Enhanced optical quality of strain-induced WSe_2 quantum emitters coupled with high-refractive-index dielectric nano-antennas

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Quantum emitters (QEs) in transition metal dichalcogenide (TMD), such as WSe_2, opens new possibilities for quantum photonic technologies, with promising integration in current device architectures. For instance, local deformations introduced by underlying nano-structures play a fundamental role in the positioning of WSe_2 QEs at the nano-scale[1,2]. In this work, we transferred monolayer WSe_2 on top of gallium phosphide (GaP) dielectric nano-antennas, acting both as deformation centres and as resonant optical cavities[3]. With this approach, the QEs are in close proximity to the electromagnetic fields confined at the nano-antennas' surface, leading to an enhancement of their light-matter interaction. We found a 100-fold increase in the photoluminescence (PL) intensity of QEs positioned on GaP nano-antennas, when compared to those localized on non-resonant SiO_2 nano-pillars. Due to the different nature of the confining potential, and the QEs position in respect to the maxima of the confined fields, we observe PL lifetimes ranging from 2 up to 200 ns. These values are up to ten times longer than for SiO_2, which result limited by non-radiative recombination channels. Moreover, we studied the temporal coherence of a QE with interferometric measurements at ultra-low power densities and quasi-resonant excitation. We found coherence times of ~3 ps, limited only by pure dephasing. Our work highlights dielectric nano-antennas as a valuable tool to improve the optical properties of strain-induced QEs in 2D semiconductors and in their integration with photonic nano-structures.

References

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Figures

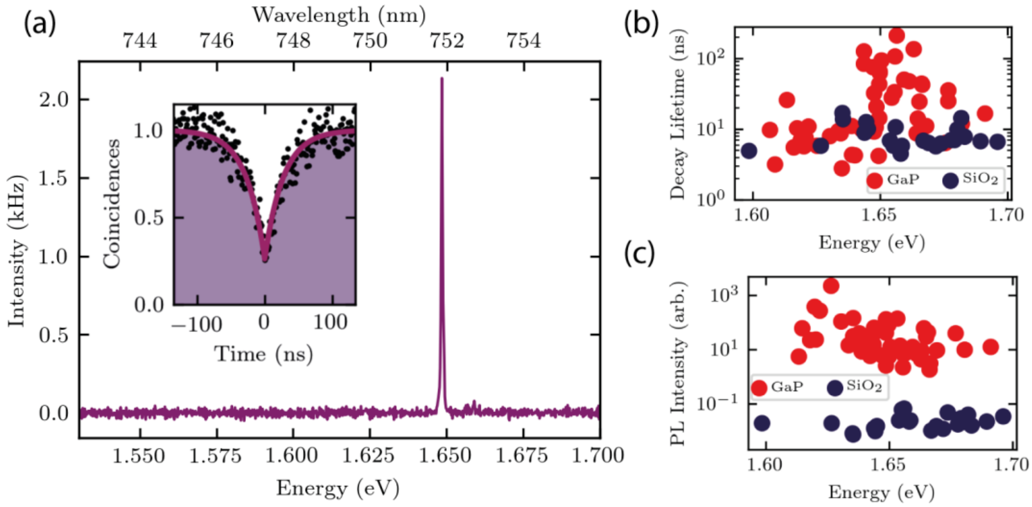

Figure 1: (a) PL emission of a strain-induced QE in a monolayer WSe_2 placed on top of a GaP dielectric nano-antenna. Inset: second-order photon correlation statistics from the QE exhibiting clear antibunching. (b,c) Comparison of the PL lifetime (b) and the PL intensity (c) values found for strain-induced QE on GaP nano-antennas (red dots) and on SiO_2 nano-pillars (blue dots).