Cathodoluminescence of color centres in diamond for quantum technologies

PhD position leading to a doctoral degree of Université Paris-Saclay. Starting October 2025.

Possibility of a master thesis in spring 2025.

Nitrogen-vacancy color centres in diamond present key properties for quantum technologies: they have a long spin coherent time at ambient temperature, they are easy to handle and to measure optically, and they present an extreme sensitivity to the magnetic field. Recent progress push forward the promises for applications: it is now possible to accurately create NV color centres by ion implantation, opening the way to magnetometry in the nanoTesla range with spatial resolution below 20 nm. Potential applications are rich and range from measurements of spin textures in spintronic devices to paleomagnetism measurements in Earth and Planetary sciences.

The ability to create NV centres at very accurate positions requires now a way to control their locations afterwards. Optical microscopy is the usual one but this technic does not allow to reach the required spatial precision. We propose a new method to visualize the location of implanted color centres based on cathodoluminescence (CL). CL consists in exciting the samples by an electron beam and to detect and analyse the luminescence by spectroscopic technics. Thanks to the nanometer size of the focused electron beam, the spatial resolution can be far better than optical technics.

You will participate to the tests of the new instrument. During the phD you will have to determine the experimental conditions to optimize both the sensitivity and the spatial resolution for NV centre imaging by cathodoluminescence. You will investigate how the exciton and free carrier diffusion affect the final resolution of CL images with appropriate modelling. The impact on the spatial resolution of the phosphorus doping used to stabilize the spin of NV centres during magnetic measurements will be studied.

The PhD thesis will take place in the GEMaC laboratory (UVSQ/CNRS) located in Versailles. GEMaC is part of the French national consortium “e-diamant” gathering 12 academic and industrial partners involved in the research on NV centres for quantum applications. Awarded by an EquipEx funding, the project includes a new advanced CL instrument taking benefits of the latest developments in scanning electron microscopy. Installed at GEMaC in 2024, it can provide a focused electron beam as small as 0.5 nm. High quality diamond samples, with controlled isotopic content and doping levels, will be provided by the GEMaC team involved in diamond fabrication by plasma assisted vapor phase epitaxy, and as well by the partners of the e-diamant project.

The candidate will be rigorous with a strong interest in solid-state physics and a clear taste for experimental work.

References

J. F. Barry et al., Rev. Mod. Phys. 92, 015004 (2020)
J. Achard et al., J. Phys. D: Appl. Phys. 53, 313001 (2020)

Contact: Julien BARJON – julien.barjon@uvsq.fr