ANR funded PhD thesis

Quantum optics with hBN single-photon sources in top-down photonic devices

PhD position leading to a doctoral degree of University Paris-Saclay. Starting October 2026.
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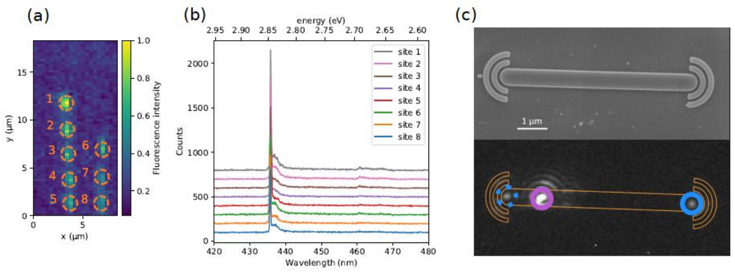
Optically active deep defects in the solid state (or color centers) can be seen as artificial atoms [1]. They represent a major interest in quantum information science, owing to their potential as single photon emitters and their possible integration in nanostructures and devices. Emblematic examples include nitrogen-vacancy centers in diamond, at the basis of emerging quantum networks [2]. In the last few years, color centers in the 2D material hexagonal boron nitride (hBN) have established themselves as excellent quantum emitters, bringing new perspectives of applications to on-chip quantum technologies [3].

The PhD thesis will take place in the GEMaC laboratory (UVSQ/CNRS) located in Versailles. In the Quantum Nanophotonics team, we have recently demonstrated a new family of single photon emitters in hBN [4] with excellent properties in terms of brightness, coherence and reproducibility [5]. These emitters can be locally created using an electron beam in a scanning electron microscope (figure 1a and 1b), which has allowed us to demonstrate top-down integration in photonic devices [6] (figure 1c).



(a) Confocal photoluminescence map of 8 irradiation sites where emitters have been created.

(b) Emission spectra of the eight sites, revealing similar emission lines.

(c) Prototype of a hBN waveguide integrating a single emitter.

The thesis is part of ANR project starting in 2025, which builds upon recent experimental demonstrations from the host team and their partners at LPENS (ENS Paris) and LPEM (ESPCI) to develop a new generation of top-down quantum photonic devices based on single-photon emitters and superconducting detectors integrated into cavities and waveguides for applications to optical quantum information.

In this context, the PhD project will consist of optical characterization and quantum optics experiments based on single-photon sources integrated into hBN monolithic photonic devices, consisting of a microcavity coupled to a waveguide. These experimental studies will be based on photoluminescence and resonant laser excitation, associated with photon counting and interferometry techniques (e.g. Hanbury Brown and Twiss, Hong-Ou-Mandel interferometry), as well as spectroscopy. The results will establish the relevant figures of merit such as quantum coherence, brightness and indistinguishability of the emitter-cavity coupled system, and will be used during the project to improve the device design and fabrication. The ultimate goal is the demonstration of quantum interference of photons emitted by distinct emitters. The experiments will be performed at both room temperature and cryogenic temperature. The candidate is also expected to participate to the sample fabrication, using nanofabrication techniques specific to 2D materials. The project will take place in the QNP team (web link), in collaboration with the project partners at LPENS and LPEM.

References

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[4] C. Fournier *et al*., Nature Communications **12**, 3779 (2021) – see also CNRS news 2021
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