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Strain tuning of the emission axis of quantum emitters in an atomically thin semiconductor: supplementary material

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1. COMSOL SIMULATION

A. Methods:

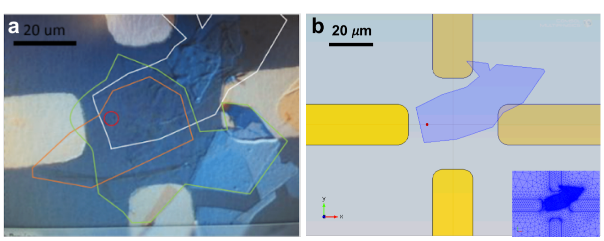

Fig. S1. a. Optical micrograph of the van der Waals heterostructure on the PMNT substrate. b. Simulated device in comsol (Inset: Mesh grids for the simulation on top view)

Fig. S1a presents the optical micrograph of the heterostructure. Graphene layer is outlined in white, hexagonal boron nitride (h-BN) in green and the WSe_2 is in orange. Red circle is the laser spot position from where the localized emitter presented in the main text were found. The geometry used for COMSOL simulation is presented in Fig.S1b. Metal electrodes are colored in gold while the graphene layer is in blue. The lateral size of a PMNT substrate, the piezoelectric material, is set as 1.5 mm so it does not have an effect on the region of interest. The thickness is set to 500 μm. The thickness of the electrode and two-dimensional materials is set to zero as it is four order of magnitude smaller than that of PMNT.

B. Strain as a function of position on the graphene top electrode:

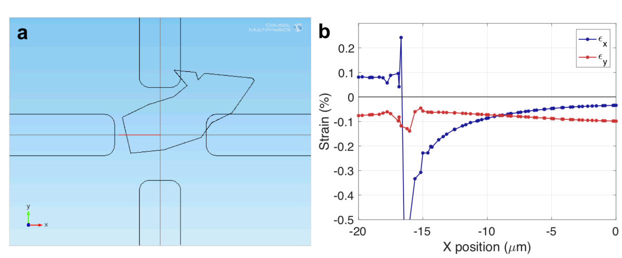

Fig. S2. a. Simulated device in COMSOL. b. Strain was calculated across the graphene flake as indicated by the red line in Fig.S2a

The strain is calculated for a maximum voltage of 210 V applied on the two electrodes connected to the graphene layer. The x- and y-directional strain values on the red line in Fig.S2a is shown in Fig.S2b. The difference is originated from the asymmetric geometry of the graphene electrode. From the simulation, we find that a compressive strain is applied on the graphene layer. However, strain in the orthogonal direction of the flake boundary changes dramatically near the edge, showing the significant effect of the geometry in this region.

2. EMISSION ENERGY AS A FUNCTION OF STRAIN FOR DIFFERENT LOCALIZED EMITTERS

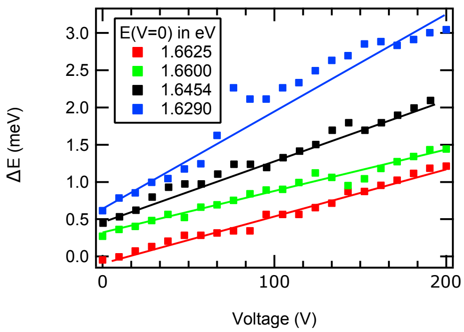

Fig. S3. Evolution of the emission energy shift as a function of strain for four different localized emitters exhibiting linear behavior. Solid lines are linear fit to the data. The emission energies of the different localized emitter are provided in the figure legend

We have measured the change in emission energy (ΔE) as a function of applied piezoelectric voltage for different emitters as shown in Fig. S3.

3. POLARIZATION RESOLVED PL

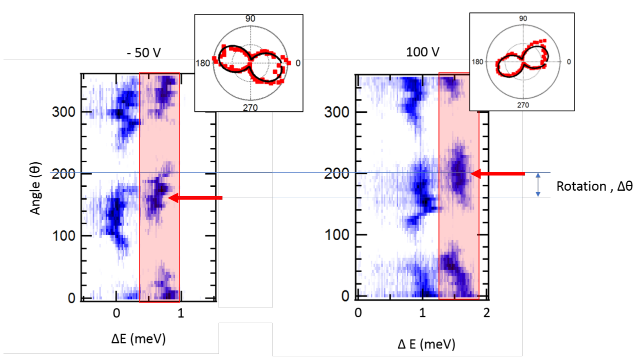

Fig. S4. Color plot presenting polarization resolved photoluminescence at two different voltage values (left:50V, right:100V) on the piezoelectric substrate. Polar plot for the highlighted higher energy peak is also presented in the main text. A clear rotation of $\Delta\theta$ is observed.

Figure S4 presents the polarization resolved photoluminescence color map of the quantum emitter at two different voltages applied on the piezoelectric substrate. The polar plot in the inset shows a clear rotation of the emission dipole as a function of voltage. The direction of the two peaks of the doublets as a function of piezoe-electric voltage (V_p) is presented in Fig. S5.

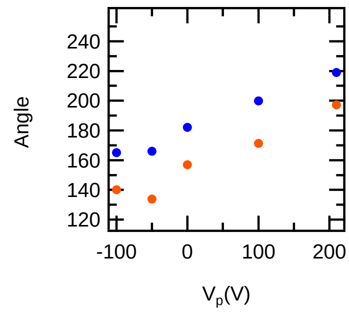

Fig. S5. Angle of emission of both the higher (blue) and lower energy peak (red) of the doublet as a function of applied voltage on the piezoelectric substrate.