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First mechanical study on a lightweight microconcentrator design for space applications

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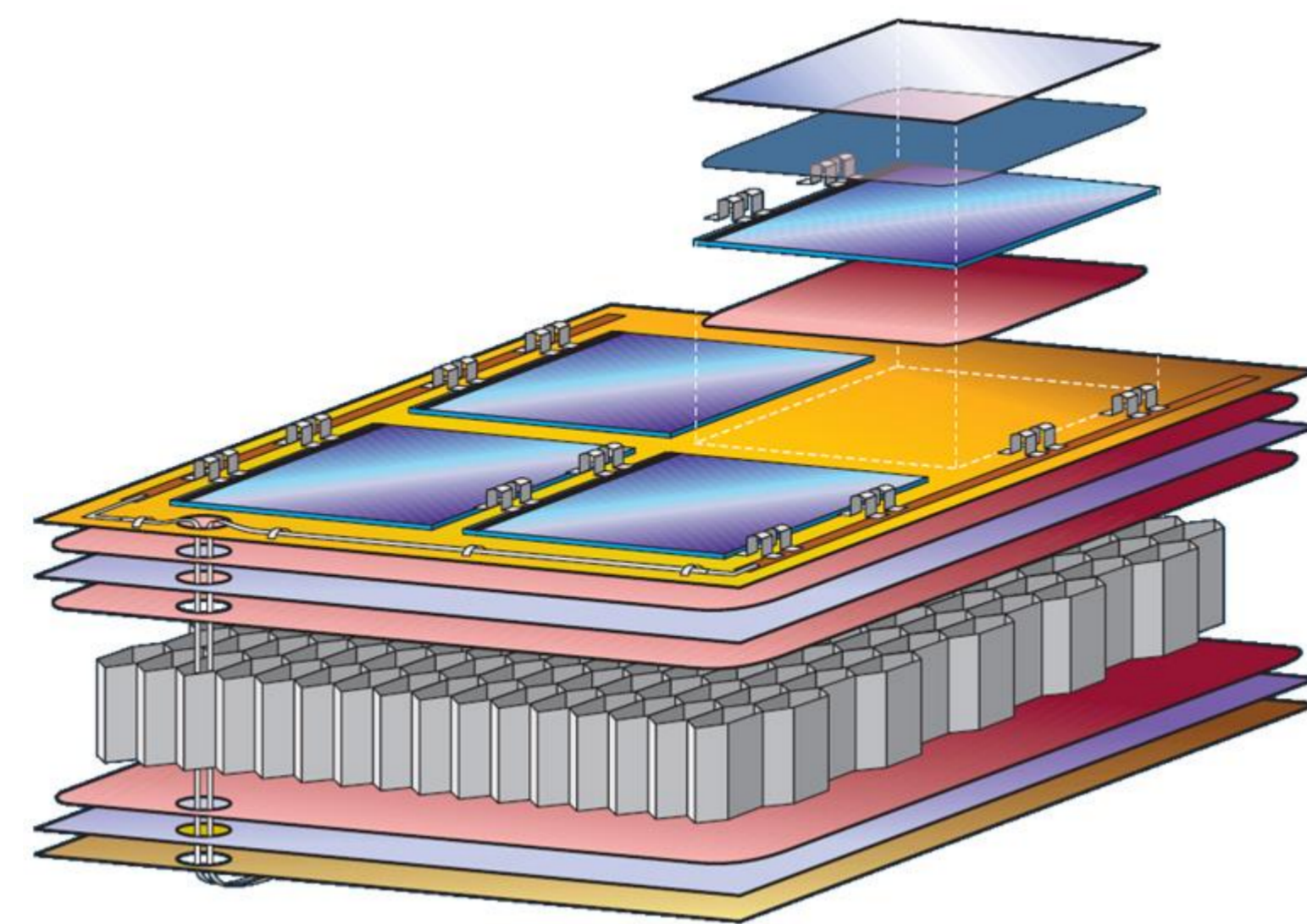
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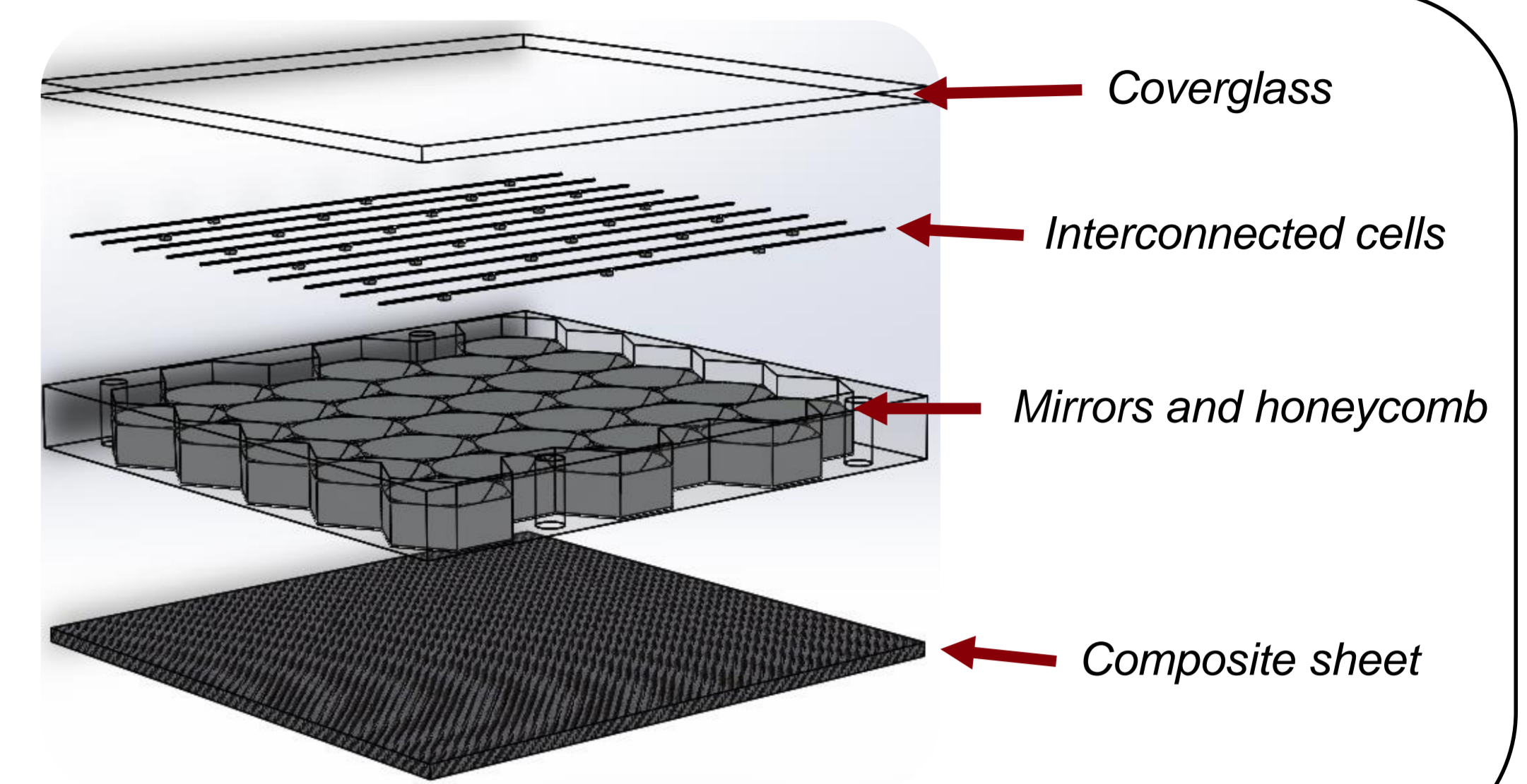
Context & objectives

Low cost trends in Space:

- Concentration to reduce cell cost
- Lightweight to reduce launch cost
- Innovative design proposal
- **Need to study the mechanical behaviour of the design**

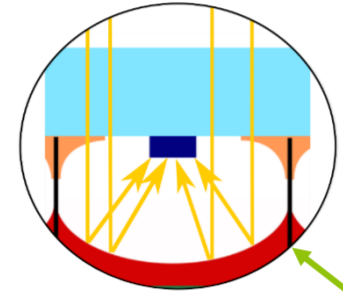


Standard rigid panel [1]



Exploded view of our concentrator design [2]

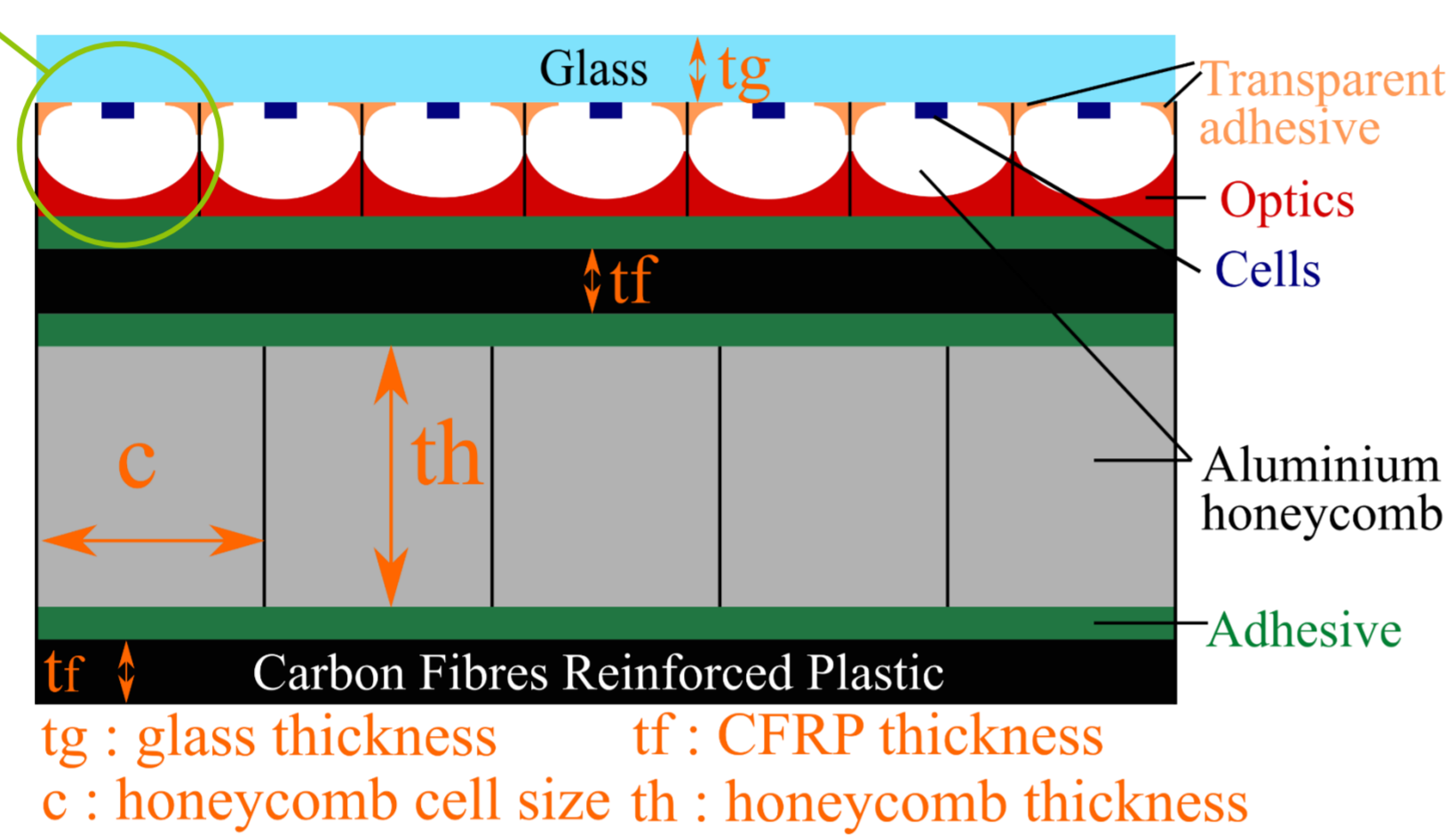
Methodology



Parametric study

- CFRP thickness (t_f)
- Glass thickness (t_g)
- Honeycomb thickness and cell size (th , c)

- Design of experiments
- Get the main effects
- Limit the number of experiments



t_g : glass thickness t_f : CFRP thickness
 c : honeycomb cell size th : honeycomb thickness

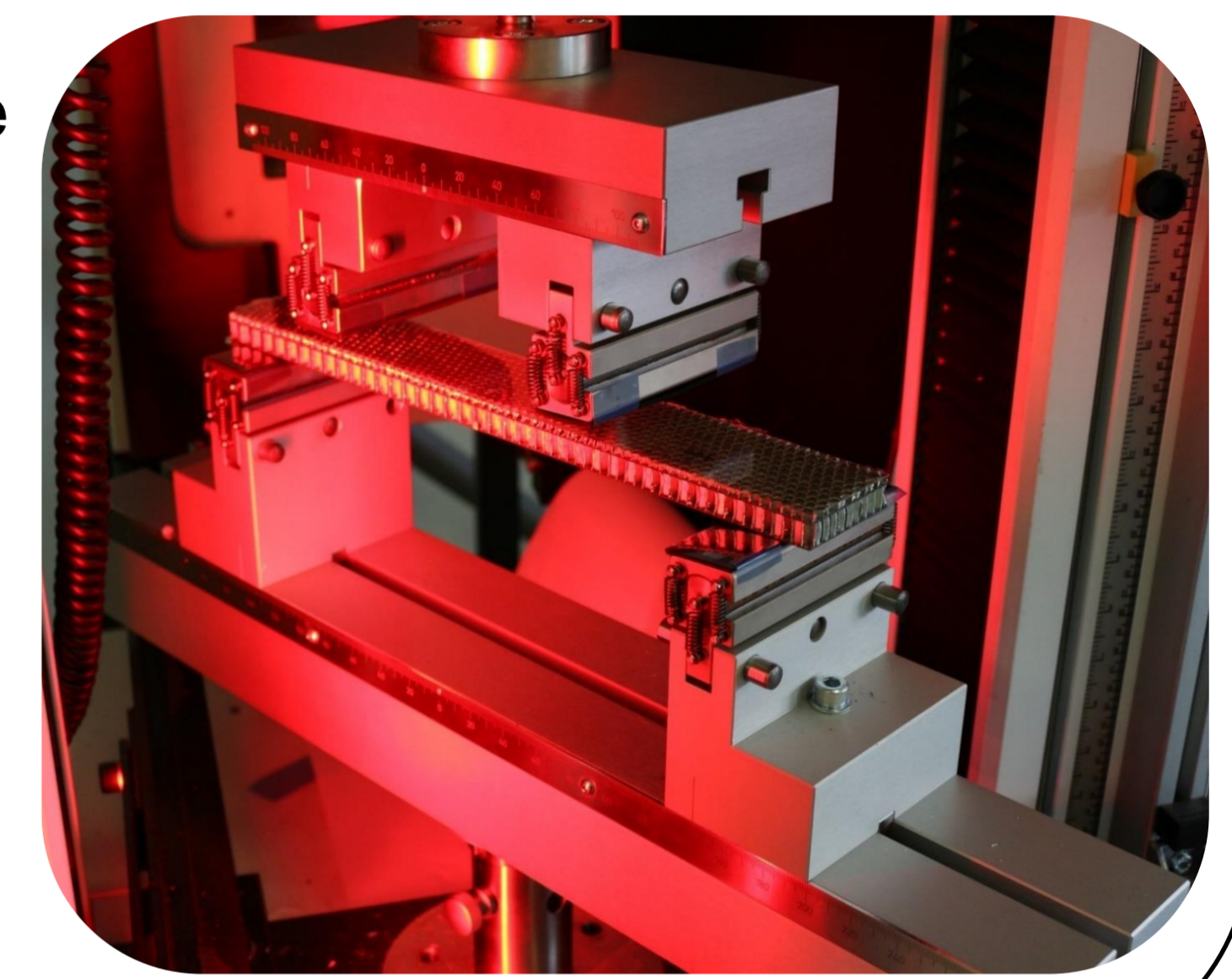
Materials

4 - point bending tests

- ASTM D7250 [3] conforming machine
- Video extensometer
- 5 samples for each configuration



Sample configuration #8



4-point bending setup

Results: bending stiffness

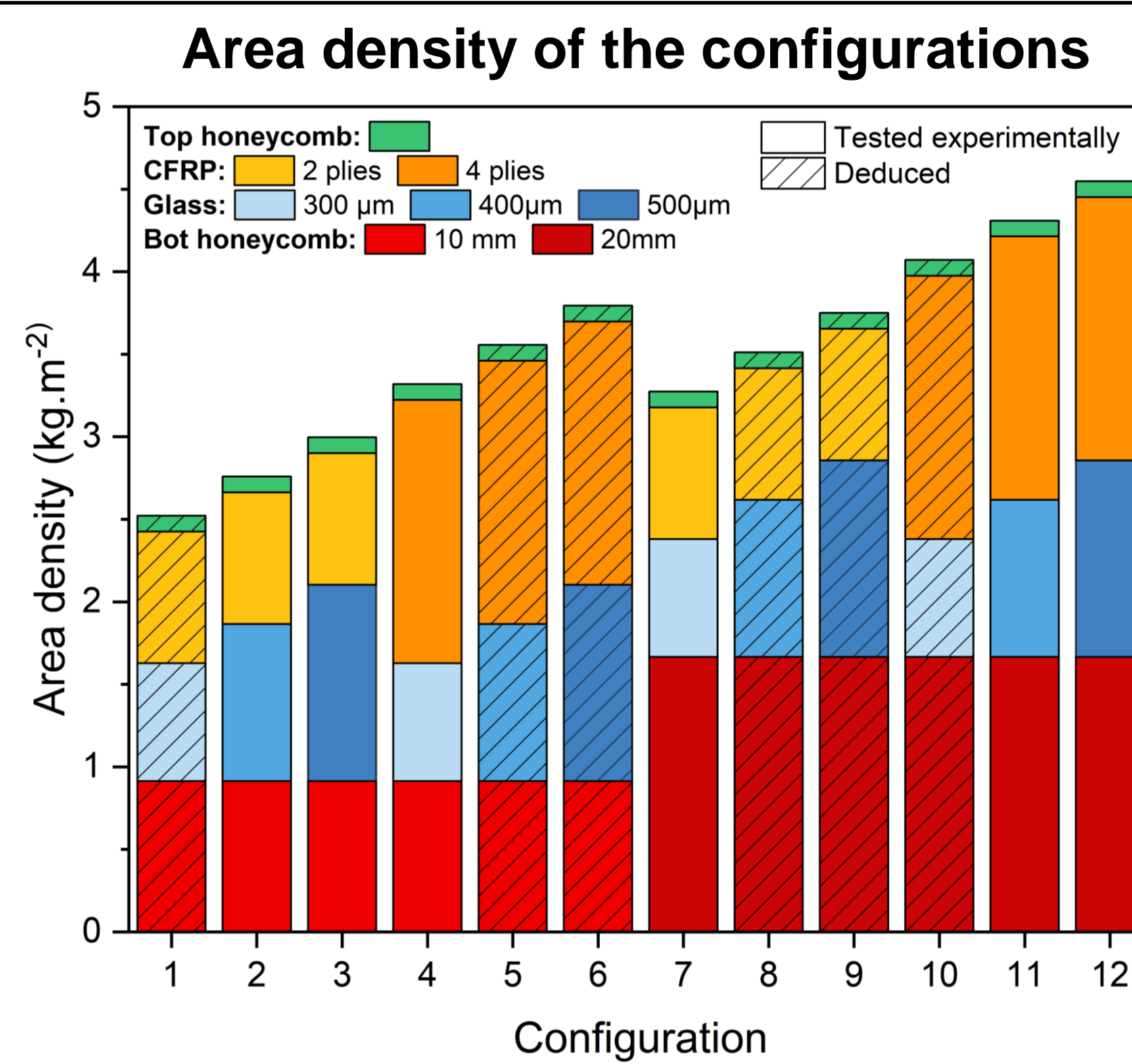
High density honeycombs were used and proved to be quite heavy

Higher specific stiffness with a thicker honeycomb

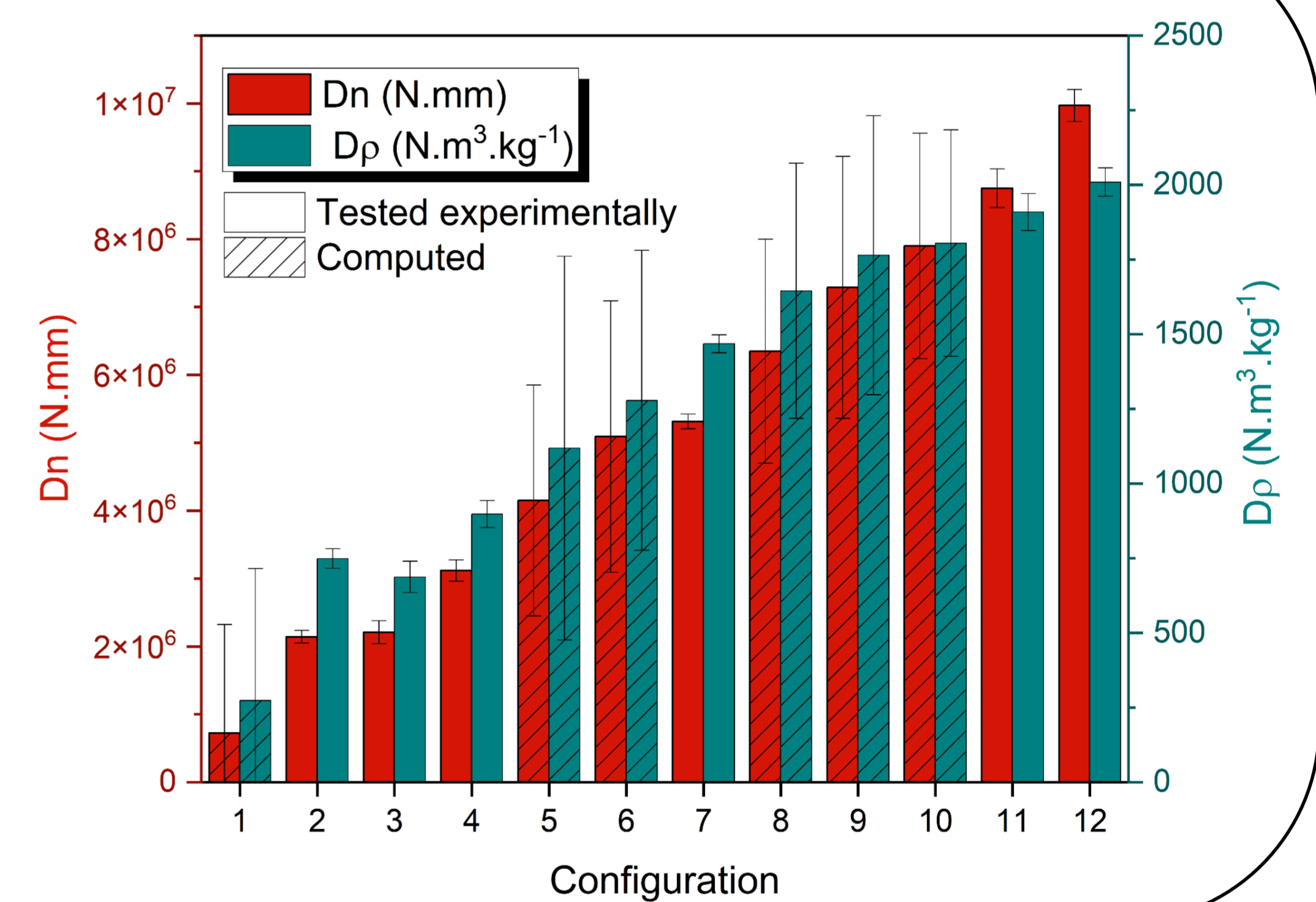
- Possibility to decrease its density without changing the mechanical behaviour a lot

Glass thickness has a lower influence than the other two parameters

- Possible way to decrease the mass of the structure



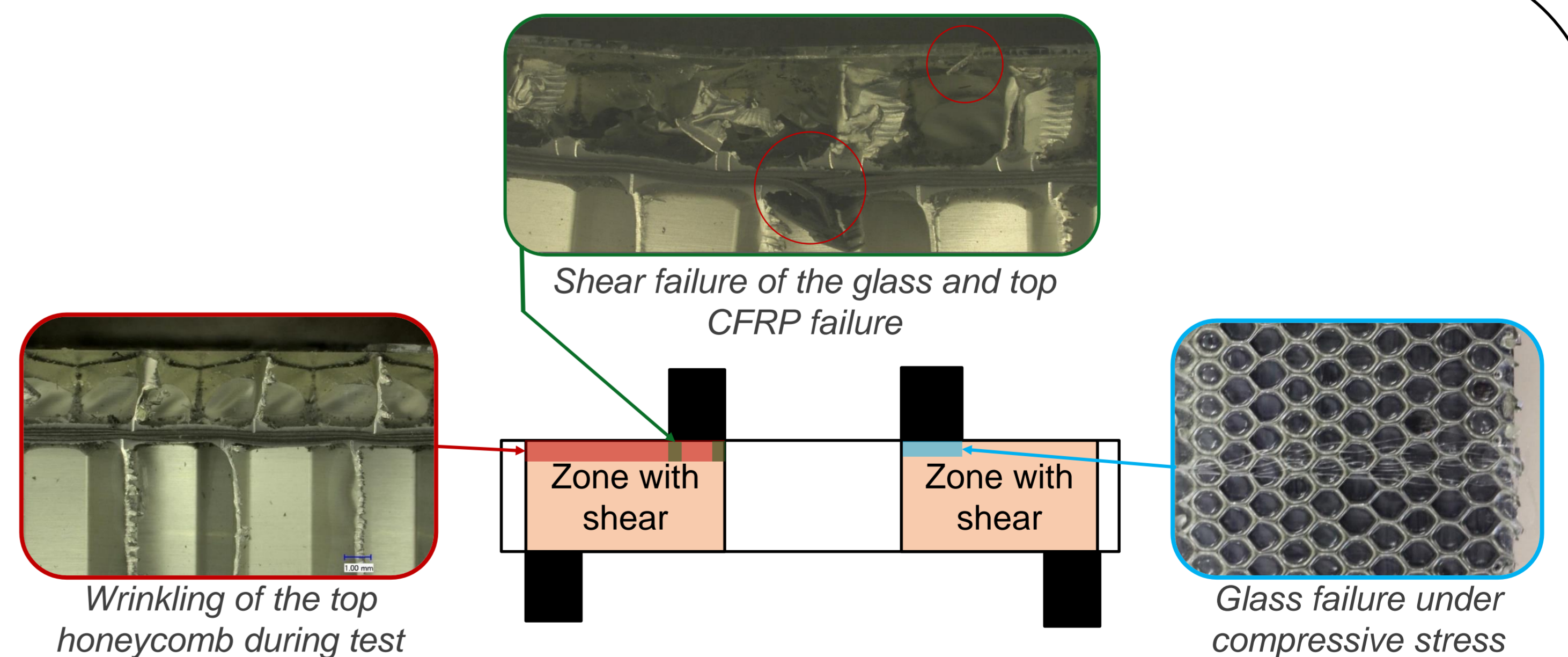
Bending stiffness for each configuration



Results: failure modes

- **Different phenomena were observed:**
 - Glass failure below the loading areas: local compressive stress
 - Glass failure on the edges of the loading areas: local shear stress
 - Crushing of the top honeycomb
 - Failure of the top CFRP → compressive stress
 - Failure of the bottom CFRP → tensile stress

For some samples with thicker glass and thinner CFRP, the glass did not break during the test



Conclusion & Perspectives

- The bending stiffness and area density of different μ -concentrator designs was determined with 4-point bending tests
- Thicker glass (400, 500 μ m) and thinner CFRP (2 plies) is useful to prevent glass failure
- A thicker honeycomb (20 mm) and a thinner glass (300 μ m) help decreasing the mass
- Compromise to be determined: configurations 8 and 11 seem to be the most promising ones
- Prospect: Finite Element Method simulations in progress

References:

- [1] R. W. Francis, C. Sve, and T. S. Wall, "Thermal Cycling Techniques for Solar Panels", Crosslink Fall, Vol. 6, No. 3, 2005
 [2] A. Bermudez-Garcia, P. Voarino, O. Racourt, patent pending, Concentrateur optique à structure alvéolaire, FR2013856, 21/12/2020.
 [3] ASTM D7250/D7250M standards: Standard Practice for Determining Sandwich Beam Flexural and Shear Stiffness, 2020

Acknowledgments:

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