Piezoelectric control of excitons in single quantum dots

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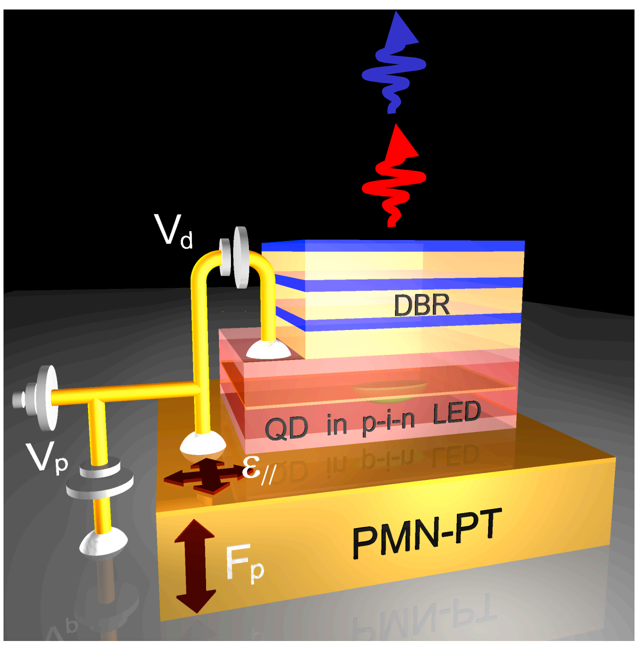
Optically active semiconductor quantum dots (QDs) can be made as epitaxial nanoinclusions of a low energy bandgap material in a matrix with larger energy bandgap. Many recent experiments have demonstrated that these QDs are excellent quantum emitters, which can be used as sources of triggered single photons, indistinguishable photons and polarization entangled photon pairs. The structural properties of self-assembled QDs are affected by unavoidable fluctuations, which make it difficult to obtain QDs with electronic and optical properties which meet (sometimes very stringent) requirements for their use in advanced quantum optics experiments. Post-growth techniques are therefore required to fine-tune the optical properties of QDs. Vertical electric fields (applied along the growth direction) represent the most powerful "tuning knob" to date.



In this talk I will discuss QD-based devices in which the semiconductor structures are integrated on top of piezoelectric actuators made of PMN-PT. This combination allows us to study in detail the effects produced by variable strains (up to about 0.2%) on the excitonic emission of single QDs and to add a "tuning knob" to QDs.

In fact, by combining strain with electric fields we are able to obtain (i) independent control of emission energy and charge-state of a QD, (ii) wavelength-tunable single-QD light-emitting diodes, and (iii) frequency-stabilized sources of single photons at predefined wavelengths. Possible future extensions and applications of this technology will be discussed.