The Bearable Lightness of Solar Modules
Part II

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Lightweight PV approach

Conventional PV module

12 – 20 kg/m²

Glass

Polymer film

Solar cells

Glass / BS

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight Range (kg/m²)</th>
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<tbody>
<tr>
<td>Glass-BS</td>
<td>12-16</td>
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<tr>
<td>Glass-Glass</td>
<td>14-17</td>
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<tr>
<td>BIPV</td>
<td>&gt; 20</td>
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Lightweight rigid PV module

Target: 5 kg/m²

Polymeric frontsheets

Sandwich structure
Our vision for rigid lightweight PV

There are thousands types of PV module on the market…
…and 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?

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

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

In conventional module, 60-70% of the weight is given by the glass layer(s)
Challenges in lightweight PV design

Market research

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

Example of commercial c-Si PV modules tested

- Flexible solutions: 2.5Kg/m², 2.4Kg/m², 2.2Kg/m²
- Rigid and semi-rigid solutions: 2.7Kg/m², 7.9Kg/m²

**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

- 73.5% degradation of $P_{\text{max}}$
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

![Image of solar panels and hail impact]

-11% degradation of $P_{\text{max}}$
**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

-3% degradation of $P_{max}$
Review of existing rigid commercial products (1)

- Few certified lightweight solutions are available
- One example: 7.7 kg/m² 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
- Deformation due to hail impact
- Yellowing
- Corrosion
- Delamination

Need for reliable lightweight solutions
Lightweight PV module
Requirements

- Lightweight (5kg/m²)
- 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

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

**S1**
- Easy to process (Proc. time 23min)
- No bending or delamination
- Lower $\Delta P$ 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)
- 1 hour: pressure & suction
- In combination with mounting structure

Hail Test: verify resistance to impact of hailstones
- 23 m/s
- 11 positions
- Ø 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.
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

Downer – external wall cladding

1. Aluminum rail
2. Fixing structures on the panel
What about an even simpler fixation system?
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

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