Electronic properties of single photon emitters in transition metal dichalcogenide micro-domes

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Abstract: Despite their atomic thickness, 2D materials feature an outstanding mechanical robustness and resilience that can be exploited to induce site-controlled single photon emission.

The presence of single photon emitters (SPEs) in two-dimensional (2D) crystals is a valuable asset of these materials that comprise semiconducting transition metal dichalcogenides (TMDs), hexagonal boron nitride (hBN), and GaSe [1]. The exceptional mechanical properties of 2D materials along with their manageability and relatively easy integration in nanophotonic structures make the SPEs therein embedded particularly attracting. SPEs based on TMDs are especially important since they prompt a rather wide palette of quantum emission energies and the possibility to tune their emission via mechanical deformations [2]. Indeed, the strain itself is deemed to be at the origin of the formation of SPEs in 2D TMDs [3].

In this work, we address the physical origin of SPEs in WS_2. To this end, we exploit the peculiar formation of hydrogen-filled micro-domes obtained by low-energy (10 eV) proton irradiation [4]. The micro-domes are subjected to internal pressures as high as hundreds of atm. The ensuing high strain values attained promote an especially favourable electronic configuration, whereby defect levels admix with extended state levels leading to intense and narrow emission lines featuring quantum properties [5]. Magneto-optical experiments provide compelling evidence of the involvement of dark states at the origin of SPEs, while emission polarization studies emphasize the role of strain. The perspectives of these SPEs in 2D nanophotonic devices will be also presented.

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