Centre de Nanosciences & de Nanotechnologies

M2 Internship offer 2026/2027

Departement/Team: Photonique/ODIN
Person in charge of the internship: **Mathieu Jeannin**
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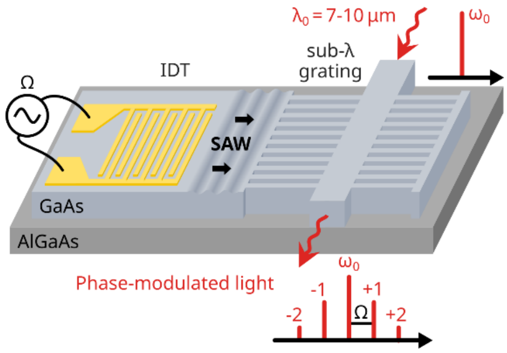
Acousto-optic interaction for non-linear integrated mid-infrared photonics

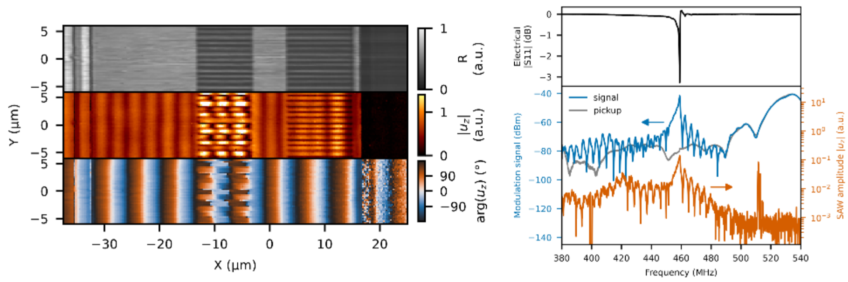
Scientific project:

The mid-infrared (mid-IR) spectral range (λ in [3 – 12] µm) has experienced an extremely fast gain in technological maturity in the past decades, owing to the development of semiconductor laser sources (quantum and interband cascade lasers) that evolved from laboratory objects to commercially available devices. However, besides lasers and detectors, mid-IR optoelectronic components run far behind their visible and near-IR counterparts and many functionalities are not easily available, hampering the development of mid-IR systems. In particular, optical *phase* and *amplitude* modulation are extremely important signal processing functions that are only scarcely available in the MIR.



In the near-IR, photonic integration represented a major breakthrough in device performances and functionalities, but also cost and scalability. Following this path, it is clear that a part of the future of mid-IR photonics lies in photonic chips allowing fast and power efficient complex photonic functions. This integration strategy is currently actively pursued on both group IV (Si and SiGe) and III-V (GaAs/AlGaAs and InGaAs/InP) semiconductors. Recently, there has been demonstrations of free-space [1] and integrated [2] mid-IR modulators. In this context, our group has identified the strong potential of the acousto-optic interaction to develop novel non-linear mid-IR integrated photonic devices, from phase modulators to magnetic field-free optical isolators. As an example, we recently demonstrated the first integrated acousto-optic phase modulator operating at a long wavelength of 8 µm, as sketched above.

These devices couple elastic waves, in the form of surface acoustic waves (SAWs) electrically generated from electrodes through the piezoelectric effect, to optical waves. They use the unique combination of properties of III-V heterostructures that offer both mid-IR transparency and piezoelectricity. They require state-of-the-art microstructuration to confine together the acoustic and optical fields in order to enhance their interaction.



The goal of this internship is to develop and study new devices geometry, allowing phase modulation but also potentially on-chip optical routing, a pre-requisite for optical isolation. The internship will be mostly experimental, involving the use and development of two existing setups. The first one is a mid-IR integrated photonic bench allowing to characterize the operation of the devices (see above, right). The second one is a heterodyne interferometer, that allows to image the SAW-related vibration (amplitude and phase) of the sample surface to characterize the acoustic properties of the devices (see above, left).

[1] Malerba *et al., Appl. Phys. Lett.*, **125**, 041101 (2024) [2] Huertas-Pedroche *et al., Optics Express*, **33**, 42408 (2025)

Methods & techniques: Optical alignment, RF electronics and signal processing, instrument control (Python)
Possibility to go on a PhD: Yes
Funding: Scholarship from EOBE doctoral school, or other competitive funding