Thermal annealing of InAs quantum dots on patterned GaAs substrates

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Quantum information devices are moving closer to realisation since single semiconductor quantum dots (QDs) can be manufactured on demand. Integrating single QDs into optical resonator structures appears to be a promising approach to realise such a device. Essentially, it is necessary to fabricate QDs with controllable properties at predefined locations. In the past decade, substrate pre-structuring has become a reliable technique in order to achieve good control of QD nucleation sites [1, 2]. Nevertheless, the lower quality of site-controlled QDs compared to randomly nucleating QDs remains an obstacle. One reason for this problem is attributed to defects which are due to a change in morphology at the patterned sites and thus originate from the regrowth interface below the QDs [3]. Growing QD stacks helps to increase the distance between the last QD layer and the regrowth interface and therefore reduces the number of defects in the QDs of this particular layer. Though, obtaining a single array of ordered QDs of high optical quality remains a challenging but meaningful task with regards to device integration.

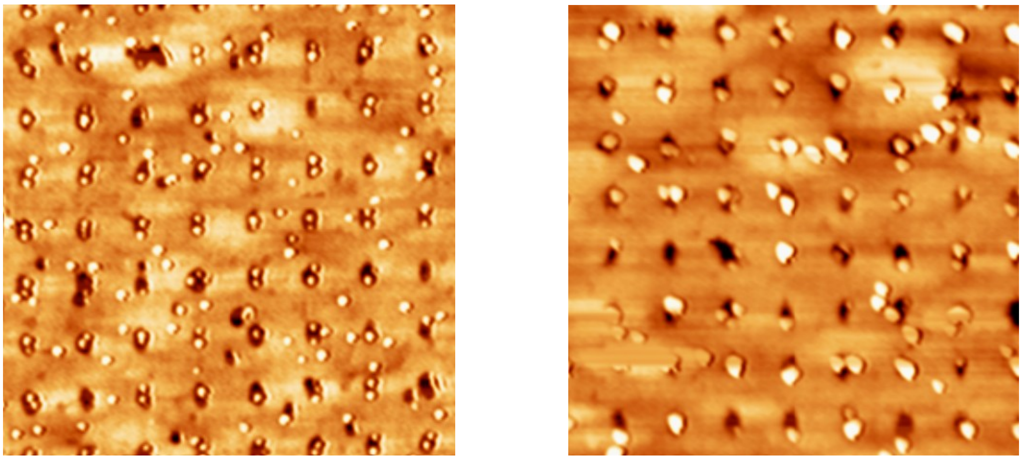

Fig. 1: AFM images (2 µm x 2 µm) of two samples with InAs QDs grown on patterned GaAs substrates. (Left) Sample with 1.7 ML InAs coverage. Double dot nucleation per hole is predominantly observed. (Right) Sample with 1.7 ML InAs coverage, annealed for 2:30 min. One dot per site is found in most cases.

A different approach to improve QD distribution and optical properties utilises an *in-situ* post-growth treatment. A transition from mainly double dot nucleation to single dot occupation per hole is observed after *in-situ* thermal annealing of a sample with 1.7 monolayer (ML) InAs coverage. Under certain annealing conditions, QD sizes remain constant while the QD density as well as the In concentration can be controlled by annealing time [4]. By studying different annealing conditions we can control, to some extent, the final QD size as well as the QD distribution, where QDs nucleating inbetween the patterns will be removed while double dots will merge into single dots at the patterned sites. This is confirmed by structural analysis of the QDs using atomic force microscopy (AFM). Additionally, optical analysis of the site-controlled QDs by spatially resolved micro-photoluminescence (µ-PL) measurements will be shown.

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