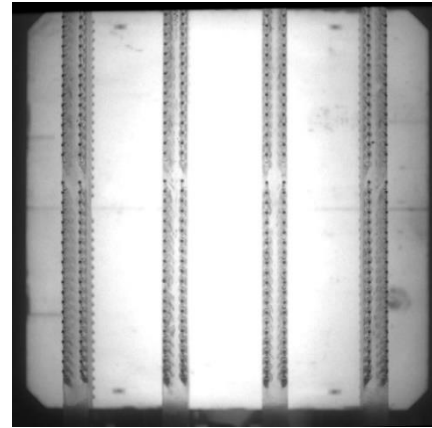
Electrical performance (IBC vs. TBC)

Group	Eta	Isc	Voc	FF	Rs
IBC	24.21%	11.83	0.700	80.15	0.0027
TBC	24.70%	11.72	0.719	80.43	0.0019

Electro luminescence



IBC

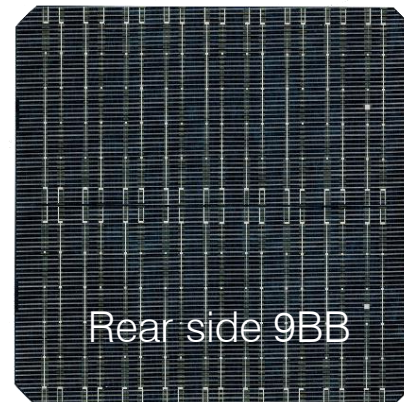


TBC

ZEBRA Solar Cells

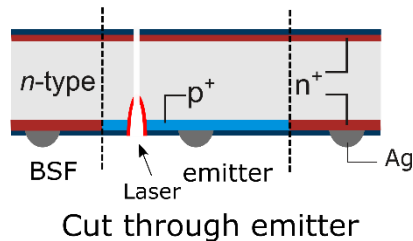
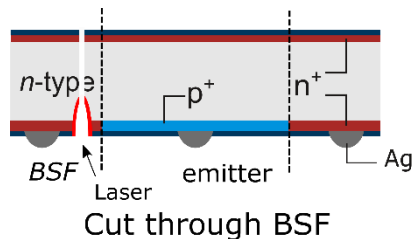
ZEBRA 太阳能电池

PART 03

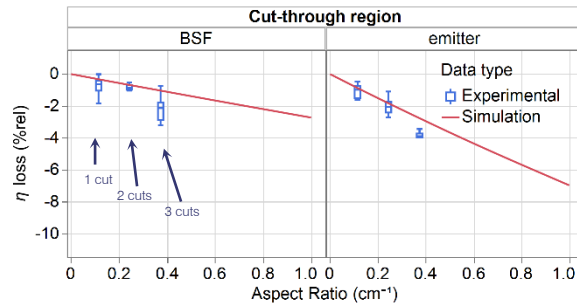


Two product versions are available

- 6 BB cells easy integration with (modified) standard equipment
- 9 BB cells with reduced consumption of metal pastes
- **Both cell version are highly bifacial! (BF > 70%)**



@ 1 sun irradiance



@ 0.25 suns irradiance

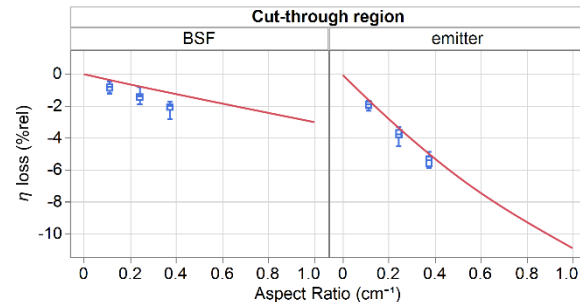


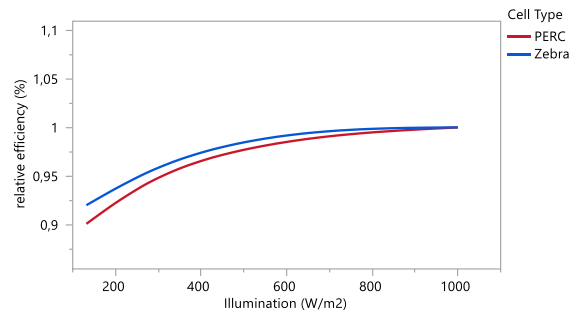
Fig. Relative efficiency loss by cutting as a function of AR and cut-through region

- ZEBRA IBC cells can be cutted in BSF region.
- This results in much smaller losses than cutting through a emitter region, especially at low irradiance

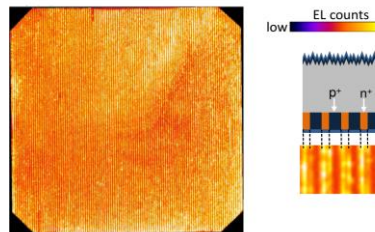
N. Chen, F. Buchholz, D. D. Tune, O. Isabella and V. D. Mihailetschi, "Mitigating Cut Losses in Interdigitated Back Contact Solar Cells," in IEEE Journal of Photovoltaics, 2022, doi: 10.1109/JPHOTOV.2022.3208507.

- Low temperature coefficient
- Good low light performance
- Low break down voltage
- Distributed junction

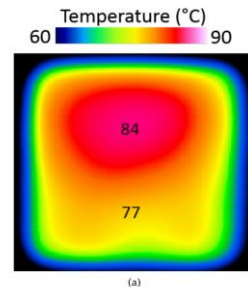
Power is dissipated in reverse bias conditions over a larger area -> cells stay at a lower temperature compared to cells with more localized breakdown -> lower risk for damaging encapsulant



Comparison of performance at low irradiation of 5 commercial ZEBRA IBC cells versus 5 commercial PERC cell from major manufacturer, ISC 2020

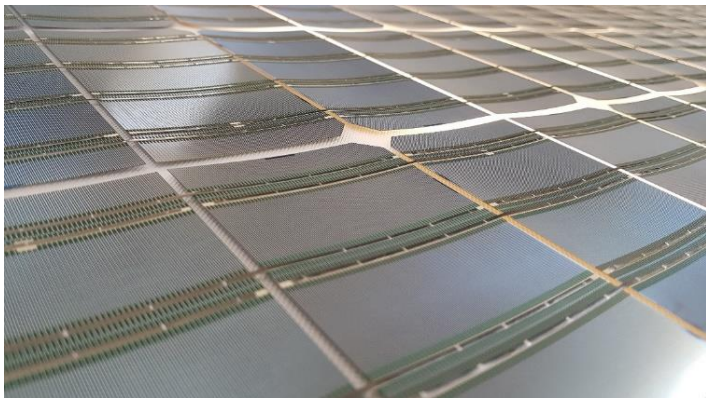


Reverse biased EL image (ReBEL) of cell operated at -7,7A. Magnification centre in small image



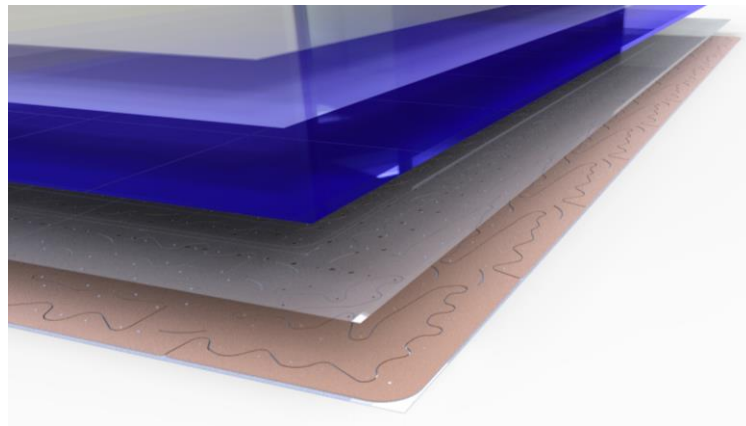
IR picture of mini module operated at -8,5A (pictures from PhD, Haifeng Chu, University Konstanz, 2019)

Ribbon based soldering



- Standard ribbon and soldering
- Only adjustment of stringer required
- Use of half cells recommended

Conductive back sheet (CBS)



- Flexibility on module layout
- Pick-and-place process with low mechanical stress on cells

Further, processes can also be mixed:

- Ribbon in combination with adhesives or LT solder

Modules

组件

PART 04

Elegant Series

Mono/ Dual Glass Series



SPIC 120Half-Cell Black

■ Mono-Glass :375/380/385W

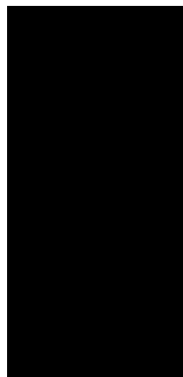
■ Dual-Glass:370/375/380W



SPIC 132Half-Cell Black

■ Mono-Glass :415/420/425W

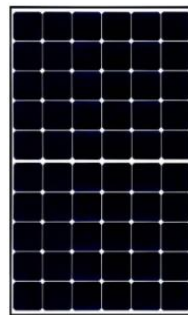
■ Dual-Glass:410/415/420W



SPIC 144Half-Cell Black

■ Mono-Glass :450/455/460W

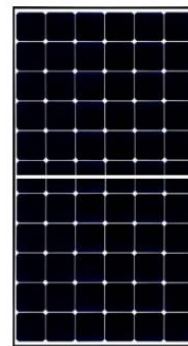
■ Dual-Glass:445/450/455W



SPIC 120Half-Cell White

■ Mono-Glass :385/390/395W

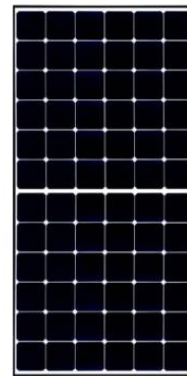
■ Dual-Glass:380/385/390W



SPIC 132Half-Cell White

■ Mono-Glass :425/430/435W

■ Dual-Glass:420/425/430W



SPIC 144Half-Cell White

■ Mono-Glass :460/465/470W

■ Dual-Glass:455/460/465W

High Performance Series

Mono/ Dual Glass Series

- Dual Glass version is prepared for bifacial use
- Worldwide first bifacial IBC modules -> combining the best of all worlds!

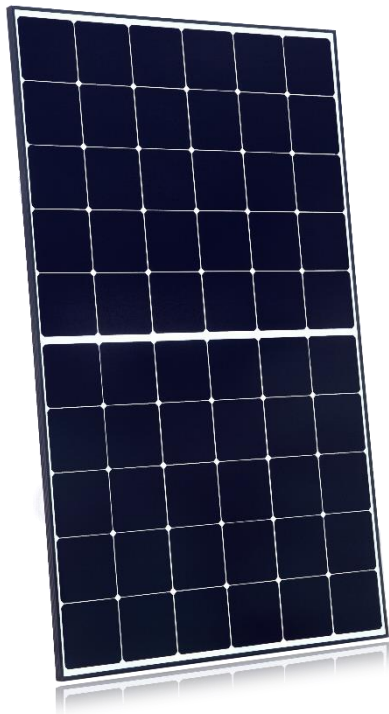
ANDROMEDA 2.0 385W

Elegant Series (Black)

FEATURES

- Up to 21.5% Module Efficiency
- All Black design
- 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





ANDROMEDA 2.0

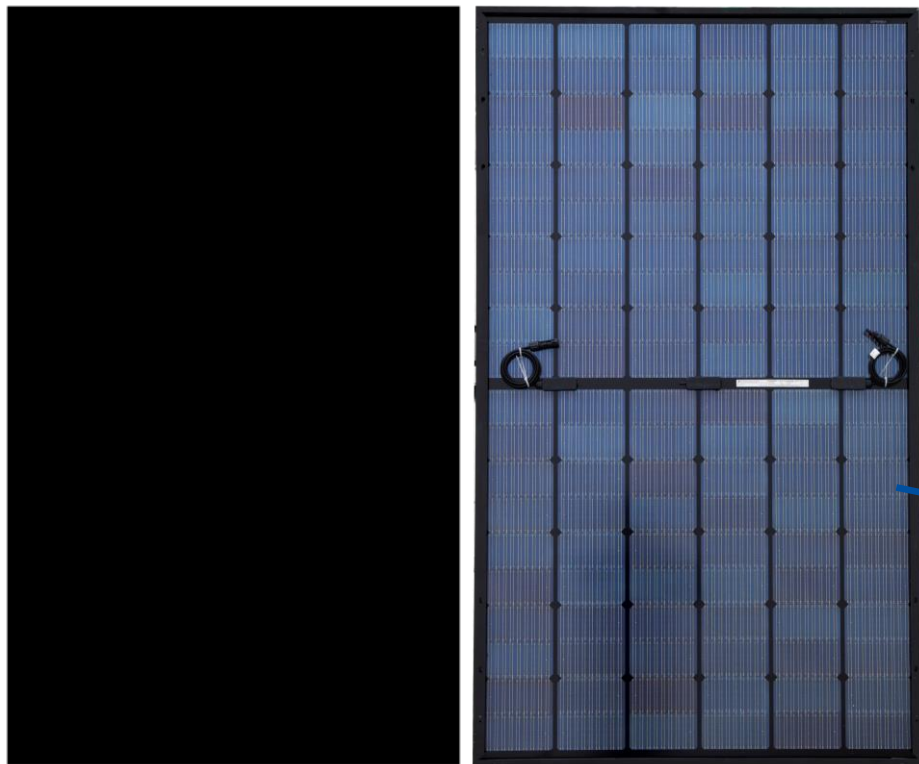
390W

High Efficiency Series

FEATURES

- Up to 22.0% Efficiency
- 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

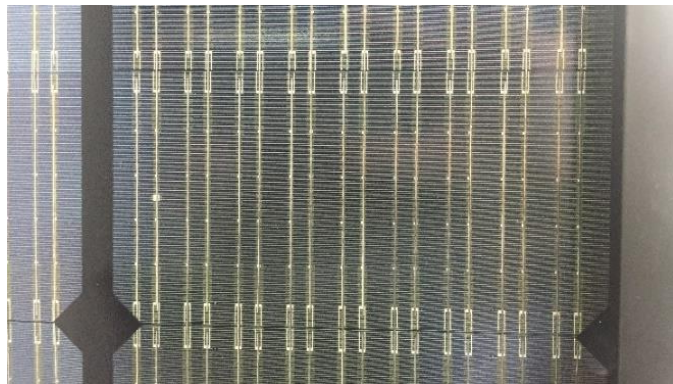


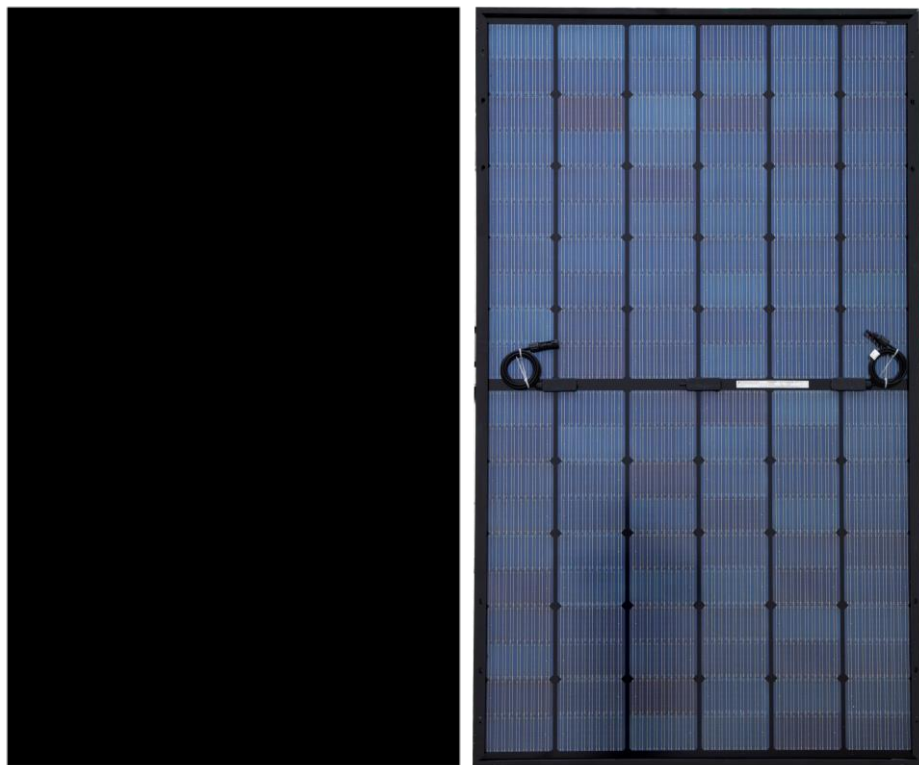


ANDROMEDA 2.0

Elegant Bifacial Series (Black)

- Glass/Glass, black, white or transparent bifacial
- Gapless cell interconnection





ANDROMEDA 2.0

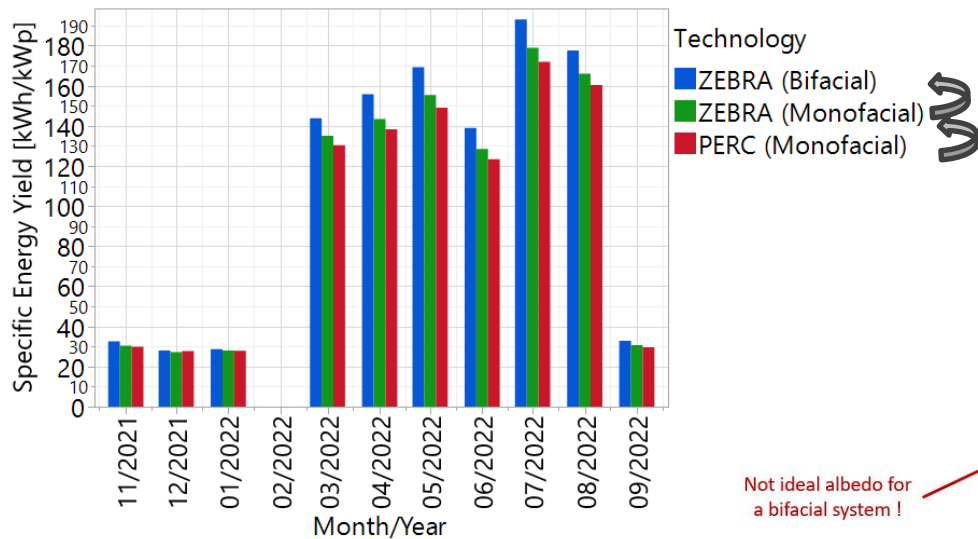
Elegant Bifacial Series (Black)

- Glass/Glass, black, white or transparent bifacial
- Gapless cell interconnection

Side (backsheet)	Isc (A)	Voc (V)	FF (%)	Pmpp* (W)	BF (%)
Front (black)	11.2	41.6	78.7	365.8	
Rear (black)	8.2	41.2	80.5	271.6	74.3
Front (transp.)	11.2	41.6	79.3	368.8	
Rear (transp.)	8.8	41.2	79.5	286.2	77.6

*non-certified in-house measurement at ISC

Yield advantage for bifacial IBC



Bifacial vs. Monofacial = **+6.6%**

ZEBRA vs. PERC = **+2.8%**

More details can be found in:

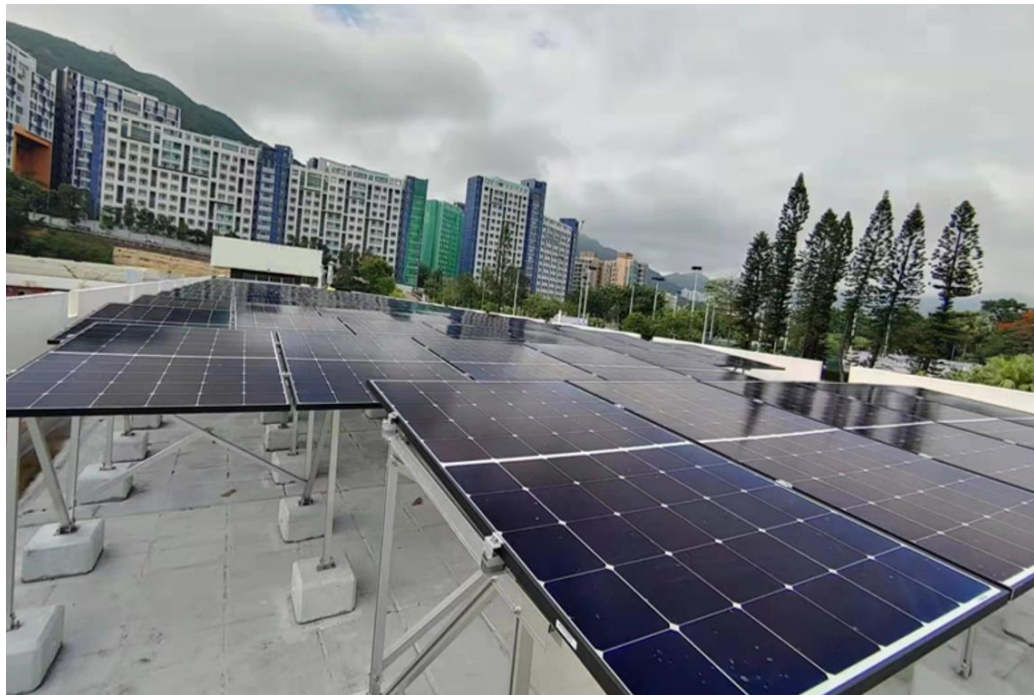
V. Mihailetschi, Bifacial IBC technology: How will it evolve?, presented at the bifiPV-workshop 2022, Ankara

Not ideal albedo for a bifacial system !



Test installation of ISC, in Konstanz, early module version based on G1 cell

Bifacial installation on flat white roof in Hongkong



Other installation examples



Façade system, SPIC HQ, Beijing



Yan'an Cadre College



Semitransparent Carport, Konstanz



Façade Systems, AOK Munich



Baozhigu Conference Center

谢 谢
Thank you