Master ICFP

Proposition de stage / Internship proposal

Date de la proposition : 25/09/2023

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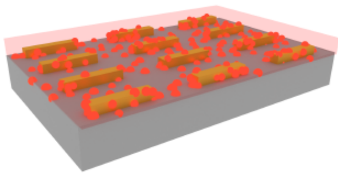
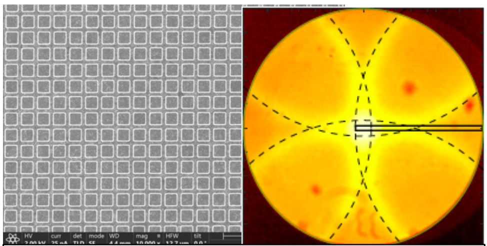
Nom du Laboratoire / *laboratory name*:
Etablissement / *institution* : Lab. Charles Fabry Code d'identification : UMR 8501
Site Internet / *web site*: https://www.lcf.institutoptique.fr/en/quantumnano
Lieu / *place*: 2 av Fresnel, 91127 Palaiseau

Titre du stage / *internship title*: **Quantum metamaterials for arbitrary control of light source properties**

A light-emitting system consists of an active material (laser, LED, incandescent source…) and of elements manipulating the light: lenses, filters and polarizers shaping the directivity, spectrum, and polarization. Adding elements inevitably leads to bulky, energy inefficient and more expensive optical systems. **Hence, fabricating sources making the best out of their supplied energy is crucial to reduce environmental footprint of light-related applications.**



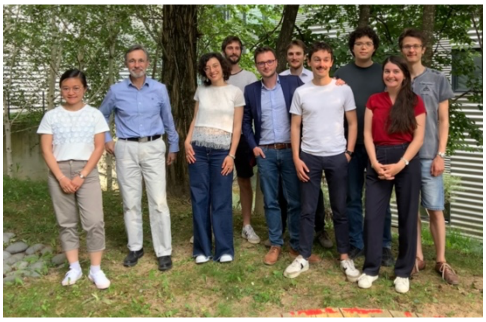
The vision of the project is to fabricate **a less than 1 µm thick light emitting system**, providing light with high efficiency, controlled spectrum, angular distribution, and polarization : **in other words, arbitrary wavefront control with no external manipulation needed.**



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.

This will be achieved by designing and fabricating **Light-Emitting Metasurfaces** (LEMs). LEMs are arrays of nanoresonators with luminescent emitters distributed over the entire surface of the device. The array of resonators is designed to provide an extended, electromagnetic mode. This mode acts as a "cavity mode", incoherently pumped by the emitters distributed over the whole system, then mediating the emission by leaking radiation into the far field. Hence, the properties of the emission can be shaped by engineering the radiative losses of an extended leaky mode.

The goal of the internship is **to engineer and characterize light sources based on ensembles of quantum dots directly delivering light with controlled properties, that is quantum metamaterials for light-emitting metasurfaces.** The work will involve theory of spontaneous emission of light, numerical modelling and design of engineering tools, experiments of photoluminescence spectroscopy, and topics including light-matter interactions at the nanoscale, electromagnetism, statistical physics.



A PhD can follow the internship after successful application to relevant funding sources. Metasurface engineering approaches will be extended to other frameworks, such as the design of electroluminescent sources and of single photon sources exploiting color centers in 2D materials.

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).

[1] Wojszvzyk, L., Monin, H., Greffet, J.-J., Light Emission by a Thermalized Ensemble of Emitters Coupled to a Resonant Structure. Advanced Optical Materials 2019, 7, 1801697.
[2] Bailly, E., Hugonin, J. P., Vest, B., & Greffet, J. J. (2021). Spatial coherence of light emitted by thermalized ensembles of emitters coupled to surface waves. Physical Review Research, 3(3), L032040.

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* **?**

Financement demandé / *Requested funding*	*X*	Nature du financement /*Type of funding*	*ANR/ EDOM*