Funded Master internship and PhD thesis at CEA-Saclay

Imaging carrier transport in cross-sectional III-nitride LEDs

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Starting date: Fall 2027, can be combined to a M2 internship before
Laboratory: SPEC, Orme des Merisiers, CEA-Saclay (https://iramis.cea.fr/spec/)

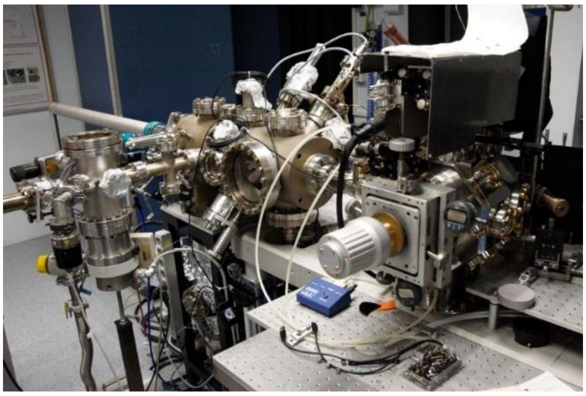
Light Emitting Diodes (LEDs) made of nitride materials are universally used for energy-efficient lighting, typically using a blue nitride LED (internal quantum efficiencies > 98%) associated to a phosphor to produce white light. However, such LEDs suffer from drastic drops in efficiency at high current densities and high emission wavelengths (green to red). This is a strong limitation to improve device efficiencies while getting a better color rendering and reducing the use of primary material.

The causes for these drops in efficiency are still debated due to their complexity. Indeed, the key aspects lie in the active region of the LEDs, where parasitic recombination processes as well as carrier escape happen. Understanding such processes requires to access carrier behavior inside the active region itself, taking into account microscopic structuration and heterogeneities. Most approaches in the literature focus on spatially averaged measurements, missing out the core of the problem.

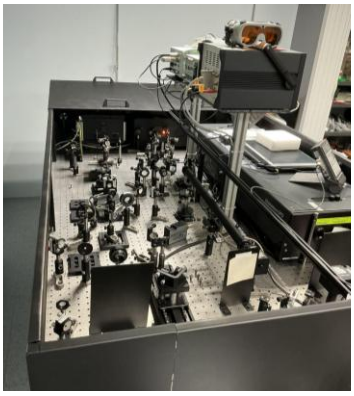
This project proposes to **develop a novel approach to directly image carrier behavior (injection, recombination et escape) in the active region of an *in operando* LED**. The aim is to perform a pump-probe electrical and optical excitation on a cleaved device observed in cross-section in a low energy electron microscope. This approach includes several challenging steps, among them the cleavage of an operating device for an observation in cross-section and the development of a mixed electrical and optical excitation of the LED under the microscope. Numerical modelling will be developed to support experimental findings.

Experimental techniques

- **Low energy electron microscopy,** including ElectroEmission Microscopy and time-resolved PhotoEmission Microscopy (10 nm spatial resolution, 150 fs time resolution and 150 meV energy resolution)
- **Ultra-fast laser optics**



Low Energy Electron Microscope



Laser lines for optical excitation

Environment

We are looking for a motivated candidate with a strong background in solid state physics, willing to continue for a PhD thesis after the internship. **The thesis is fully funded by an ANR grant.** A visit of the lab and the discussion of the project to adapt to the candidate's interest is possible. The project is in collaboration with the University of Santa Barbara (Prof. Speck's group) for device fabrication, and the University of Cambridge (Prof. Rao's group) for complementary ultrafast investigation techniques. Scientific stays at these places might be arranged during the thesis. Numerical modelling will be performed in collaboration with Dr. Banon in Saint-Etienne University.