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PhD thesis (2023-2026)  
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## Architecturing papers and boards with bio-based grid printing: a low-cost approach to lightweight packaging

Papiers et cartons architecturés par impression de renforts bio-sourcés :  
développement d'une approche à bas coût pour alléger les emballages.

MatBio  
FunPrint

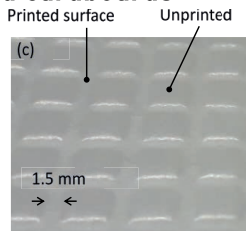
### Context / Objectives

#### Reducing the weight of paper-based packaging

- ➔ Paper production demands substantial resources:
  - ✓ 15-25 m<sup>3</sup>/ton of water,
  - ✓ 2.9 MWh/ton of energy,
  - ✓ 2-3 ton/ton of wood

#### Idea: architecturing papers and cardboards

- ➔ Embossing paper sheets to increase their bending stiffness
- ➔ Low cost biodegradable route:
  - ✓ Printing patterns with starch suspensions
  - ✓ Sheet embossing induced during suspension drying



#### Thesis objectives

- ➔ Optimization of the printing process
- ➔ Multiscale analysis of :
  - ✓ Drying, shrinkage, buckling phenomena
  - ✓ Induced meso and microstructures
  - ✓ Induced hygro-mechanical properties

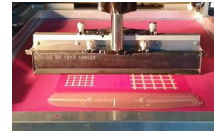
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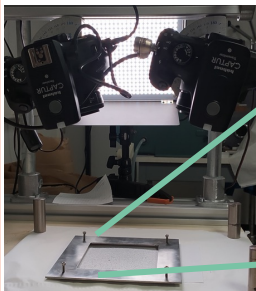
### Methods

#### Materials & Processing route

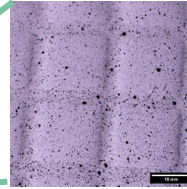
- ➔ Handmade model paper sheets:
  - ✓ Softwood kraft bleached pulp
  - ✓ Rapid Köthen former
  - ✓ Basis weight: 80-120g/m<sup>2</sup>
- ➔ Aqueous suspension with 40 wt% of low molecular weight corn starch
- ➔ Screen printing



#### Monitoring the drying/embossing



Measurement of meso kinematic fields during drying and shrinkage of the starch.



#### Mechanical test:

##### *Cantilever strip of paper*



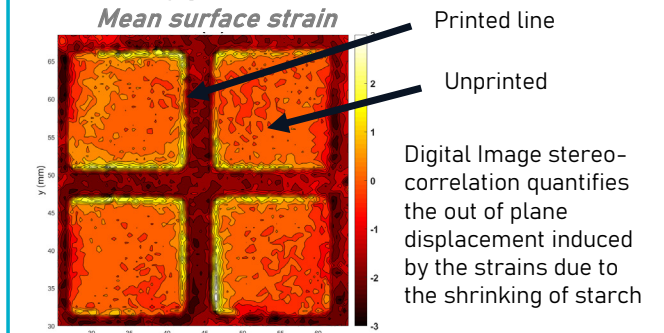
Bending stiffness measurement based on image analysis

#### Microstructure observations :

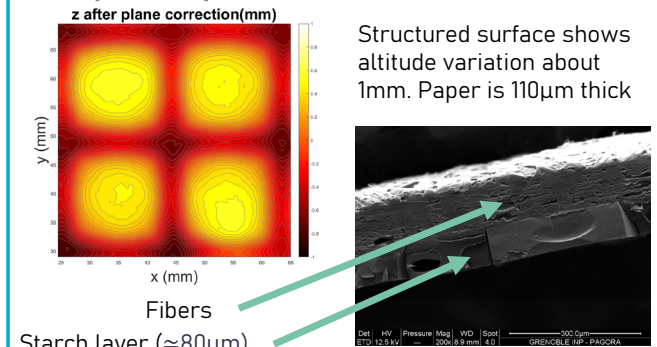
ESEM

### Results

#### Embossing phenomenon



#### *Out of plane displacement (mm)*



Printed starch presents good adhesion, homogeneous thickness and many cracks due to its brittleness

**Conferences:** Turpin, C et. al. (2023). 8<sup>th</sup> EPNOE International Polysaccharide Conference, Graz