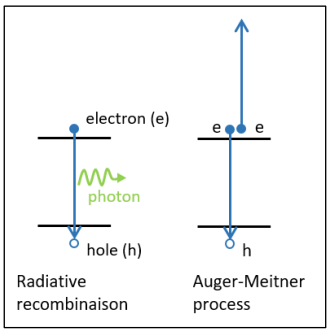
Funded PhD thesis at CEA-Saclay

Electronic processes in nitride LEDs: interplay between spatial heterogeneities and efficiencies

Supervision: Mylène Sauty (mylene.sauty@cea.fr), Ludovic Douillard
Starting date: Fall 2025
Laboratory: SPEC, Orme des Merisiers, CEA-Saclay (https://iramis.cea.fr/spec/)

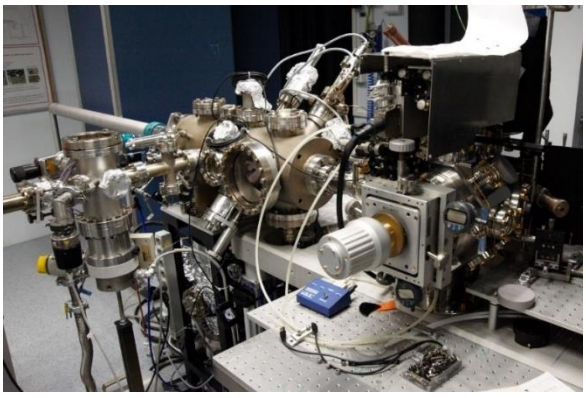
Light Emitting Diodes (LEDs) made of nitride materials are universally used for energy-efficient lighting, typically using a blue nitride LED (internal quantum efficiencies > 98%) associated to a phosphor. They however suffer from a drastic drop in efficiency at high current densities and high indium concentrations (for green or red emission). It is an obstacle to extending their use, especially for using less material, and getting better color rendering, closer to sunlight illumination. These efficiency drops are largely due to an increase in non-radiative Auger-Meitner processes, which are strongly impacted by local device heterogeneities like alloy disorder or structural defects.

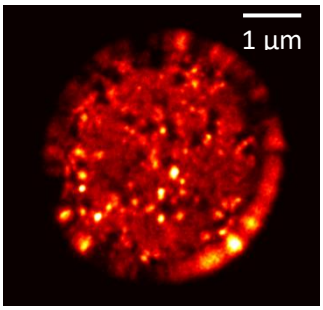


Thesis goal: identify the role of defects and spatial heterogeneities
→ on the charge injection mechanisms in the LED active region (both laterally and vertically)
→ on the spatial distribution of Auger-Meitner processes vs radiative recombination

Experimental approach

- **Electroemission microscopy (EEM)**: direct mapping of the Auger-Meitner electrons in the active region of the LED in operation, with a spatial resolution of 10 nm.
- Combined to scanning near-field optical microscopy (SNOM): mapping of the radiative recombination


Low Energy Electron Microscope for EEM



Map of the lateral distribution of Auger-Meitner electrons in a green LED by EEM

Experimental developments during the thesis

- Mixed electrical-optical excitation scheme to image all conduction electrons by EEM
- Cross-sectional imaging of the device to access the dynamics of carriers injection in the different quantum wells of the LED active region

Thesis environment

The thesis is fully funded by CEA. We are looking for a motivated candidate with a strong background in solid state physics. Mastering the experimental techniques of EEM and SNOM is not required. 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.