ILM — INSTITUT LUMIÈRE MATIÈRE

Master/PhD in Biophysical Opto-Acoustics (BOA)

Supervising team : Thomas Dehoux, Maroun Abi Ghanem
Contact : thomas.dehoux@univ-lyon1.fr

Institut Lumière Matière
UMR5306 CNRS
Université Claude Bernard Lyon 1
Domaine Scientifique de La Doua
Bâtiment Kastler, 10 rue Ada Byron
69622 Villeurbanne CEDEX, FRANCE

http://ilm.univ-lyon1.fr

T +33 (0)4 72 43 29 93

FAX +33 (0)4 72 43 11 30

E-mail contact.ilm@univ-lyon1.fr

Bio-based metamaterials

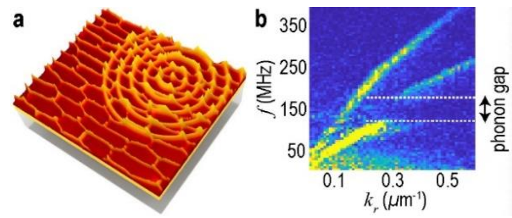

*Figure 1: **a.** Profilometry image of the onion epidermal surface with a superimposed illustration of the propagating SAWs. **b.** Dispersion curve measured on the organic layer showing a clear gap (white lines)*

Several recent review articles and recommendations from the European community are calling for greener biocomposites made from plant-derived fiber and crop-derived materials to advance a key sustainability goal. In photonics, recent awareness has granted the emergence of innovative solutions using chemically purified wood and silk extracts. In phononics however, no sustainable approach has been investigated because there has been no observation of phonon-based biological functions at the supramolecular scale, making phononic bioinspired strategies inoperative. In this project, we want to invent what we call *biobased phononic materials (BPM).*

We have recently demonstrated that biological composites in the form of decellularized plant cell scaffolds can behave as phononic materials, including forbidding the propagation of elastic waves in select frequency ranges (i.e. band gaps). In these pioneering experiments, our biological composite was composed of a micron-thick onion cell epidermis with slender cell walls extruding up from it that resemble blind bore beehive structures. We measured the dispersion of sub-GHz surface acoustic waves (SAWs) in the onion composite (**Fig. 1a**), and revealed their interaction with compressional and flexural resonances of the wall structure, which open deep and wide band gaps (**Fig. 1b**).

The field of biological composites is expanding rapidly with applications in photonics, soft robotics and human augmentation, but has not yet met phononics. This project should be the start of a new research area of what we call “biophoNonics”, whereby biological materials are not copied, but are genetically engineered, harvested and used as phononic materials. In the years to come, we believe that the ability to tailor the genome by controlled mutations or gene editing in plants could provide a plausible, scalable, sustainable manufacturing route for future phononic materials design.

The objective of this internship will be to 1) develop an optical scheme to detect surface acoustic waves in plant epidermis, 2) implement finite element analysis of the results and 3) analyse the influence of various genetic cues on the phononic gap formation. The student will have to carry out the necessary optical assembly and implement the acquisition on plant samples. This work will be supported by the expertise in optoacoustics of the host team.

Local collaborative network : The student will work at ILM in the Biophysics team. She/he will be supervised by Thomas Dehoux and Maroun Abi Ghanem. The preparation of the plant samples will be developed in collaboration with the team of our collaborator, Olivier Hamant from the lab Reproduction et Développement des Plantes (RDP).

Candidate background: The candidate will have a background in Physics/Engineering. Will to work at the interface between physics and biology is required.

Keywords : optics, photonics, acoustics, metamaterials

The project can continue as a PhD

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