Service ID: WP5-3.1

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Confocal NV characterization

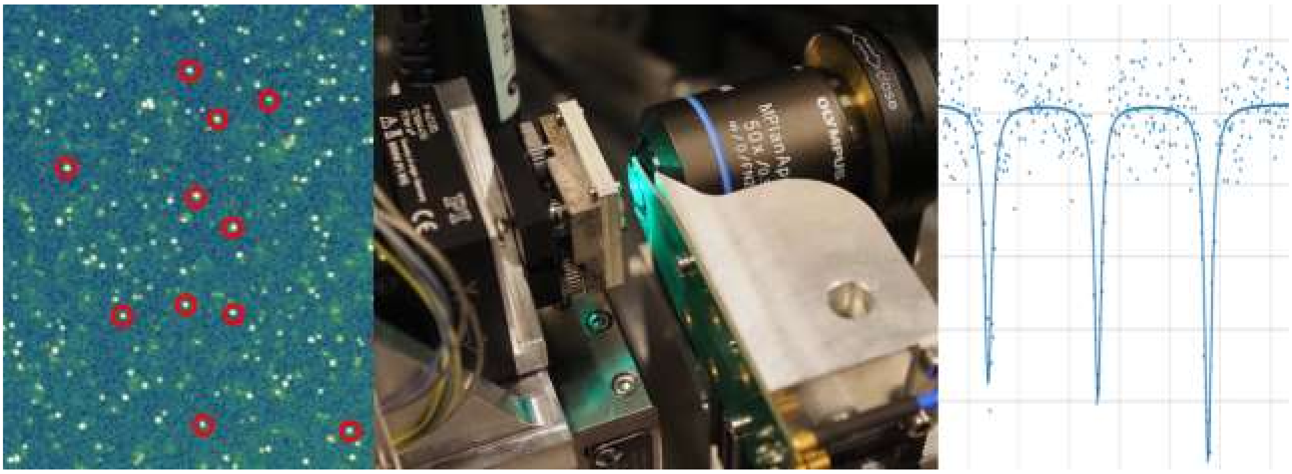

Fig. 1. *Left*: 2D Photoluminescence map of low NV-density substrate with automatic recognition of promising candidates (marked in red). *Center*: Photo of the characterization setup. *Right*: Pulsed ESR of single NV.

Overview

Localize, screen and characterize NVs in diamond - have your color centers tested

Nitrogen vacancy (NV) centers are a workhorse of several quantum technology applications. They are a unique type of imperfections in diamonds, where two carbon atoms are removed, and one of them is replaced by a nitrogen atom. NV centers can be stimulated to emit individual photons, their spin can be controlled with microwaves, which makes them suitable for quantum computing and networking applications. They also react to magnetic fields, temperature, and pressure, which makes them suitable for quantum sensing. At the same time, the surrounding diamond protects keeps the center stable, and makes their quantum properties operative in ambient conditions.

We can automatically, rapidly and reliably screen, select, characterize, and mark NV centers at room-temperature (and soon cryogenically). The characterization laboratory is equipped with a setup allowing to scan a volume of the diamond sample to automatically identify individual NV canters with sub-micron precision, to measure the density and uniformity of their distribution. Additionally, it can automatically perform measurements with certain pass criteria to automatically select suitable candidates for an application or further investigation. These measurements include orientation of the NV centers in the crystal lattice, their brightness (as a function of laser power), as well as quantum coherence times ($T2^*$ and $T2$ under dynamical decoupling), and ESR (CW and pulsed) linewidths. We can also perform G2 measurements.

With this, we can test diamonds with NVs for various applications. After deciding with you on a plan, we will conduct the measurements and generate a characterization report with info like PL maps, relative location of NV centers, their orientations, brightness, lifetime ($T1$) and quantum coherence times ($T2^*$ and $T2$). This can be followed by an optional meeting with a measurement specialist in which the results can be discussed.

Field of Application and applied technology

Specifications

Workable diamonds:

Property	**Value(s)**	**Comment**
Size	0.5×0.5×0.05mm – 10×10×5mm	Smaller sizes can be possible after discussions on the details.
NV density	⪷ 1 NV/µm³ (ideal)	For samples with higher concentrations, individual NVs cannot be differentiated anymore.
Surface treatment	Polished and cleaned	Can be cleaned in-house, if needed. Surface coatings need to be decided case-by-case.
NV depth in substrate	⪷ 10µm	The SNR can be low near to the surface (workable with proper cleaning), but becomes too low at larger depths.
Crystalline orientations	All	We have experience with 100 and 111 diamonds. Measurements (like magnetic field alignment) can be influenced by NV orientation.

Setup parameters:

Property	**Value(s)**	**Comment**
Laser power	1 µW – 5 mW	Focussed into spot size approx. 450nm (FWHM). Laser power calibrated before objective. Saturation measurements (PL counts vs. laser power) can be conducted.
MW range	1 ~ 6 GHz	Could easily be extended.
Magnetic field bias	20 ~ 800 G	Field perpendicular to investigated diamond surface. Applied with neodymium magnet.
Localization accuracy	< 200 nm	Not fully characterized. Presumably much better than indicated.
Achievable Rabi frequencies	Up to 5MHz	Without fabrication on sample. Can be increased, if needed.
Minimal pulsed ESR width measured	110 kHz	Typically limited by T2 at RT.
G2 preconditions	PL SNR ⪸ 2	Typically, a low NV density and a really low background is required to be able to perform G2 in bulk. For devices with increased count-rates (e.g. SIL) the signal is typically much higher and thus more background is acceptable.