EMPLOYMENT PORTAL SECTION	CONTENT PhD Student – *fixed-term contract*
Title of post	**PhD position – Towards Ultra-Efficient, Red-Emitting III-Nitride LEDs**
General information	***Reference*** **: Poste2018001 (cf AM)** ***Workplace*** **: Laboratoire de Physique de la Matière Condensée –LPMC- Ecole polytechnique – Route de Saclay – 91128 Palaiseau cedex** ***Publication date:*** ***Scientific supervisor: Alistair Rowe*** ***Type of contract: 3-year PhD contract (fully funded by the Agence Nationale de la Recherche)*** ***Contract period: Start date between 01/03/2027 and 01/10/2027*** ***Remuneration: 2300 euros monthly before tax*** ***Section number :***
Description of the thesis subject	**Scientific context** III-nitride light-emitting diodes (LEDs) are key devices for next-generation solid-state lighting and micro-LED displays. Achieving efficient emission at long wavelengths, particularly in the red spectral range, remains a major challenge. Recent work has demonstrated significant improvements in the wall-plug efficiency of green- and red-emitting III-nitride LEDs containing high densities of V-defects. We have shown that these improvements arise from efficient charge injection into the LED's multiple quantum wells through the semi-polar, low-indium-content facets of the V-defect sidewalls at low forward bias [1]. The physical picture that emerges is one in which charge injected through the sidewalls subsequently travels over a characteristic length, *l*, before reaching the (0001)-oriented quantum wells, where radiative recombination takes place. This leads to an optimum V-defect density of approximately $1/l^2$. However, V-defects form naturally at threading dislocations and are therefore randomly distributed, limiting the control that can be achieved over the resulting device architecture. **PhD project** In the framework of a multi-partner, ANR-funded project, we will investigate a fundamentally different approach based on III-nitride LEDs grown on intentionally macro-structured substrates. These substrates exhibit alternating (0001) and (11-20) facets, potentially providing independent control of the injection and emission regions [2]. The non-polar (11-20) facets can be used as controlled charge-injection planes, while the polar (0001) facets, whose width is determined by the initial wafer miscut angle, host quantum wells optimized for long-wavelength electroluminescence. The principal objective of the PhD will be to establish a fundamental understanding of charge injection, transport and recombination in these operational macro-structured LEDs. Rather than probing the device only at the macroscopic scale, the candidate will use a scanning tunnelling microscope (STM) as a highly localized charge injector. This approach will enable nanometre-scale mapping of the electrical and optical response of individual regions of the LED. The thesis will therefore address fundamental questions such as: How does charge enter the quantum wells from the different crystallographic facets? Over what length scales does charge propagate? How do atomic-scale disorder, polarization fields and local structural variations influence carrier transport and recombination? How can these microscopic mechanisms be exploited to design more efficient long-wavelength-emitting LEDs? **Experimental approach** The work will be principally experimental and will make extensive use of a modified ultra-high-vacuum (UHV) Beetle-type STM equipped with in-situ optical spectroscopy. The system enables simultaneous measurements of surface topography and local electroluminescence spectra while the STM tip acts as a nanoscale electrical probe. The experimental programme will be complemented, where appropriate, by LED fabrication and device characterization. The candidate may also use the 2D_DDCC simulation framework developed by collaborators at National Taiwan University to model charge transport and recombination in the structures. An additional opportunity will be to contribute to the development of a home-built table-top shear-force microscope, which is being explored as an alternative approach for probing local optoelectronic properties of semiconductor materials. References and reading [1] C. Fornos et al., Nanoscale imaging of reduced forward bias at V-shaped defects in nitride-based green LEDs Physical Review Applied 26, 014014 (2026) https://doi.org/10.1103/x3kp-7nqg [2] Y. Jousseaume et al., Surface Structuring of Patterned 4H-SiC Surfaces Using a SiC/Si/SiC Sandwich Approach Materials Science Forum 1124, 7 (2024) https://doi.org/10.4028/p-auZ0OI

Work context	The *Laboratoire de physique de la matière condensée* (LPMC) is one of 22 laboratories located at the Ecole polytechnique research centre working on the frontier of knowledge on the major interdisciplinary scientific, technological and societal issues. Within the Teaching and Research Department of Ecole polytechnique, LPMC is a mixed research unit (Ecole polytechnique/CNRS) whose work is organized around two research poles, one dedicated to quantum phenomena and devices, the other dedicated to materials and interface chemistry. The PhD will be carried out principally within the “Optoelectronics of Low-Dimensional Semiconductors” group within the quantum phenomena and devices pole at LPMC, and will be co-supervised by Alistair Rowe and Jacques Peretti, with additional support from members of the research group and from the laboratory’s technical support group. The candidate will also have the opportunity to spend up to three months at the Centre de Recherche sur l'Hétéro-Epitaxie et ses Applications (CRHEA), near Nice, contributing to III-nitride heterostructure growth and/or device characterization under the supervision of Jean-Yves Duboz.
Constraints and risks	The successful candidate will be enrolled in a PhD program of the IP Paris doctoral school. The candidate will learn to work safely with lasers, cryogenic liquids, and ultra-high vacuum systems.
Supplementary information	We are looking for a highly motivated candidate with a degree equivalent to a European Master's (M2) in condensed matter physics, semiconductor physics, materials science, electrical engineering, or a related field. Experience or a strong interest in semiconductor devices, optical spectroscopy, scanning probe microscopy, or experimental physics, will be particularly valuable. A practical interest in mechanical or electronic DIY and instrument development would be an advantage. Knowledge of spoken French is welcome but is not a prerequisite.