Static strain tuning of quantum dots embedded in a photonic wire

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Epitaxial semiconductor quantum dots (QDs) embedded in nanophotonic structures are very efficient single photon sources [1]. However their use in quantum information protocols involving more than two sources has been hindered by the dispersion in energy of different QDs. QD energy tuning can be achieved using temperature, electric field, or material strain. In this work, we used strain to statically tune the QDs embedded within a photonic waveguide.

Our system consists of InAs QDs embedded within a GaAs photonic wire as a waveguide featuring very efficient single photon collection efficiency [1]. Four years ago, these photonic structures were used in our team as mechanical oscillator to demonstrate strain-mediated optomechanical coupling [2,3]. Owing to its off-centered position within the nanowire circular cross-section, the quantum dot strained as the wire is bent. This strain alters the quantum dot energy levels [2] and therefore the spectral position of the photoluminescence lines.

In the present work [4], we used strain to statically tune the semiconductor band gap (up to 25 meV) of QDs embedded in a photonic waveguide. As opposed to our previous work [2,3], the strain is produced statically using a nanomanipulator enabling the realization of bright and broadly tunable quantum light sources. Moreover, owing to the strong transverse strain gradient generated in the structure, we can relatively tune two QDs located at different locations in the waveguide and bring them in resonance, opening the way to the observation of collective effects such as superradiance.

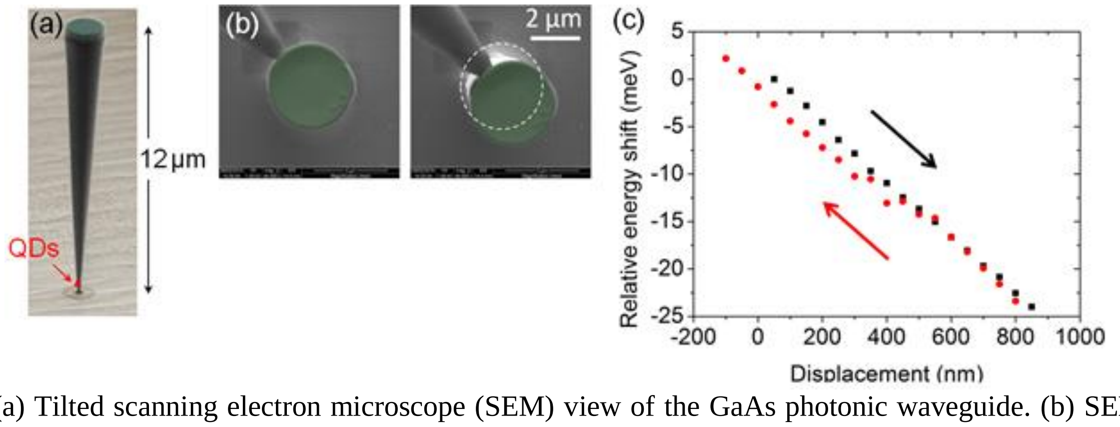

Fig. (a) Tilted scanning electron microscope (SEM) view of the GaAs photonic waveguide. (b) SEM top view showing the top facet of a waveguide displaced by the tip of a nanomanipulator. (c) Relative energy shift as a function of the displacement of nanomanipulator tip.

References
[1] M. Munsch et al, Phys. Rev. Lett 110, 177402 (2013).
[2] I. Yeo, et al, Nat. Nano 9, 106 (2014).
[3] P.L. de Assis et al, Phys. Rev. Lett. 118, 117401 (2017).
[4] D. Tumanov et al, Appl. Phys. Lett. 112, 123102 (2018).