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

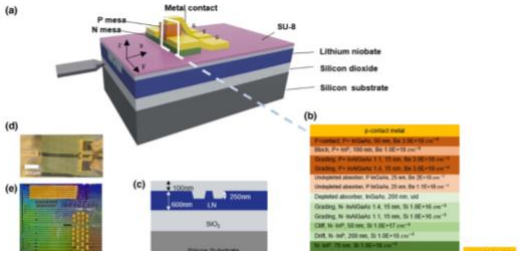
MASTER INTERNSHIP POSITION

Proposé par : Emilien Peytavit Numéro de Tel. : 0320197871

E-mail : Emilien.peytavit@iemn.fr Groupe de Recherche : Photonique THz

Titre : High-Speed Photodiode Integration on Lithium Niobate for THz Signal Generation and Detection

Context and Motivation: Over the past decades, III–V based modified uni-traveling-carrier photodiodes (MUTC-PDs) have established themselves as the benchmark for high-speed optical-to-electrical conversion. Continuous progress in epitaxial design, transport engineering, and waveguide geometries has pushed their performance far beyond initial expectations, with record bandwidths exceeding 200 GHz, responsivities above 0.8 A/W, and amplifier-free wireless demonstrations at 120 Gbit/s. These advances confirm MUTC-PDs as the most efficient devices for bridging optics and sub-THz/THz domains, and as indispensable components for future 6G systems[1].



Example of a Photodiode integrated on a thin film lithium niobate waveguide. Drawn From Ref. [6]

In parallel, the field of integrated photonics is being reshaped by the em film lithium niobate). This platform combines ultra-low optical losses with an exceptional electro-optic coefficient, enabling modulators and passive circuits that already outperform long-established technologies [2]. Recent breakthroughs extend LNOI operation well into the THz regime[3], [4], highlighting its potential not only for scalable modulators but also for broadband signal processing and detection.

Toward Integration of MUTC-PDs and LNOI: The convergence of these two technological trajectories—III–V MUTC-PDs and LNOI photonics—opens unprecedented opportunities. Integrating high-speed photodiodes directly with LNOI circuits would provide a promising avenue toward broadband tailored THz signal generation and detection, where the intrinsic speed of III–V photodiodes is combined with the electro-optic agility of LNOI to address applications from ultrafast communications to THz spectroscopy and radar[5]. Recent demonstrations of MUTC-PDs integrated on LNOI[6] already point in this direction, reporting state-of-the-art bandwidth‑efficiency products (BEP). Pushing beyond these results requires optimized co-design of optical coupling, device geometry, and electrode layouts.

Internship Objective&Mission: The internship will investigate the feasibility and design of waveguide-integrated UTC-PDs on LNOI, in collaboration with the Delft group of Prof. S. Rajabali expert in LNOI photonic circuits design and fabrication. The candidate will model optical coupling, photodiode architectures, and high-frequency electrodes using photonic (Lumerical), Electromagnetic (CST, HFSS) and semiconductor (SILVACO) dedicated softwares, with the aim of competing with and extending the current state of the art [6]**.**

Expected Profile: A background in semiconductor physics and integrated photonics is required, along with a strong motivation for applied physics and device-level innovation.

References

[1]L. Li *et al.*, "Ultra-fast, high-power MUTC Photodiodes with bandwidth-efficiency product over 130 GHz * 100%," Jan. 2025, Accessed: Sep. 16, 2025. [Online]. Available: https://arxiv.org/abs/2501.02812v1

[2]M. Zhang, C. Wang, P. Kharel, D. Zhu, and M. Lončar, "Integrated lithium niobate electro-optic modulators: when performance meets scalability," *Optica*, vol. 8, no. 5, p. 652, May 2021, doi: 10.1364/optica.415762.

[3]I. Wilke, J. Monahan, S. Toroghi, P. Rabiei, and G. Hine, "Thin-film lithium niobate electro-optic terahertz wave detector," *Sci Rep*, vol. 14, no. 1, Dec. 2024, doi: 10.1038/s41598-024-55156-9.

[4]A. Herter *et al.*, "Terahertz waveform synthesis in integrated thin-film lithium niobate platform," *Nature Communications 2023 14:1*, vol. 14, no. 1, pp. 1–9, Jan. 2023, doi: 10.1038/s41467-022-35517-6.

[5]S. Rajabali and I. C. Benea-Chelmus, "Present and future of terahertz integrated photonic devices," *APL Photonics*, vol. 8, no. 8, p. 80901, Aug. 2023, doi: 10.1063/5.0146912/2905252.

[6]X. Guo *et al.*, "High-performance modified uni-traveling carrier photodiode integrated on a thin-film lithium niobate platform," *Photonics Res*, vol. 10, no. 6, p. 1338, 2022, doi: 10.1364/prj.455969.

ATTENTION : TWO MONTHS DELAY BETWEEN APPLICATION AND INTERNSHIP STARTING (ZRR CLEARANCE DELAY)

Salary : ~600€/month. **Duration : between 4 and 6 months** **Starting date : Mars 2026**

Cité Scientifique, Avenue Poincaré - CS 60069
59652 Villeneuve d'Ascq Cedex
http://www.iemn.univ-lille1.fr