Layered materials as platforms for quantum technologies

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Research on layered materials (LMs) has seen an extraordinary surge in recent years, owing both to the new fundamental physics they exhibit and to the technological advantages that they offer. Lack of dangling bonds, atomically precise interfaces, flexibility and optical transparency are only a few attributes they possess.

2-d transition metal dichalcogenides (2d-TMDs) are also hosts of quantum emitters (QEs) at different wavelengths in the visible[1]. As such, they present real potential for silicon-compatible quantum information technology (QIT). QEs in 2d-TMDs until now have appeared randomly and with unstable emission properties. Here we present a method to deterministically create large-scale QE arrays in LMs[2]. We present results showing QE arrays of tens of microns square and more than 100 QEs, in both WSe_2 and WS_2. We do this through strain-engineering at the nanoscale, placing monolayers onto nanopatterned substrates. The quality of the QEs is equal or superior to those appearing randomly. We present results on the susceptibility of the deterministic QEs to pillar height, TMD material source and fabrication method, studying their excitonic and optical properties through micro-resolved photoluminescence. Our most current work focuses on charge-controlled experiments using hybrid and 2d-heterostructures towards the creation of optically active spin qubits. Our work places LMs as potential key players in QIT – both through enabling a more efficient study of the 2d-QEs and advancing towards real and competitive quantum circuit architectures.

References

[1] Palacios-Berraquero, C. *et al.* Atomically thin quantum light-emitting diodes. *Nat. Commun.* **7,** 12978 (2016).
[2] Palacios-Berraquero, C. *et al.* Large-scale quantum-emitter arrays in atomically thin semiconductors. (2016).

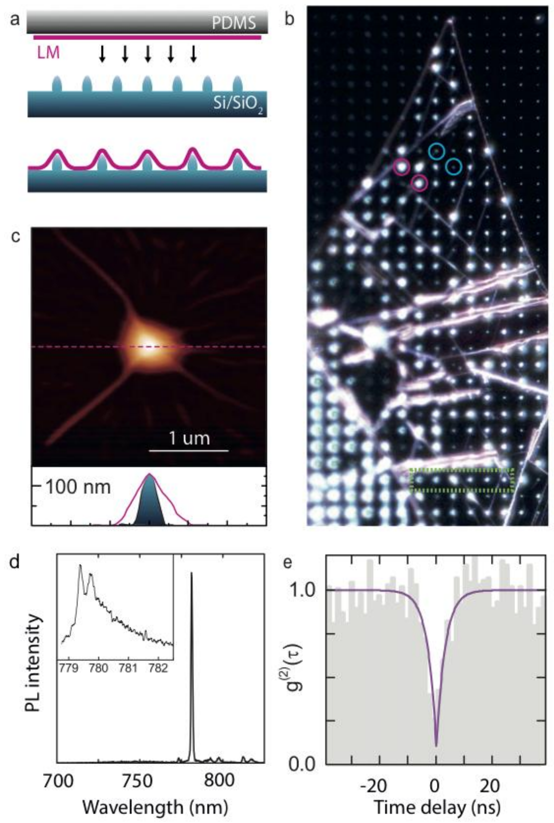

Figure 1: Deterministic creation of large scale 2d-QE arrays. a. Schematic of all-dry deposition of LMs onto patterned substrate. b. Dark field optical microscopy image of WSe2 monolayer on nanopillars. c. AFM scan and profile of LM on nanopillar. d. Spectrum of WSe2 QE peak. e. photon-photon correlation measurement of QE emission showing single-photon emission.