High yield ultrafast laser fabrication of single NVs within high purity diamond

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The nitrogen-vacancy (NV) defect centre in diamond is a promising candidate in spin-photonic applications such as quantum computing and sensing. Ultra-fast laser fabrication has demonstrated the ability to produce coherent NV centres with high accuracy and yield.[1] Following this initial seed the processed site can be exposed to a low energy ultra-fast pulse train which allows the vacancy to migrate through the lattice without causing additional damage. The formation of an NV centre can be monitored using a confocal fluorescence microscope to observe the centre's 637-800 nm fluorescence window.[2] However, this technique has only been demonstrated in a low purity diamond samples and therefore has not been applicable to spin-photonic applications.

Within we present the deterministic fabrication of NV centres within high purity ([N] ~ 1ppb), commercially available diamond. A homebuilt, aberration corrected, fabrication system was used in both accurate vacancy creation and high speed laser diffusion to form NV centres. Within, we additionally present post fabrication characterisation confirming single defect creation with a positioning accuracy of <300 nm. This represents a significant step forward in NV based photonic applications. Finally, we present how this technique offers a unique window into both defect fabrication and migration with a joint theoretical and experimental study into the various observables during fabrication.

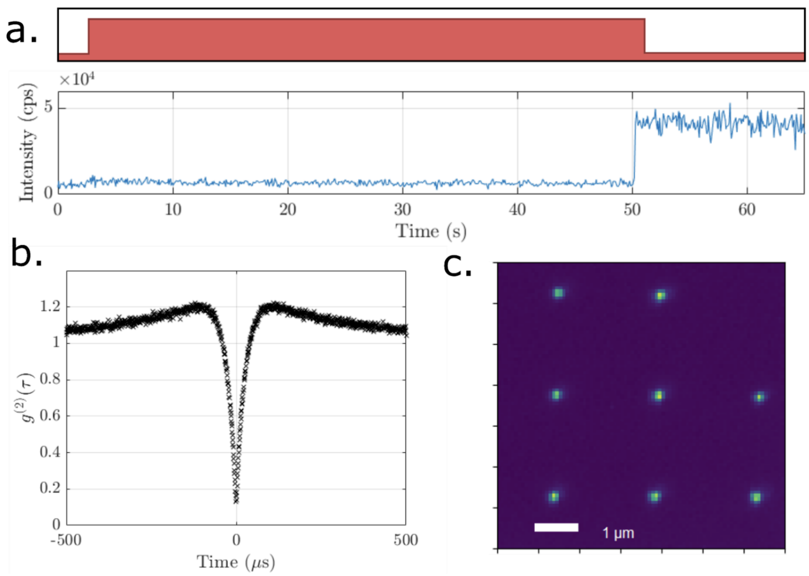

Figure 1: (a) Example of a SPAD detection trace (blue) during NV fabrication. Red pulse chart indicates the diffusion pulse train. (b) Typical HBT interferometer signal demonstrating NV singularity (g(2)(0) ~ 0.1). (c) x-y confocal microscope scan of laser written NVs in high purity diamond.

References

1. Chen et al, Nature Photonics, 11 (2017) 77
2. Chen et al, Optica, 6 (2019) 662