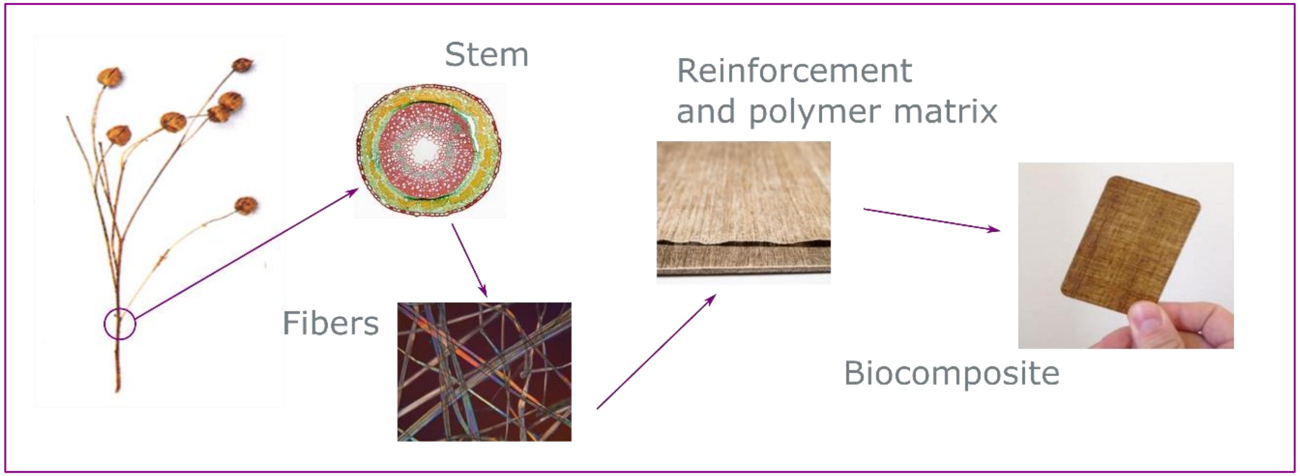
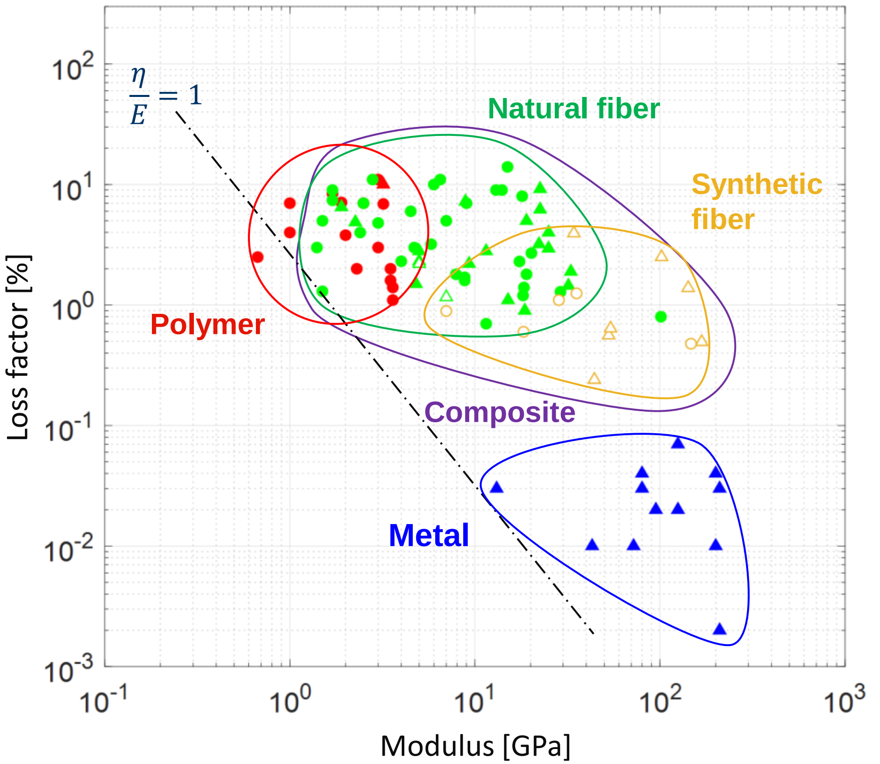
Dynamic characterization of synthetic and plant fibers



Pauline Butaud, Morvan Ouisse, Vincent Placet, Gilles Bourbon

Composite context

Loss-modulus map from literatures



Bio-based composite: application in the field of sports

Objective: go further in **structural and multifunctional applications**

- to master the natural resources
- to control the **mechanical properties in a specific environment**
- to **optimize the architecturation** of the composite

Bio-based composites

Renewable

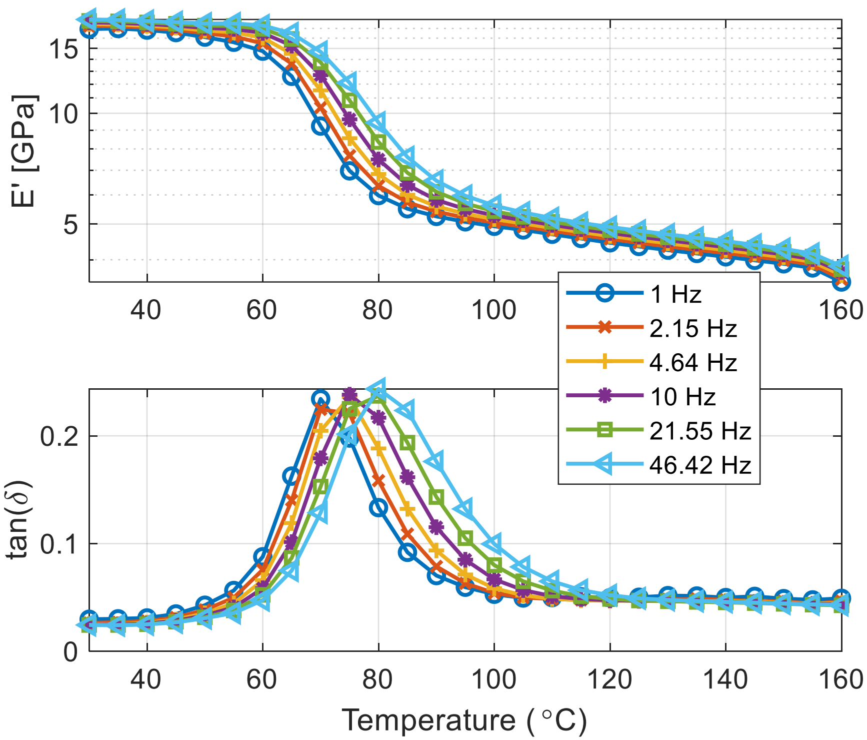
Market demand

Natural fiber resources

Damping: macroscale analysis

UD flax composite

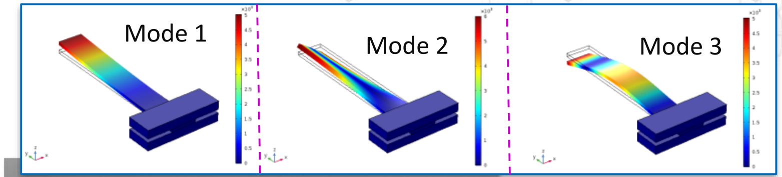
Dynamic Mechanical Analysis (DMA tests)

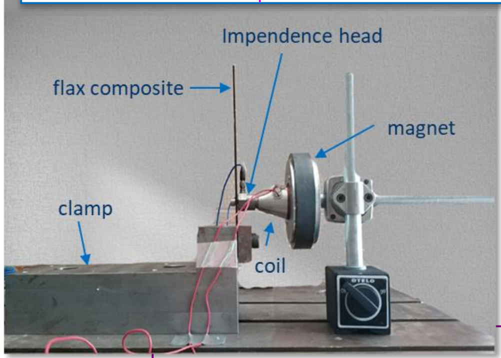


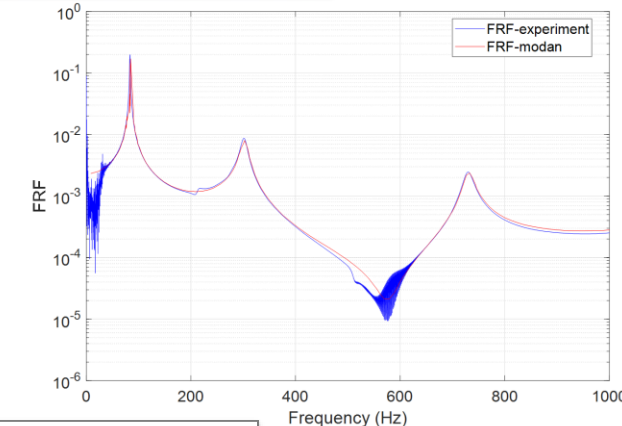
Storage modulus : 18 GPa in glassy state
to 3,8 GPa in rubbery state

Loss factor : 2,5 to 24% according to the
temperature and the frequency

Modal analysis



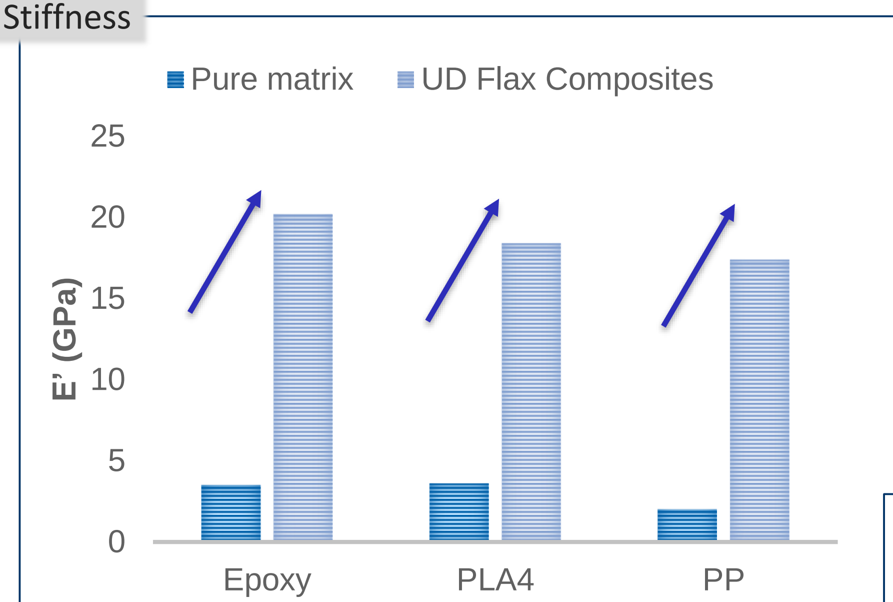


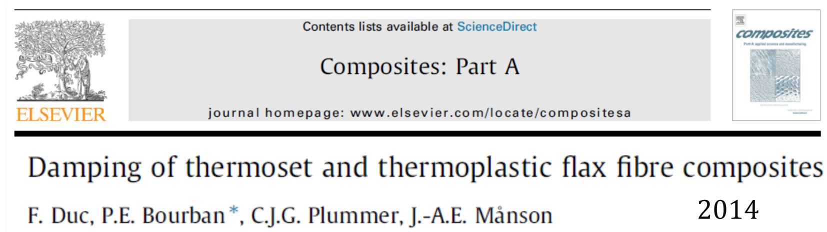


Loss factor: 1,3 to 2,5%
according to the frequency

Composite mechanical properties: matrix / fibers

Stiffness

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composites

Damping of thermoset and thermoplastic flax fibre composites

F. Duc, P.E. Bourban *, C.J.G. Plummer, J.-A.E. Månson

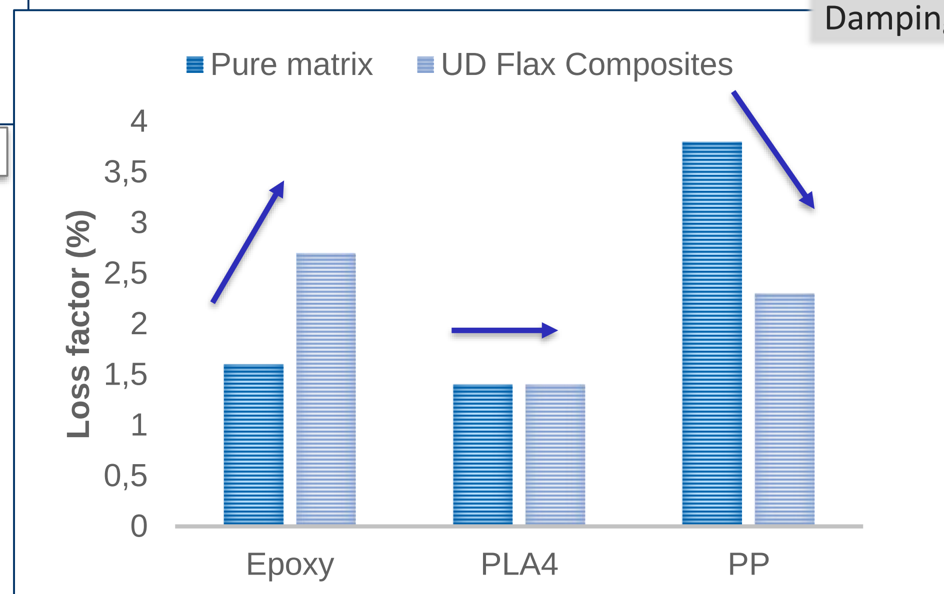
2014

Flexion – 1 Hz – 25°C

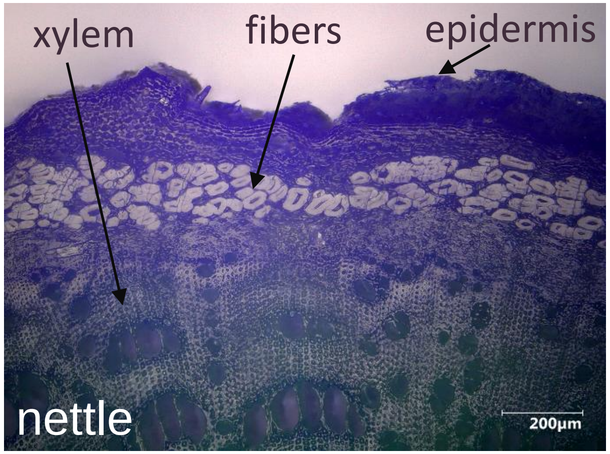
Impact of **flax fibers reinforcement polymer composite** on:

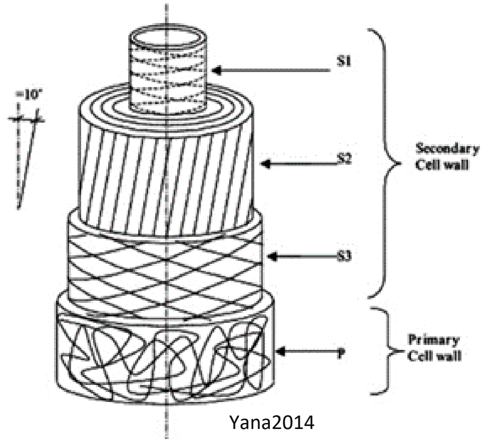
- **stiffness**: the storage modulus increases
- **damping**: the loss factor evolution is depending on the matrix…

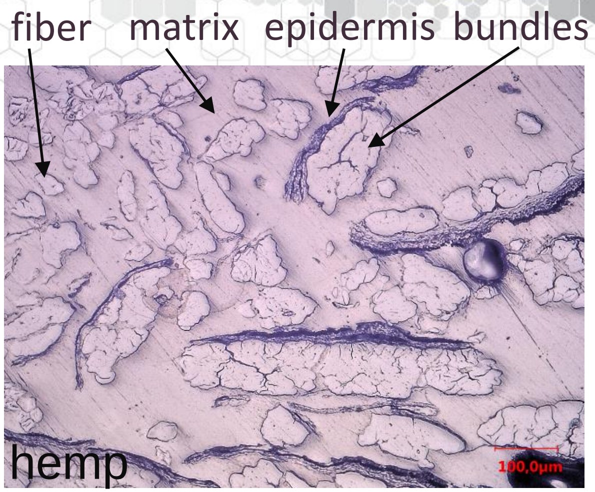
Damping



Bio-based composite microstructure







Energy dissipation could come from :

- **fiber** properties: polymeric and hierarchical
- **interface** fiber/matrix
- interface in fiber bundles (**friction**)
- **damage**
- **matrix properties**

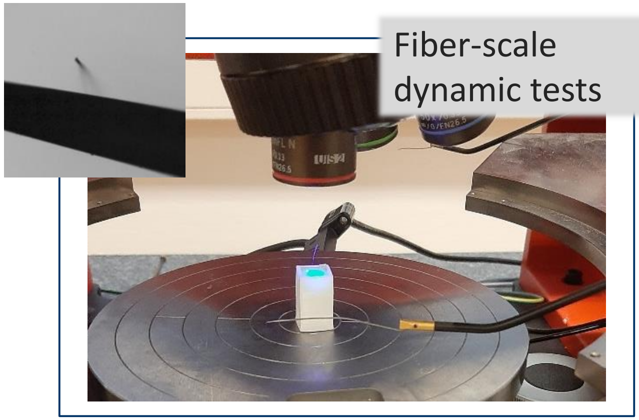
Difficulties to study bio-based material

variability
hierarchical
sensitivity

environment influence

humidity
temperature
frequency
fiber type

Fiber-scale dynamic tests



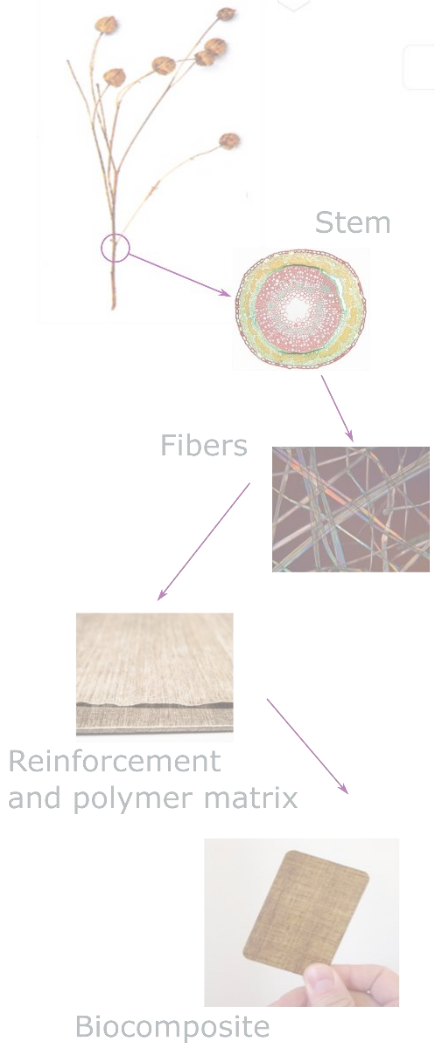
Outline

Context and motivations

State of the art on fiber-scale tests

Dynamic tests on elementary fiber

First measurements and discussions

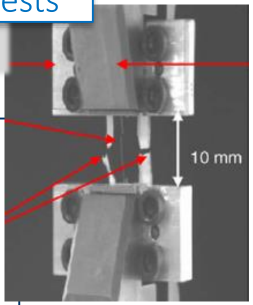


Modulus at the fiber-scale

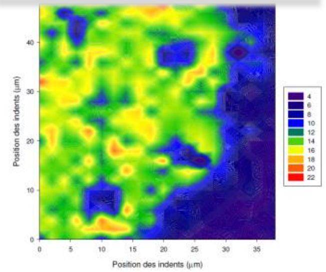
DMA tensile tests

Placet et al. 2009

hemp fibers



Bourmaud, 2009

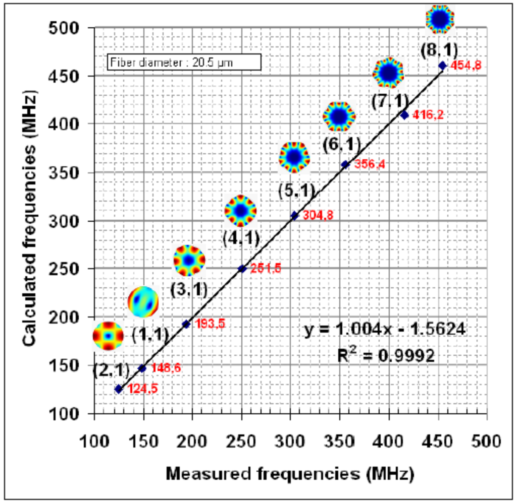


flax fiber

Nanoindentation test: modulus identification

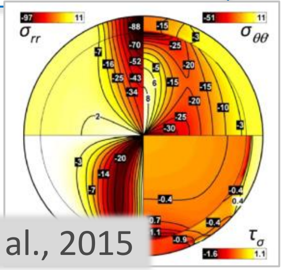
Mounier et al. 2012

Determination of the transverse elastic properties of by laser resonant ultrasound spectroscopy



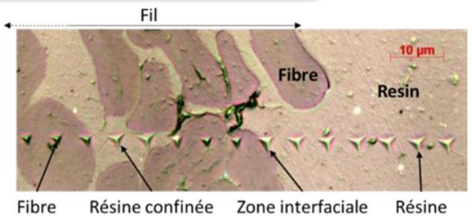
glass fiber and carbon fiber

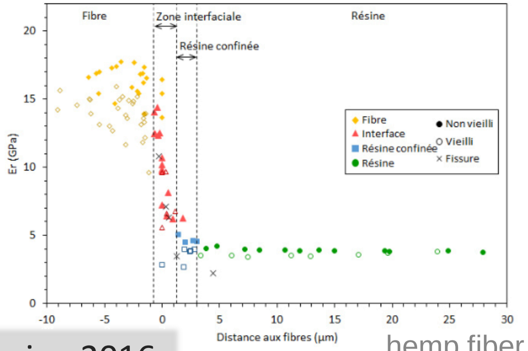
Single fiber transverse compression testing



aramid fibers

Wollbrett et al., 2015





Perrier, 2016

hemp fiber

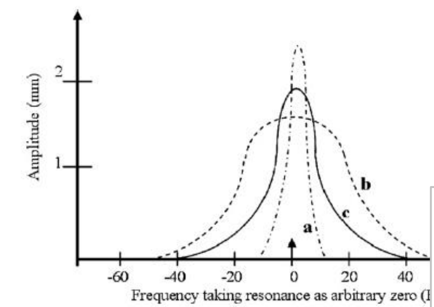
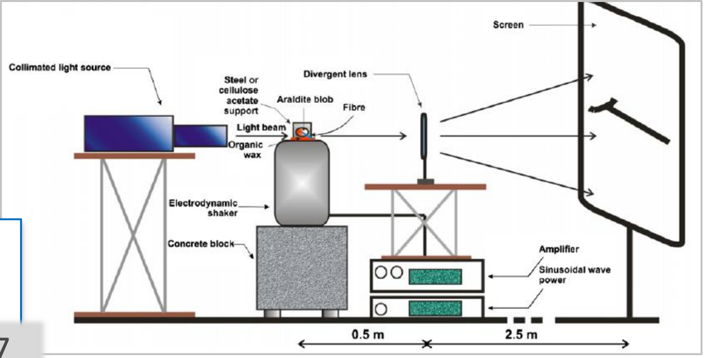


Fig. 5. Schematic representation of: (a) expected resonanc
and those found with (b) fibre mounted on a polymeric su
fibre mounted on a steel support.

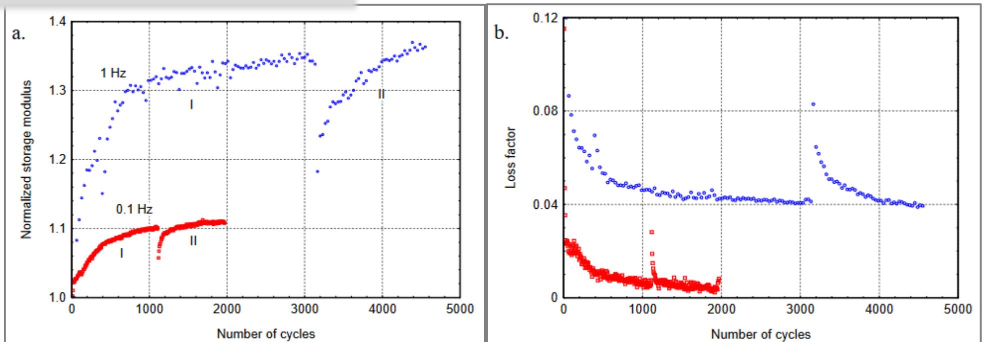


Determination of the elastic moduli of glass by forced vibrations

Perrin et al. 2007

Damping at the fiber-scale

Placet et al. 2014



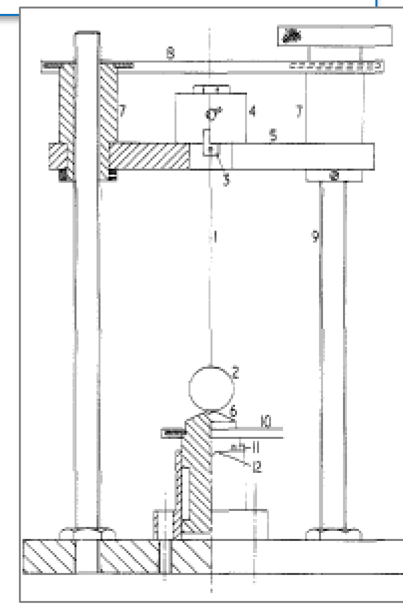
DMA tests on elementary hemp fiber

Adams et al. 1975

Torsion pendulum for elementary fiber: determination of the modulus and the loss factor under vacuum.

Philips, 1987

Yu, 2016



Key points to measure the damping at the fiber-scale:

- To quantify the aerodynamic effect (vacuum)
- To control of the limit conditions:
  - Clamp design
  - Measure method
  - Excitation mode
- To know the sample (geometry, density…)

Outline

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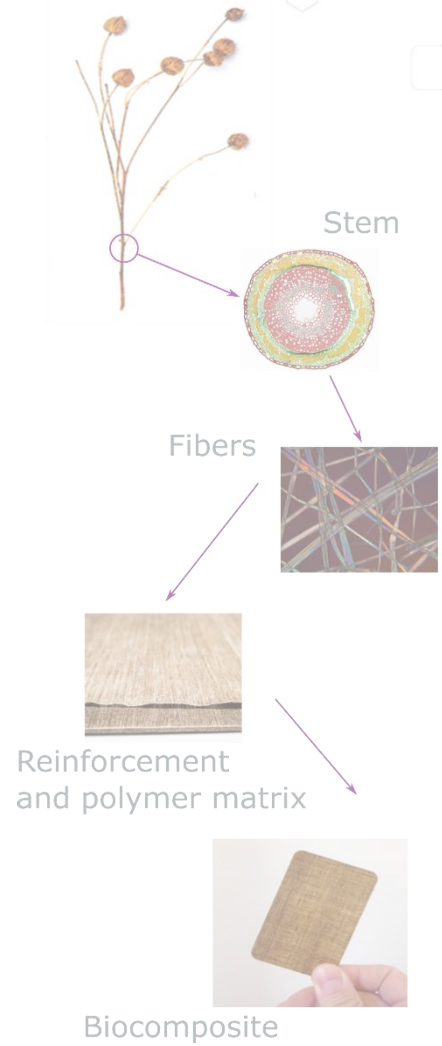
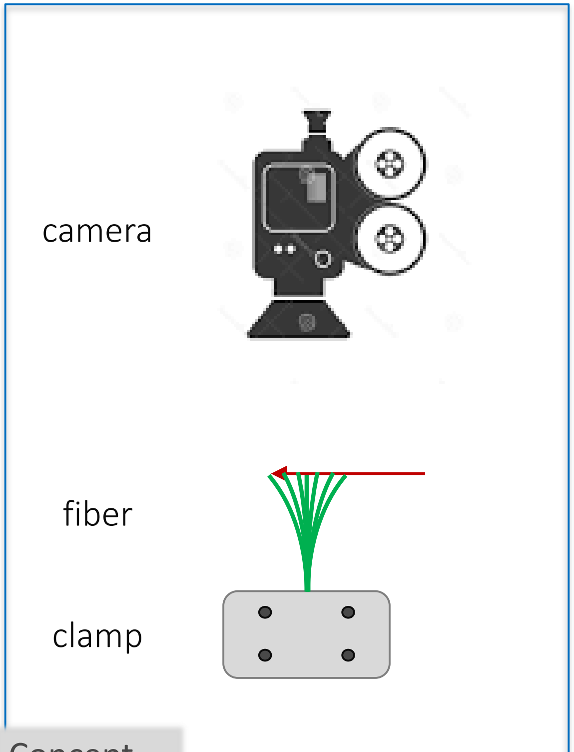
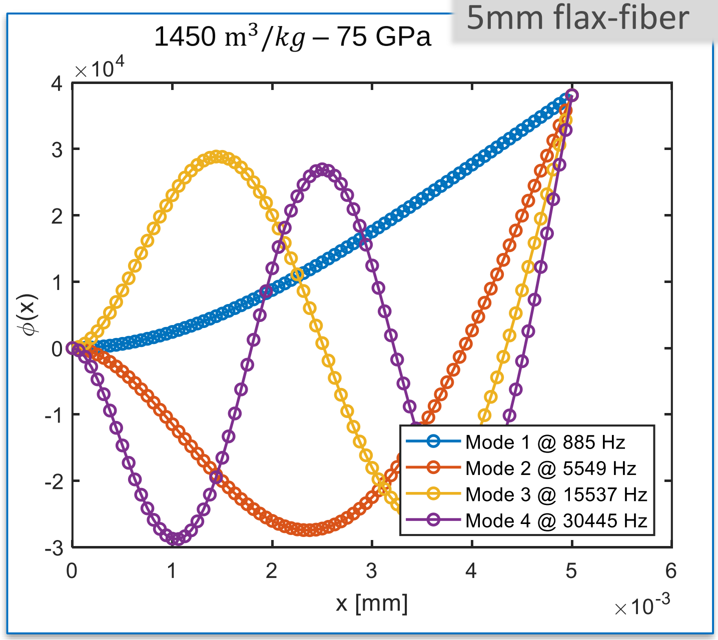


Dynamic test on fiber: concept

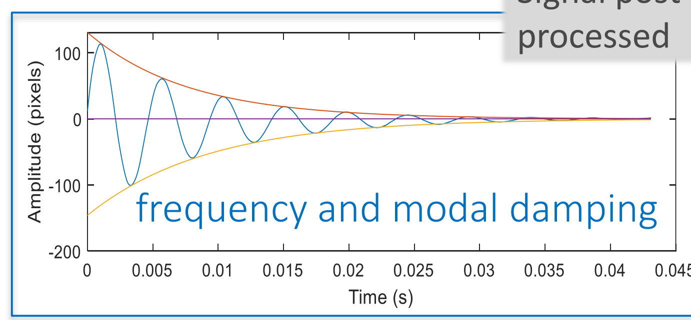


Concept

Vibration modes
5mm flax-fiber

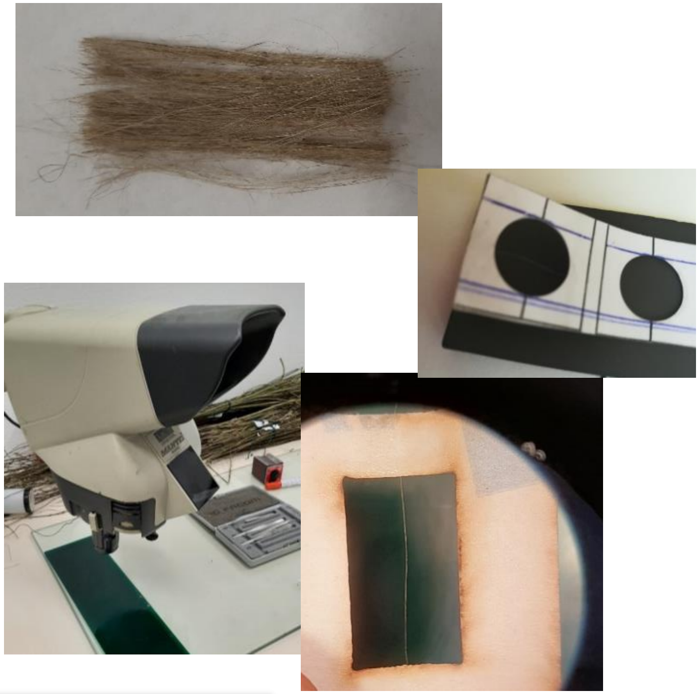


Signal post-processed

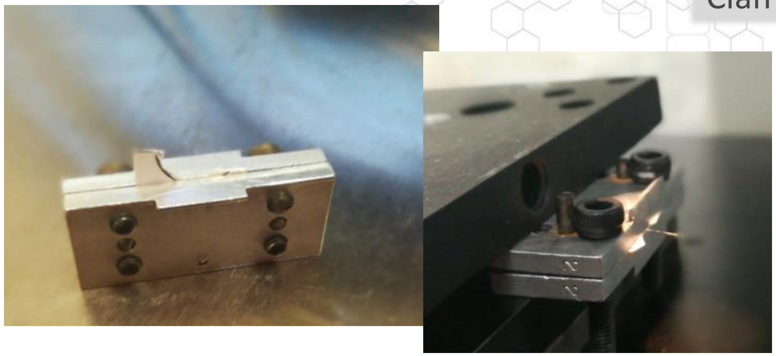


Objective: develop an **experimental method** to characterize the **damping** at the fiber scale

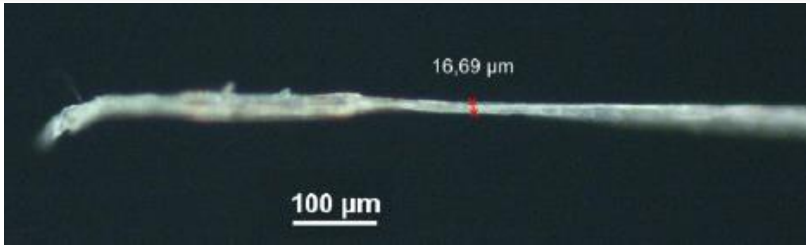
Elementary fiber



Fiber preparation

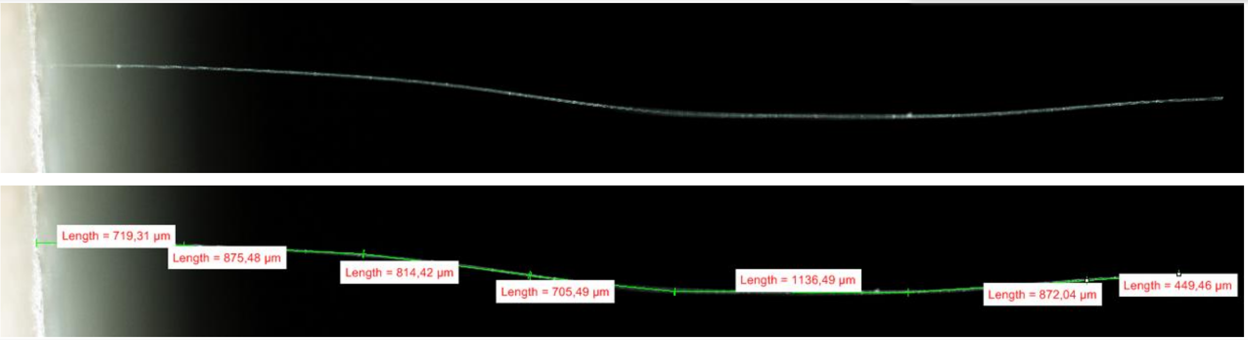


Clamp



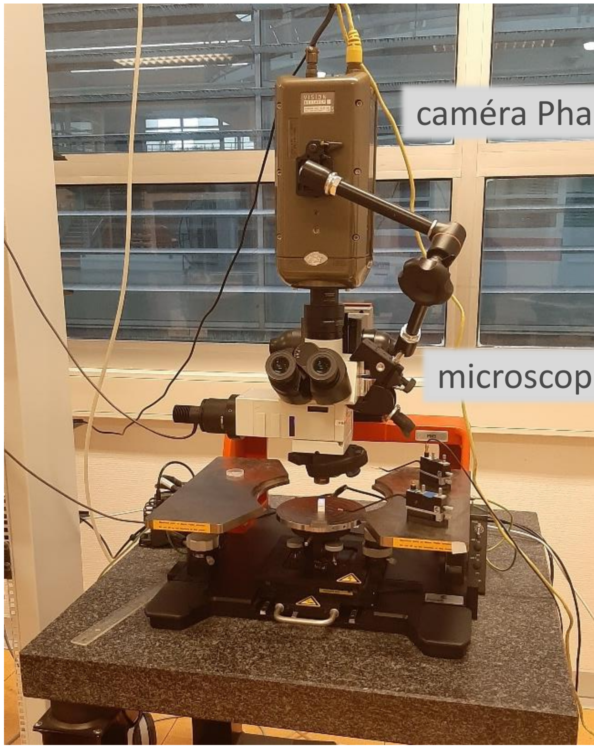
Hair : 50 to 100µm

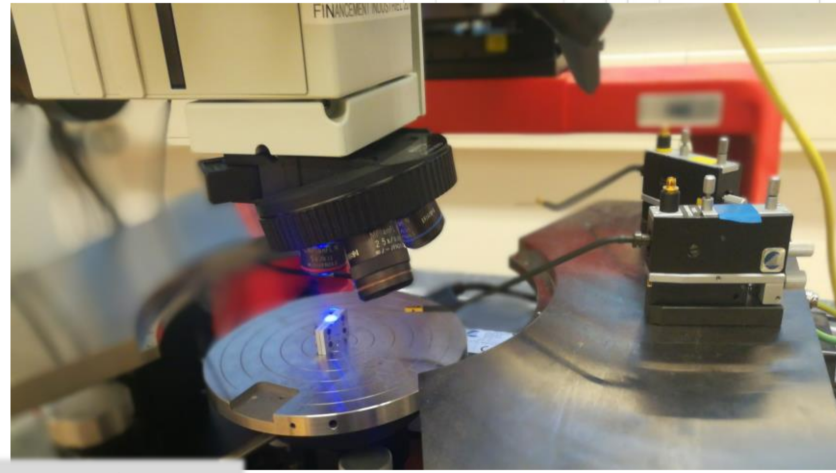
Flax fiber dimensions



O. Hoy - Intership ENSMM
G. Bourbon

Experimental setup





Microscale measurement in **MEMS room** :

- camera and microscope isolated from vibrations
- excitation with an electrical probe

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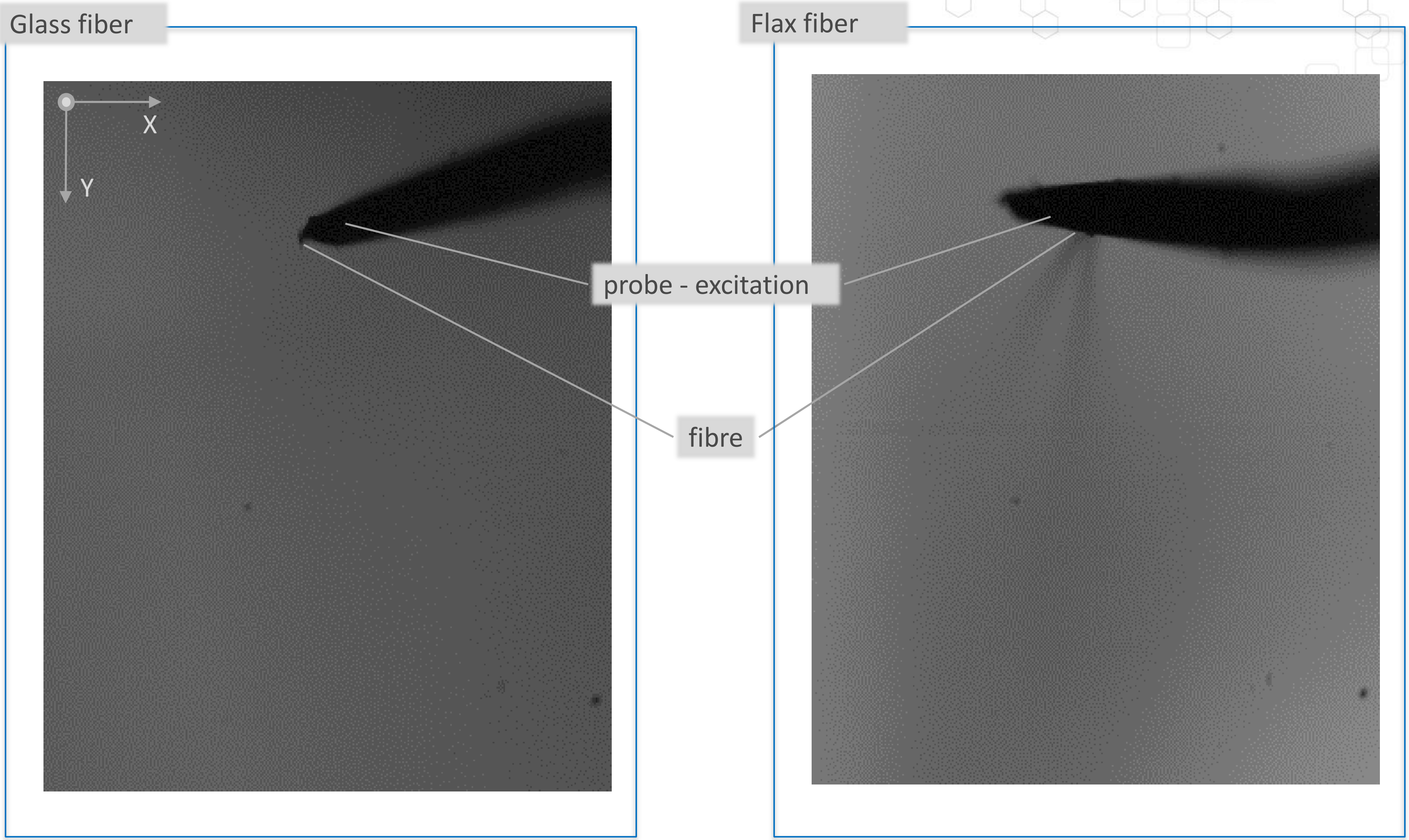
G. Bourbon

Vidéos types obtenues



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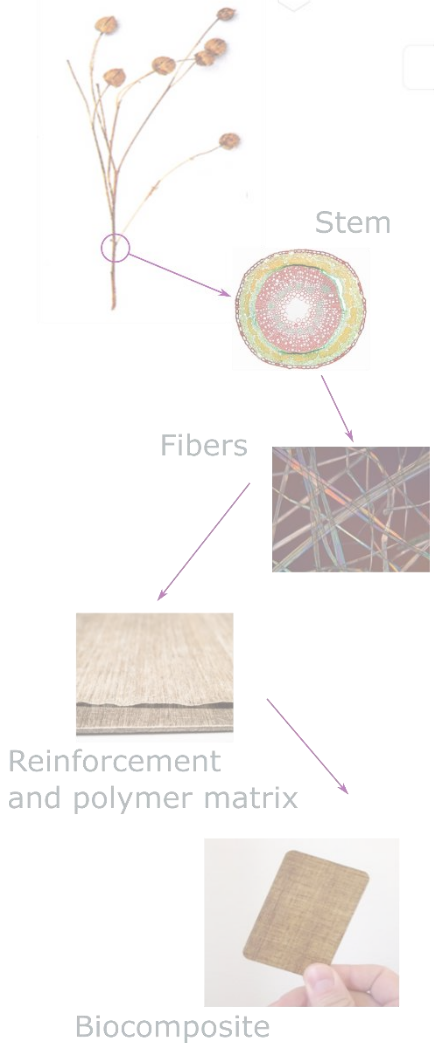
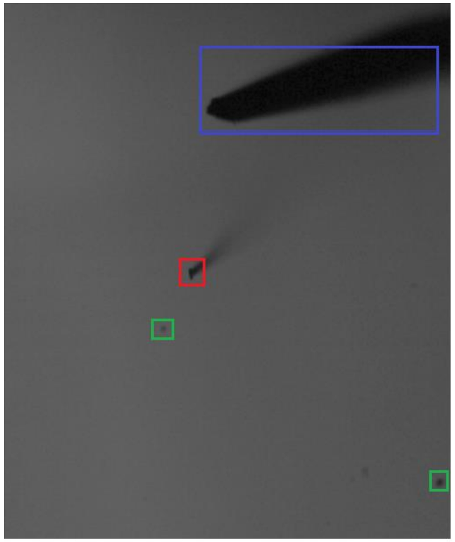


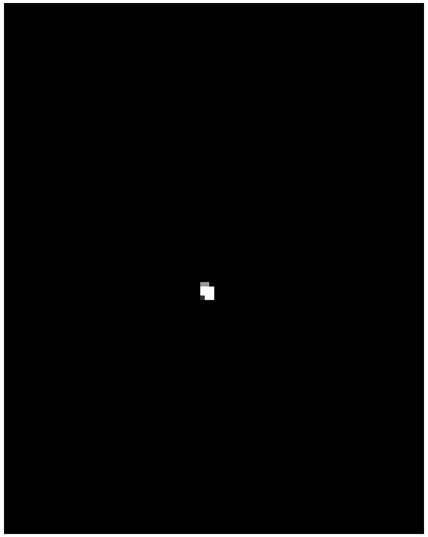
Data analysis

Recorded image



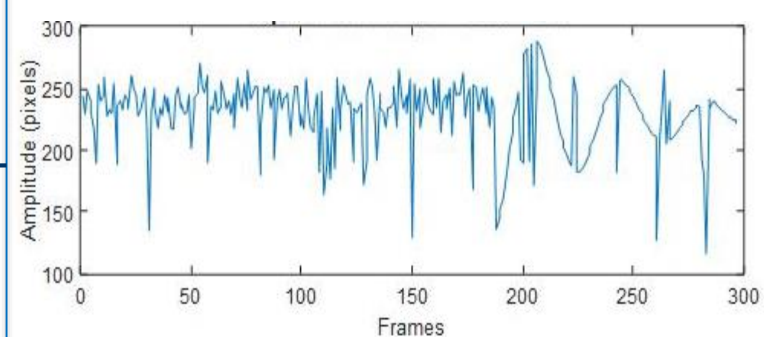
Substraction and binarization

Modified image



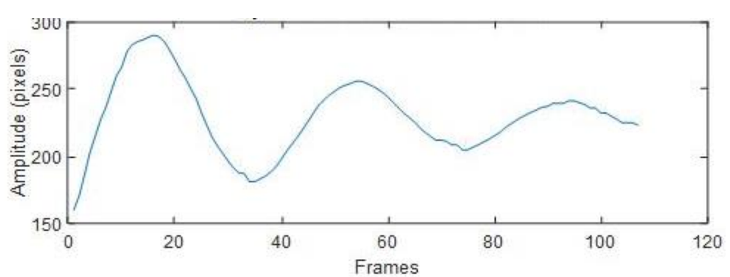
Track the largest object

Fiber displacement – raw data



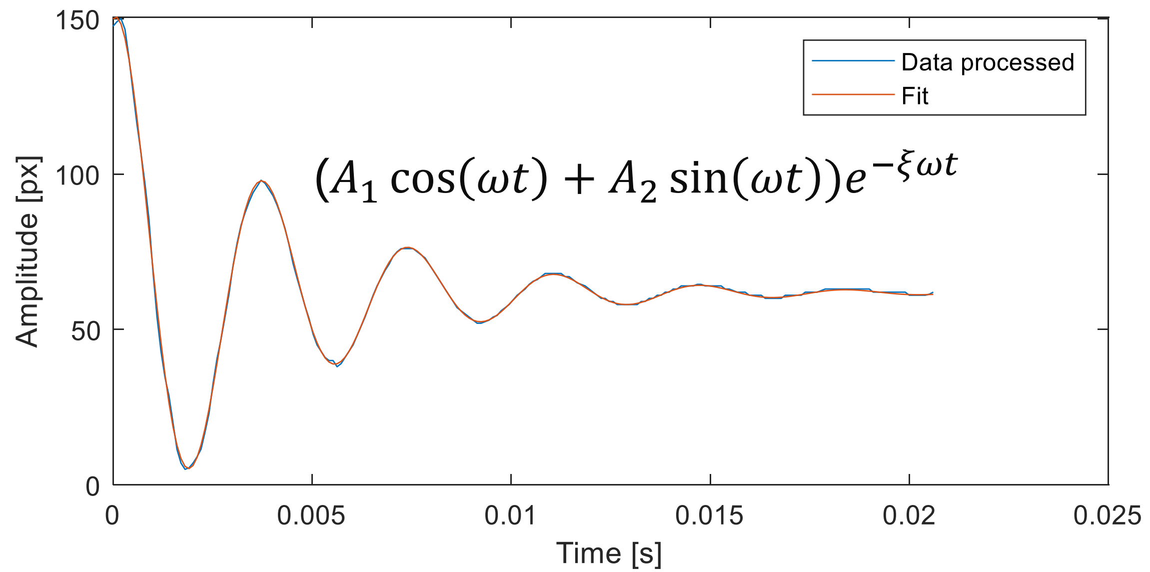
Isolation of the area of interest (time and spatial)

Fiber displacement – processed data



Mechanical properties analysis

Model approximation



Determination of the resonance frequency and of the modal damping

E’ and tan(δ)

On going work!

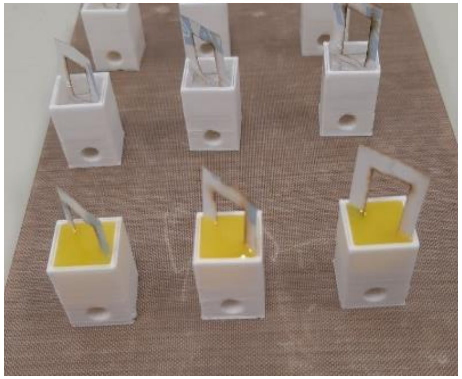
Uncertainty about:

- the clamp
- the excitation
- the geometry of the fiber (S, L, ρ)
- the aerodynamic effects

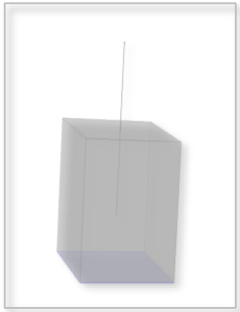
Perspectives

Work on:
- the clamp
- the excitation
- the environment effects

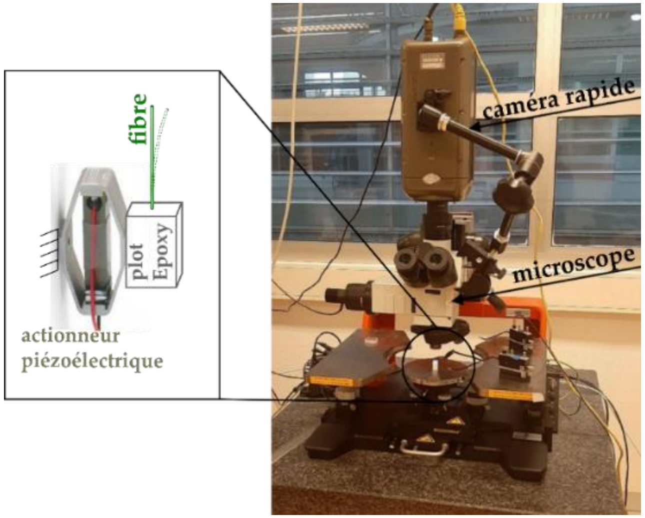
Clamp optimization



modelization



Excitation control



Environment effects

humidity

temperature

frequency

fiber type

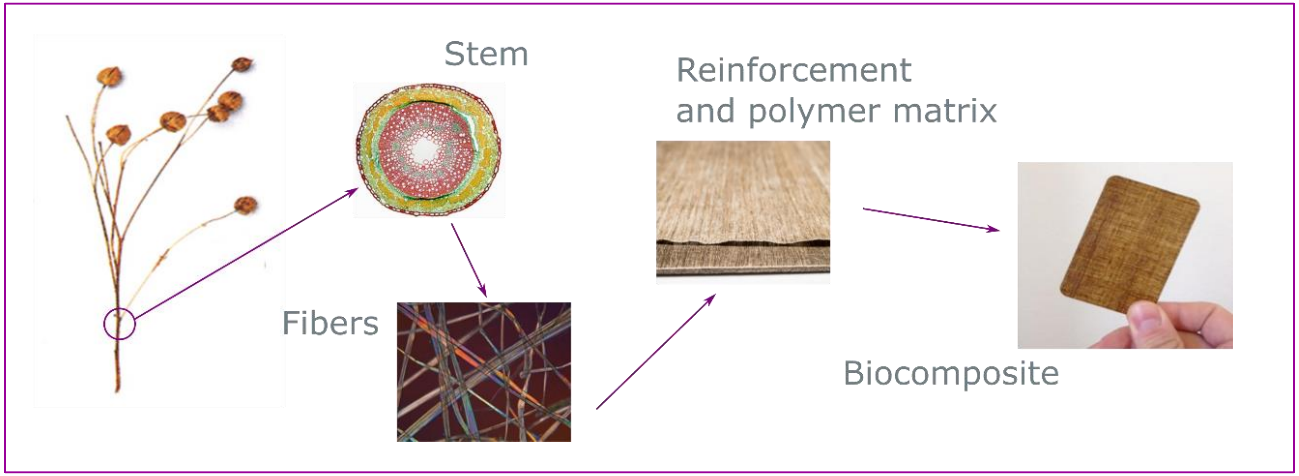
vacuum level

femto-st SCIENCES & TECHNOLOGIES

Thank you for your attention

Any questions ?

Dynamic characterization of synthetic and plant fibers



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