Université Lille Nord de France
Pôle de Recherche et d'Enseignement Supérieur

Ecole doctorale régionale Sciences Pour l'Ingénieur Lille Nord-de-France - 072

Titre Thèse	Broadband modulator of mid-infrared radiation	
(Co)-Directeur	Stefano Barbieri	E-mail : stefano.barbieri@univ-lille.fr
(Co)-Directeur	Emilien Peytavit	E-mail : emilien.peytavit@univ-lille.fr
(Co)-Encadrant		E-mail :
Laboratoire	IEMN	Web : https://www.iemn.fr
Equipe	Photonique THz	Web :https://www.iemn.fr/la-recherche/les-groupes/photonique-thz
Financement prévu	Contrat Doctoral Etablissement	ULille X ☐ UPHF ☐ Centrale Lille ☐ Yncrea ☐
	Région – Autre ☐	Contrat de recherche ☐ Préciser :
Financement acquis ? ☐	Contrats de Recherche ☐ Préciser	Autre ☐ Préciser

Résumé du sujet: Applications relying on mid-infrared (MIR, $\lambda\sim$3-12 μm) radiation have progressed at a very rapid pace in recent years, stimulated by scientific and technological breakthroughs. MIR cameras have propelled the field of thermal imaging. The invention of the quantum cascade laser (QCL) has been another milestone, which has enabled a vast range of civilian, and defense-related applications. All the recent breakthrough advances stemmed from the development of transformative optical components.

In addition to the generation and detection of light, a key functionality for most photonics systems is the possibility to electrically control the amplitude, phase, and polarization state of an optical beam up to ultra-short time scales. Fast amplitude and phase modulation are essential for a large number of applications, including laser amplitude/frequency stabilization, coherent detection, FM/AM spectroscopy and sensing, mode-locking, optical communications, military countermeasures, etc.

Contrary to the visible and near-IR range, in the MIR range broadband modulators with modulation bandwidth of several tens of GHz do not exist, which hampers the progress of MIR photonics.

The goal of this PhD thesis project is the demonstration of a power-efficient, broadband (up to ~40 GHz bandwidth) and integrated semiconductor-based MIR amplitude and phase-modulator. The modulator will be optimized for operation at λ=10μm, since this wavelength (i) matches an important atmospheric window for free space communications, and (ii) because it is ideal for the spectroscopy and gas sensing applications.

The envisaged device exploits the electro-optical properties of Gallium Arsenide (GaAs) in a double waveguide allowing the simultaneous propagation of MIR radiation and of the microwave modulating signal. During the thesis, the development of the device will be done schematically in three steps: (i) a first phase of design and simulation using a commercial FDTD (Finite Difference Time Domain) code; (ii) a second phase of device fabrication in a clean room environment, followed by a (iii) final stage where the modulator will be characterized optically and electrically using an ultra-broadband MIR detector recently developed in our laboratory [1]. In the final part of the project, we plan to carry out a dedicated experiment to characterize the performance of the modulator for telecom applications in free space.

For this PhD project we seek a motivated student with a solid background in electromagnetism, and optoelectronics.

[1] M. Hakl, et al., “Ultrafast quantum well photodetectors operating at 10μm with flat frequency response up to 70GHz at room temperature”, ACS Photonics, *in press* (February 2021). https://dx.doi.org/10.1021/acsphotonics.0c01299