**Direct-measurement of the quantum efficiency of single photon emitters in few-layer hexagonal boron nitride**

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**Introduction**

Single photon emitters (SPEs) in hexagonal boron nitride (hBN) are promising candidates for the future generation of quantum photonic technologies. Recent progress in the chemical vapour deposition (CVD) of few-layer hBN has allowed for the controlled fabrication of SPEs with desired optical properties,1,2 providing a scalable platform for integrated quantum optics. Here we experimentally determine the quantum efficiency (QE) of SPEs in these films.3 We find that the emitters exhibit very high QEs approaching (87±7) % at wavelengths of ~580 nm, which is amongst the highest QEs recorded for a solid state SPE.

**Methods**

Few-Layer hBN films were grown by CVD on copper and transferred to a glass slide for optical characterisation. For the quantum efficiency experiments, we employ a metal hemisphere that is attached to the tip of an atomic force microscope (depicted schematically in **Fig. 1a**) to directly measure the lifetime variation of the SPEs as the tip approaches the h-BN. This technique enables non-destructive, yet direct and absolute measurement of the QE of SPEs. The underlying modification of spontaneous emission of the emitters in close proximity to a metal surface is a quantum electrodynamic effect and related to the local density of states (LDOS). Since the intrinsic non-radiative decay rate is assumed to be independent of the LDOS, changes in the total decay rate can be attributed to an alteration of the radiative decay rate alone.

**Results & Discussion**

We identified and measured 17 individual SPEs in the few-layer hBN film. In each case an oscillation of the SPE lifetime is observed, depending on the distance between the AFM tip and SPE, an example of which is shown in **Fig. 1b.** Fitting the distance-dependant lifetime curve allows for the extraction of the QE for each measured SPE. We observed a maximum QE for SPEs in the hBN thin-films of η= (87±7) %, one of the highest QEs recorded to date for a solid-state SPE. Interestingly, we found the QEs values vary with the relative zero-phonon line (ZPL) position of the SPE, suggesting either different electronic transitions or different charge states of the defect. Those emitters with ZPLs λ= (597±11) nm had higher quantum efficiencies of η= (62±9) %, while those at λ= (661±4) nm displayed lower quantum efficiencies of η= (36±8) %, **Fig. 1c.**

**Figure 1.** a) Schematic illustration of the setup used. b) A typical distance-dependent lifetime measurement (dots) and corresponding fit (blue solid line) determines the QE. A function with a QE of 1.0 is shown for reference by the green solid line. c) QE of 17 emitters plotted against their central ZPL position.

**References**

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