

Back-Contact Solar Technology

Endurans™ Solar
will take you a long way

Peter Pasmans, Lawrence Theunissen, Hugo Schoot

February 16, 's-Hertogenbosch



Welcome to Endurans™ Solar

A global solar materials solution provider



Since June 2021



Since February 2023

We believe that the solar industry has a huge role to play in creating a better, more sustainable future for our planet.

And we are making this a reality by boosting the performance of PV modules and developing solutions that are circular by design.

Endurans™ Solar in a nut shell

Innovative material solutions for solar panel manufacturers

Experts
in polymer
science, co-
extrusion, solar
technology

Production
facilities across
Asia, Europe &
America

Market leader
in co-extruded
backsheets.

Endurans™ HP
*All-purpose
Sustainable*

Market leader
in conductive
backsheets.

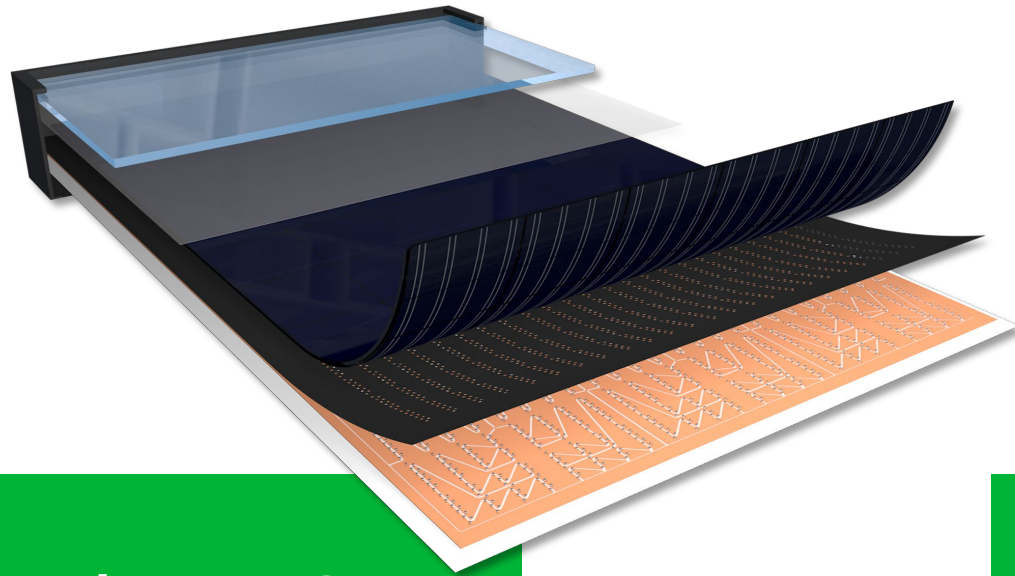
Endurans™ CB
*For high-end
aesthetics &
output*

Pipeline of new
solar films:
Encapsulants
Flex frontsheets
Rear Perforated
Insulators



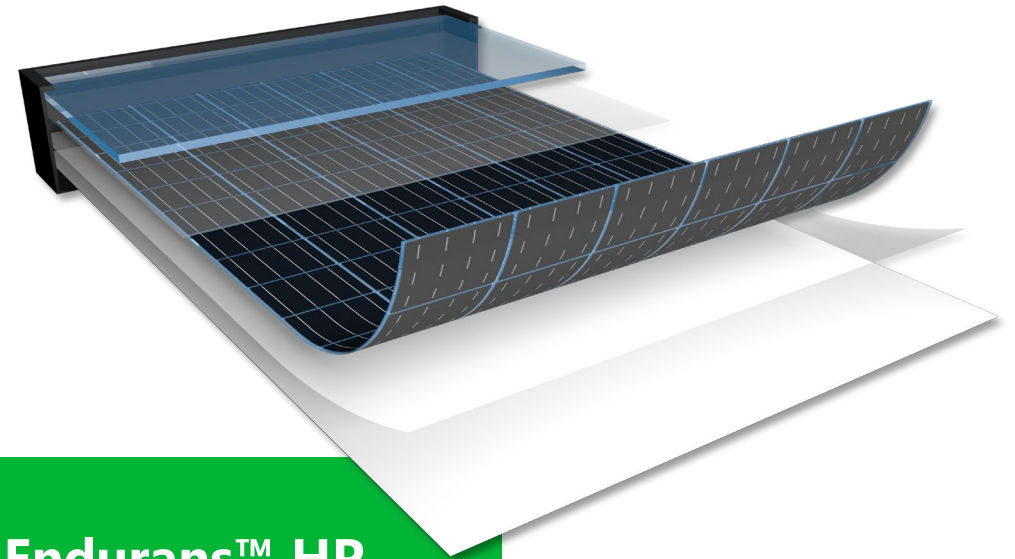
Our products

Game-changers in technology, sustainability and performance



Endurans™ CB

For high-end aesthetics & output



Endurans™ HP

*All-purpose
Sustainable*

Back-contact solar technology

with Endurans™ CB/RI



Back-contact technology for high-power modules

When high power density, flexible design and aesthetics count



Residential and commercial rooftop



Building Integrated PV



Vehicle Integrated PV



Back-contact module technology

Cells combined with conductive backsheets (CBS)

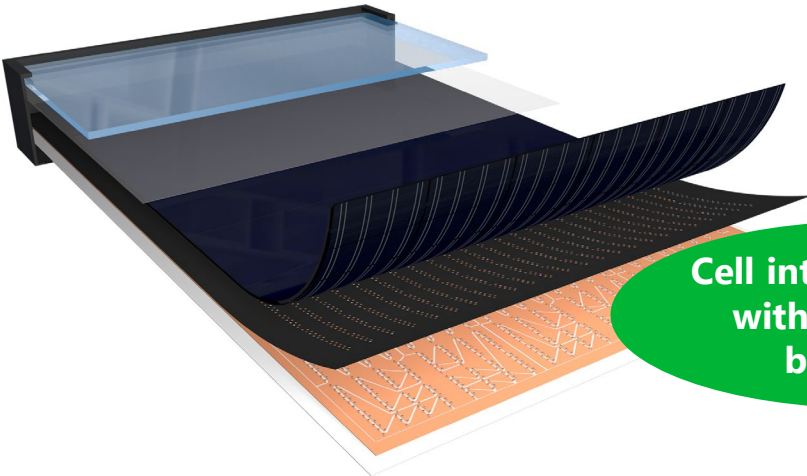
Conventional module technology



Cell interconnection:
via tabbing and stringing

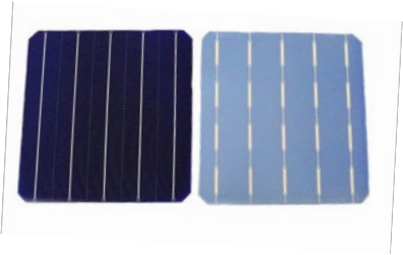


Back-contact module technology

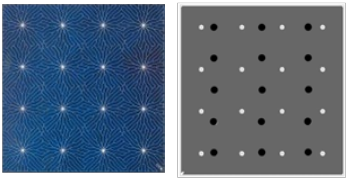


Cell interconnection:
with conductive backsheet

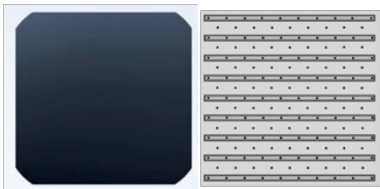
Standard cell



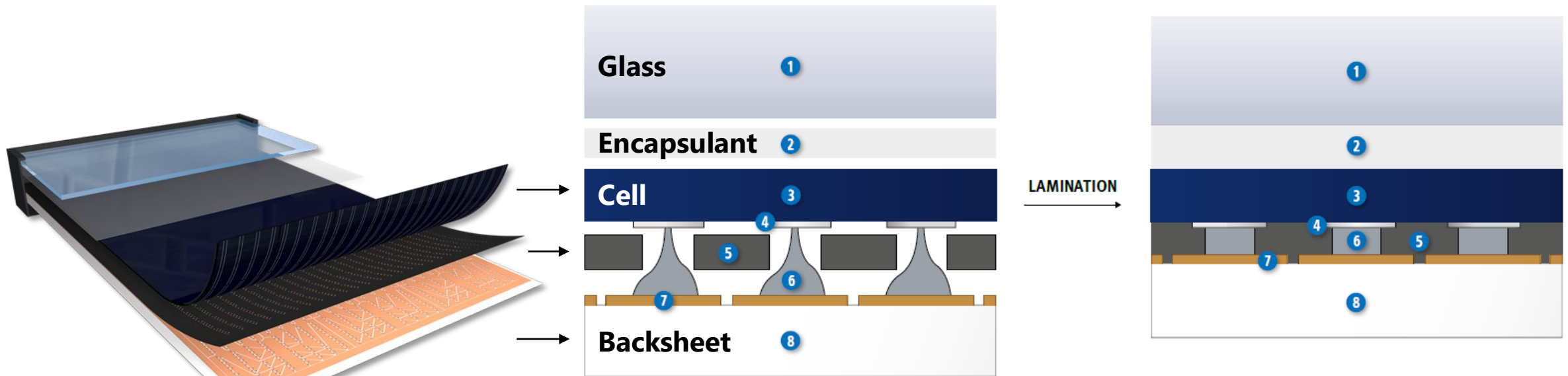
MWT cell



IBC cell



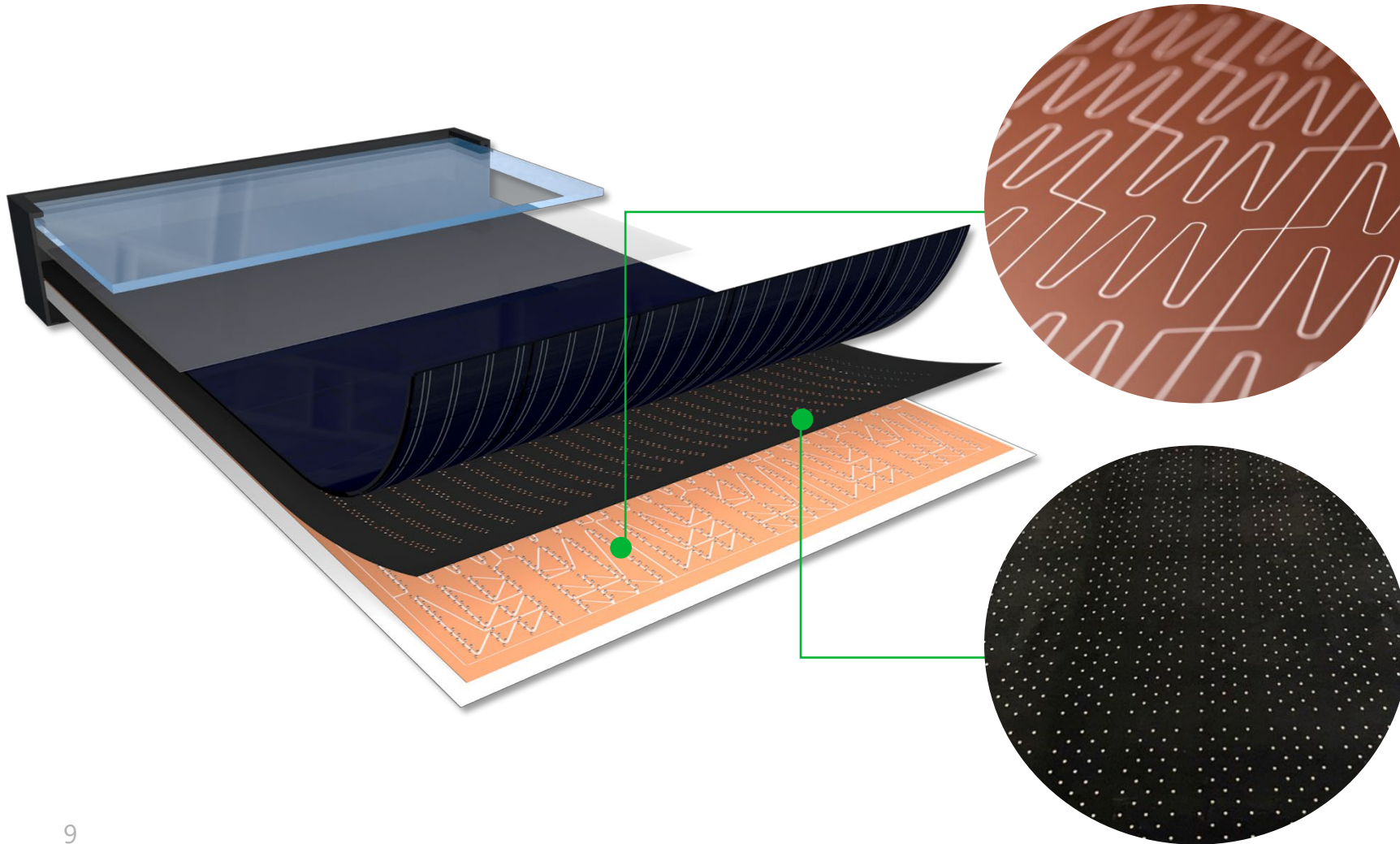
The BC cell interconnection is obtained during the lamination process using a conductive paste



- 4 Cell: rear-side metallization
- 5 Rear Perforated Insulator
- 6 Conductive paste
- 7 CBS: patterned metal layer

Back contact modules with CBS interconnection

Endurans™ Conductive Backsheet (CB) and Rear Insulator (RI) products



Conductive backsheet

- Rear side insulation
- Cell interconnection
- Commercial >5yrs

Rear perforated insulator

- Internal insulation contacts (+/-)
- Holes for contact points
- Black (or white)

Endurans™ Conductive Backsheets

Enabling high power back-contact technology

- Launched in 2018, designed for high power density back-contact modules
- Innovative cell interconnection concept, integrated in the backsheet of the module, allowing all electrical contacts to be positioned **at the rear** of the solar cell
- No metallization at the front of the cell, so more sun can be captured
- Modules with back-contact technology deliver **higher efficiency** and **great aesthetics**
- Flexible design, compatible with different cell configurations

Rear Perforated Insulator (RPI) development at Endurans™

Drive for cost reduction, higher performance and sustainability

- Unique material concept based on the Endurans™ proprietary HPO technology
 - Polyolefin based – fully recyclable
 - Dimensionally stable
 - Excellent flatness
 - Unparalleled adhesion to cells, metal foil and backsheet
- Unique perforation technology
 - High speed
 - High accuracy
 - No risk of chads or ridges

Performance

Superior power density



Superior power density

With Endurans™ CB and RI

• Power density

- Maximal use of area → integrated bussing
- Minimal resistive losses → tapered interconnection
- Reduced operating temperature → heat spreading

• High reliability

- Highly automated manufacturing
- Cell handled only once in module production
- Less risk of cell damage
- Thickness down to 90 μm has been proven
- Improved tolerance to cell defects (e.g. cracks)

WCPEC-8
2022 in
Milan

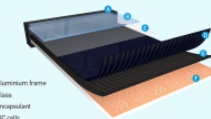
Performance benefits and end-user value of conductive backsheets for back-contacted solar modules



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IBC and CBS: the ideal combination!

Interdigitated back-contacted (IBC) solar cells and conductive backsheets (CBS) are the ideal combination to enable high-efficiency solar modules and are of great value to both the module maker and end-user.



Simulation results which substantiate some of the key advantages of using a CBS for interconnection are presented and the value created for the module maker and end-user is demonstrated by a detailed cost calculation.

About Endurans™ CB

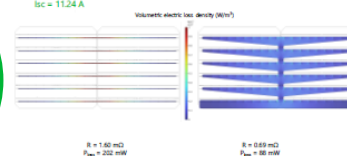
Endurans™ Solar (formerly DSM Advanced Solar, acquired by Worthen Industries Inc. in 2021), is a leading supplier of science-based material solutions for PV modules:

- Endurans™ HP, high-performance polyolefin backsheets which is fully recyclable
- Endurans™ CB, a conductive backsheet for high-efficiency, aesthetically pleasing back-contact solar modules, based on metal wrap-through (MWT) or interdigitated back-contact (IBC) technology.

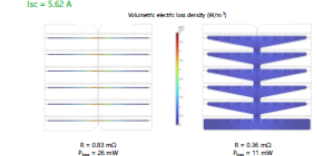
Key advantages of back-contact technology with CBS interconnection

- Higher cell efficiency of back-contacted cells → less (MWT) or no (IBC) front metallization on cell
- Highly automated manufacturing and less risk of cell damage → each cell is only picked and placed once; down to 90 μm thick cells has been proven
- Smaller module area = higher efficiency → no bussing area required (integrated in CBS with flexible pattern design)
- Higher energy output → reduced operating temperature (CBS helps heat spreading) and improved low-irradiance performance (with full cells)
- Reduced electrical losses → shown by Consol simulations:

Full-cell IBC interconnection: ribbon vs CBS



Half-cell IBC interconnection: ribbon vs CBS

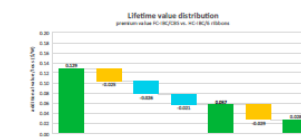


Assumptions: M6 cell size with 6 busbars / polarity; ribbon cross-section: 1.0 x 0.2 mm; CBS thickness: 35 μm; losses in solder paste not included in above simulation.

Value creation for module maker and end user

- A detailed cost-analysis for different IBC interconnection options has been performed using optical and electrical simulation results as input.
- The table below shows the performance difference between modules using 6 busbar Zebra IBC cells for ribbon vs CBS interconnection.
- The power density is ~2.9% (for HC) or ~3.4% (for FC) higher when using a CBS compared to ribbon interconnection of half cells.
- The specific yield is ~1.5-3.5% higher due to thermal and low-irradiance benefits (see EU PVSEC, 2020, 4AV.1.18)
- The total increase of 4-7% in energy yield with CBS allows for an increased module price vs. ribbon module design.
- The added value of the module across the value chain is presented in the graph below.

	ZEBRA IBC Half cell + 6 Ribbons	Zebra IBC Half cell + CBS	Zebra IBC Full cell + CBS
Cell efficiency	24%	24%	24.2%
# Cells	6x20 HC M6	6x20 HC M6	6x10 FC M6
Module area (m²)	1.80	1.77	1.76
CTM loss (kWh/m²)	3.26%	2.66%	2.78%
Module efficiency	20.7%	21.3%	21.4%
Module energy density (Wh/m²)	207	213	214
Module power (kW)	324	328	328



Conclusions

The results presented in this work demonstrate that using conductive backsheets for interconnection of IBC cells, compared to ribbon interconnection, can improve module efficiency by ~0.6-0.7% (absolute) due to reduced resistive losses and reduced module area. An additional value of ~0.03 €/Wp can be created for both the end-user and the module maker.

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CBS increase performance vs other technologies

Comparison of key performance parameters

- Performance calculations based on a combination of simulation tools:



Cell → Interconnection →	PERC Half cell 12 BB	MWT Full cell CBS	IBC Half cell ribbons	IBC Half cell CBS	IBC Full cell CBS
# Cells	6x20 HC M6	6x10 FC M6	6x20 HC M6	6x20 HC M6	6x10 FC M6
Module area (m ²)	1.86	1.76	1.80	1.77	1.76
Module power (Wp)	358	368	374	378	378
Module power density (Wp/m ²)	192	209	207	213	214
Specific yield (kWh/kWp)	1100	1138	1122	1138	1160

Value model presented in more detail at Back-Contacted workshop 2022 in Konstanz
Available at: www.endurans-solar.com



Flexibility

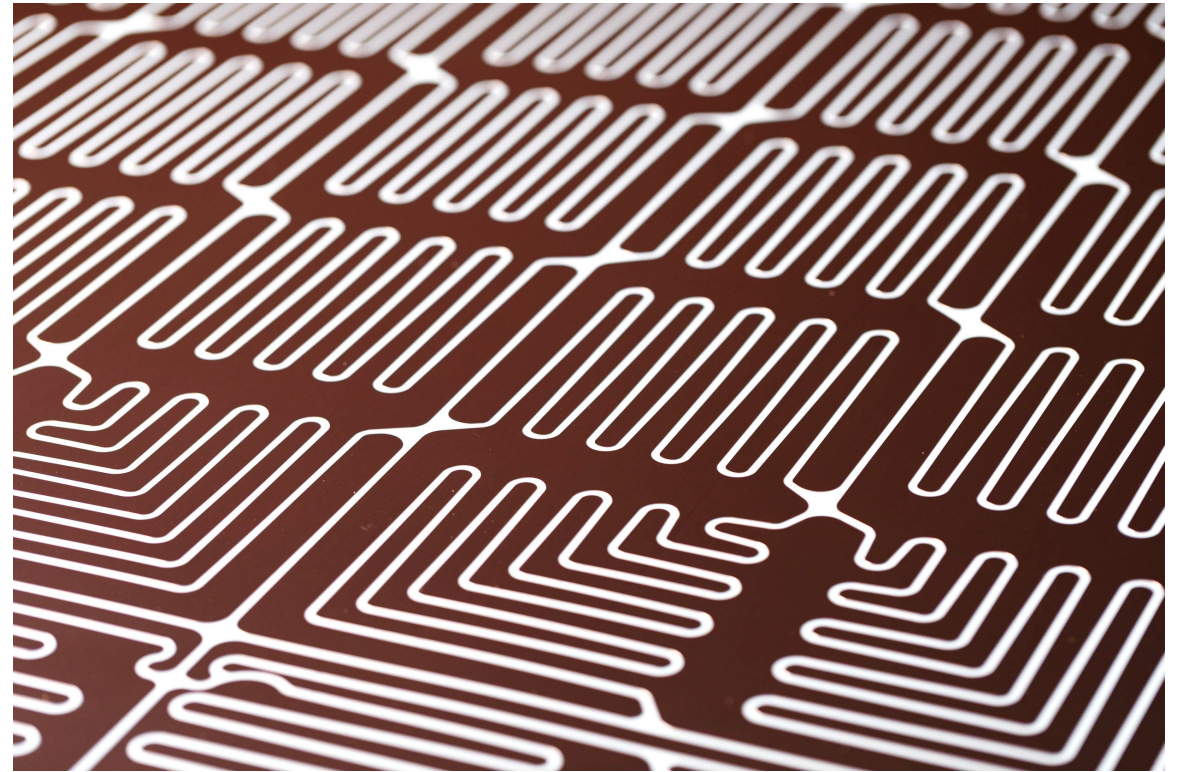
Optimal design freedom



Optimal design freedom

With Endurans™ CB

- **Freedom to optimize string layout**
 - Bussing integrated in CBS design
 - Optimal use of area
 - Irregular shapes
 - Shading tolerance
- **Ideal for curved modules**
 - Cell layout can be optimized for curvature
 - Reduced stress on cells (no ribbons)



Aesthetics

Great appearance



Great appearance

With Endurans™ CB: less/no cell metallization - no ribbons – all black



Conclusions

Back contact Solar Technology

Endurans™ CB will take you a long way



Aesthetics




Flexibility



Performance

How can we help?

 www.endurans.com

 info@endurans.com



Same sun. More power.TM

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