Site-controlled Ga droplet epitaxy by deposition through shadow masks

V. Zolatanosha and D. Reuter*

Department of Physics, University of Paderborn, Warburger Str. 100, 33098 Paderborn, Germany

Semiconductor quantum dots (QDs) have been an area of intensive research in the past [1, 2, 3, 4].Very high quality QDs can be produced by self-assembly either by the Stranski-Krastanov (S-K) growth mode or *via* droplet epitaxy [5, 6]. One big disadvantage of self-assembled growth is the random nucleation of QDs on the surface. There are a few approaches which allow controlling the exact position of a single QD for strain-mediated S-K grown InAs QDs quite well [3, 7]. In contrast, for droplet epitaxy, just two groups have reported some degree of site control [8, 9].

In this contribution, we propose selective area epitaxy (SAE) by employing a movable shadow mask to achieve site-controlled QDs *via* droplet epitaxy. In SAE the material is deposited locally through apertures in the mask. In our approach, from these local deposits, droplets are formed via self-assembly, ideally one droplet per aperture. Our removable robust shadow mask is based on a nano-patterned 100 nm Si_3N_4-membrane on a 1 mm thick Si(100) support wafer. The circular apertures have diameters from 5 µm down to 100 nm. The smallest openings are intended for single droplet formation. A crystallization step under As flux would transform the site-controlled droplets into QDs. A GaAs layer, which is deposited on the mask, results in a fresh mask surface, allows for an *in-situ* hole size reduction and can be re-evaporated without damaging the mask, i.e. the mask can be used many times.

Deposition experiments of Ga through the mask show that one has to minimize the gap between substrate and mask as well as that the diffusion has to be suppressed to obtain a localized deposition governed by the hole size. Therefore, we employ close contact between mask and substrate and deposit the Ga at 100° C substrate temperature. After removing the mask, we employ an annealing step to form the droplets.

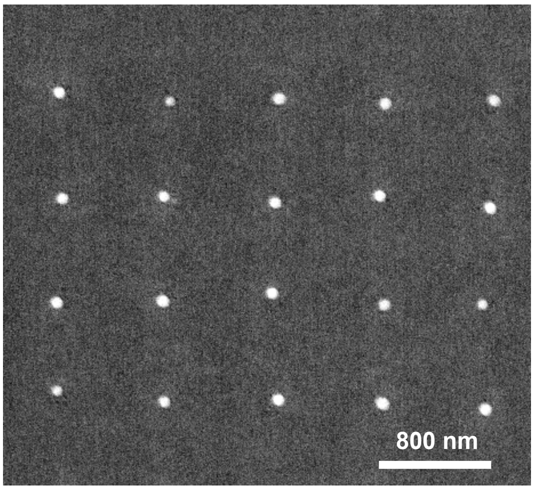

Fig. 1: SEM image of an array of single Ga droplets.

By optimizing the Ga amount deposited and the *in-situ* annealing parameters we were able to induce a single Ga droplet for each aperture with high probability (see Fig. 1). Subsequent crystallization under As flux results in an array of GaAs QDs.

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*Contact: dirk.reuter@upb.de