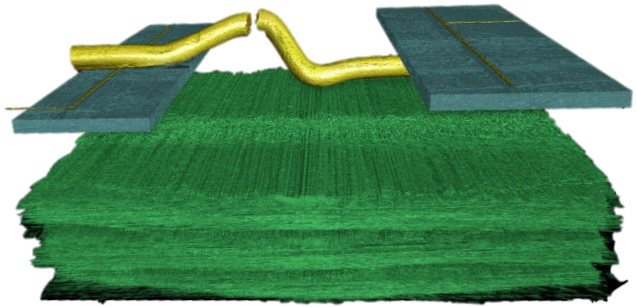
Investigation of Multi-Wire Interconnected Lightweight PV modules Using Micro-Computed Tomography

Bin Luo, Rik Van Dyck, Jonathan Govaerts, Tom Borgers, Bart Ruttens, Jan D'Haen, Hariharsudan Sivaramakrishnan Radhakrishnan, Michael Daenen, Aart Willem Van Vuure, Jef Poortmans



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  - Motivation for lightweight modules
- Experimental Setup
  - Sample preparation and experimental matrix
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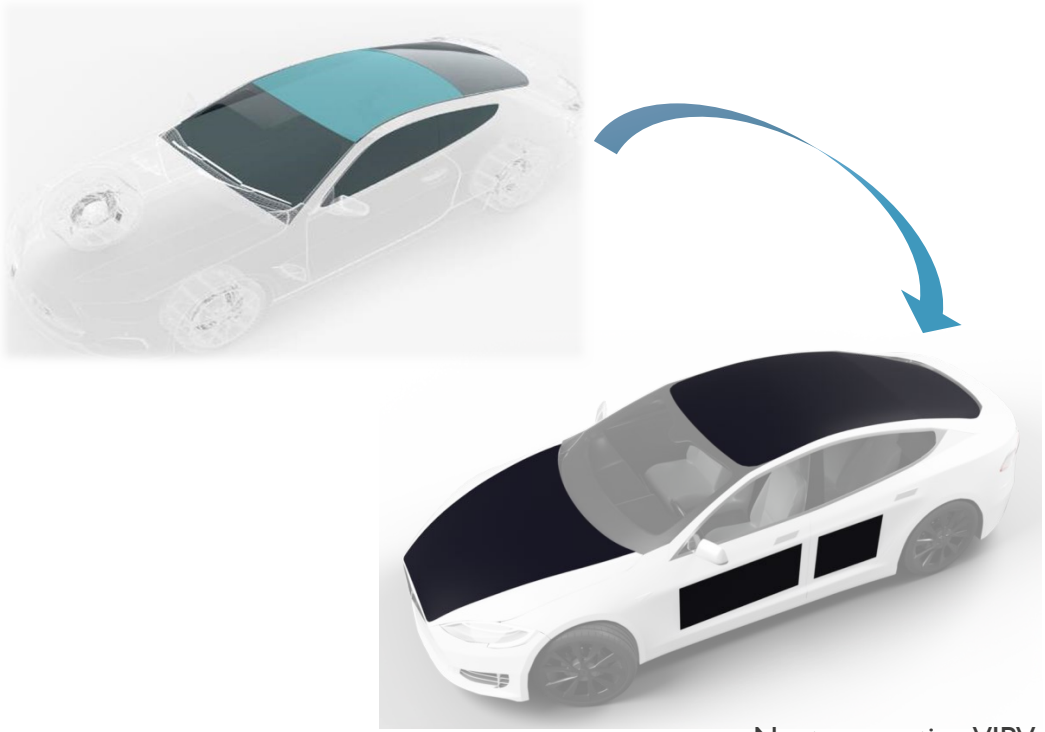
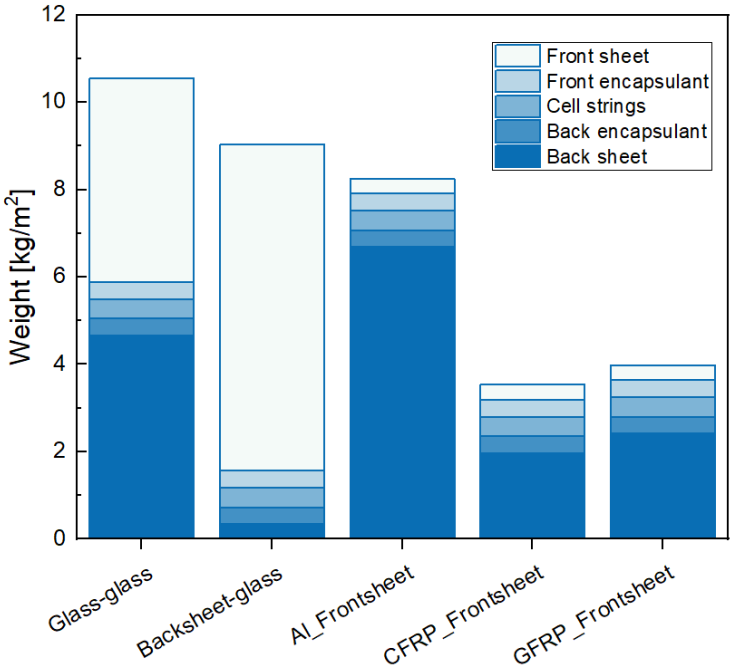
Motivation for lightweight modules



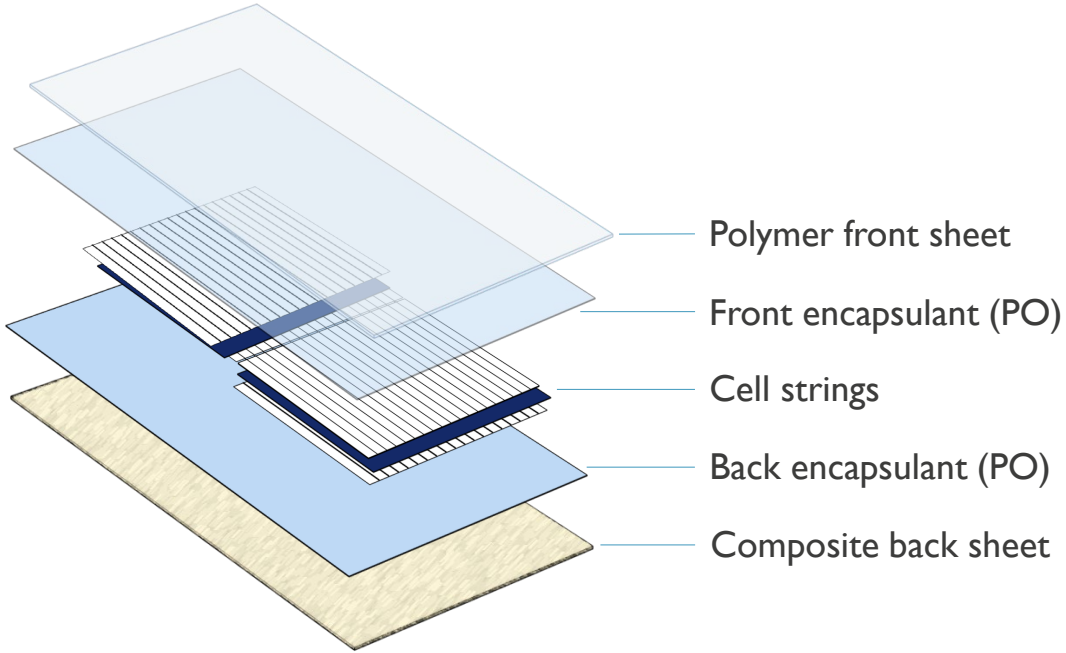
Next-generation VIPV



B. Luo et al, EUPVSEC-WCPEC 2022

Sample fabrication

Module exploded view



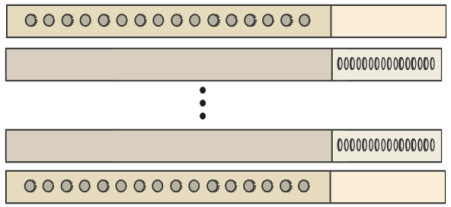
Sample fabrication

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

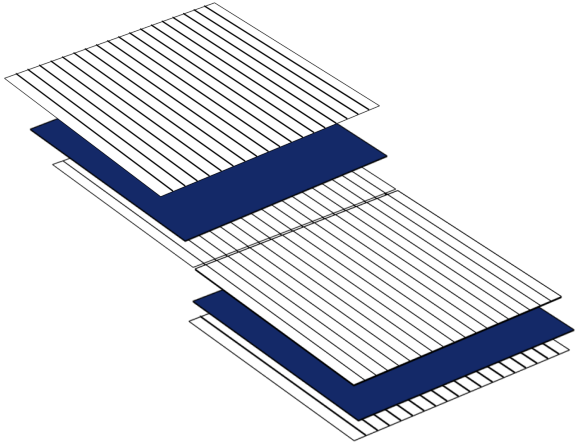


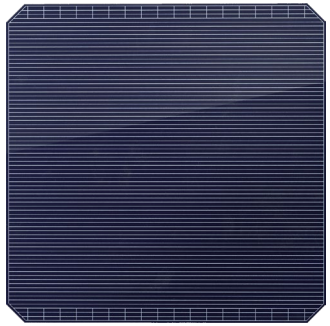
Fiber reinforced polymer backsheet $[0/90]_s$

Sample fabrication

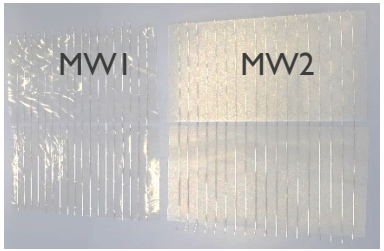
Cell interconnection

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





Cell frontside

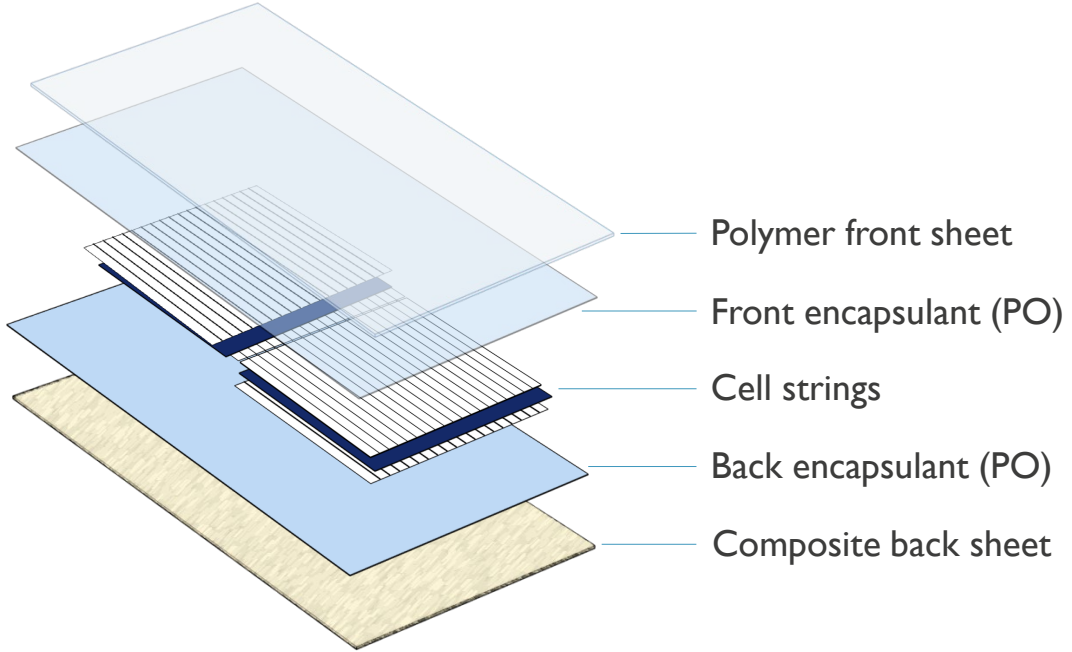


Connection foils

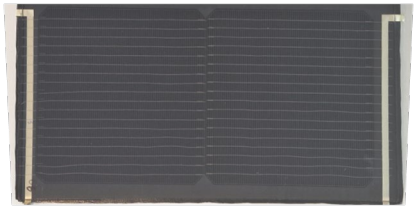
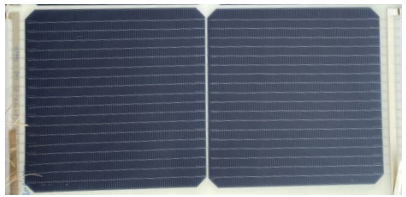
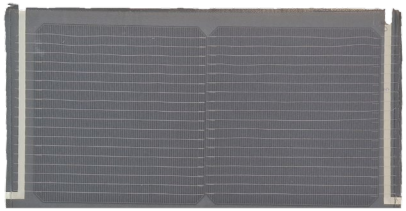
T. Borgers and J. Govaerts, patent EP3790059A1

Module fabrication

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



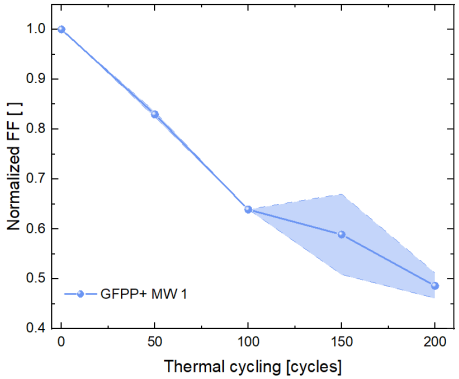
Experimental matrix

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

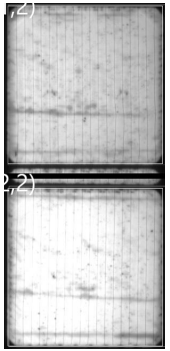
- Thermal cycling according to IEC61215

Reliability assessment

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

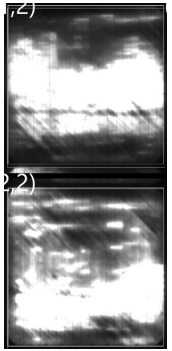


MW1

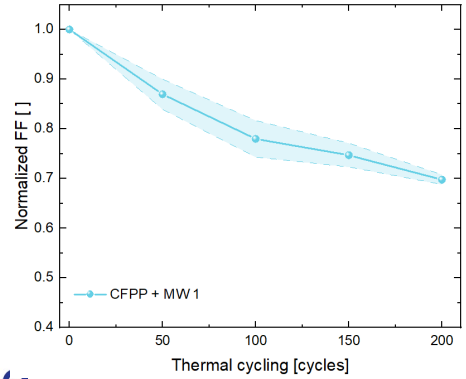


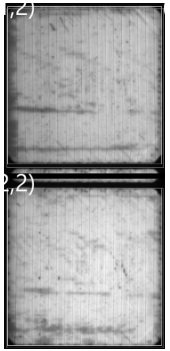
Before TC

MW1

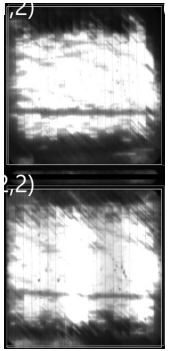


After TC 200





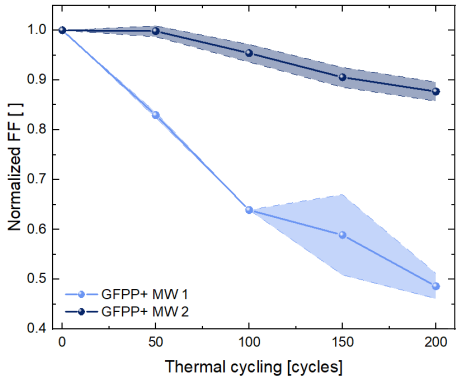
Before TC

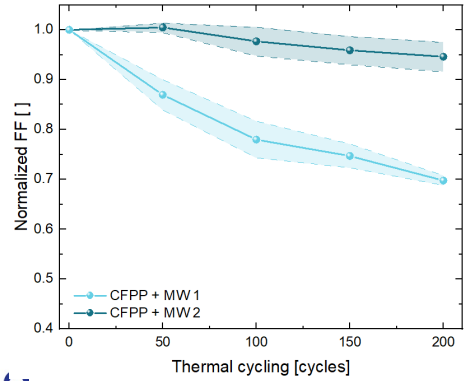


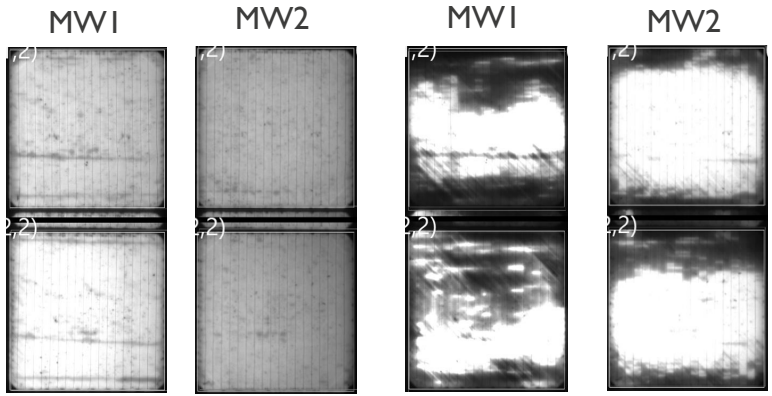
After TC 200

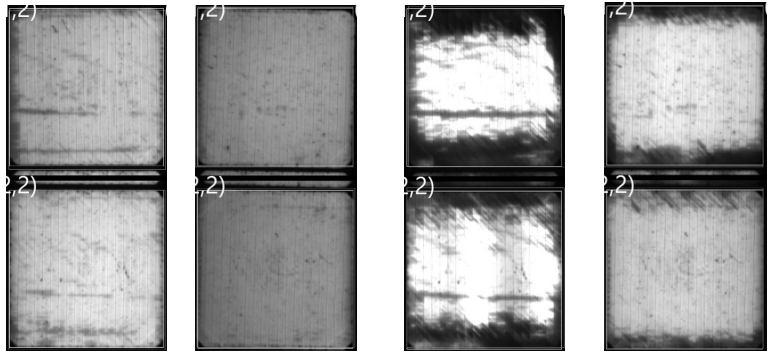
Reliability assessment

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





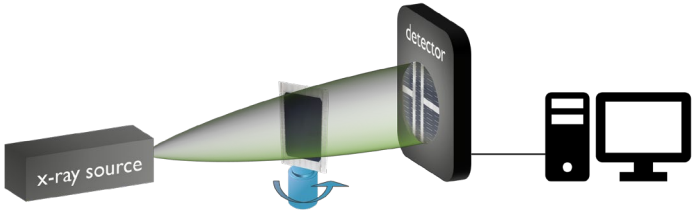




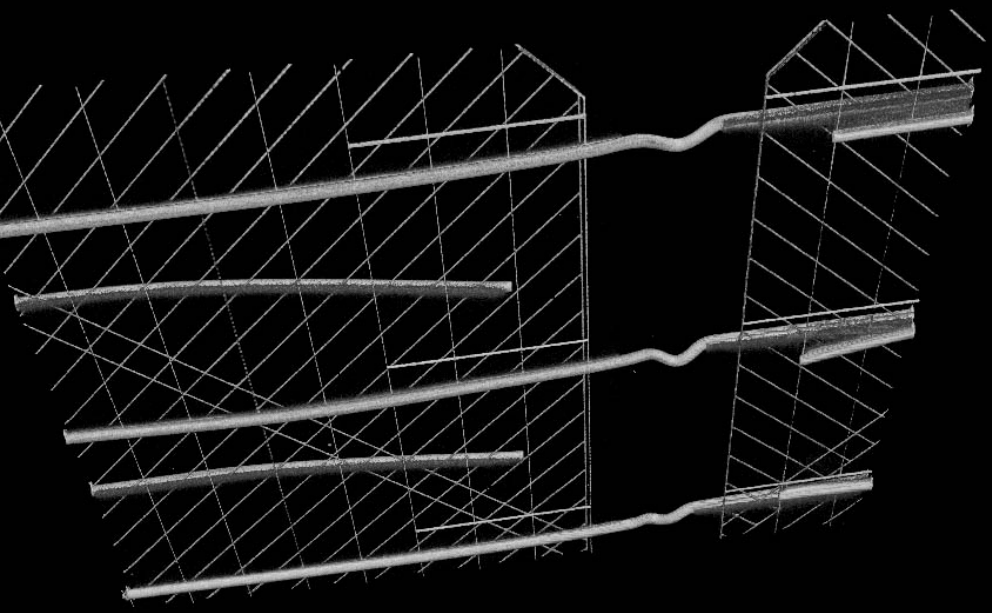
3D Micro-computed tomography

- 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

Tescan Unitom XL

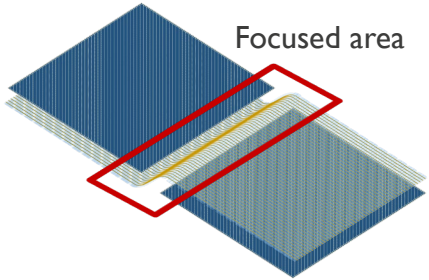


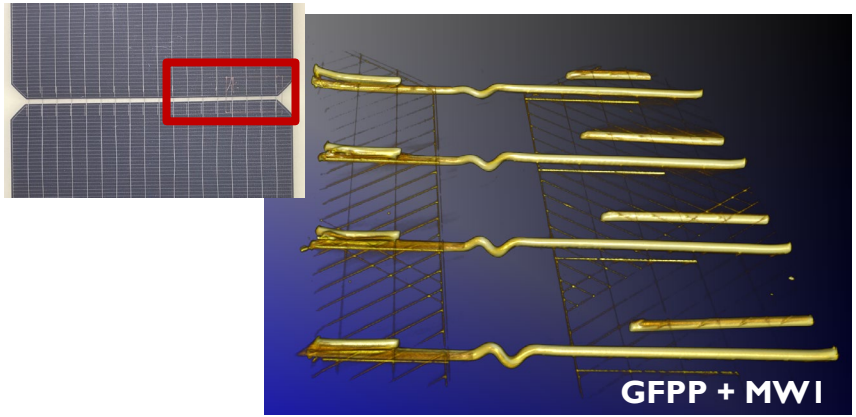
Van Dyck, R., et al (2023). **Solar Energy Materials and Solar Cells**

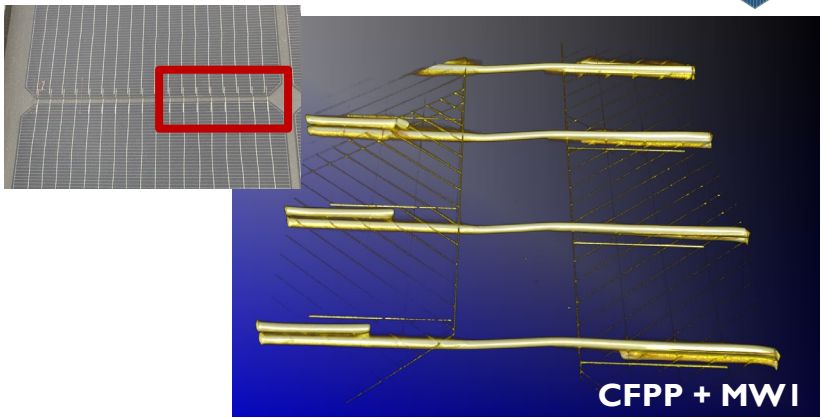


Reliability assessment and characterization

Micro-computed tomography (μ-CT) imaging

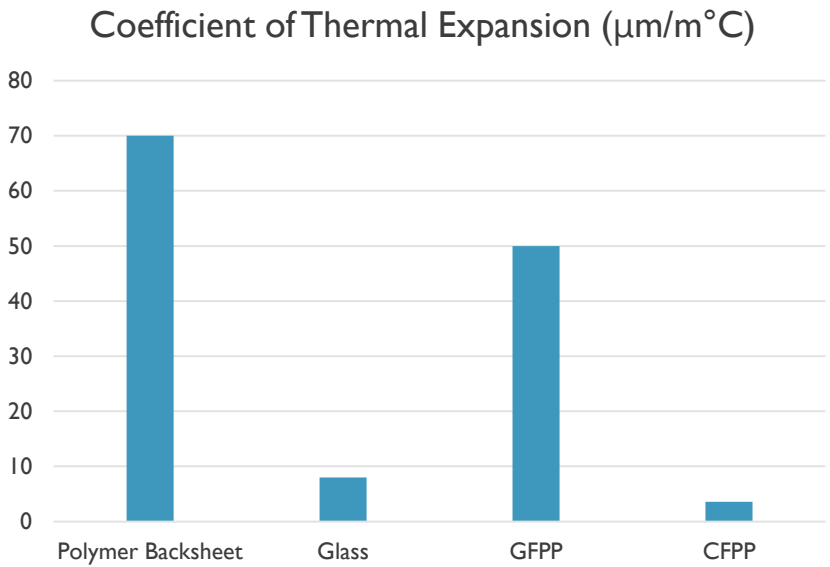


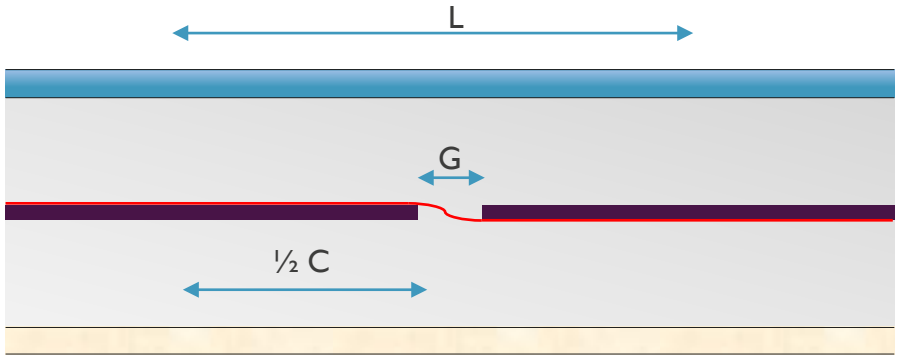




- Wire deformation between cells due to thermal strain

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

Conclusions

- Lightweight modules using a multi-wire interconnection are prone to degradation due to thermo-mechanical stress
- Decreasing the backsheet CTE improves the reliability
- 3D micro-computed tomography can be used to visually inspect interconnections
- Further investigation using FEM is ongoing

Thank you for your attention

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For more information:
Lightweight modules at imec: bin.luo@imec.be
3D computed tomography: rik.vandyck@imec.be