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Institut d'Electronique, de Microélectronique et de Nanotechnologie
UMR CNRS 8520

Master and Engineer Internship: 2020-2021

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Research group : THz photonics

Title: Infrared mapping of micrometer scale bio-architectures

Abstract: For butterflies, heat transfer between their body and the surrounding environment is critical to their survival and behavioral activities. Temperature monitoring is achieved by the exposure of their wings when basking to sunlight. Theses organs are covered by microstructured scales showing a rich distribution of patterns responsible of their optical and thermal properties (Fig. 1). Recent research has employed Infrared Thermography on butterfly wings to understand the contribution of the micro-architecture of the wings to the temperature regulation process 1. However, to date, no direct infrared measurement has been realized on such microstructures. Indeed, spatial resolution of classical infrared imagery is diffraction-limited and rather long wavelength are used (λ: 2-25 µm). We propose here to employ the Scattering Scanning Near-field Optical Microscopy technique 2 , combining an Atomic Force Microscope with the detection of the light focused and scattered at nanoscale to resolve the physical morphology and the optical properties of these biostructures in the mid-infrared. These measurements will be compared to far- field spectral analysis by Fourier Transform Infrared Spectroscopy to interpret the local contribution of the microstructures at larger scale. The specimen of interest in this study is the common rose butterfly, *Pachliopta aristolochiae*. The bio-architecture of this species has been already studied in the visible range to design bio-inspired solar cells 3 . Through this work, we aim to get insight into the basic principles of heat transfer and IR radiation in such structures. Taste for multidisciplinary research, experimental science, patience and good communication kills in English are mandatory.

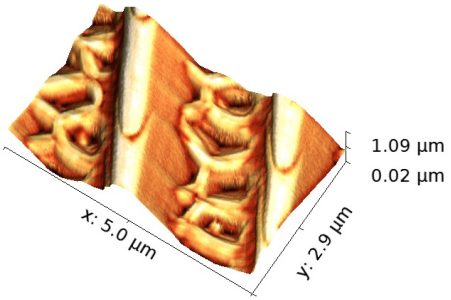

Figure 1: Atomic Force Microscopy topography of a scale of *Pachliopta aristolochiae*

Profile : The Photonic THz group is looking for a motivated master student (or equivalent), preparing a degree with a concentration in Optics & Photonics, Biophysics or Material Science to run an experimental study during an internship (at least 3 months). This work will investigate the optical properties in the mid-Infrared of butterfly scales microsructures.

References :

(1)Krishna, A.; Nie, X.; Warren, A. D.; Llorente-Bousquets, J. E.; Briscoe, A. D.; Lee, J. Infrared Optical and Thermal Properties of Microstructures in Butterfly Wings. Proc. Natl. Acad. Sci. 2020, 117 (3), 1566–1572. https://doi.org/10.1073/pnas.1906356117.

(2) Chen, X.; Hu, D.; Mescall, R.; You, G.; Basov, D. N.; Dai, Q.; Liu, M. Modern Scattering-Type Scanning Near-Field Optical Microscopy for Advanced Material Research. Adv. Mater. 2019, 1804774. https://doi.org/10.1002/adma.201804774.

(3) Siddique, R. H.; Donie, Y. J.; Gomard, G.; Yalamanchili, S.; Merdzhanova, T.; Lemmer, U.; Hölscher, H. Bioinspired Phase-Separated Disordered Nanostructures for Thin Photovoltaic Absorbers. Sci. Adv. 2017, 3 (10), e1700232. https://doi.org/10.1126/sciadv.1700232.