Sujet thèse / PhD subject 2025

Titre Thèse	**Modélisation et Fabrication de réseaux linéaires de photodétecteurs ultrarapides pour la génération et la détection d'ondes THz.**	
PhD Title	**Modeling and Fabrication of Linear Arrays of Ultrafast Photodetectors for THz Wave Generation and Detection.**	
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Projet phare principal	Micro&nano devices	
Thèse fléchée Flagships IEMN ?	Oui ./ Non : Non Flagship concerné :	
Demande de labellisation Université de Lille (GREAL, labellisée)	Oui / Non :Non Label :	
Financement acquis Oui ☐ Non ☒ Partiel ☐	Si acquis (total ou partiel), préciser : (contrat, organisme, Université étrangère, , ….) :	
Financement demandé	Contrat Doctoral Etablissement	ULille ☒ Centrale Lille ☐ JUNIA ☐
	Région ou Autre ☐ Préciser :	Co financement (Préciser l'origine, demande en cours, et si acquis ou pas) :

Abstract

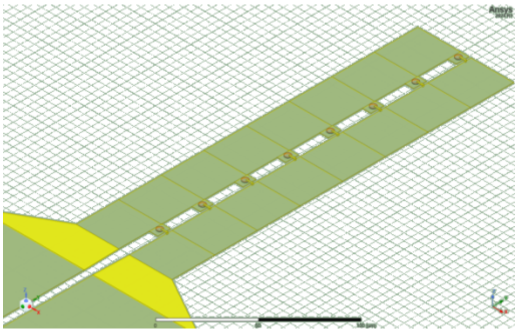

Figure 1 : Example of a linear photodiode array. Electromagnetic modeling using the finite element method with Ansys HFSS software.

Background: One of the most promising continuous-wave (CW) THz sources operating at room temperature is based on the photodetection of a beat frequency generated by the spatial superposition of two infrared lasers. This technique, known as photomixing, involves frequency down-conversion from the high frequencies (~300 THz) of infrared lasers to lower frequencies in the THz range (~1 THz), making it inherently broadband. Additionally, photomixing-based sources are potentially compact due to the use of laser diodes and semiconductor amplifiers but suffer from low output power, approximately 10 µW at 1 THz. The output power is mainly limited by the trade-off between the small size of the photodetector (photodiode, photoconductor) required to minimize its electrical capacitance and the photocurrent needed to generate high THz power. Therefore, the photocurrent density is the key factor for improving output power. The best photomixers achieve photocurrent densities of around 200 kA/cm², which is only ten times lower than those in state-of-the-art electronic devices, despite not being optically pumped. To overcome this intrinsic limitation, one solution is to arrange unit components in a linear array to phase-add the currents generated by each element. This type of structure has been extensively studied as it also addresses the limitations of standard PIN photodiodes in terms of linearity, bandwidth, and saturation current for optical telecommunication or ultra-pure signal generation applications, operating at wavelengths ranging from 780 to 1550 nm. Today, commercial photonic circuits enable efficient illumination of such arrays with near-unity efficiency, paving the way for a new generation of ultrafast photodetectors (electrical cutoff frequency >300 GHz) with very high saturation currents (>50 mA).

Mission: This PhD project aims to study this concept using transfer matrix methods to establish design guidelines for optimizing THz wave generation performance. Subsequently, 3D electromagnetic simulations using finite element methods (Ansys HFSS) or finite difference methods (Lumerical, CST) will be employed to design an 8-element array that will be fabricated and characterized up to 500 GHz using the microfabrication and optical&RF characterization platforms at IEMN. In the later stages of the project, a multiphysics model combining optoelectronic device physics and electromagnetism may also be developed.

Candidate Profile: We are seeking a highly motivated student with a background in Electrical Engineering (EEA) or Physics, with a solid foundation in RF/microwave engineering, wave physics, and semiconductor physics. The candidate should be passionate about applied physics research with a focus on optoelectronics and wave physics.

Career Opportunities: Upon completing the PhD, the candidate can pursue a postdoctoral position or transition to the industry, which is currently booming in the field of RF&microwave components and systems or optoelectronics.