Optical coherence of nitrogen vacancy centres for applications in open microcavities

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Negatively charged nitrogen-vacancy (NV) is among the most promising solid-state systems identified to date to be applied as a quantum bit. Yet, interconnecting many nitrogen vacancies for large-scale computation suffers from the small rate of generating indistinguishable photons from individual NV centres. Diamond-based photonics is still at a relatively early stage of development and there is a major obstacle to overcome: the optical transitions of the NV centres embedded in these nanostructures have poor quality. It is manifested in large spectral diffusion and faster dephasing, resulting from random spectral fluctuations in the exact frequency of the ZPL, caused by charge noise present in the nano-structured crystal

Open microcavity with plano-concave mirror configuration is a promising candidate to radically enhance the rate of generating indistinguishable photons from individual NV centres [1]. Crucially, it requires the absolute minimum in diamond processing. However, even this minimal processing results in a significant broadening of the linewidth, significantly decreasing NVs photon emission and collection efficiencies.

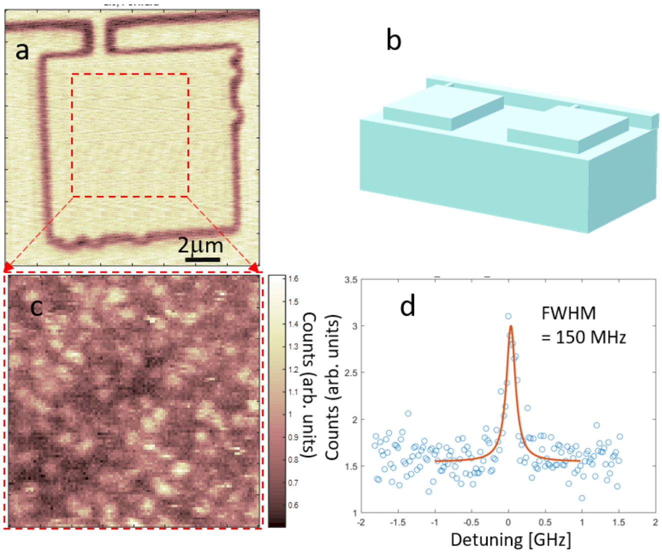

Fig. a) Confocal scan image of a structure after shallow (approx. 2 µm) plasma etch , as depitcted schematically in b); c) photoluminescence scan of a selected area of the platelet, bright spots correspond to single NVs; d) photoluminescence-excitation of the ZPL of a selected NV from the scan in c)

To elucidate the role of various etching steps on the optical linewidth degradation we perform a systematic study. We etch markings on the diamond allowing us to track single NV centres throughout consecutive processing steps. We then analyse the zero-phonon line (ZPL) linewidths that are measured in a resonant photoluminescence excitation experiment.

We determine that shallow plasma etch is at the origin of around 100 MHz broadening of the optical results in further deterioration of the linewidths to a range above 1 GHz. We exclude the detrimental role of e-beam lithography and other processing steps. We investigate laser-induced creation of NV centres as a possible solutions of creating optically coherent NVs in thin platelets.

[1] Riedel, D. *et al.*. *Phys. Rev. X* **7**, 20932–20943 (2017).