The Bearable Lightness of Solar Modules
Part II

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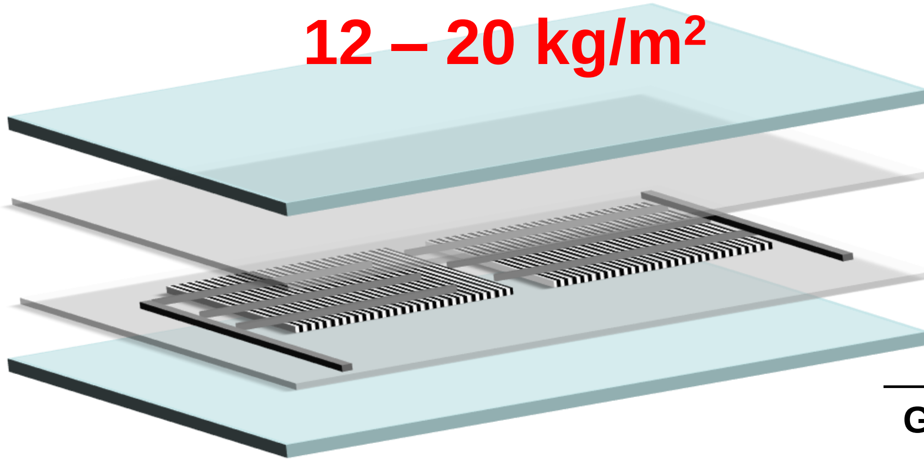
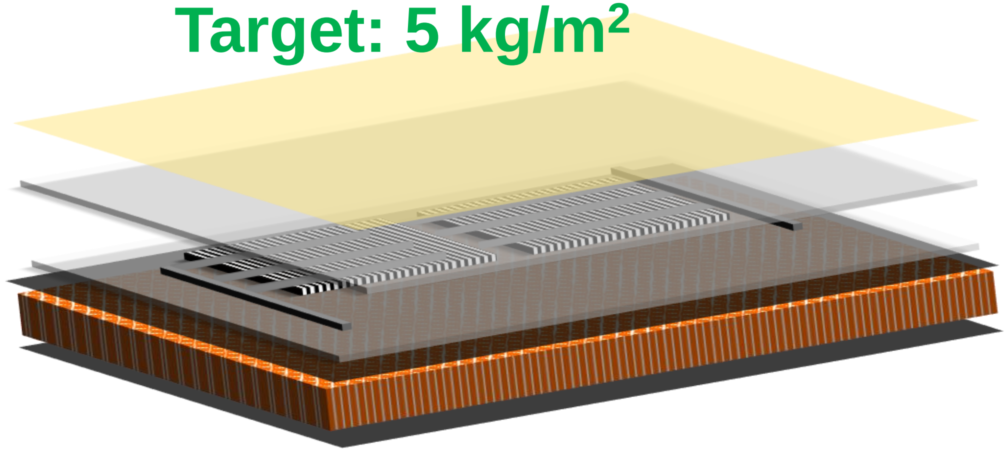
Lightweight PV approach

Conventional PV module



Glass-BS	12-16 kg/m^2
Glass-Glass	14-17 kg/m^2
BIPV	> 20Kg/m^2

Lightweight rigid PV module



Our vision for rigid lightweight PV

There are thousands types of PV module on the market…

… so which kind of application do we target?

- Façade elements
- Refurbish buildings

Advantages of our solutions

- Reduced fixation systems
- Reduce cost of installation
- Easy to install and remove
- Unbreakable
- Reliable
- Independent on the building structure

How can we reach lightness?

What are the challenges in lightweight PV design?

In conventional module, 60-70% of the weight is given by the glass layer(s)

During PV module design there are a limiting set of glass-substitute materials available with ideal properties, such as:

- lightness
- long lifetime (min. 25years) - reliability
- stable under outdoor conditions (no yellowing, no breaking…)
- rigidity
- compatible with building codes
- Full structure has to be easy to manufacture

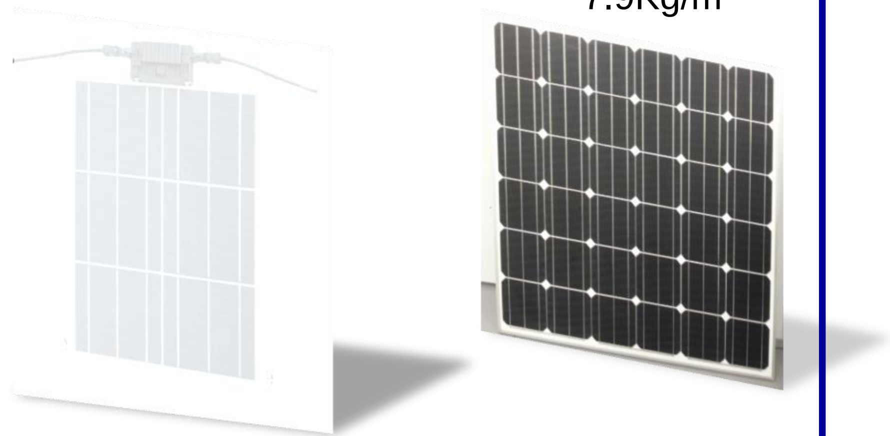
Challenges in lightweight PV design

Market research

2.5Kg/m^2 2.4Kg/m^2 2.2Kg/m^2

Flexible solutions

2.7Kg/m^2 7.9Kg/m^2



Rigid and semi-rigid solutions

Example of commercial c-Si PV modules tested

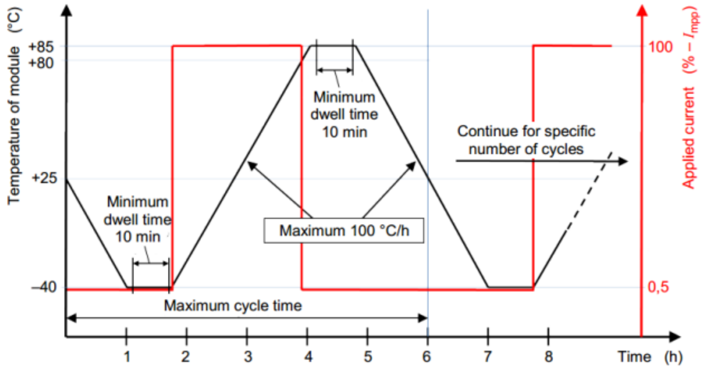
Reliability of PV modules is assessed by means of sets of laboratory tests developed to induce accelerated ageing: **Accelerated Lifetime Testing** (ALTs)

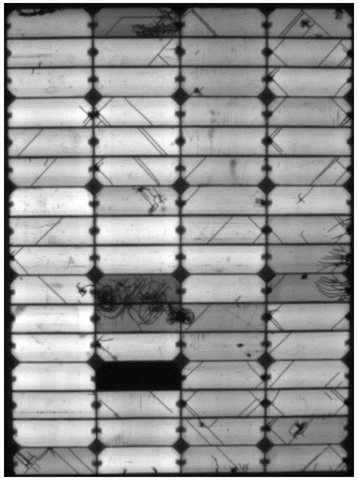
Qualification of c-Si PV modules: IEC 61215

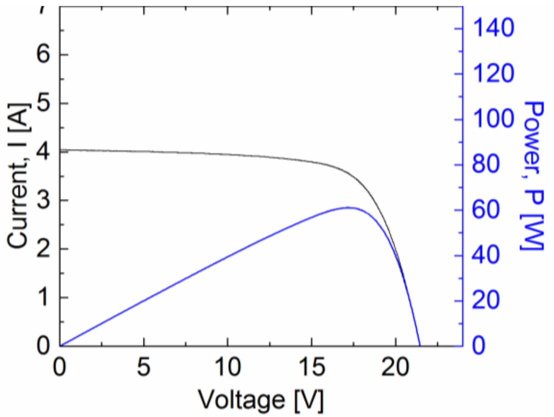
Failure modes observed in Thermal cycling (1)

Thermal cycling: ability to withstand thermal stresses

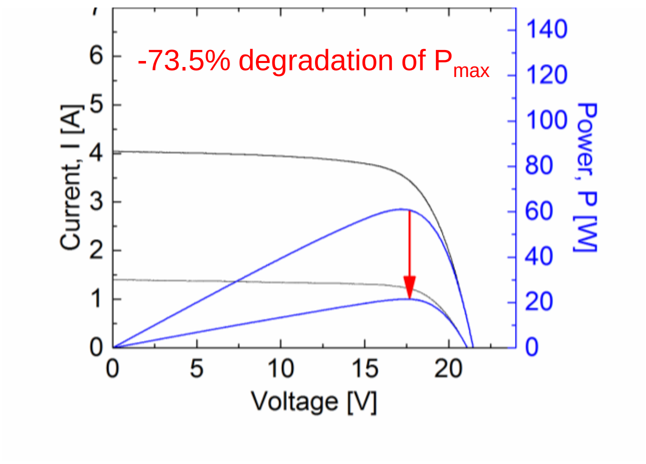
- -40 / 85°C







Failure modes observed in Thermal cycling (2)

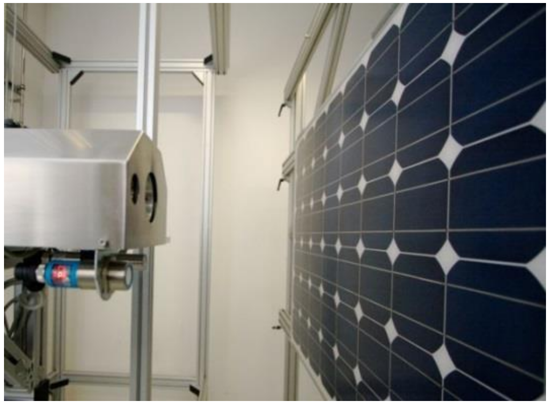


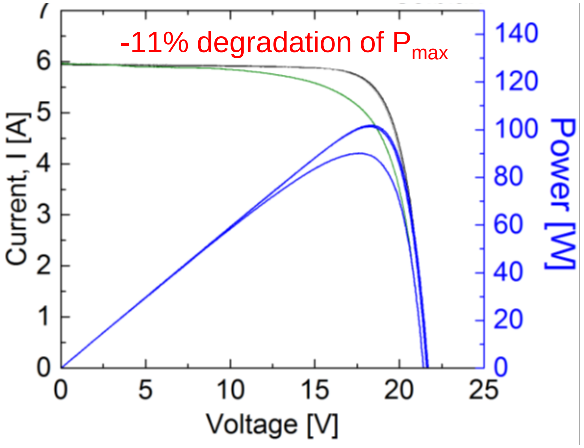
- Module failure due to thermal expansion of materials

Failure modes observed in Hail Test

Hail Test: verify resistance to impact

- 23 m/s
- 11 positions
- ∅ 2.5 cm



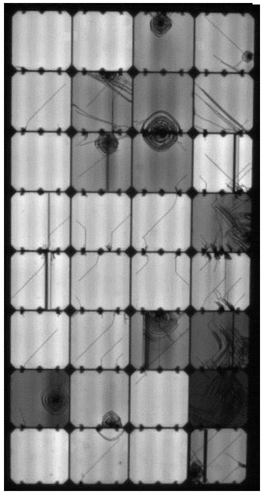


- Cells cracks due to weak protective frontsheet
- Huge decrease in power output

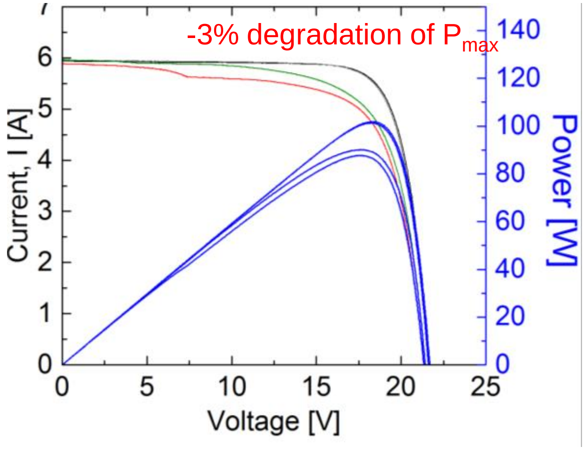
Failure modes observed in Damp Heat

Damp-heat: ability of the module to resist long-term exposure to humidity at elevated temperature

- 85°C and 85% RH
- 1000 h



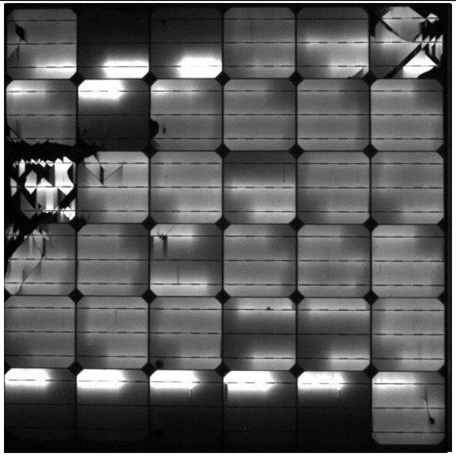
- Cells cracks propagation
- Decrease in power output
- Delamination of the frontsheet
- Interconnection corrosion



Review of existing rigid commercial products (1)

- Few certified lightweight solutions are available
- One example: 7.7 kg/m^2 made of:
  - fluoropolymer frontsheet
  - glass/carbon reinforced polymer at the back

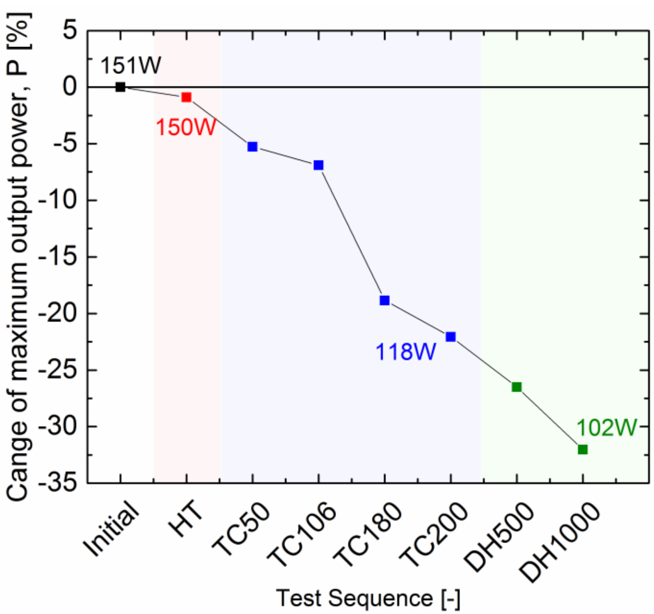
Review of existing rigid commercial products (2)



- No visual defects
- Power output in accordance with manufacture datasheet
- Module was in good conditions

- Strong frontsheet deformation

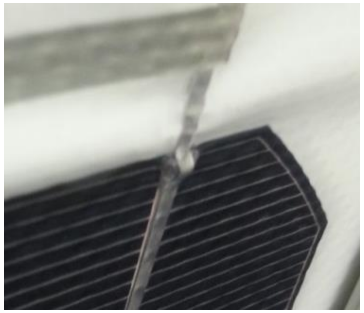
- Cracks propagation
- Interconnection failure
- Delamination of BS



Lightweight approach

Main failure modes

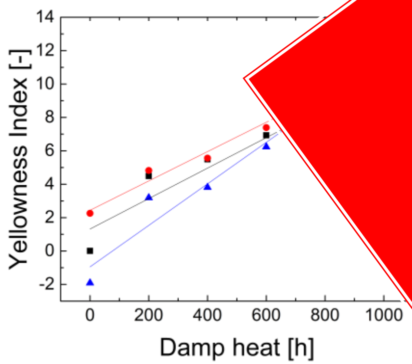
- ✓ Thermal expansion mismatch



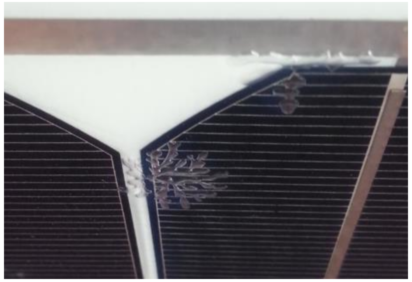
- ✓ Cell cracks
- ✓ Deformatio... ...ail impact

Need for reliable lightweight solutions

- ✓ Yellowing



- ✓ Corrosion
- ✓ Delamination



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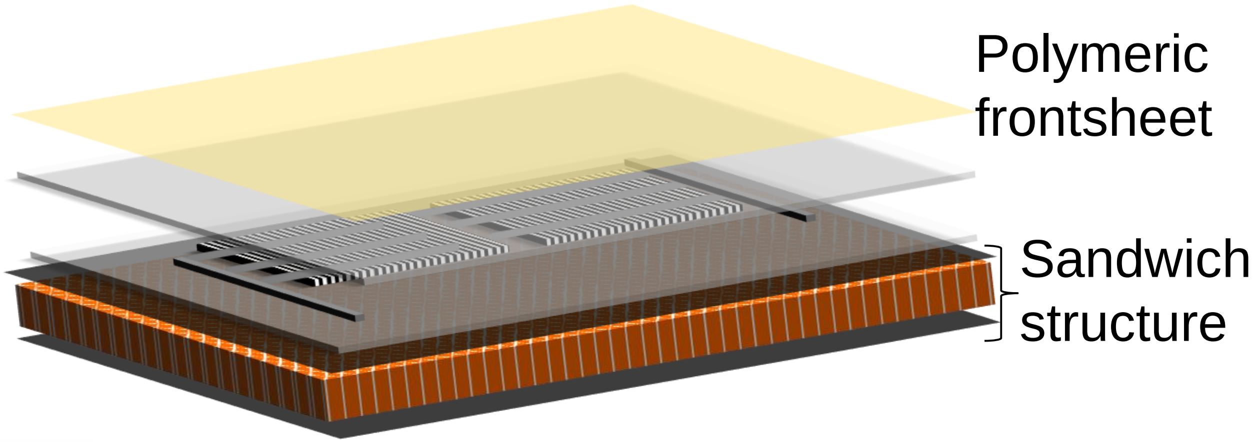
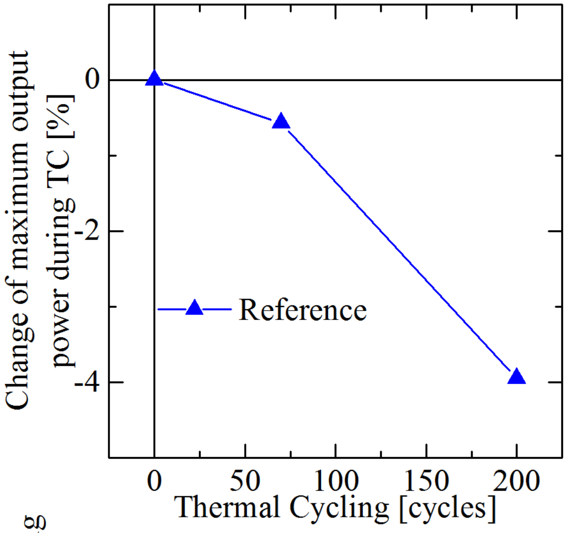
Lightweight PV module

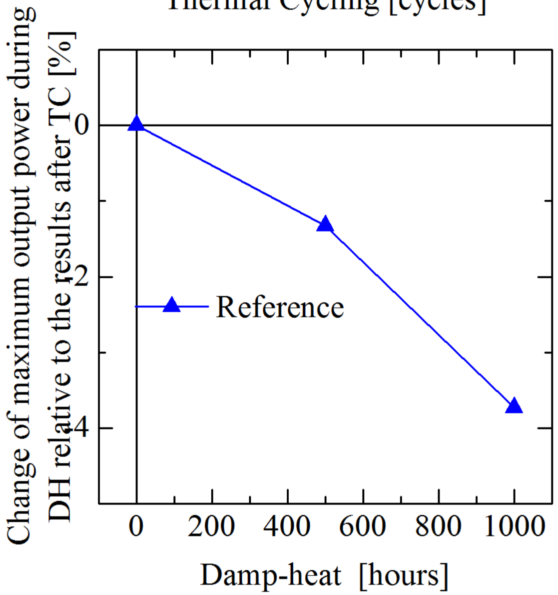
Requirements

- Lightweight ($5 kg/m^2$)
- Materials should have similar CTEs
- Simple process
- Rigidity
- Resistance (Unbreakable)
- Reliable under different ALT's (For the moment: TC / DH / HT)
- Aesthetics



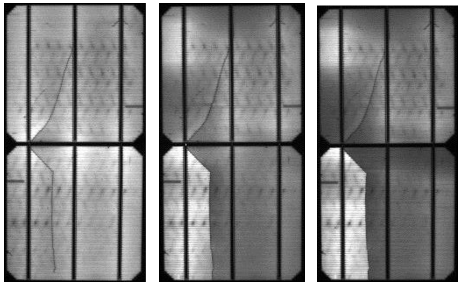
Rigid lightweight solution reliability



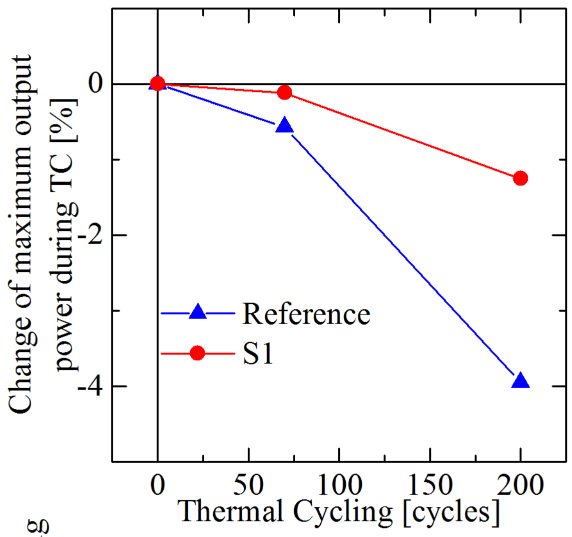


Reference

- Time consuming process (2-steps)
- Dangerous solar cells handling (easy to crack)



Rigid lightweight solution reliability



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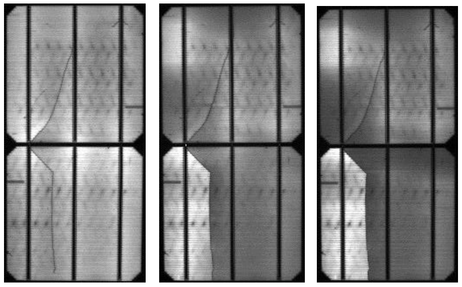
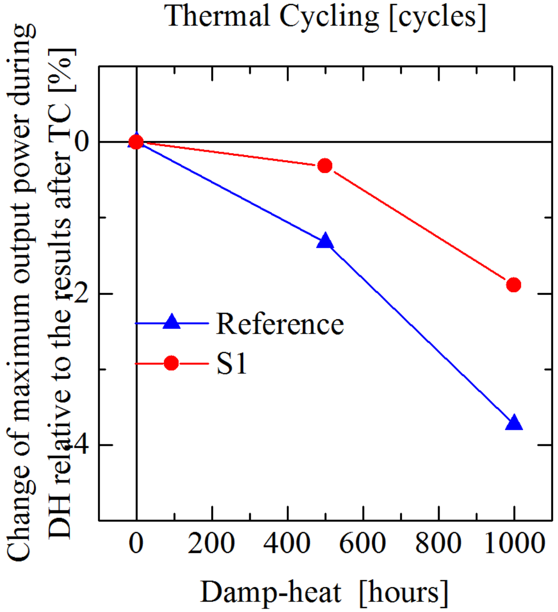
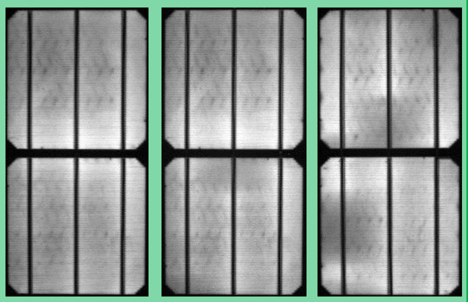




S1

- Easy to process (Proc. time 23min)
- No bending or delamination
- Lower ΔP than our Reference

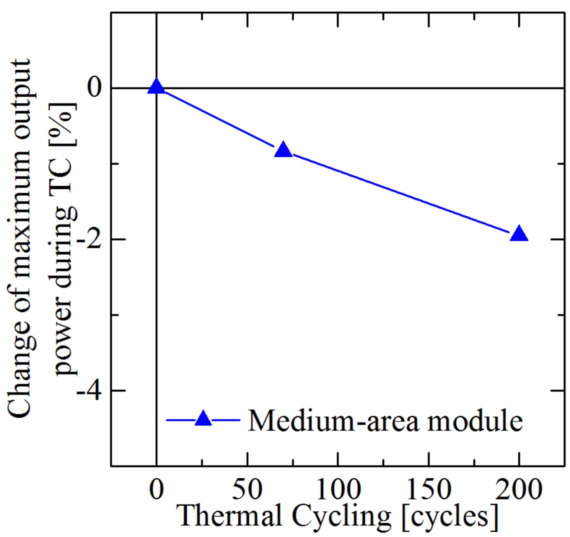


Upscale Solution

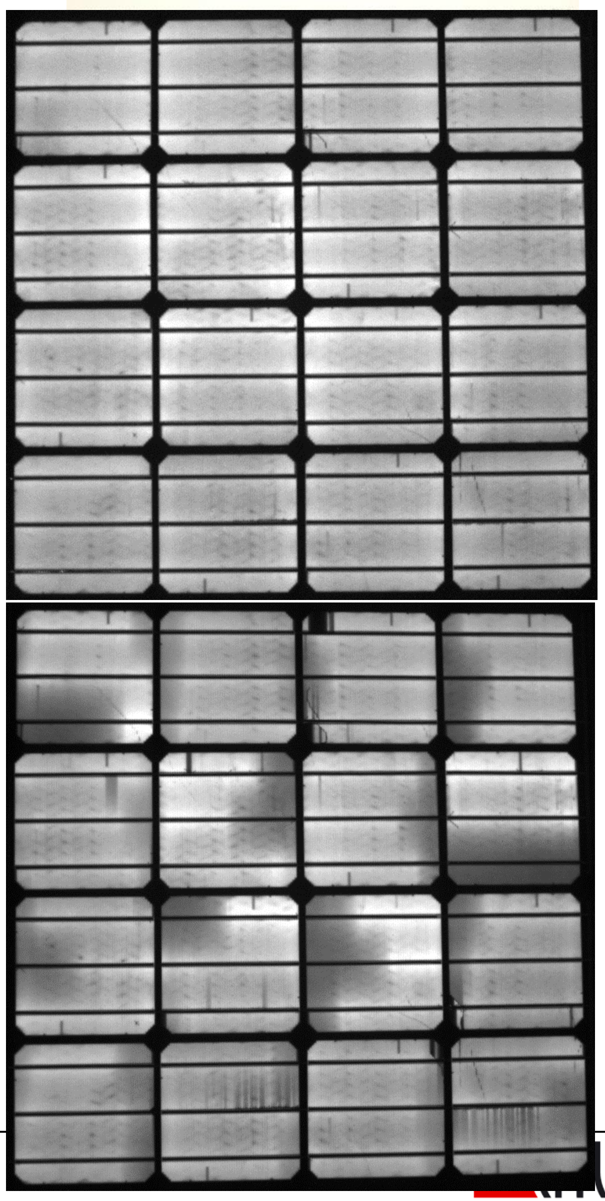
Rigid lightweight solution upscaling

Medium-area module

- 16 cells module
- Simple manufacture process
- Good appearance: no bubbles / cracks / bending



- Some finger interruption, micro cracks did not get worst
- No Vis changes



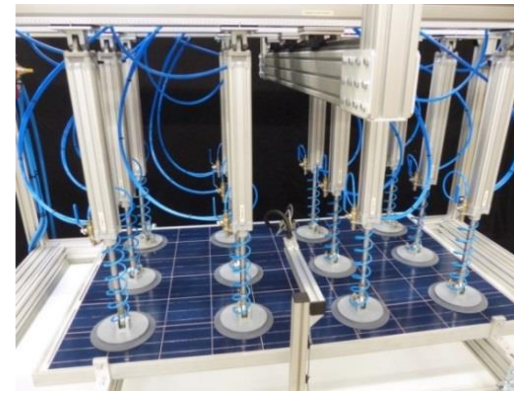
Size upscaling

constraints during PV design

16-cell medium-area module

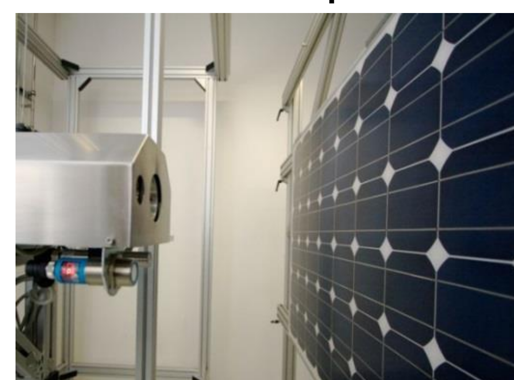
Mechanical loading test: ability to withstand wind, snow, ice loads

- 2400Pa (or higher)
- 1hour: pressure & suction
- In combination with mounting structure



Hail Test: verify resistance to impact of hailstones

- 23 m/s
- 11 positions
- ∅ 2.5 cm (or larger)
- In combination with mounting structure

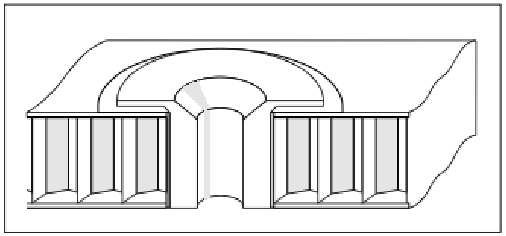


Need of ideal fixation system to be able to optimize PV design !

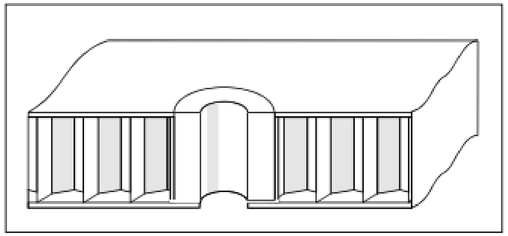
Typical sandwich panels

Mechanical fixing to panel faces is achieved in a variety of ways. The choice of method depends on:

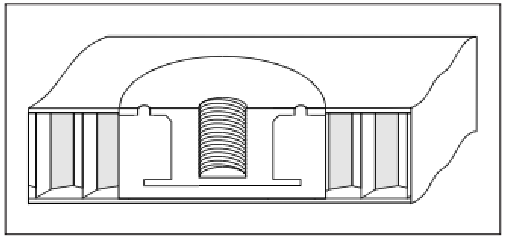
- the desired strength
- the finish required
- the quantity to be produced.



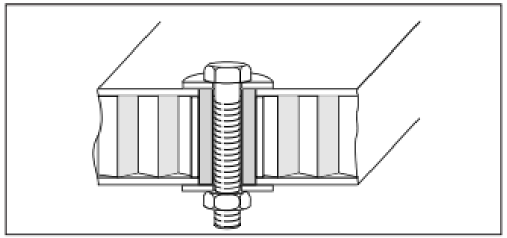
■ Single part ferrule



■ Distance tube



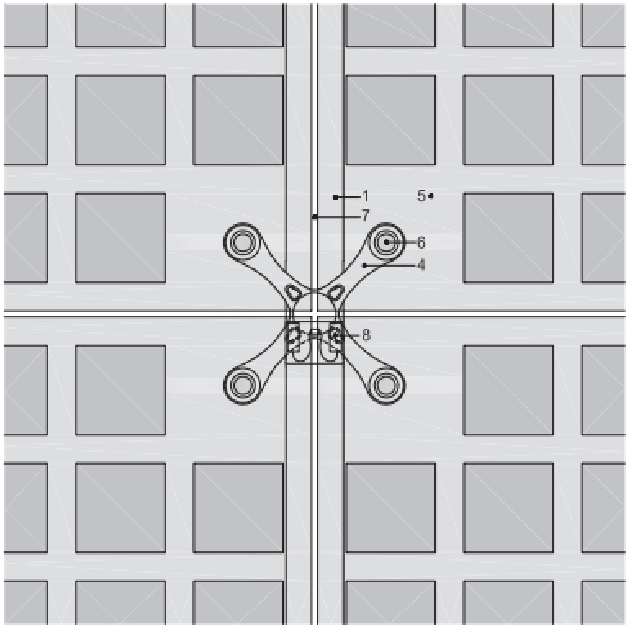
■ Threaded insert

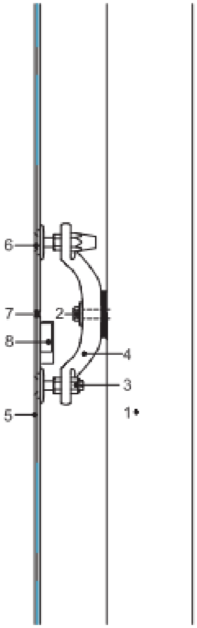


■ Through panel distance tube using penny washer

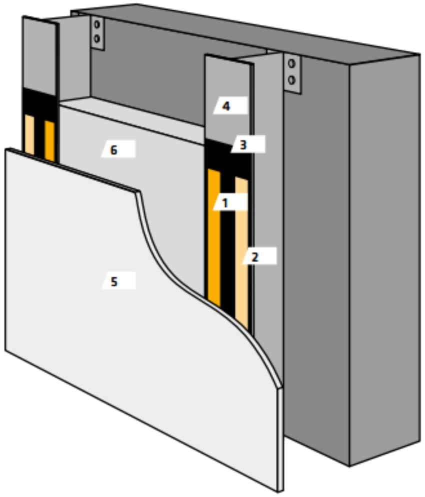
Point fixing systems

- Typical fixation system for transparent building facades
- Compatible with composite perforation





Gluing panels



SikaTack Panel

1. Adhesive: one-part moisture curing and structural adhesive
2. Tape: closed-cell PE foam core with pressure-sensitive adhesive for panel fixation
3. Primer: pigmented, solvent-based adhesion promoter
4. Panel

Mechanically fixed panels

<u>Downner – external wall cladding</u>

1. Aluminum rail
2. Fixing structures on the panel

What about an even simpler fixation system?

Conclusions

- Challenges of lightweight PV design
  - Thermal mismatch
  - Yellowing
  - Delamination / low adhesion between materials
  - Low resistance to humidity
  - Rigid enough to resist mechanical stresses

- Our rigid lightweight solutions
  - Easy to process
  - Reliable under TC / DH / HT
  - Stable
  - Rigid

- Lightweight structures can easily be adapted to many types of fixation
  - Does an “ideal” fixation system exist for façade of refurbished buildings?

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Thank you for your attention