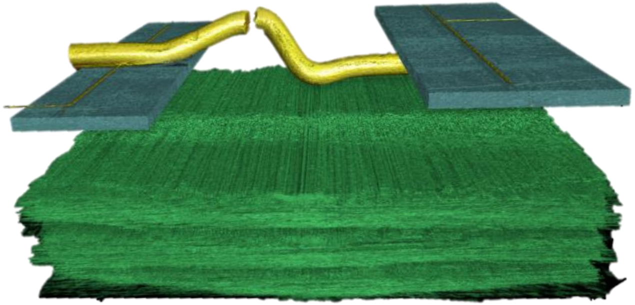
Composite Structures in Lightweight Photovoltaic Modules for Vehicle Integration

Rik Van Dyck, Bin Luo, Tom Borgers, Jonathan Govaerts, Jef Poortmans, Aart W. van Vuure



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2. Vehicle-integrated PV: A Motivation for weight reduction
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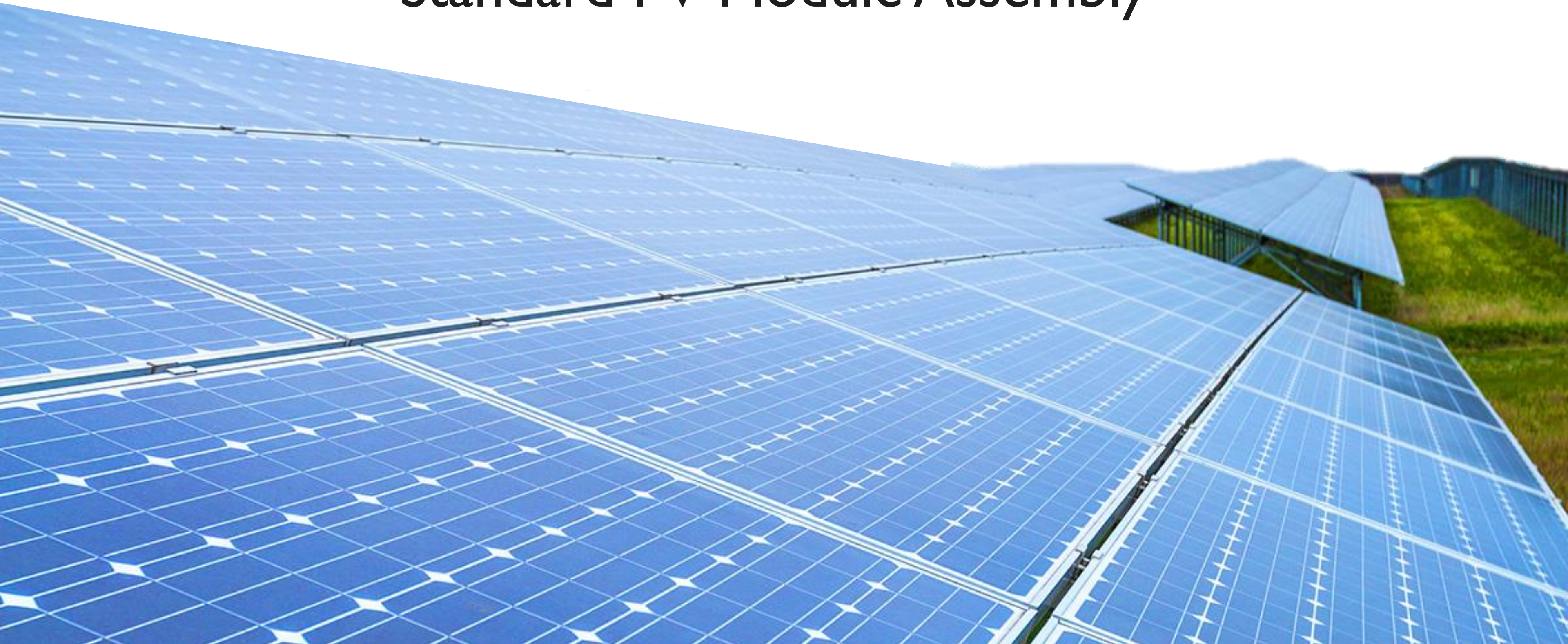
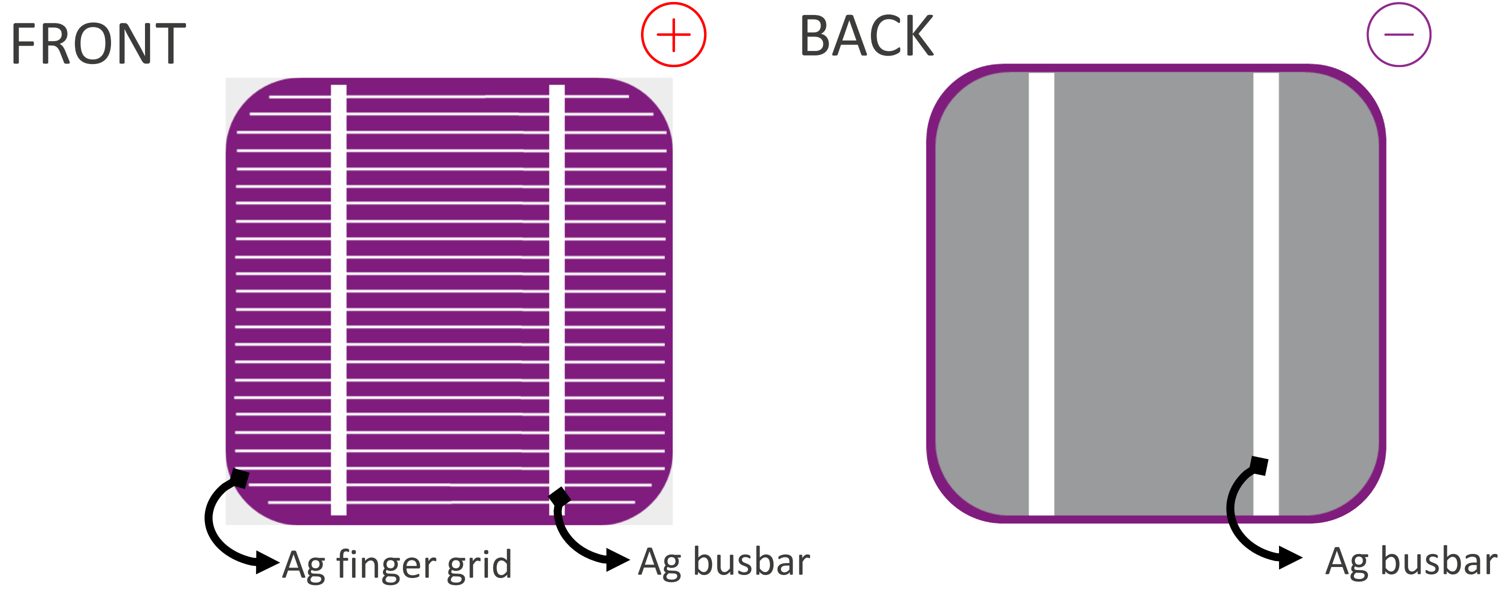
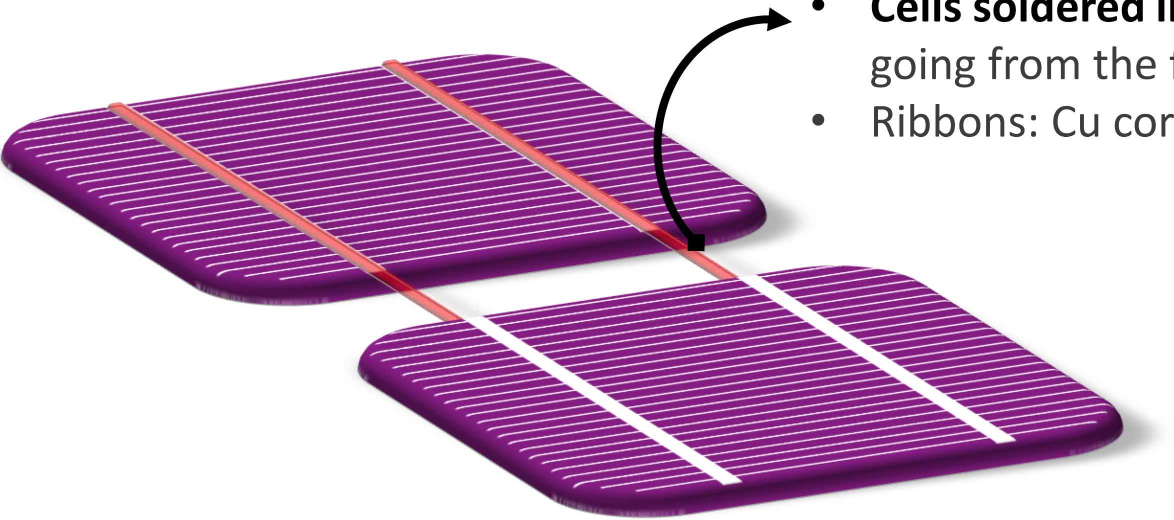
Standard PV Module Assembly



Standard cells for standard modules



Cell interconnection

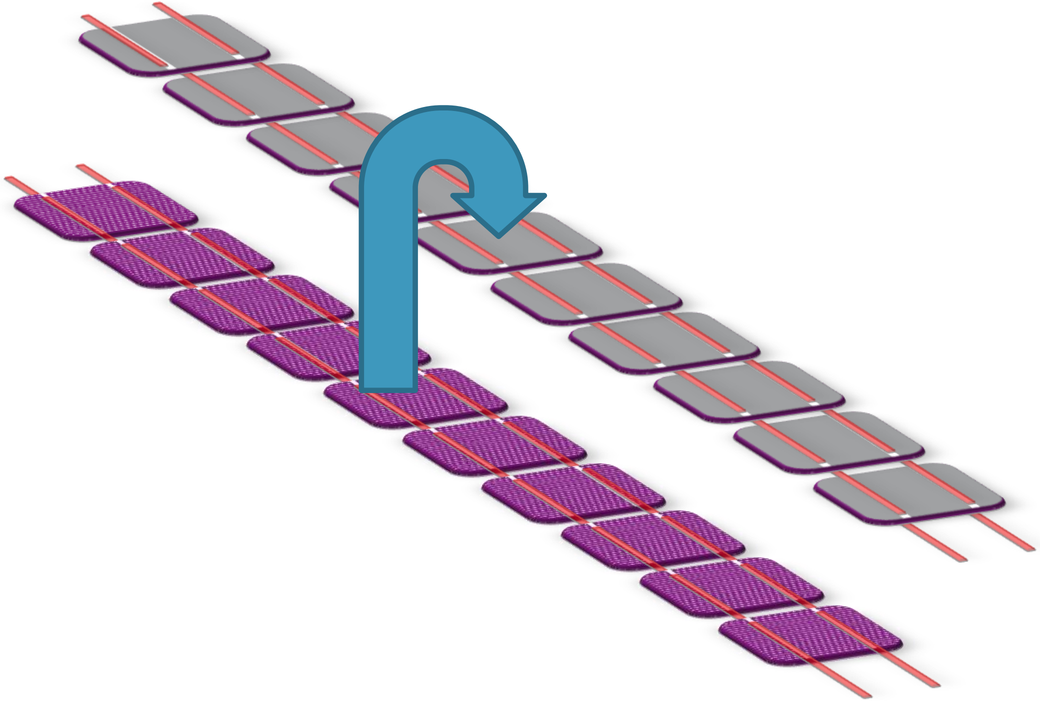


- **Cells soldered in series connection** using ribbons going from the front to back of neighboring cells
- Ribbons: Cu core with SnPb(Ag) coating

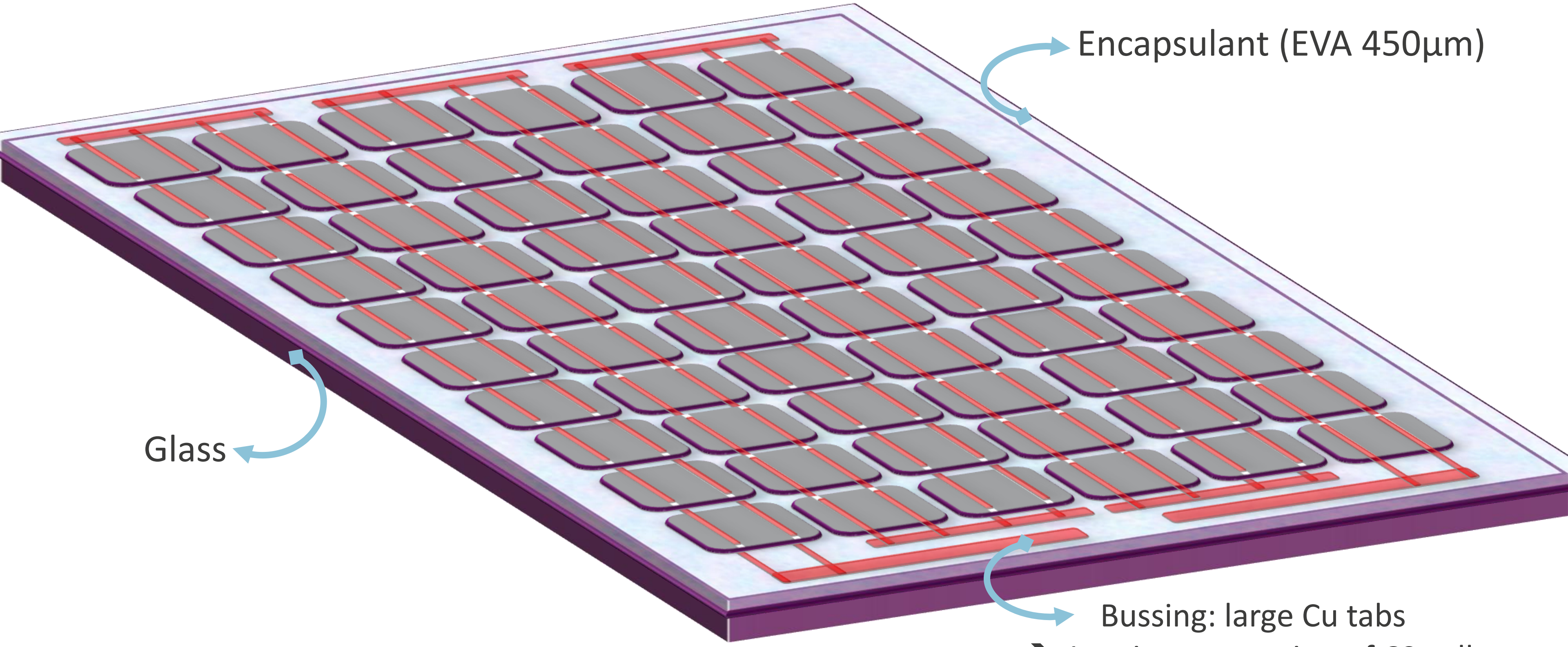
- **Improve performance by**

optimal number and size of busbars and ribbon are a shading vs. series loss trade-off

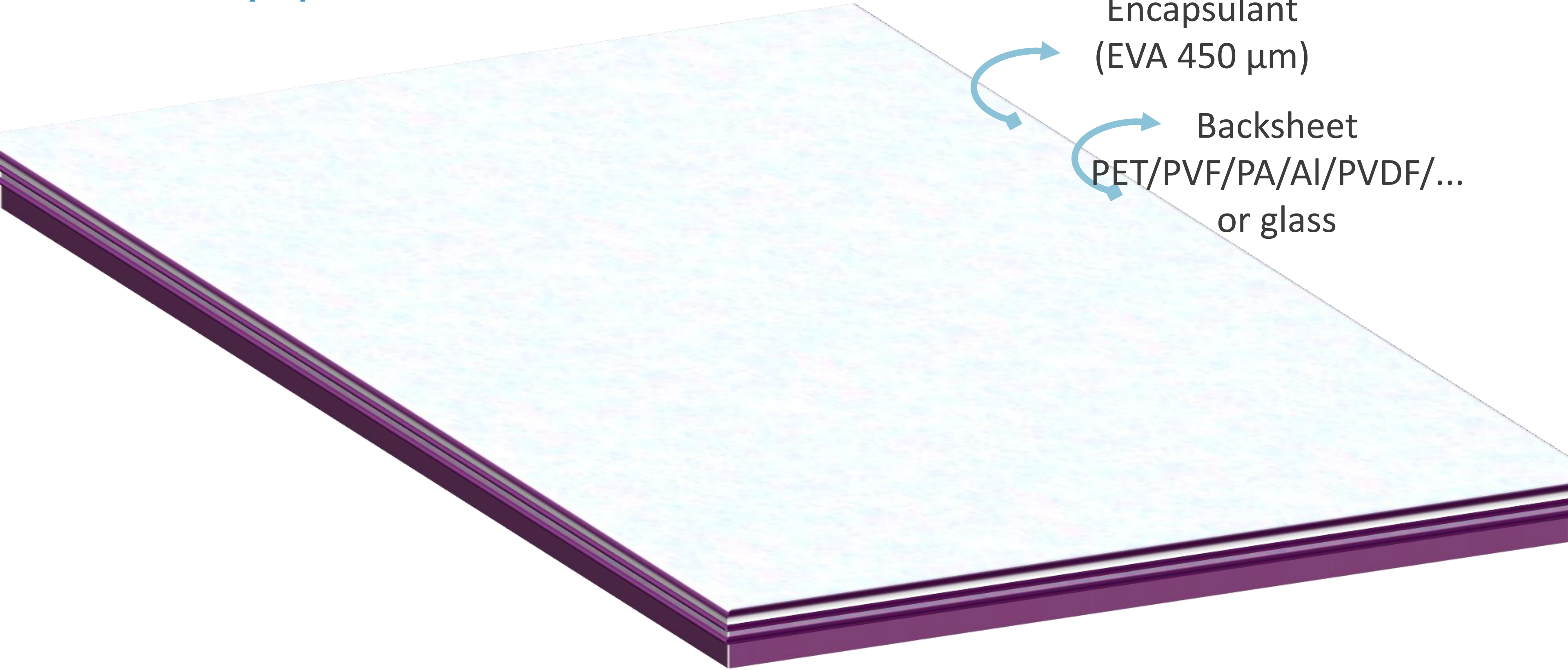
Soldering (tabbing) into strings (stringing)



Layup of strings and bussing

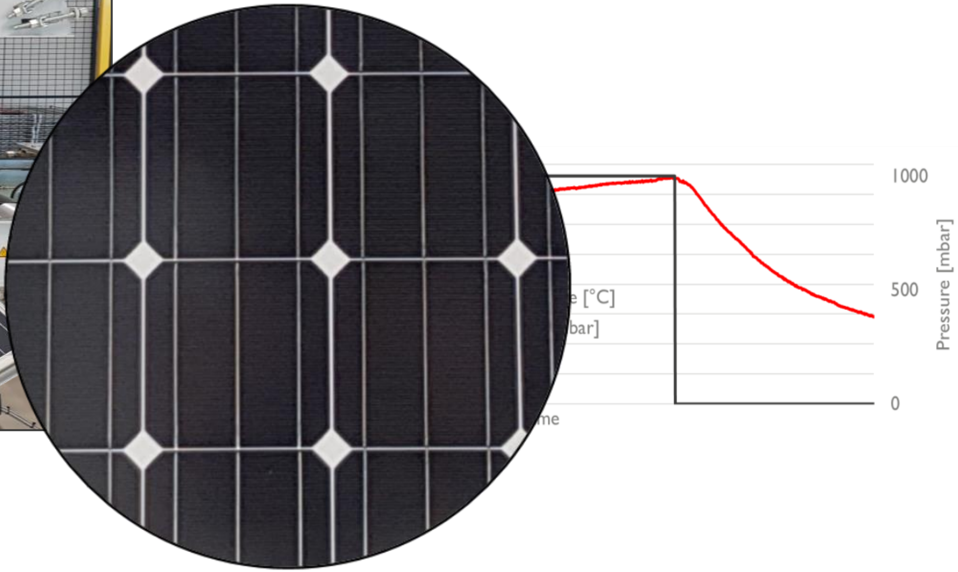


Module layup

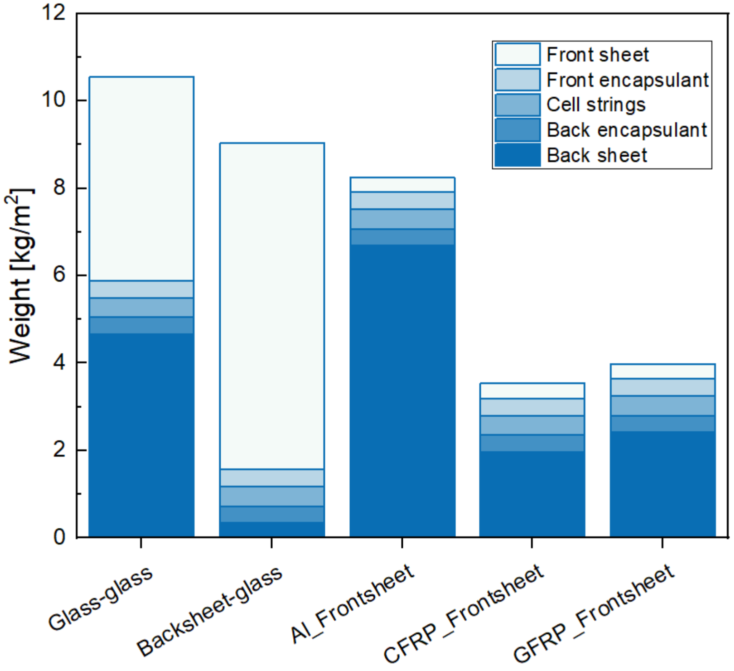


Module lamination

Encapsulant cures or melts, layup becomes a module.



Motivation for lightweight modules



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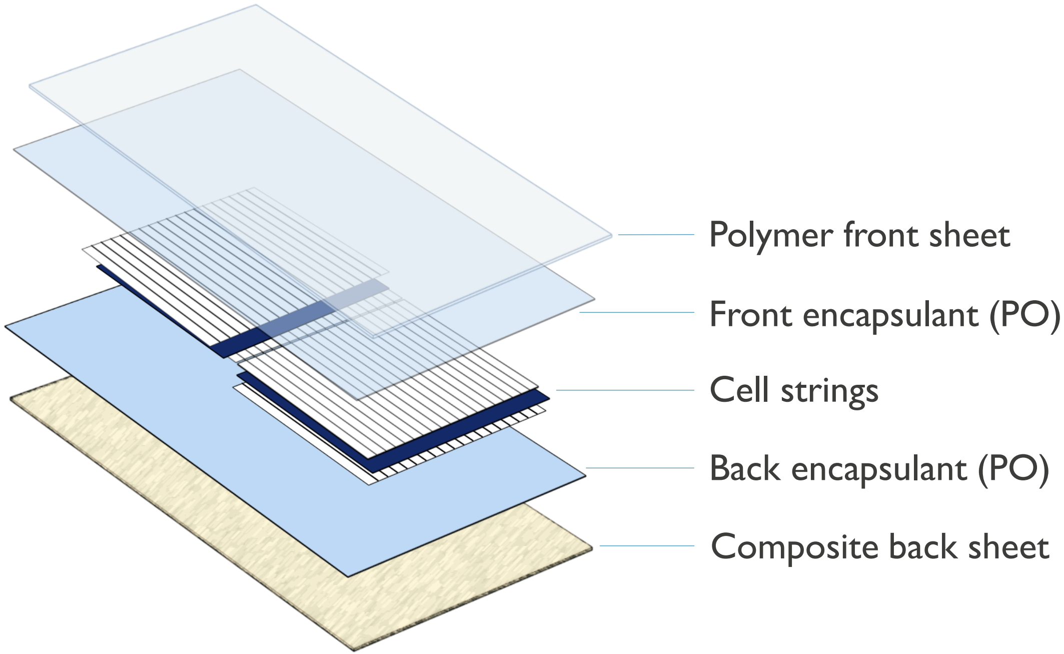
B. Luo et al, EUPVSEC-WCPEC 2022

Reliability assasment of photovoltaics

- Hail impact testing
- Thermal cycling

Sample fabrication

Module exploded view



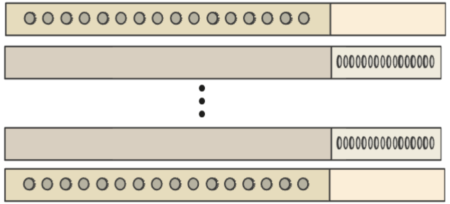
Sample fabrication

Fiber reinforced polypropylene backsheet

- Lamination of 8 plies
  - [0/90] unidirectional fibers
  - 60 w% glass fibers and 50 w% carbon fibers
- Glass and carbon fiber reinforcements

GFPP backsheet

CFPP backsheet

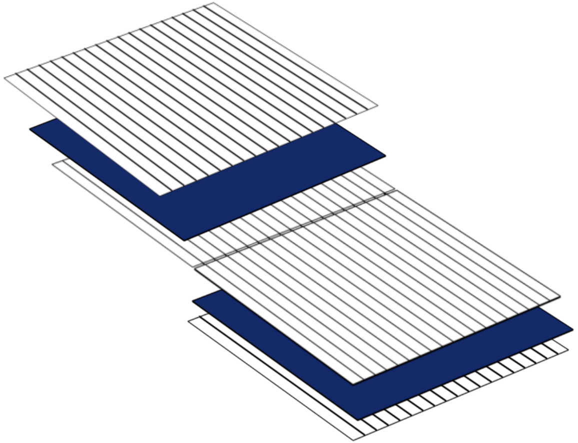


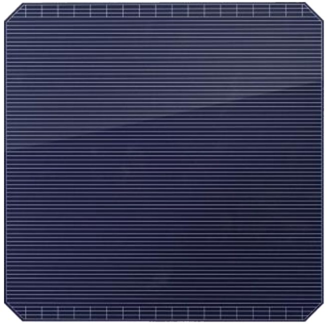
Fiber reinforced polymer backsheet $[0/90]_s$

Sample fabrication

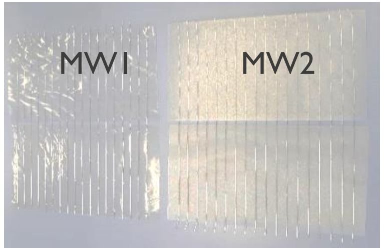
Cell interconnection

- Cell interconnection foil
  - 18 Cu wires with SnBiAg-coating
  - Polyolefin-based carrier foil





Solar cell frontside

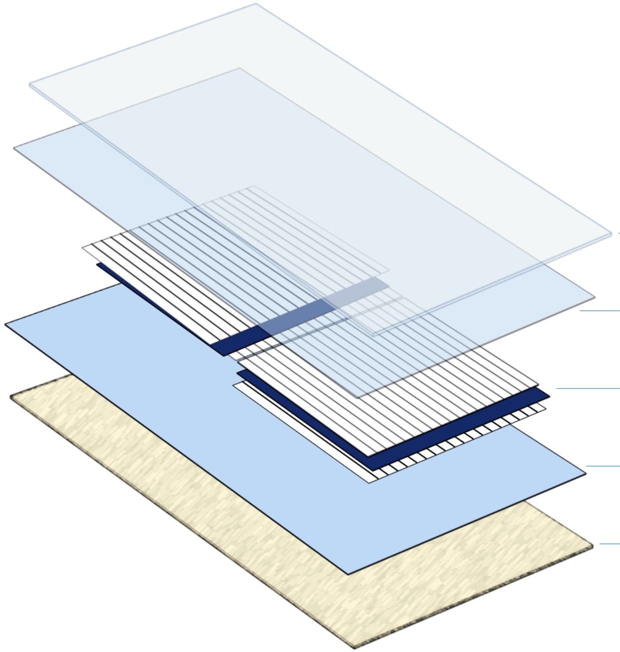


Connection foils

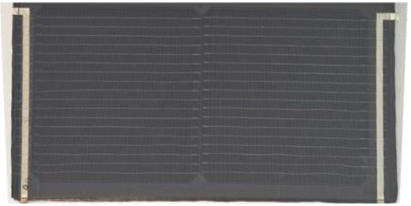
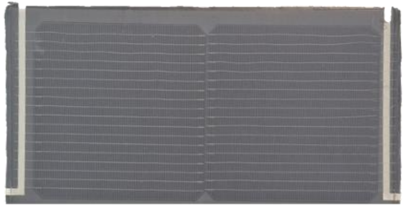
T. Borgers and J. Govaerts, patent EP3790059A1

Sample fabrication

- Module layup and lamination
- During lamination:
  - Encapsulation
  - Soldering



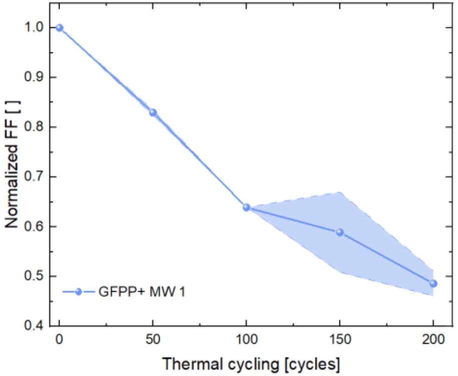
Experimental matrix

	GFPP Backsheet	CFPP Backsheet
MW1 (PO)		
MW2 (PO + GF)		

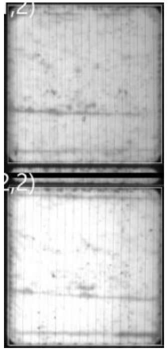
- Thermal cycling according to IEC61215

Reliability assessment

Thermal cycling (-40 to 85 °C, IEC 61215)

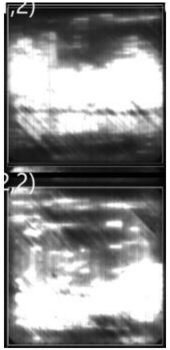


MW1

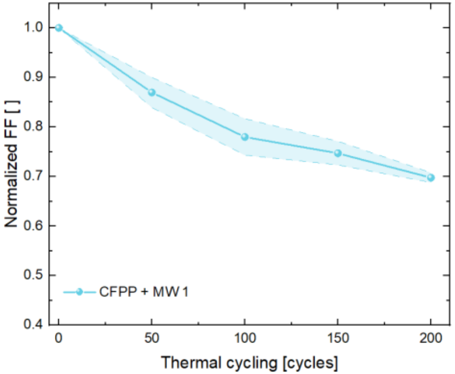


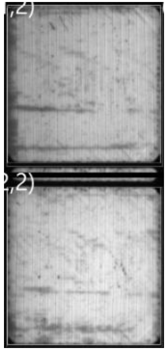
Before TC

MW1

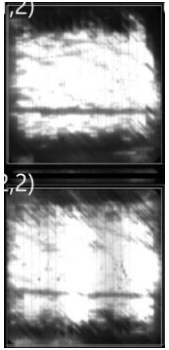


After TC 200





Before TC



After TC 200

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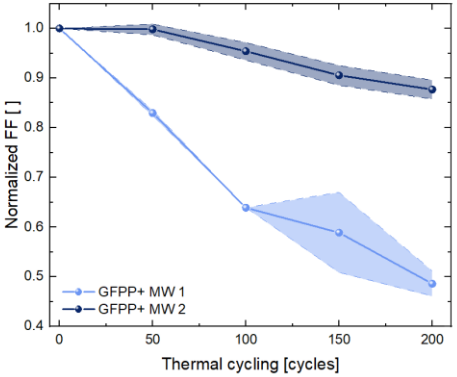
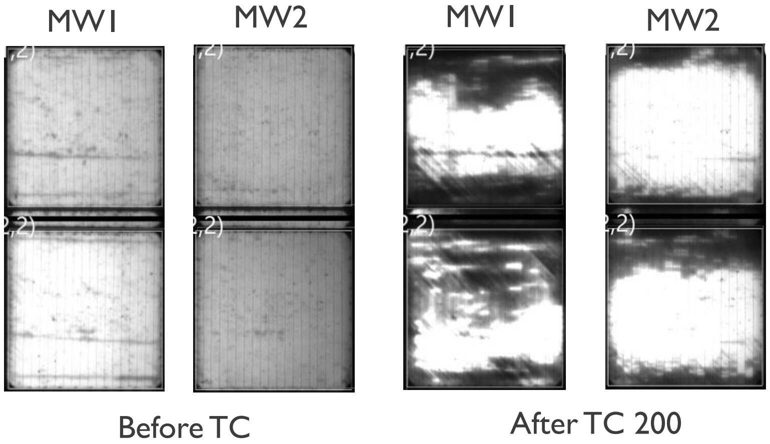
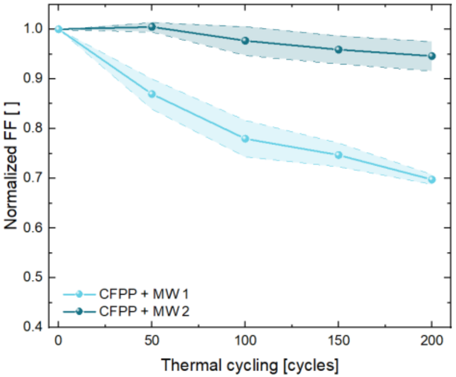
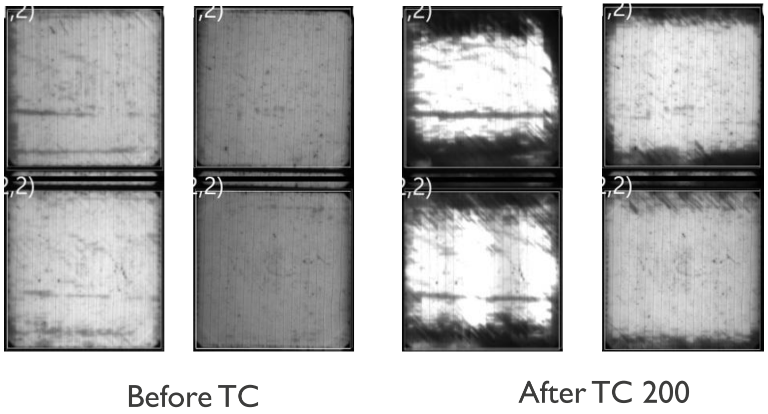
Reliability assessment

Thermal cycling (-40 to 85 °C, IEC 61215)



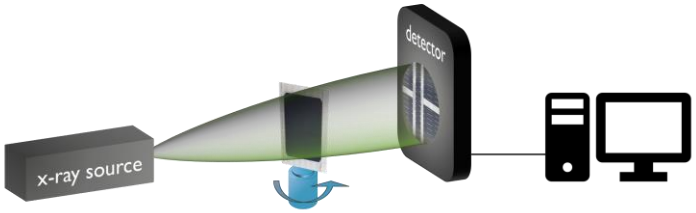




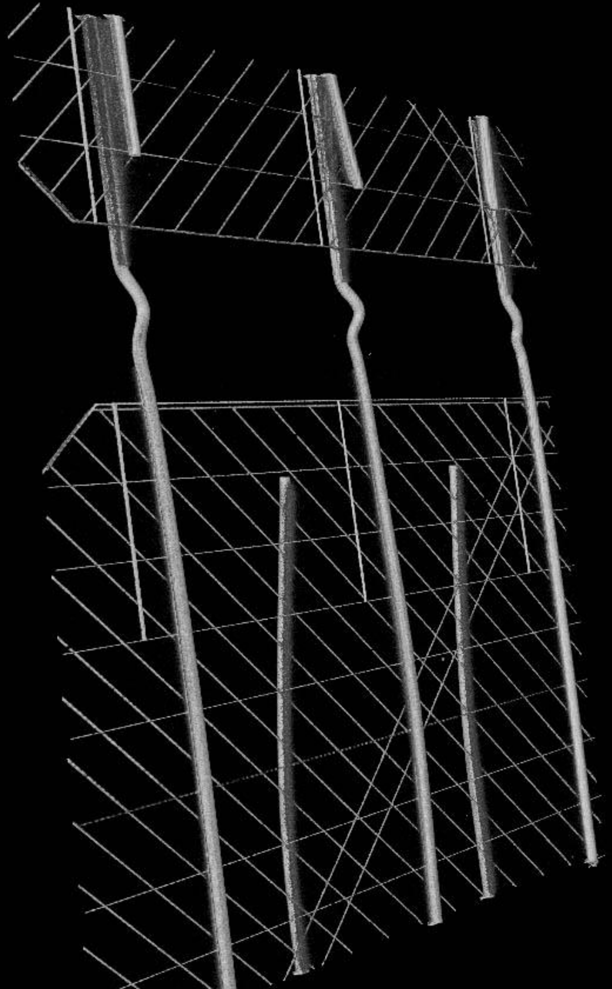


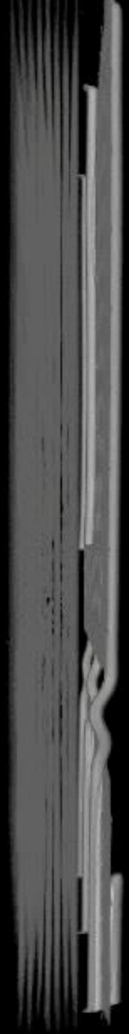
3D Micro-computed tomography

- Non-destructive analyzing technique
- Multiple X-ray scans of rotating sample, followed by reconstruction to create 3D volume rendering
- Voxel (3D Pixel) sized as low as 1-3 µm
- Resolution depends on sample size



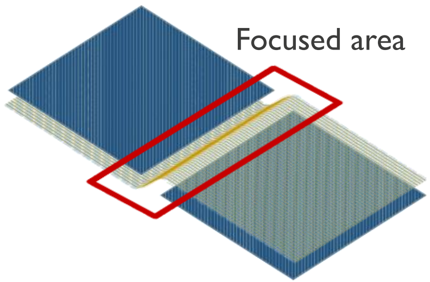
Van Dyck, R., et al (2023). **Solar Energy Materials and Solar Cells**

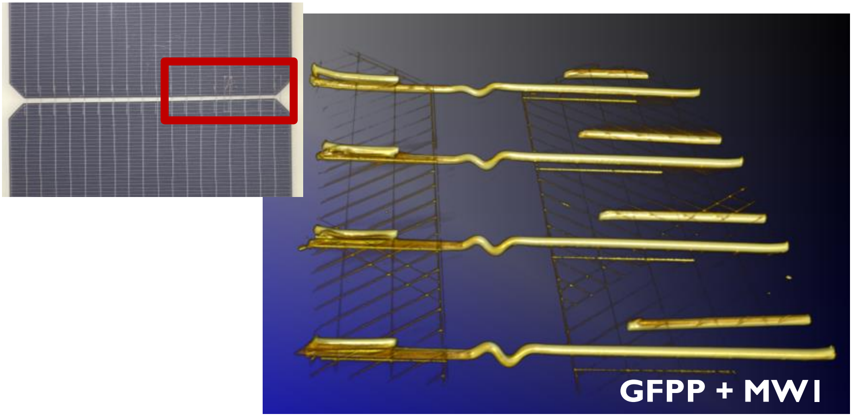


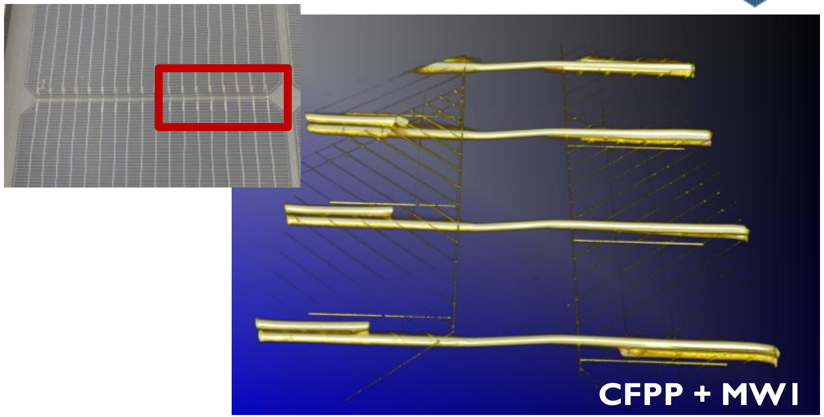


Reliability assessment and characterization

Micro-computed tomography (μ-CT) imaging

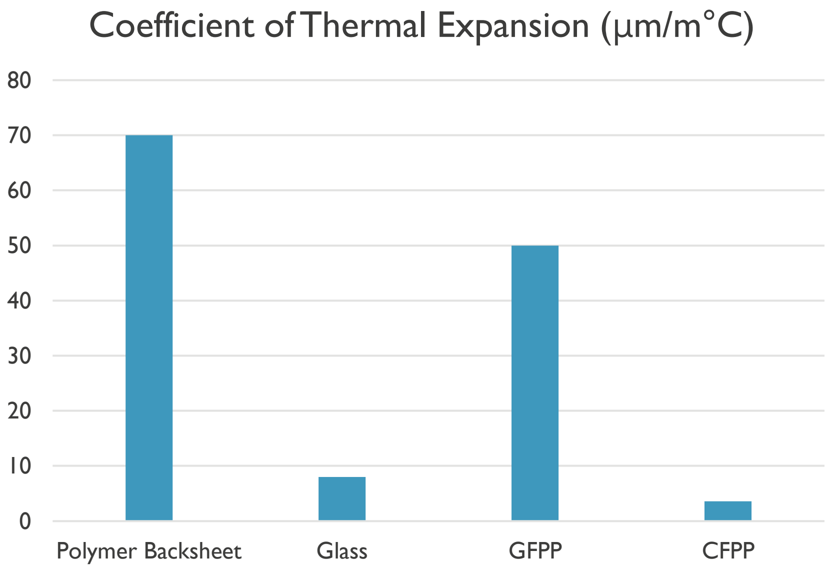


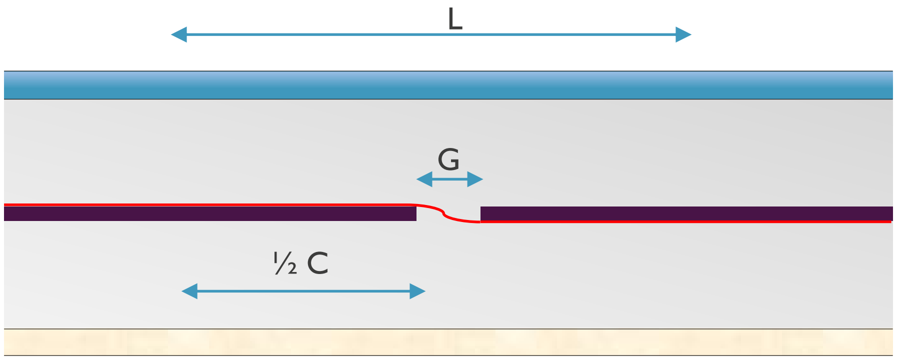




- Wire deformation between cells due to thermal strain

Reduced thermal strain





$$\Delta G = L \cdot \alpha_{backsheet} - C \cdot \alpha_{Si}$$

GFPP: $\Delta G = 7.5$ µm/ °C
CFPP: $\Delta G = 0.2$ µm/ °C

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Conclusions

- Lightweight modules using a multi-wire interconnection are prone to degradation due to thermo-mechanical stress
- Decreasing the backsheet CTE improves the reliability
- Using carbon fibre reinforcement in a polymer backsheet increases module reliability
- Further investigation using FEM is ongoing

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Thanks for your attention!!

Questions

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discussion