Internship + PhD Proposal

Date de la proposition : 28/11/2024

Principal investigators : Stéphane ALTAZIN, Quentin ABADIE (CEA-Leti/DOPT) — Benjamin VEST, Jean-Jacques GREFFET (Institut d'Optique/LCF)

PhD director VEST Benjamin — benjamin.vest@institutoptique.fr

Nom du Laboratoire / *laboratory name*:

Etablissement / *institution* : Lab. Charles Fabry Code d'identification : UMR 8501

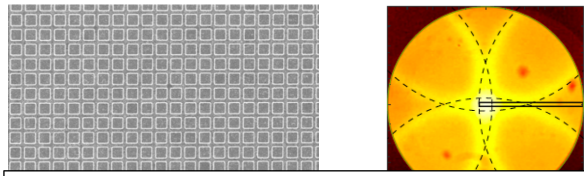
Site Internet / *web site*: https://www.lcf.institutoptique.fr/en/quantumnano

Lieu / *place*: 2 av Fresnel, 91127 Palaiseau

Titre du stage / *internship title*: **Light-emitting Metasurfaces for new architectures of performance-enhanced AR/VR displays**

The topic of the internship and the follow-up thesis is the engineering of light-emitting material and devices for display technologies. It brings together two teams : a) the Quantum Nanophotonics team at IOGS/LCF, that investigates the fundamental physics of spontaneous emission of light, and b) the LITE team at the Département d'optique et de Photonique of the CEA-Leti, which designs and develops state-of-the-art light emitting devices such as microLEDs for targeted technological applications.

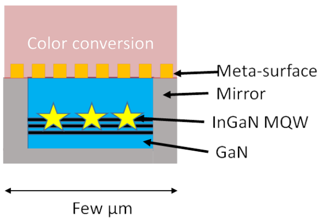
The goal of any light-emitting device system is to provide light "*shaped the adequate way*" based on the envisioned application. **The core of the project is AR/VR displays, which requires small light-emitting pixels, with very directional angular radiation pattern and high energy efficiency**. At macroscopic scales, processing light is done with components such as lenses, mirrors and filters. At the pixel level, stringent size requirements drastically limit the use of bulky solutions to arbitrarily shape light.



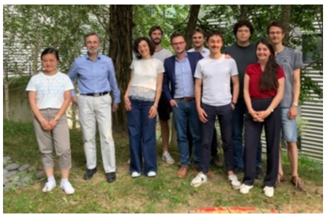
SEM image of a LEM made of Ag grating covered with quantum dots. The image on the right is the angular radiation pattern of the device acquired experimentally in the Fourier plane of the system. (from [1])

The fundamental approach followed by the LCF team is the engineering light-emission *at the source level* without the need for further external components. This can be done by developing **Light-Emitting Metasurfaces,** consisting of an active material coupled with an array of resonators to form a few micron thick pixel. The LCF team developed a theoretical framework to model light emission and recently reported the development of a directional light-emitting metasurface engineered and optimized with this approach [1]

Concept of an envisioned Micro-LED architecture, with a first active layer emitting blue to pump a QD layer achieving color conversion. The metasurface shapes light emission of the QD layer onto a directional pattern.



CEA-Leti and LCF will team up and exploit this approach to address an important technological bottleneck. Current pixel architectures in microLEDs displays are based on color conversion. Short wavelength emission from a first active material is absorbed by a second active layer to be re-emitted at longer wavelength. In current architectures, re-emission follows a lambertian profile, and directivity is extremely limited, making them unsuitable for AR/VR applications. The project will start with the candidate getting accustomed with concepts related to light-matter interaction at the nanoscale, the LCF theoretical and numerical approach, and technological aspects of microLEDs architecture. The goal of the internship at LCF/IOGS will be to propose a first generation of architectures for directional emission designed in interaction with the LITE team. The PhD project will progressively shift geographicallly towards Grenoble, as technological aspects in terms of fabrication and characterization will significantly grow in importance. Different generations of devices will be fabricated and characterized in the perspective of **demonstrating a device surpassing the state-of-the art.**



The *Quantum Nanophotonics and Plasmonics @Institut d'Optique* team investigates **the physics and engineering of spontaneous light emission** (fluorescence, incandescence, electroluminescence, at different scales (quantum regime with single photon and single atoms, collective effects, photon condensates, condensed matter systems…).
The *LITE (Laboratoire d'Intégration des Technologies Emissives*) focuses on manufacturing micro-emitting devices (µLED, OLED, LCD) in a silicon microelectronics foundry-type environment. This includes, for example improving µdisplays performances, made above ASICs, while reducing the pixel size, or demonstrating new use cases of these light sources in the field of biomedical optical sensors.

[1] Bailly, E., Hugonin, J. P., Coudevylle, J. R., Dabard, C., Ithurria, S., Vest, B., & Greffet, J. J. (2024). 2D Silver-Nanoplatelets Metasurface for Bright Directional Photoluminescence, Designed with the Local Kirchhoff's Law. ACS nano, 18(6), 4903-4910.

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : YES**

Si oui, financement de thèse envisagé ou acquis / *financial support for the PhD* **? Yes - Secured**

Financement demandé / *Requested funding*		Nature du financement /*Type of funding*	*CEA funding*