Spécialité de Master « Optique, Matière, Paris »

Stage de recherche (4 mois minimum, à partir de début mars)

Proposition de stage (ne pas dépasser 1 page)

Date de la proposition : November15th, 2017

Responsable du stage / *internship supervisor*:

Nom / *name*: Delga — Prénom/ *first name* : Alexandre

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Courriel / *mail*: alexandre.delga@3-5lab.fr

Nom du Laboratoire / *laboratory name*: III-V Lab

Code d'identification : — Organisme : Thales R&T

Site Internet / *web site*: www.3-5lab.fr

Adresse / *address:* 1 av. Augustin Fresnel, F-91767 Palaiseau Cedex

Lieu du stage / *internship place*: Palaiseau

Titre du stage / *internship title*: ***Optical Antennas for high-speed infrared detection***

The Mid InfraRed (MIR : 3-12 µm) window of the electromagnetic spectrum is opening up to exciting new scientific, technological and industrial applications thanks to the availability of a powerful, mature and robust source of light, namely the Quantum Cascade Lasers (QCLs) [1] : free-space optical communications, integrated spectroscopy, LIDAR… One fundamental building block is missing to tackle these new challenges: a high-speed detectors in the MIR spectral window functioning at room temperature does not exist. Bridging this gap is the ambition of a PhD thesis from which this internship will be the first step.

We will focus on the technology of Quantum Cascade Detectors (QCDs) that the III-V Lab pioneered worldwide[2,3], and that present unparalleled assets for high speed detection: a fundamental bandwidth ranging in up to several 100s of GHz, limited only by ultrafast electron-phonon processes, a very strong technological maturity and a unipolar regime of electronic transport. However, this technology is up to date still bound to cryogenic operating temperatures for thermodynamic reasons. To beat this fundamental limitation, we will add to the core knowledge of infrared detectors the concepts from other fields of physics, such as optical antennas [4,5] which provide a very elegant and efficient way to overcome the restrictions of optical selection rule in intersubband detectors. We will also use the technological similarity with QCLs to explore new avenues for heterodyne detection architectures.

The III-V Lab, a joint venture between the companies Thales, Nokia and CEA-Leti, is an industrial laboratory closely linked to academics. Its goal is to develop cutting edge III-V semiconductor devices for highly demanding, high-end applications. The full development chain from design, nanofabrication (more than 2000m^2 clean-room facilities), packaging and measurements is gathered on the Palaiseau site on Université Paris-Saclay campus.

During the scope of the internship, the objective is to study, design, fabricate and characterize plasmonic and/or dielectric antennas co-integrated with mid-infrared QCDs. The first stage will focus on passive structures without detectors, though the full heterodyne platform will be developed in the upcoming PhD thesis. The candidate will contribute to every stage of the development cycle of the device, dipping into a broad range of knowledge and know-how: electromagnetism for antenna and wave guide design, electronic transport in QCLs, QCDs and TIA, DC and AC optical and electro-optical measurements. At the beginning of the project, a particular emphasis will be put on clean-room nanofabrication, where metal-insulator-metal and high-speed processes will be developed.

[1] Vitiello, M. S. et al (2015). *Quantum cascade lasers: 20 years of challenges*. Optics express, 23(4), 5167-5182.

[2] Gendron et al (2004) *Quantum cascade photodetector*. Applied physics letters, 85(14), 2824-2826.

[3] Delga, A. et al (2013). *Performances of quantum cascade detectors*. Infrared Physics & Technology, 59, 100-107.

[4] Novotny, L., & Van Hulst, N. (2011). *Antennas for light*. Nature Photonics, 5(2), 83-90.

[5] Palaferri, D. et al, (2015). Patch antenna terahertz photodetectors. Applied Physics Letters, 106(16), 161102.

Mandatory qualifications and qualities:	**Additional qualifications:**
Pioneering mindset	Nanophotonics, plasmonics
Electromganetism (theory and experiment)	Infrared
Semiconductor physics	Nanofabrication
Telecoms (theory and experiment)	Simulation tools (FEM, RCWA…)
Fluency in English	Fluency in French

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : Yes, favored option**

Si oui, financement de thèse envisagé/ *financial support for the PhD***: thèse CIFRE**

Lumière, Matière, Interactions	**yes**	Lasers, Optique, Matière	**yes**