ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: Constructing complex multilayer stacks from sustainable materials with anisotropic properties

Internship supervisor

Name, first name	FELIX Olivier
E-mail, Telephone	olivier.felix@ics-cnrs.unistra.fr, 03.88.41.40.67
Laboratory	Institut Charles Sadron
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : PAULY Matthias, ROLAND Thierry

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☒ Physics
Other indications if necessary	Student having skills and/or interests in the following areas: materials, physical chemistry, thin layers, polymers and surfaces

Internship description

Nature has developed composite materials (e.g. plant cell walls and Arthropod exoskeleton) with complex and hierarchical organization from the nano- to the macro-scale via molecular assembly. Such materials often possess remarkable optical and/or mechanical properties by simply assembling hard and soft elements. The outstanding properties of these materials have prompted the fabrication of bio-inspired composites.

Among all methods available for the preparation of multifunctional nanostructured composite materials, layer-by-layer (LbL) assembly,[1] is currently one of the most simple and versatile nanofabrication method.[2] Recently, we have assembled isotropic and anisotropic transparent wood-inspired nano-composite materials with mechanical properties challenging even medium quality steel.[2][3] The combination of LbL assembly with grazing incidence spraying (GIS)[4-5] has permitted us to extend our approach toward the preparation of complex (e.g. helical) multilayer films in which the composition and orientation of anisotropic nano-objects like nanocelluloses can be controlled independently in each layer. The goal of this internship is to study the preparation of nanocellulose-based composite materials using different deposition methods (dipping, spray-assisted, GIS, ...) and various surface analysis techniques (ellipsometry, UV-vis spectroscopy, …) and their optical and mechanical properties. The performance of these materials will be determined by advanced mechanical and optical characterization tools as a function of their composition and structure, the orientation of reinforcing agents, and the experimental conditions.

[1] G. Decher *Science* **1997**, *277,* 1232.
[2] R. Merindol, S. Diabang, O. Felix, T. Roland, C. Gauthier, G. Decher *ACS Nano* **2015**, *9*, 1127.
[3] R. Merindol, S. Diabang, R. Mujica, V. Le Houerou, T. Roland, C. Gauthier, G. Decher, Felix. O. *ACS Nano* **2020**, *14*, 16525.
[4] R. Blell, X. Lin, T. Lindström, M. Ankerfors, M. Pauly, O. Felix, G. Decher, *ACS Nano* **2017**, 11, 84.
[5] R. Mujica, A. Augustine, M. Pauly, V. Le Houerou, G. Decher, Y. Battie, O. Felix. *Compos. Sci. Technol.* **2023**, *233*, 109889.