Growth control with RAS of highly ordered Ga(As)Sb quantum dots grown on pre-structured GaAs

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Ga(As)Sb quantum dots (QD) are usually grown by self-organization in the Stranski-Krastanov growth mode on a plane GaAs surface. In different publications we have shown that we are able to change the diameter, the height, and the density of the QD as well as their emission wavelength (from 876 nm up to 1309 nm) by variation of the growth parameters [1-3].

Here we report on the opportunity to achieve highly ordered QD on a pre-structured GaAs substrate. An array of holes/depressions is milled into the GaAs substrate/buffer with a gallium focused ion beam (FIB) machine. It is possible to control the density, the depth, and the diameter of the holes. By overgrowth of these structures for optimum growth parameters the QD can be forced to form exactly at the positions of the holes.

During FIB milling surface contaminations can occur. Also the samples have a vacuum brake during the transfer from the FIB to the MBE and a native oxide layer is formed on the sample surface. An overgrowth of the pre-structured substrate/buffer can only be successful, if these contaminations are removed.

Several approaches have been pursued with dry and wet etching outside the MBE chamber. Different heat ramps in the MBE chamber and overgrowth parameters have also been tested. The best results are achieved with a hydrochloric acid etching step before the sample is overgrown with a 50 nm thick GaAs layer.

To control and verify the crystalline structure of the structured surface reflection anisotropy spectroscopy (RAS) and reflection high-energy electron diffraction (RHEED) are used in-situ during the epitaxial process. The recorded RAS spectra are compared with those of unstructured samples.

The QD will grow in the holes, if the diameter of the dots fits almost the diameter of the holes. The distance from hole to hole is 200 nm.

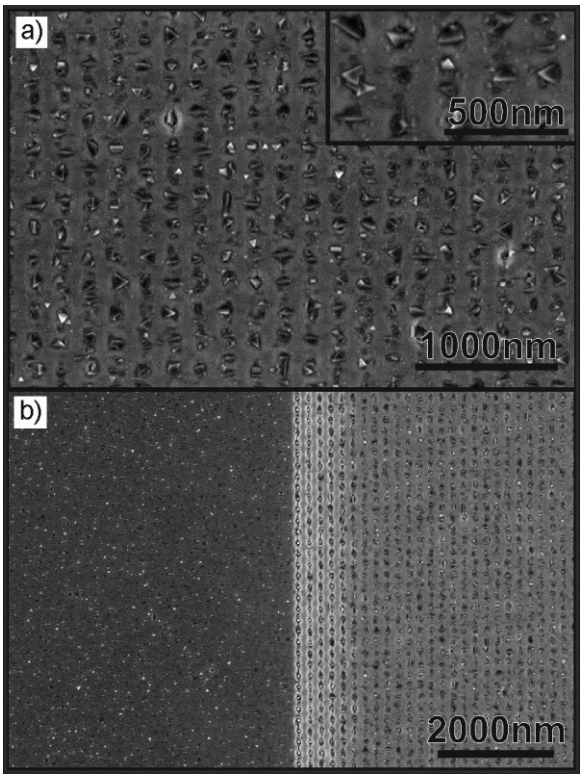

Fig. 1: a) Scanning electron microscope (SEM) images of highly ordered QDs. The dots grow in the milled holes. b) SEM image of the edge of the array of holes. On the left side the QDs grow randomly on the plane part of the buffer layer. On the right hand side they grow highly ordered in the holes on the pre-structured GaAs buffer layer.

[1] T.H. Loeber, D. Hoffmann and H. Fouckhardt, *Proc. SPIE* 79470N (2011)
[2] J. Strassner, J. Richter, T.H. Loeber and H. Fouckhardt, *Proc. SPIE* 92880F (2014)
[3] H. Fouckhardt et al., *J. Cryst. Growth,* **404**, 48-53 (2014)

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