LABORATOIRE PMC

# INTERNSHIP OFFER : Efficiency gains in III-nitride LEDs via defects

The wall-plug efficiency (WPE) of light-emitting diodes (LEDs) is defined as the output optical power per unit input electrical power. Today, blue-emitting, III-nitride LEDs exhibit WPEs > 90 % [1]. However, as the Indium content in the InGaN quantum well alloys is increased in order to produce LEDs emitting at longer wavelengths, WPE drops precipitously [2], resulting in the so-called green gap [3]. There are on-going efforts in academic & industrial research laboratories to explore strategies aimed at improving WPEs of long-wavelength III-nitride LEDs, with the goal being to produce efficient white-light emitters. Success would have major technological & economic advantages in lighting and micro-LED screen applications [4].

Recently, record-high WPE [5] in green- and yellow-emitting nitride LEDs were obtained in devices containing high ($\approx 3 \times 10^8$ cm$^{-2}$) densities of crystalline defects known as a V-pits. The mechanism which yields this significantly improved WPE is only just becoming clear thanks to our recent experimental work [6]. Numerical modelling [7] had suggested that lower internal potential barriers arising from the semi-polar nature of V-pit sidewalls might facilitate charge injection into the active zone of the LED resulting in higher WPE. Using a novel technique – scanning tunneling luminescence microscopy (STLM) – which combines the nanoscale spatial resolution of scanning tunneling microscopy with the advantages of optical spectroscopy [6], we prove this to be the case on state-of-the-art, green-emitting commercial LEDs.

We propose an internship and subsequent Ph.D. thesis which aims to study the effect on WPE of electrical injection through semi-polar and non-polar crystal facets of commercially viable III-nitride LED heterostructures using the scanning, tunneling tip of the STLM as a nanoscale electrode for charge injection into one side of the LED. The candidate will have the choice to work with a range of possible heterostructures and devices sourced through our collaborators in France and the United States, as well as from Asian producers of commercial LEDs. The internship therefore offers the candidate to participate and in the development and use of original experimental methods able to probe the optoelectronic properties of LED materials at the nanoscale. In addition to fundamental physical aspects touching on the recombination dynamics of charge in semiconductors, the work is of immediate, direct relevance to industrial-scale producers of LEDs.

The internship and thesis would suit a candidate interested in all aspects of semiconductor physics, and will provide the opportunity to become expert in a range of techniques, from cryogenics, ultra-high vacuum, local probe methods and electronics, to instrumental interfacing and optical spectroscopy methods. The candidate will be supervised by a team of scientists and engineers and will have the opportunity to work directly with our colleagues in France, Asia and North America.


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[5] S. Zhang et al., Photonics Research **8**, 1671 (2020).
[6] C. Fornos et al., arXiv:2506.18025 (2025).
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