Master ICFP

Proposition de stage / Internship proposal

Date de la proposition : 25/09/2023

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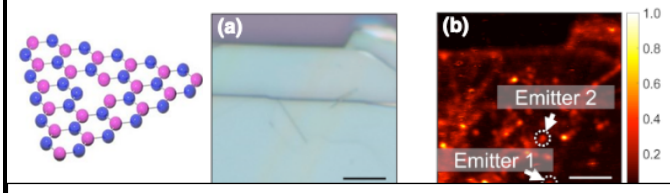
Nom du Laboratoire / *laboratory name*:
Etablissement / *institution* : Lab. Charles Fabry Code d'identification : UMR 8501
Site Internet / *web site*: https://www.lcf.institutoptique.fr/en/quantumnano
Lieu / *place*: 2 av Fresnel, 91127 Palaiseau

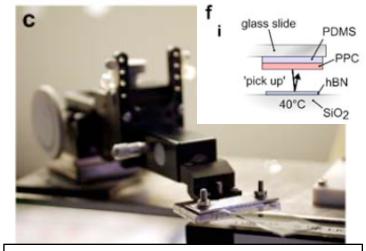
Titre / *title*: **Quantum light emission with color centers in 2D materials coupled to metasurfaces**



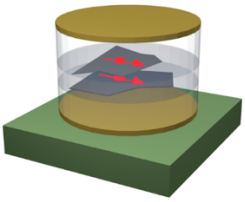
Structure of a vacancy-based hBN color center. Optical microscope image and confocal photoluminescence map.

Hexagonal Boron Nitride (h-BN) is a 2D material that hosts colored centers emitting single photons in the visible range. h-BN has the remarkable property of displaying remarkable brightness and great photophysical properties at **ambient temperature** making it a good candidate for single photon emission in less constraining temperature conditions[1].

Emission of a single photon can be achieved using a two-levels system and controlling its excitation. An important issue is to control the emission mode and the emission time. This can be achieved by **controlling the environment and the excitation of the emitter.** 2D nature of hBN enables to envision original strategies **to achieve coupling between color centers and nanostructures for the control of single photon emission. Micro-manipulation of 2D** materials is well-known, and is based on the use of transfer stations to build 2D heterostructures. **The goal of the internship is to develop a setup dedicated to the characterization of quantum light emission via scanning confocal mapping samples. This setup will be designed in order to implement functionalities that will combine, on the same instrument, functionalities dedicated to the manipulation of 2D layers containing emitters, and their localization.**



Typical micromanipulator designed to perform a pick-up and transfer method on 2D materials flakes. From Nature Communications volume 7, 11894 (2016)

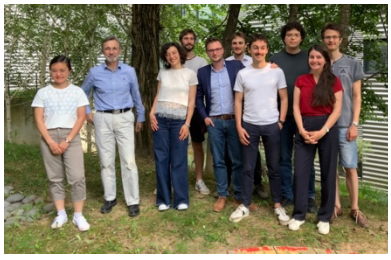


Concept of an hBN based quantum memory exploiting the coupling between emitters hosted by two stacked layers.

The longer term goal of the project is **to demonstrate controlled positioning of emitters around nanostructures** with unprecedented accuracy in order to fabricate complex structures. For instance, one could stack two emitters in close proximity **to control spontaneous emission**. Their mutual coupling provides a means to control in time domain the emission [2] : this single photon emitting system with an adaptable bandwidth could be useful to build **quantum memories**, able to store and release quanta on demand. **Metasurfaces** can also be used **to collect optimally the single photon flux and provide an arbitrary control of the wavefront.**

A PhD can follow the internship, and will explore the design, fabrication and characterization of single photon emitting devices based on hBN color centers coupled to engineered nanostructures such as metasurfaces as well as the indistinguishability of the photon flux [3].

The *Quantum Nanophotonics and Plasmonics team @ 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] Tran, T. T., et al.. (2016). Quantum emission from hexagonal boron nitride monolayers. *Nature nanotechnology*, *11*(1), 37-41.
[2] Shlesinger, et al. (2019). Time-Frequency Encoded Single-Photon Generation and Broadband Single-Photon Storage with a Tunable Subradiant State, Optica 8, 95 (2021).
[3]Akbari et al (2022), «Lifetime-Limited and Tunable Quantum Light Emission in h-BN via Electric Field Modulation » Nano Lett.2022, 22, 19, 7798–7803 ; https://doi.org/10.1021/acs.nanolett.2c02163

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*	*Bourse EDOM*