Strain-Tuning a Quantum Dot in Nanopost with a Phase-Change Shell: Towards Broadly-Tuneable Single-Photon Sources

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Wavelength-tuneable single-photon sources are key devices for scaling-up photonic quantum technologies. Embedding a quantum dot (QD) inside a broadband photonic structure (such as a nanowire waveguide or a nanopost cavity) represents an appealing strategy to realize such devices. Among various wavelength "tuning knobs", material strain stands out as it preserves the remarkable QD optical properties upon spectral tuning.

In this work, we demonstrate in-operando and non-volatile strain-tuning of self-assembled InAs QDs embedded in a top-down GaAs nanopost (see Figure 1) [1]. The latter is covered by a conformal shell made of a phase-change material (HfO_2), which is deposited in the amorphous phase. Above ~400°C, HfO_2 crystallises, which in turn induces a strain on the GaAs core. Here, we excite and detect the QD photoluminescence in a cryogenic micro-photoluminescence setup. We perform an in-situ annealing of the HfO_2 shell using an intense laser beam focused on a selected nanopost. By controlling the annealing power (a few tens of mW), the illumination time (1-10 s) and the number of annealing steps, we demonstrate large spectral redshifts (cumulative tuning range of up to 9 meV) as well as fine tuning steps (as small as a few µeV, see Figure 2).

These results establish this technique as powerful tool for the future developments of nanowire-based quantum photonics, in particular for the realization of bright and broadly tuneable single-photon sources.

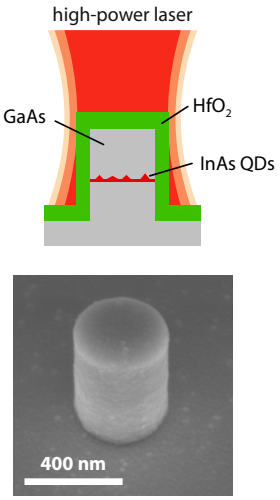

Fig. 1: *Nanopost structure capped with HfO_2. Schematic illustration of the structure (top) and SEM image (bottom).*

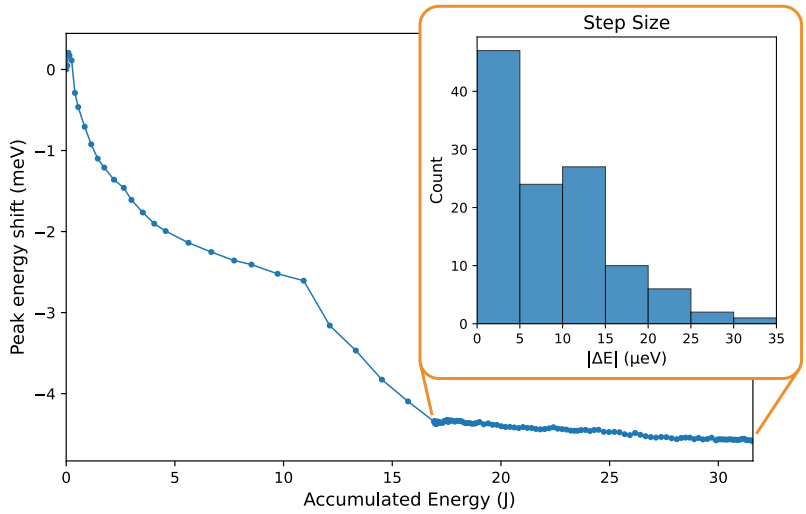

Fig. 2: *Photoluminescence peak energy shift of a QD embedded in a nanopost as a function of the accumulative energy due to successive high-power laser-annealing steps. Inset: Average step size during fine steps adjustments.*

References

[1] B. Viollet et al., "Strain-tuning a quantum dot in nanopost with a phase-change shell", in preparation.