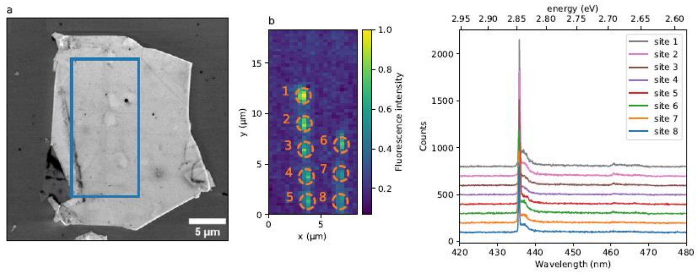
Towards deterministic creation of quantum emitters in 2D materials for optical quantum technologies

PhD position leading to a doctoral degree of Université Paris-Saclay.
Possibility of a master thesis in spring 2024

Optically active deep defects in the solid state (also called 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. An emblematic example is the nitrogen-vacancy (NV) center in diamond, at the basis of emerging quantum networks [2]. Recently discovered color centers in the 2D material hexagonal boron nitride (hBN) bring new perspectives of integration and applications in 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 [4] a new family of single photon emitters in hBN with excellent properties in terms of brightness, coherence and reproducibility [5]. These emitters can be locally activated using an electron beam in a scanning electron microscope (figure 1), which has allowed us to demonstrate top-down integration in photonic devices [6].



(a) hBN flake (single crystal of a few tens of nanometers thickness).
(b) Confocal photoluminescence map. Eight irradiation sites gave rise to color centers.
(c) Emission spectra of the eight sites, revealing similar emission lines.

The first objective of this PhD thesis is to develop a setup for the controlled generation of individual color centers. This will unlock scalable integration into complex photonic chips, and will constitute the new state of the art for the controlled creation of quantum emitters in 2D structures.

In a second step, based on this unique setup, the candidate will design, fabricate and characterize quantum photonic devices incorporating color centers at chosen positions in microcavities and waveguides. The fabrication involves the most recent process techniques that are specific to the recent field of 2D materials, and will involve partners in LPENS.

Finally, the candidate will use the quantum optics toolbox to control the emitters with lasers and investigate the properties and phenomena relevant to the field of quantum information. They will continue resonant spectroscopy experiments carried out in the group [5]. They will also perform Hong-Ou-Mandel interference so to improve the photon indistinguishability [5].

The PhD project is mostly experimental and will include the development of a new optical setup (the equipment is already present), sample fabrication and quantum optics experiments.

References

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