Cathodoluminescence of color centres in diamond for quantum technologies

PhD position leading to a doctoral degree of University Paris-Saclay.

Possibility of a master thesis in spring 2024.

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 20nm. 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.

The PhD thesis will take place in the GEMaC laboratory (UVSQ/CNRS) located in Versailles. The lab is part of the 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 in fall 2023 at GEMaC, it provides a focused electron beam as small as 0.5 nm.

You will first participate to the test of the CL instrument (internship). During the phD you will have to determine the best 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. High quality diamond samples, with controlled isotopic content and doping levels, will be provided by GEMaC thanks to the team involved in the epitaxial growth in vapour phase and assisted with microwave plasmas.

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

Contact: julien Barjon – julien.barjon@uvsq.fr – 01 39 25 46 63