Manipulation of the exciton fine-structure splitting in telecom-wavelength quantum dots via uniaxial strain

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Telecom wavelength quantum dots are required for efficient communication of single photons via fibre, free-space through the atmosphere, or on-chip. However, to date most progress has been made with quantum dots (QDs) emitting at $\lambda < 1$ μm which are unsuitable for long-distance communication. Here, we investigate a single layer of self-assembled InAs quantum dots (QDs) in an $In_{0.18}Ga_{0.82}As$ quantum well which emit at $1150 < \lambda < 1300$ nm. We embed the quantum dots in a charge tunable structure and collect the photoluminescence (PL) as a function of applied voltage (Fig. 1a). In typical self-assembled quantum dots, the rotational symmetry is broken and the electron-hole exchange interaction mixes the bright exciton states into a non-degenerate doublet referred to as a fine structure splitting (FSS). Using polarization-resolved PL, we measure nominal FSS values (Fig. 1b) significantly smaller than previously reported, which we can further manipulate using uniaxial strain [1]. We observe varied responses of the splitting to the external strain, including positive and negative tuning slopes, different tuning ranges (up to ~50 μeV), and linear and parabolic dependencies, indicating that these physical parameters depend strongly on the unique microscopic structure of the individual quantum dot [2]. To better understand the experimental results, we apply a phenomenological model describing the exciton polarization and fine-structure splitting under uniaxial strain (Fig. 1c) [3]. The model predicts that, with an increased experimental strain tuning range, the fine structure can be effectively canceled for select telecom-wavelength dots using uniaxial strain. These results are promising for the generation of on-demand entangled photon pairs at telecom wavelengths.

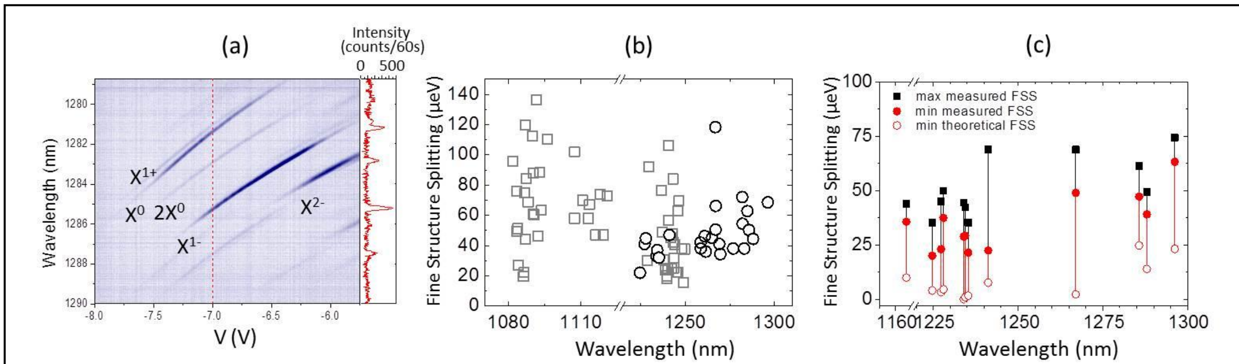

Fig.1 (a) Photoluminescence spectra collected as a function of the applied gate voltage at a temperature T = 4 K. The peaks corresponding to the emission from different states of a single QD are labeled accordingly. The right panel shows a linecut of the contour plot at the corresponding red dashed line, at V = 7 V. (b) FSS measured on single QDs with no applied external strain. The circles represent values obtained from the charge tunable device while the open squares correspond to measurements from a layer of QDs grown in the bulk. (c) Experimentally measured (solid symbols) and calculated (open circles) maximal and minimal FSS under uniaxial strain.

References

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