First mechanical study on a lightweight microconcentrator design for space applications

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FIRST MECHANICAL STUDY ON A LIGHTWEIGHT MICROCONCENTRATOR DESIGN FOR SPACE APPLICATIONS

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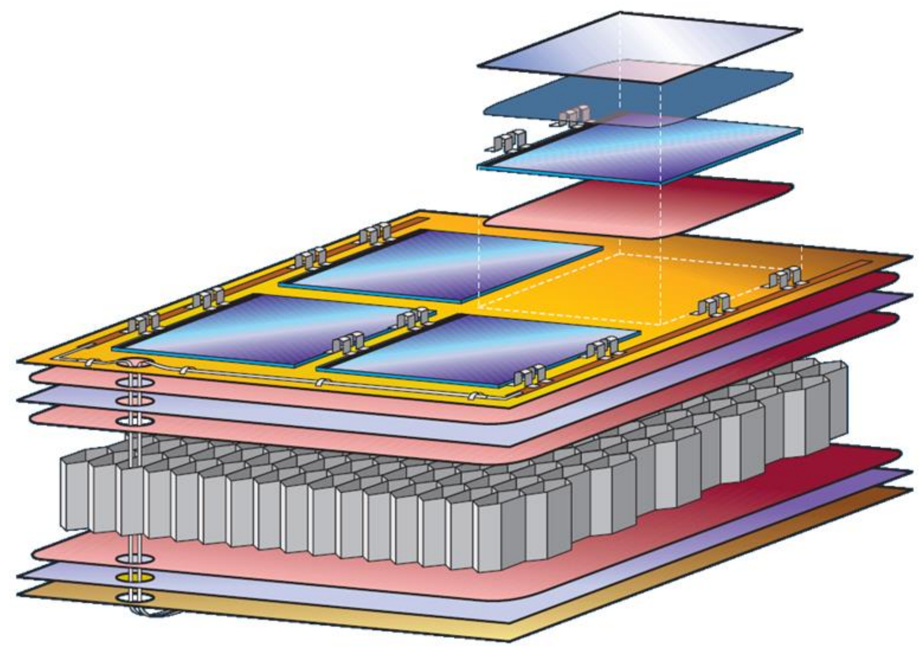
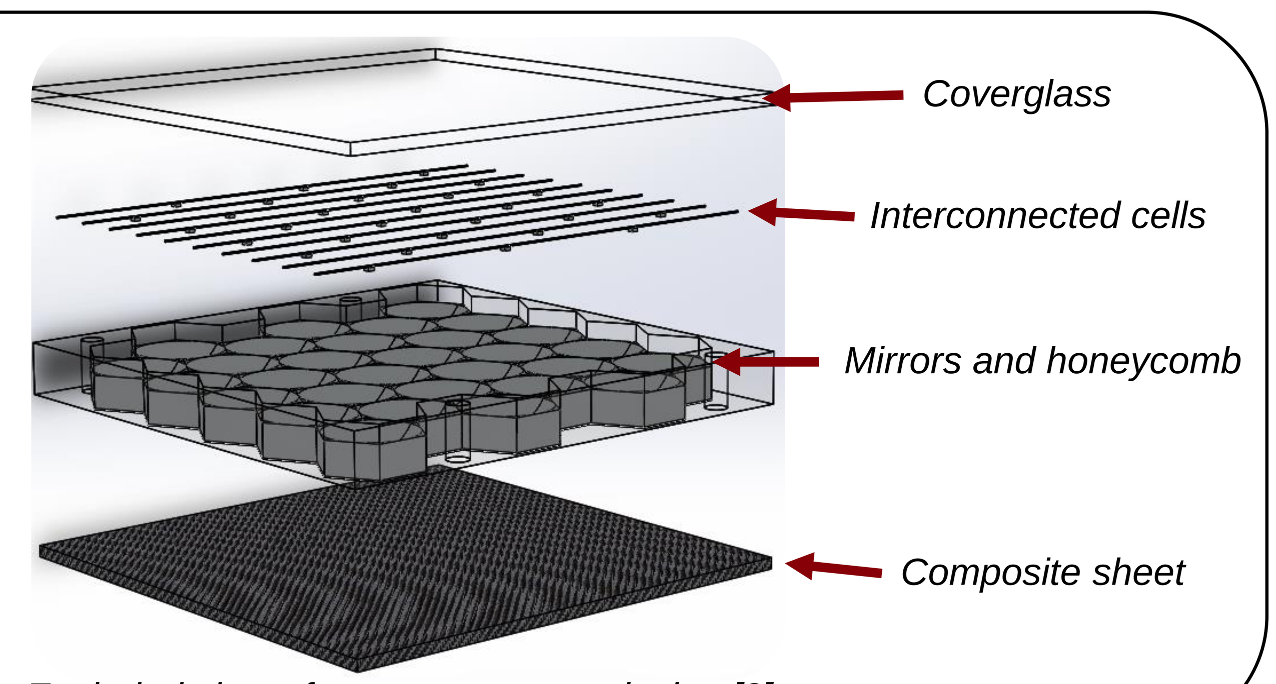
Context & objectives

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]



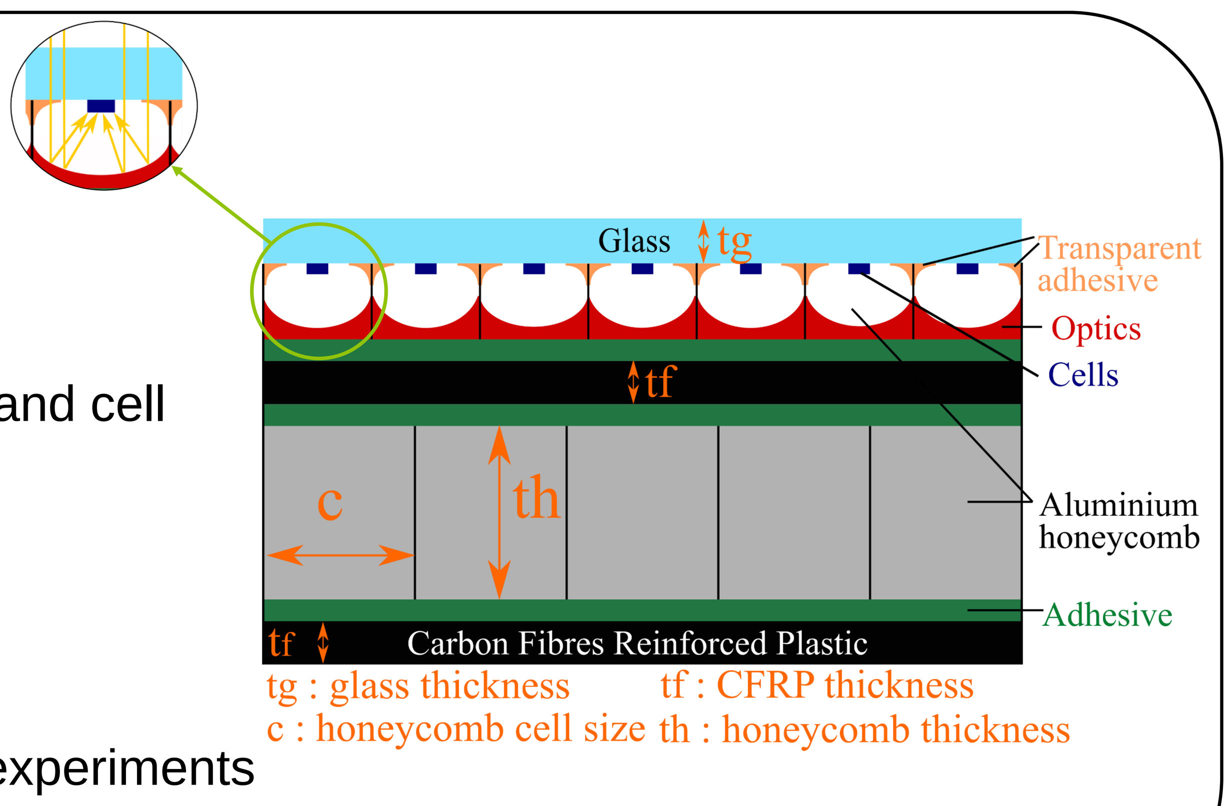
Exploded view of our concentrator design [2]

Methodology

Parametric study

- CFRP thickness (*tf*)
- Glass thickness (*tg*)
- Honeycomb thickness and cell size (*th*, *c*)

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

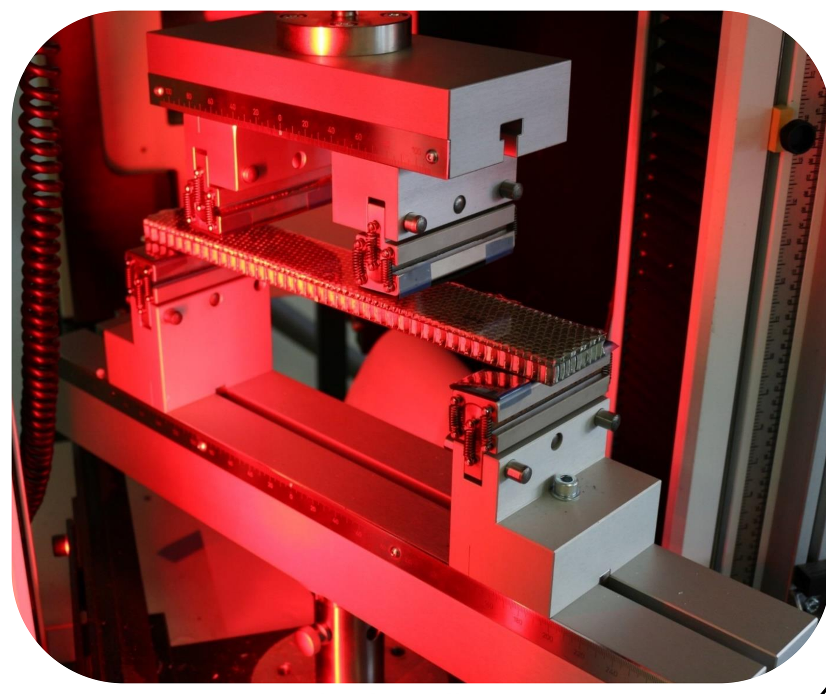


Materials

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

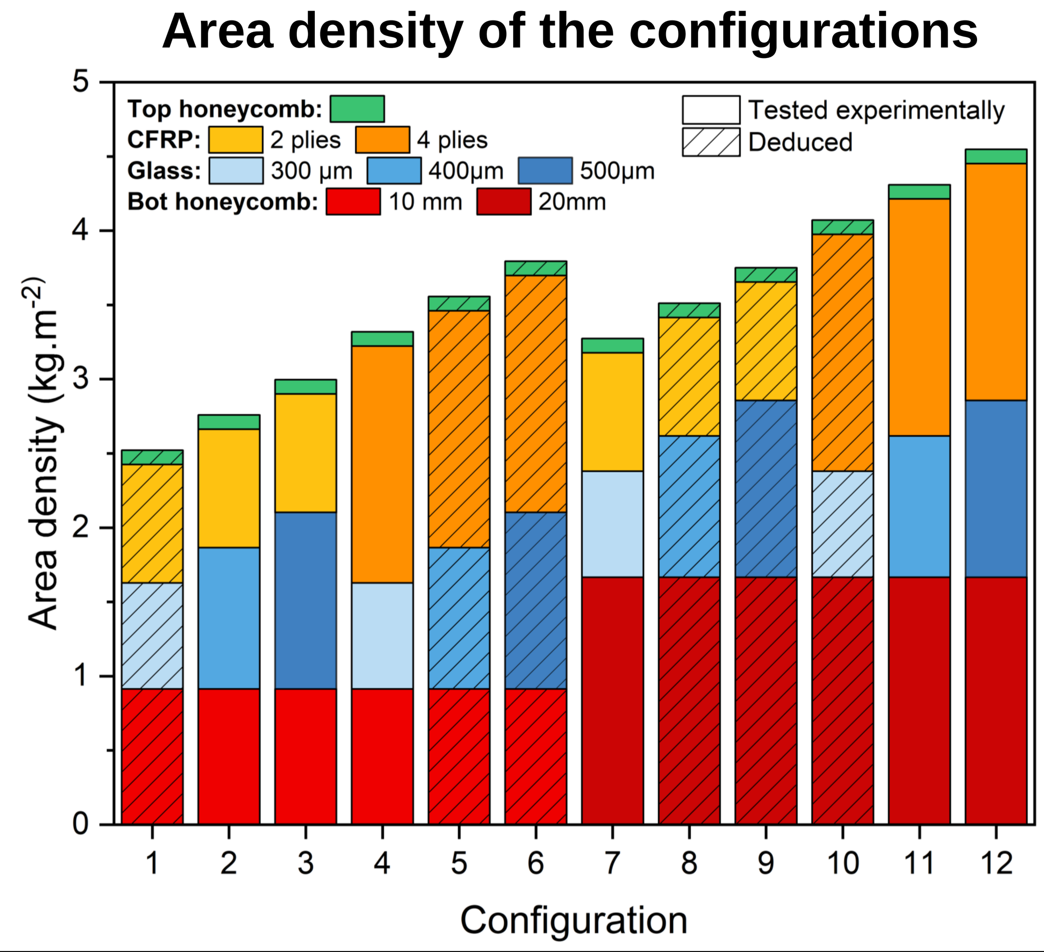
Higher specific stiffness with a thicker honeycomb

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

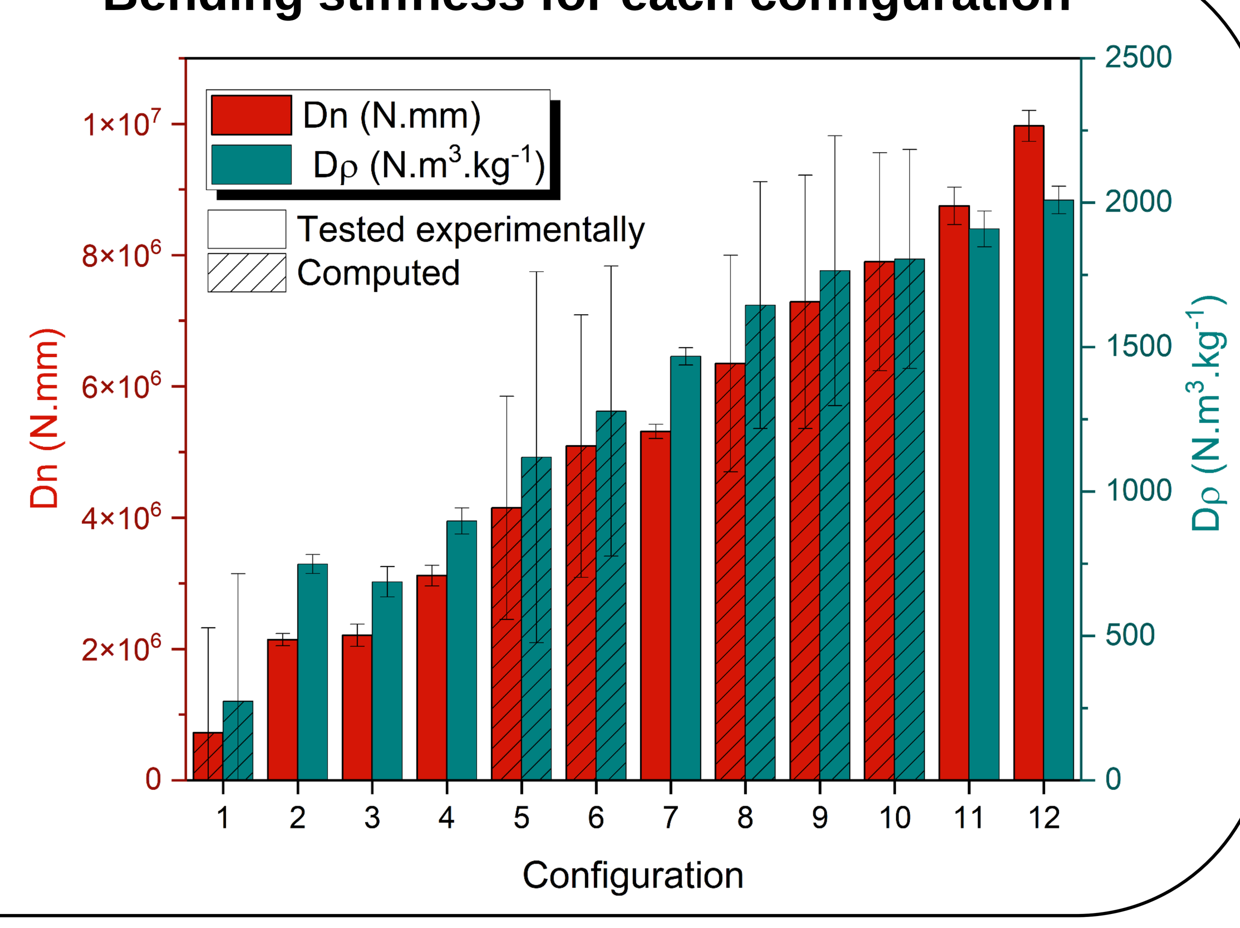
Glass thickness has a lower influence than the other two parameters

- Possible way to decrease the mass of the structure

Area density of the configurations



Bending stiffness for each configuration

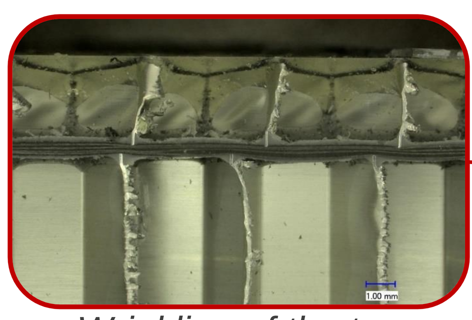


Results: failure modes

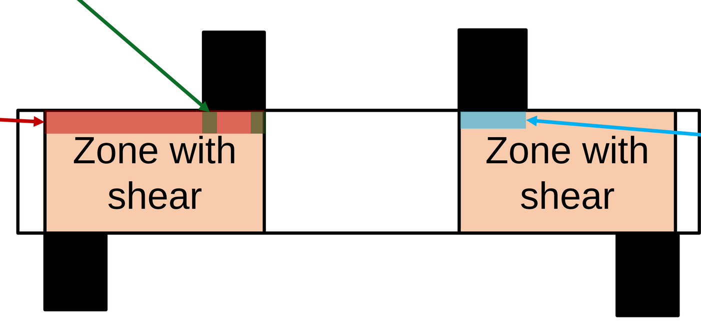
- **Different phenomena were observed:**
  - Glass failure below the loading areas: local compressive stress
  - Glass failure on the edges of the loading areas: local shear stress
  - Crushing of the top honeycomb
  - Failure of the top CFRP → compressive stress
  - Failure of the bottom CFRP → tensile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

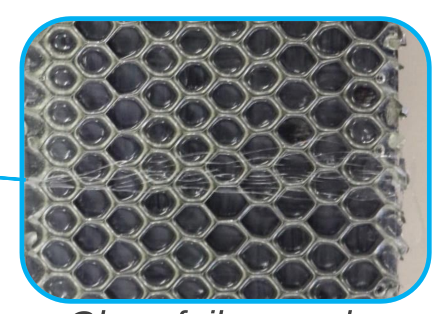
For some samples with thicker glass and thinner CFRP, the glass did not break during the test

Shear failure of the glass and top CFRP failure



Wrinkling of the top honeycomb during test





Glass failure under compressive stress

Conclusion & Perspectives

- The bending stiffness and area density of different µ-concentrator designs was determined with 4-point bending tests
- Thicker glass (400, 500 µm) and thinner CFRP (2 plies) is useful to prevent glass failure
- A thicker honeycomb (20 mm) and a thinner glass (300 µm) help decreasing the mass
- ➢ Compromise to be determined: configurations 8 and 11 seem be to 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. Raccurt, 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

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