Strain-tunable Quantum Optical Emission in WSe_2 Monolayers

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Abstract

The development of novel ultra-compact two-dimensional (2D) photonic technologies for quantum information processing relies on our ability to fabricate single photon sources (SPS) in 2D van der Waals materials with controlled optical emission properties and on-demand [1]. However, the efficient exploitation of such quantum emitters in quantum information science and technology requires an in-depth understanding of their physical origin and a deliberate control over their optical emission properties. In this regard, elastic strain engineering provides interesting possibilities. One the most prominent experimental approaches to date for the introduction of controlled in-plane strain fields in nanomaterials is based on the use of a novel class of piezoelectric actuators [2,3].

In this work, we demonstrate reversible tuning of the emission energy of SPS in wrinkled WSe_2 monolayers upon their integration onto piezoelectric actuators capable of introducing in-plane isotropic and anisotropic strain fields [4]. Our findings demonstrate that it is possible to have a full control of the emission energy with a high energy shift up to 20 meV while leaving the single photon purity unaffected. Finite element simulations suggest that the type of strain (tensile or compressive) experienced by the quantum emitters, i.e. red or blue emission energy shift, strongly depends on their localization across the wrinkles. Our findings shed light on the understanding of the physical origin of SPS in 2D monolayers and are of strong relevance for the practical implementation of single photon devices based on 2D materials as well as for understanding the effects of strain on their emission properties.

References

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[3] R. Trotta, J. Martín-Sánchez et al. Nature Commun. 7 (2016) 10375
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Figures

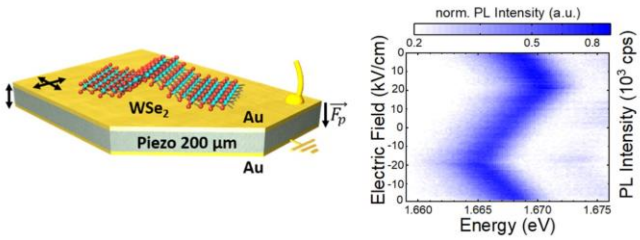

Figure 1: (Left) Schematics of a WSe_2 monolayer on a piezoelectric actuator to introduce reversible in-plane strain fields. (Right) Reversible and active tuning of the optical emission of single photon emitters.