Thin-Film Solar Energy

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08/04/2019

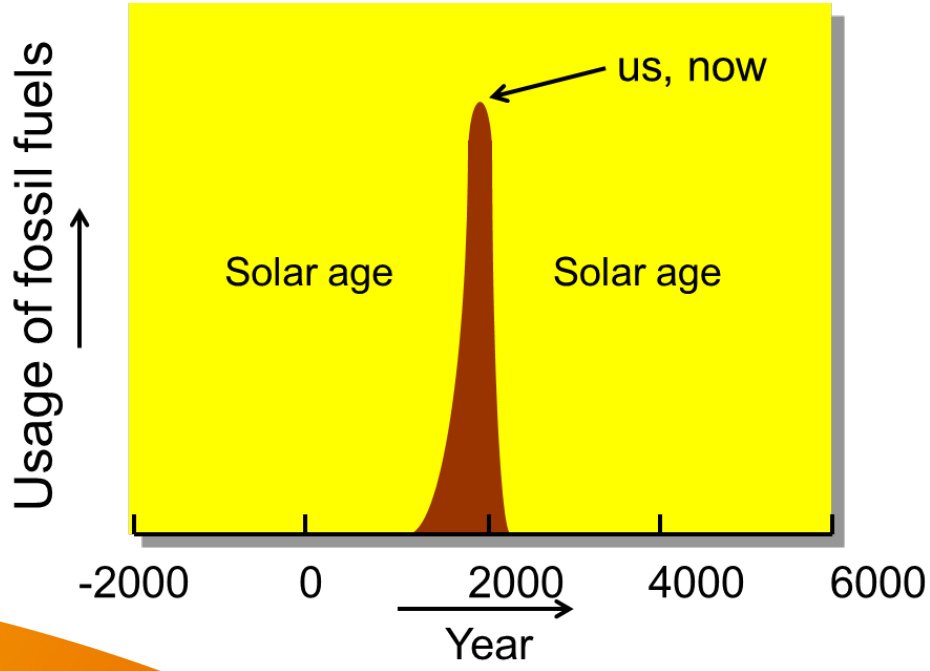
THIN FILM SOLAR RESEARCH
SOLLIANCE
SOLAR RESEARCH LED BY IMEC AND TNO

Solliance Vision

SOLLIANCE

Solar Energy

- **From Solar to Solar: *back to normal***



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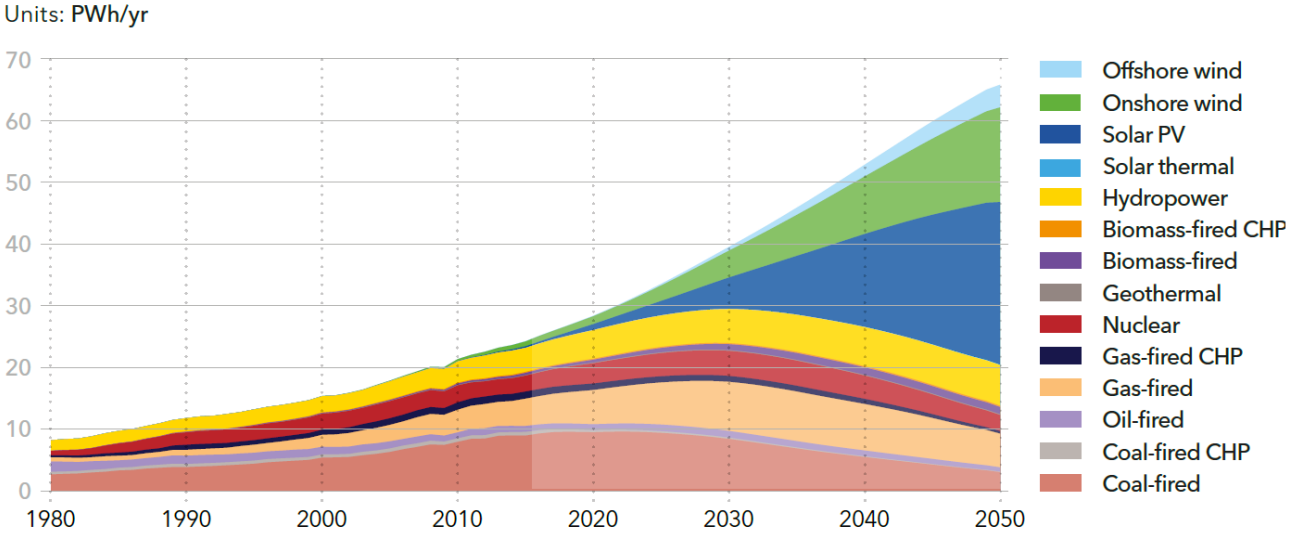
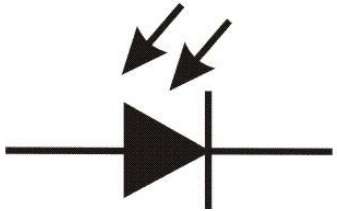
Solar Energy

- **World electricity generation by power station type**

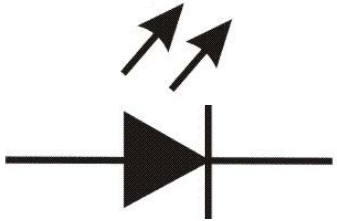


Source: Energy Transition Outlook 2018, DNV GL

Solar Cell

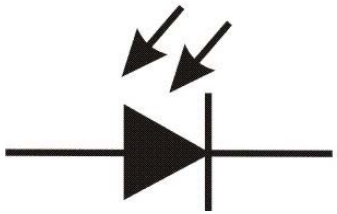


Photovoltaic Cell



LED

Solar Cell



Photovoltaic Cell

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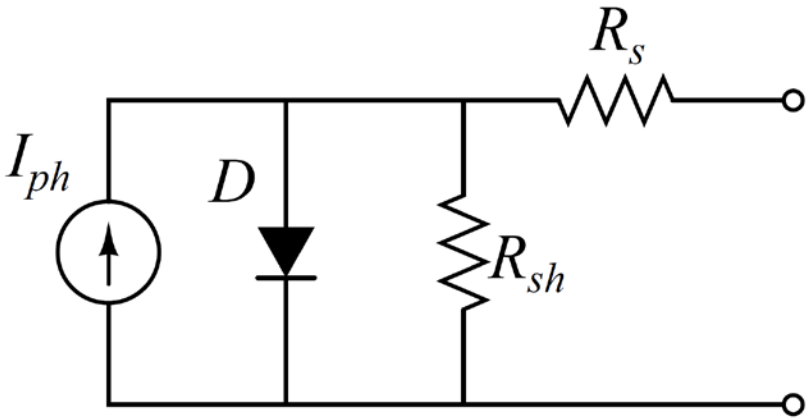

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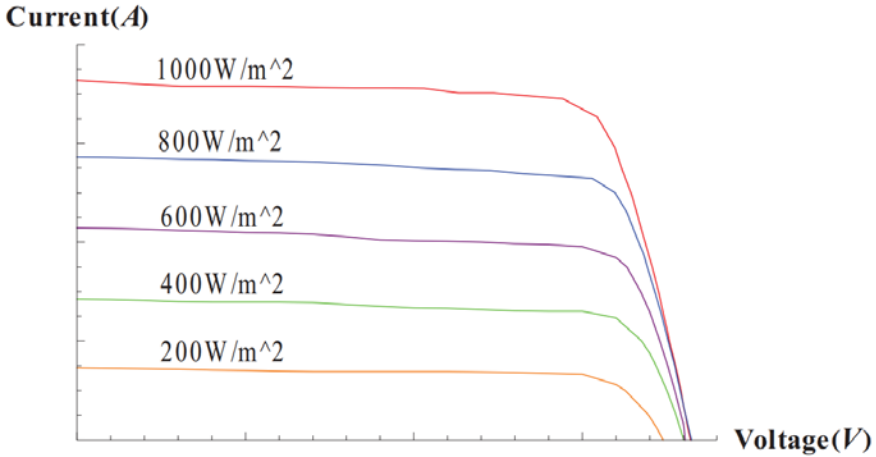
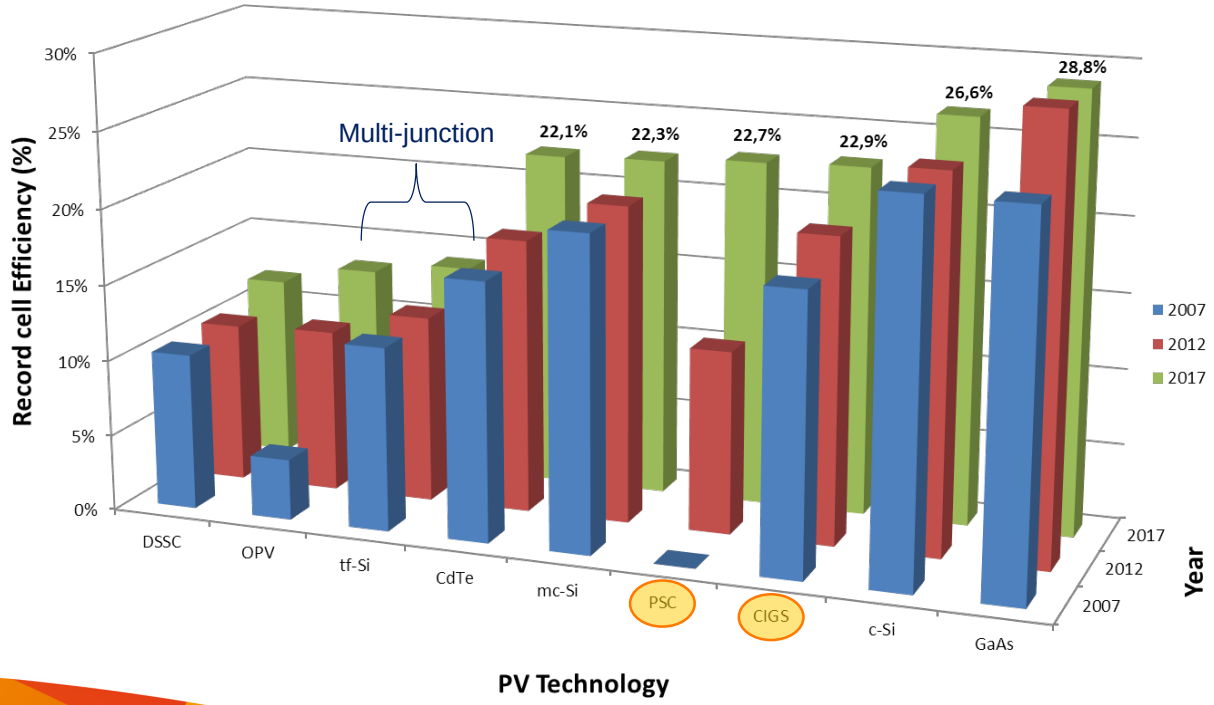
Solar Cell



Solar Cell Materials

- **Crystalline Silicon**
  - Monocrystalline silicon (c-Si)
  - Polycrystalline (multicrystalline) silicon (mc-Si)
- **Thin Film**
  - Gallium Arsenide (GaAs)
  - Cadmium Telluride (CdTe)
  - Copper indium gallium selenide (CIGS)
  - Perovskite materials

Solar Cell efficiency evolution: 2007 - 2017



- **PSC:**
  - **P**erovskite based **S**olar **C**ells
- **CIGS:**
  - **C**opper **I**ndium **G**allium **S**elenide **S**ufide based solar cells
- **Efficiency:**
  - **PSC** & **CIGS** in between mc-Si and c-Si
- **Maturity (MRL):**
  - **PSC** << **CIGS** < CdTe <Si
- **Cost targets ($/m^2):**
  - **PSC** << CdTe < **CIGS** < (m)cSi
  - **PSC** < 20$/m^2

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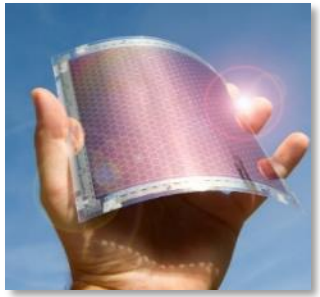
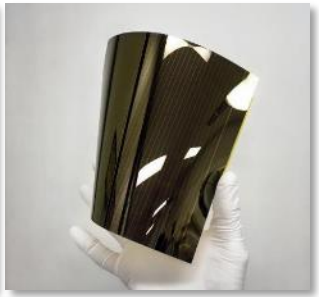
What is Solliance?

Unique collaboration of Industry, Universities and Research & Development Institutes





- Founded in 2011, based on 20 years experience
- > 80 FTE
- > 6.000 m^2 Labs
- Open research lines for CIGS and Perovskite Thin film PV
- >13,5 M€ turnover/year
- >70 granted patents

➡ https://solliance.eu/news/

Solliance Organization: 3 Research Programs

From Lab to Fab

Through the value chain

New Seeds

PSC

efficiency, stability, up-scaling until packaged standard modules

Thin Film PV Module & Packaging Technologies

lower cost processes, customized modules, thin-film packaging

Thin Film PV Integration Technologies for:

IIPV, BIPV, VIPV*

COMPETENCIES - PROJECTS

- Front-end /Deposition technologies
- Back-end / Customization
- Encapsulation technologies
- Integration Concept development
- Life time testing & modelling
- Business Case & Cost modelling
- Mechanical & electrical integration

*IIPV: Infrastructure Integrated PV
BIPV: Building Integrated PV
VIPV: Vehicle Integrated PV

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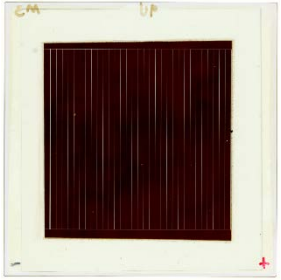
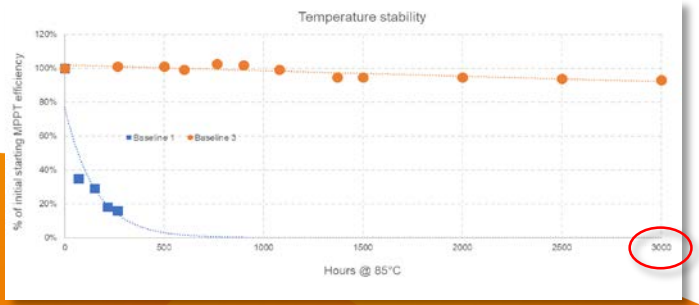
Some highlights of the Perovskite PV Program

▪ S2S opaque on glass

- For PV utility plants & BAPV
  - Up-scaled module 10x10cm^2: **13,7%**

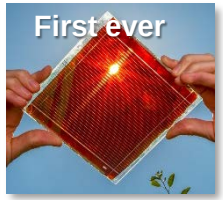


  - Very good thermal stability
  - **≥ 93%** after 3.000 hrs@85°C



▪ Semi-transparent on glass

- For Si/PSC tandems :
  - **27,1%** tandem cell efficiency
  - **25,3%** 4 cm^2 mini-tandem module



  - Up-scaled module 10x10cm^2: **13,6%**

▪ Translucent on glass

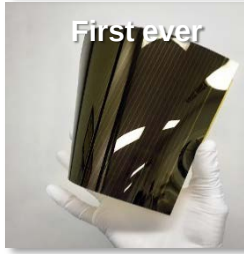
- For PV windows or CE's

10% & 10% TrL

6% & 50%TrL

▪ Roll-to-Roll on PET

- For (m)any application(s)
  - > 2.000 meter of PER produced
  - **12,2%** 10cm^2 mini-module;**16%** cell



10,1% (opaque)

5% & 40%TrL

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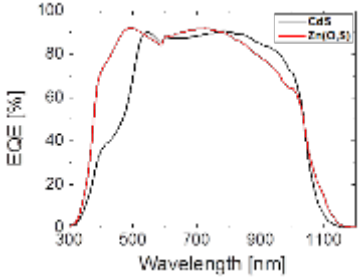
Some highlights of the CIGS → MOD PV Program

▪ Front window:

- Replacement of solution processed CdS by sALD ZnO:S
- Non-toxic and better performance



- **On glass with S2S sALD: + 0,5% absolute**
- **On flex (PI) with R2R sALD: + 1% absolute**

First ever

▪ Lowering CIGS production costs

- Vacuum → ambient (ECD)
- Material usage
- S2S → R2R

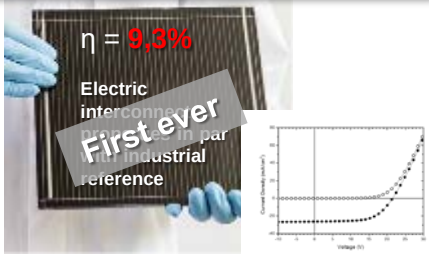
Champion Cell (0.5 cm², no AR):

Efficiency: 15.6%

World record: 17.3% (with AR)

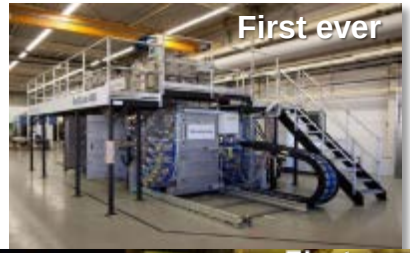
▪ S2S & R2R back-end interconnection

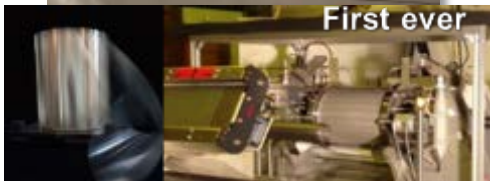
- First complete stack deposition
- followed by fully digital interconnection process
  - Any form/any shape
  - Higher efficiency
  - Higher production yield



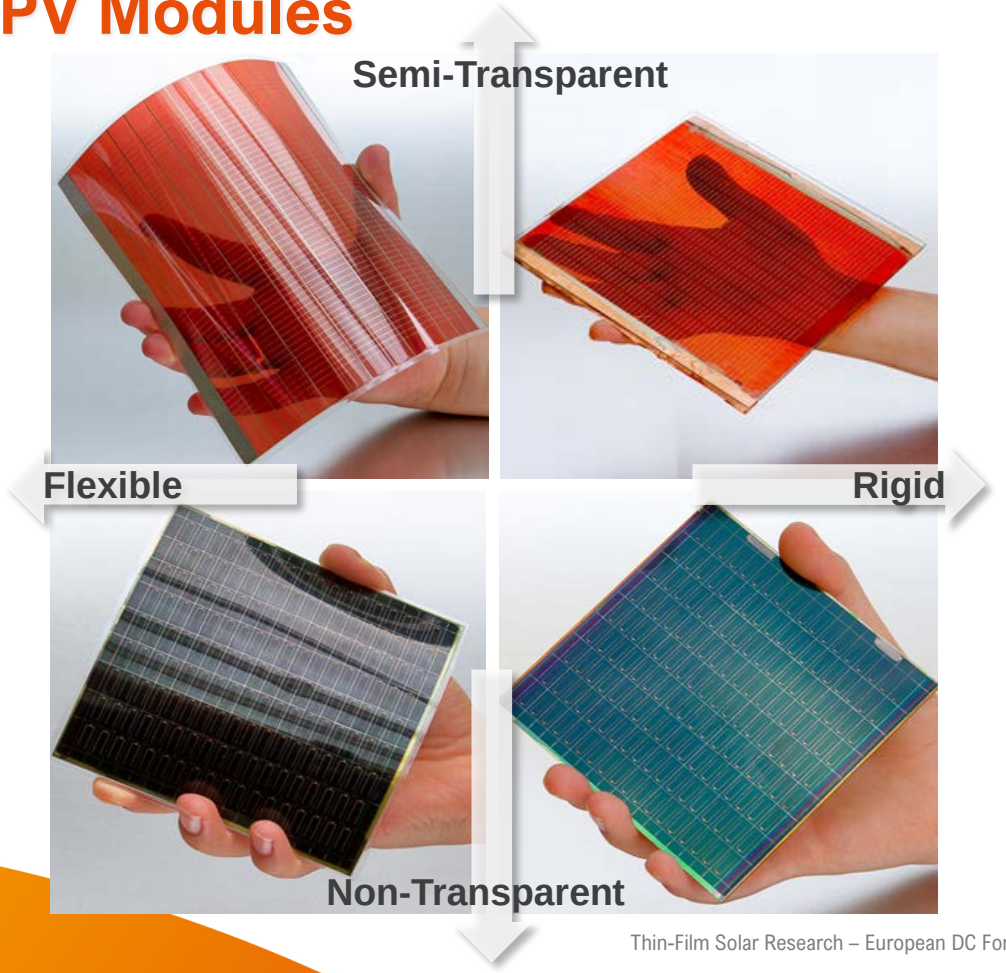
▪ Flexible barriers and packaging

- Two approaches:
- **PECVD** SiNx:
  - Vacuum, TRL 9
- **sALD** Al_2O_3
  - Ambient, TRL 7
- WVTR tune-able between 10^{-3} and < 10^{-6} g/m².day
- Ambient alternative process under evaluation: R2R sALD





Thin Film PV Modules



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Integration Opportunities

Semi-Transparent

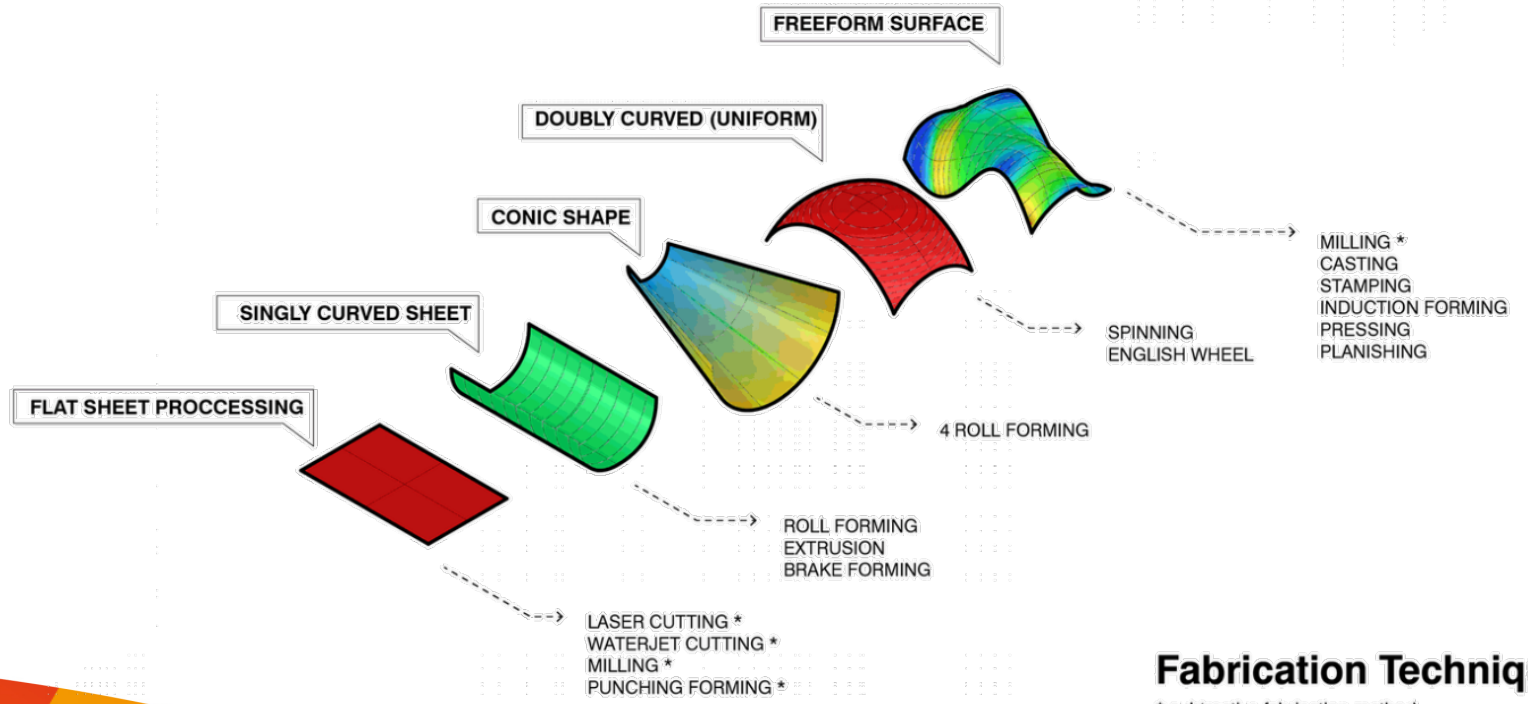
Flexible

Non-Flexible

Non-Transparent

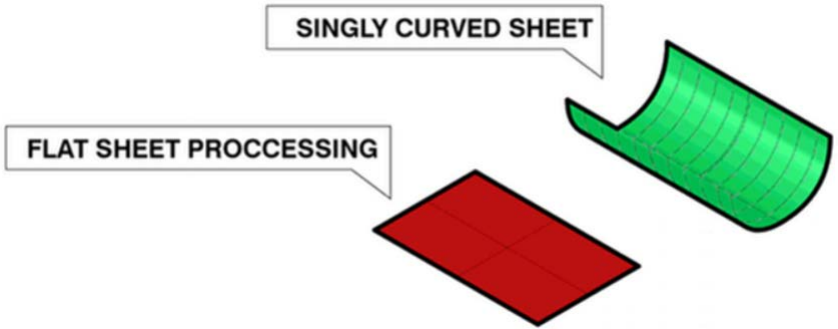
SOLLIANCE

Surface Typology

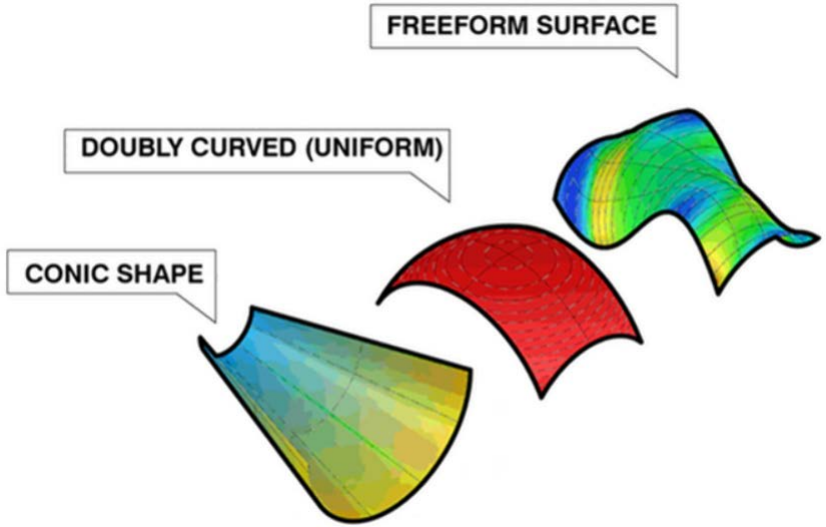


Shaping

- **Bending of material required**

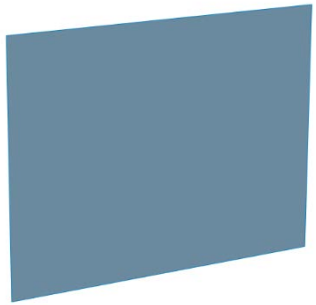


- **Stretching and contracting of material required**

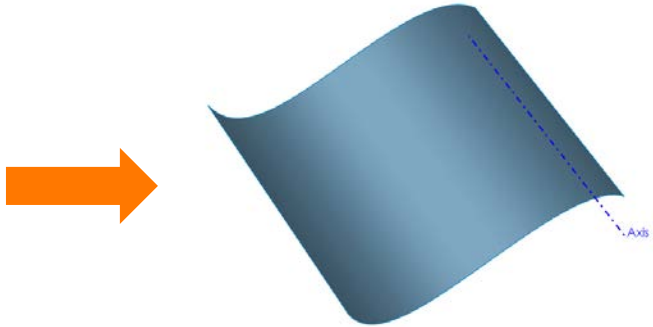


Current Surface Typology for TF-PV

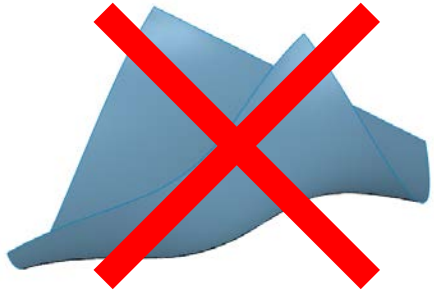
- **Limited to Single Curvature**
  - Curved on one linear axis



2D
Flat



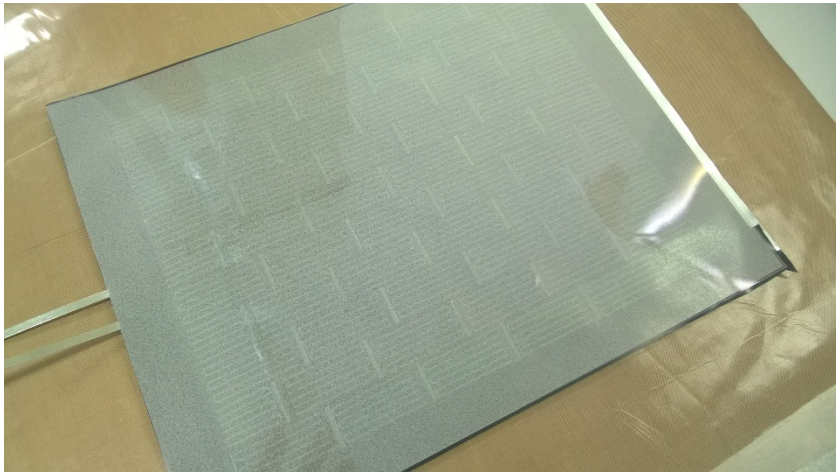
2 ½ D
Single Curvature

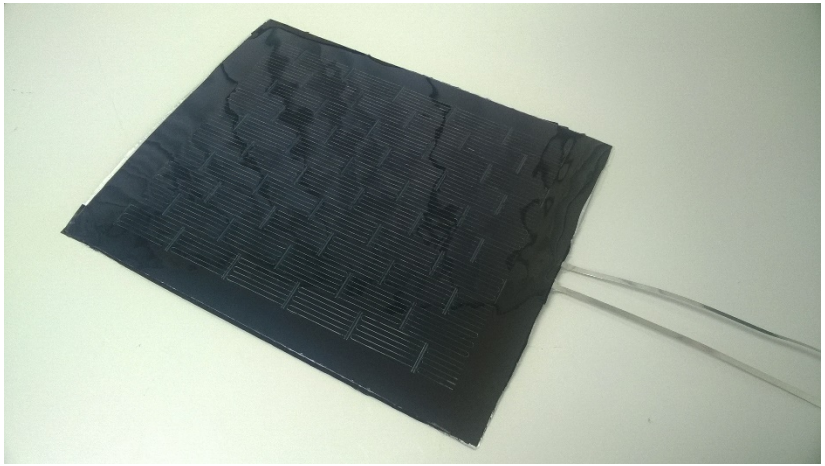


3D
Freeform Curvature

Lamination of PV Cell assembly stack

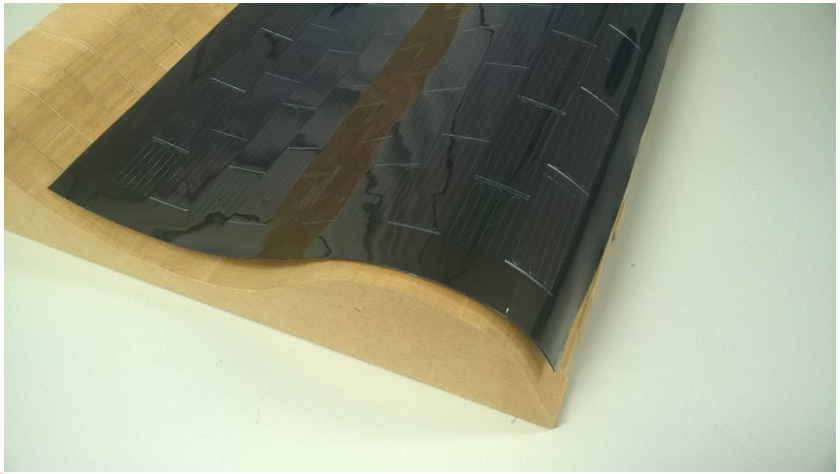
- **Single Curvature**

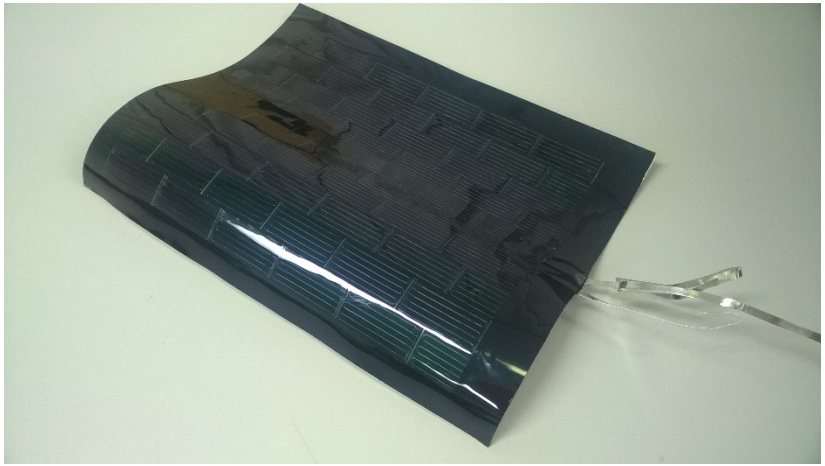




Pre-forming in mould at elevated temperature

- **Heating at 110°C in hot air oven**
  - Dedicated mould in combination with pre-heated Silicone sheets

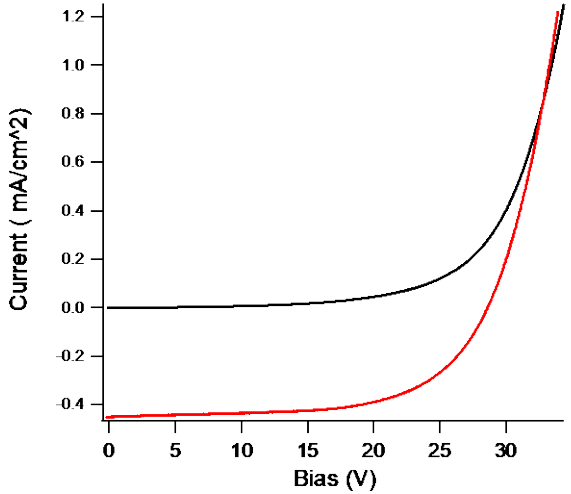




And they work !

- **EL image**

- **IV Curves**



Why Integration of PV ?

- Maximize usage of PV without occupying extra space
- Adding electrical energy generation as a feature within an existing product
- Reduction of assembly cost related to labour and materials

Integration in Infrastucture

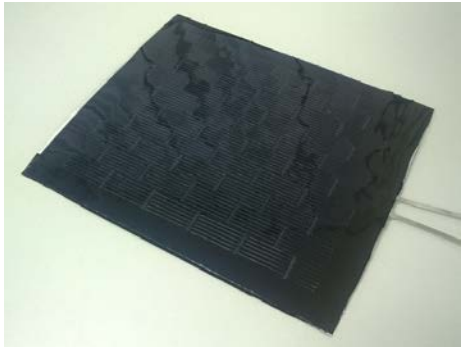
- Development of complete PV semi-product
- Manufacturing, design, integration
- Validation

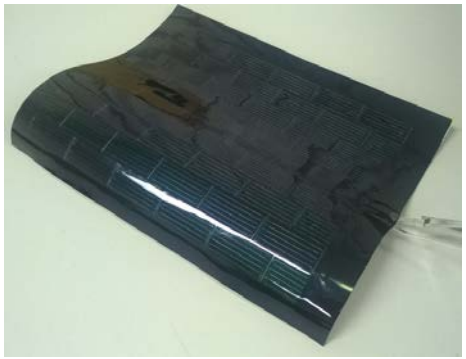
SolaRoad

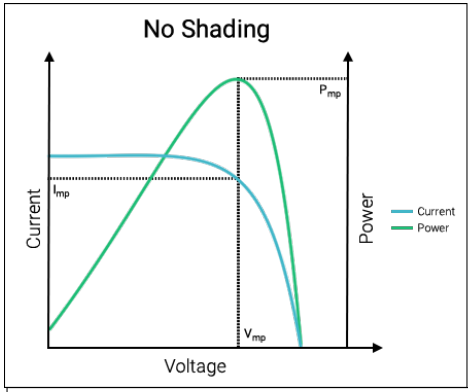
Interreg
Euregio Maas-Rijn

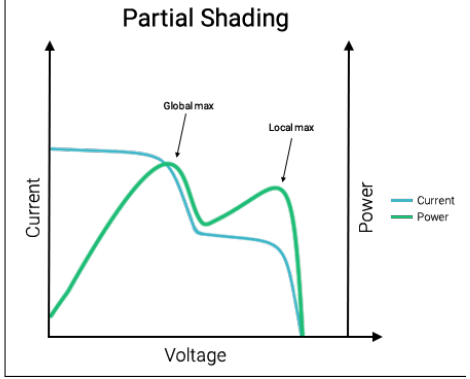
Challenges in TF-PV

- **Maximum Power Point Tracking**
  - Inherent partial shading









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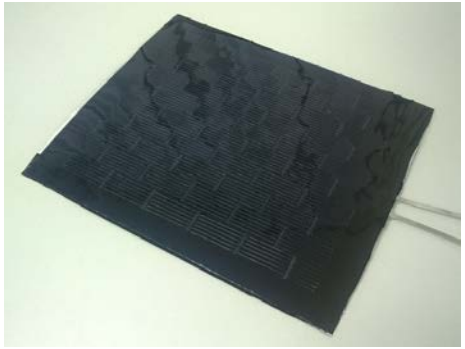
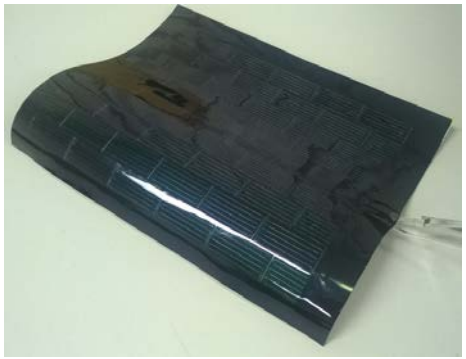
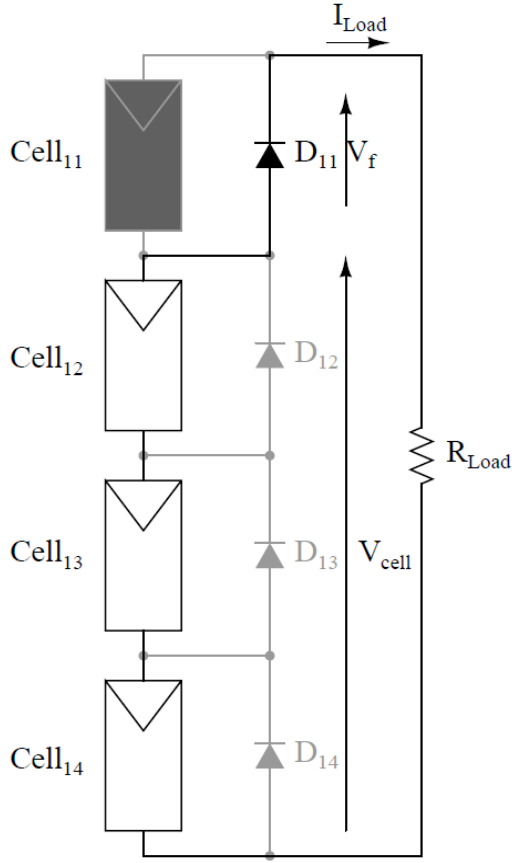
Challenges in TF-PV

- **Maximum Power Point Tracking**
  - Inherent partial shading
- **Low breakdown voltage**
  - More bypass diodes
  - More shadow tolerance







Advantages of Thin Film Solar Technology

- Light-weight
- Thin
- Flexible
- Cuttable

It’s happening!

SOLLIANCE

Bespoke flexible PV
is our daily business!
THIN FILM SOLAR RESEARCH
SOLLIANCE
SOLAR RESEARCH LED BY IMEC AND TNO
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