III-V semiconductor quantum dots for efficient quantum light sources.

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Photonic crystal microcavities (PCMs) with embedded quantum dots (QDs) have been shown as excellent test bed systems for experiments in the field of cavity quantum electrodynamics (c-QED) [1] that may open doors to efficient quantum photonic devices for the generation of single-photons, entangled photon pairs and ultra-low threshold lasing. Based on fundamental excitonic emission and on biexciton-exciton recombination cascade, a single QD embedded in a PCM become efficient emitters of single photons or entangled photon pairs provided that both spectral and spatial matching of the optical cavity mode and the optical emission of the single nanostructure occur.

Within this approach, we have explored several systems and growth methods with the aim of fabricating QD which fulfil the requirements for an efficient coupling between a single QD and a PCM. We have fabricated QD by molecular beam epitaxy (MBE) using a) droplet epitaxy [2] and b) selective nucleation at nano-holes fabricated by atomic force microscopy local oxidation (AFMLO) lithography [3]. Results will be presented of QD in GaAs/AlGaAs(111)A, InAs/GaAs(001) [4,5] and InAs/InP (001) [6].

With the aim of obtaining coupled QD-PCM, we have followed two procedures: one is based on the fabrication of a PCM around a buried QD whose position and wavelength emission are previously determined; the other approach consists of locating a single QD by using AFMLO, at the maximum of the electric field of a prefabricated PCM. A MBE re-growth procedure has been developed for completing the PCM membrane thickness [7].

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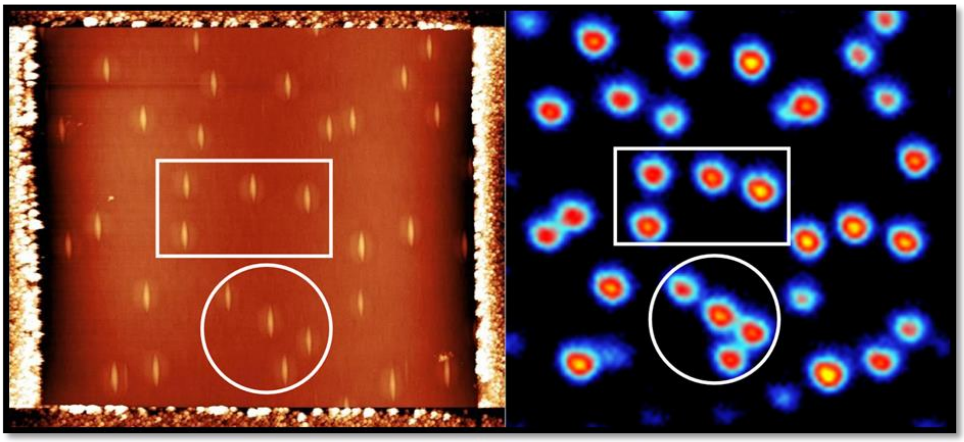

Fig. 1: AFM (left) and µPL (right) images of buried InAs quantum dots grown at nanoholes formed by droplet epitaxy on GaAs (001) substrates. Notice the one to one correspondence between the µPL signal from buried nanostructures and the mounds of the surface.

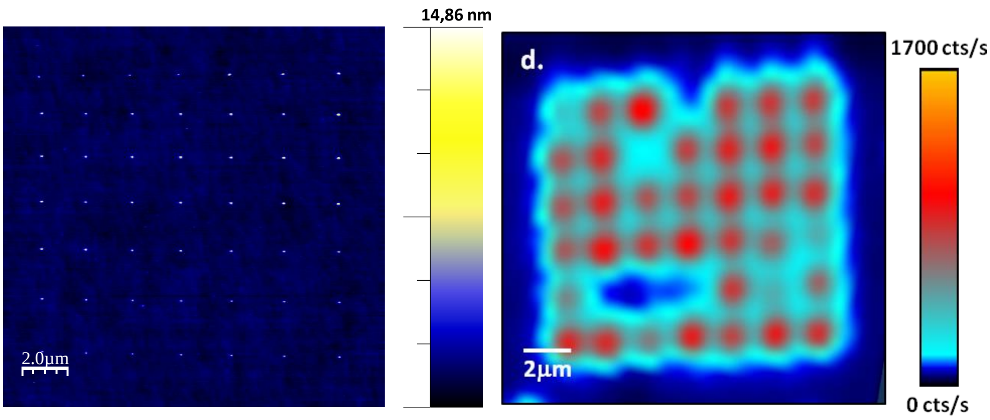

Fig. 2: AFM image of a 2D array of GaAs oxide dots obtained by AFM local oxidation lithography (left). µPL map obtained on a square array of buried site control QD (right) grown on GaAs patterned surfaces similar to that shown on the left AFM image.