Influence of AlAs monolayer on InAs quantum dots stacks embedded in an InGaAs/GaAs matrix

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Quantum dots (QDs) are attractive due to their potential benefits in photoelectronic devices such as LED, laser diodes and solar cells. In solar cell applications, multilayer stacks of InAs QD are typically used to absorb a larger fraction of the incident solar radiation as compared to single layers, thereby achieving higher efficiencies. The ability to tune QD density, size, and chemical composition is very useful to cover the desired spectral region. In studies dealing with InAs QDs, an annealing procedure is often used. During annealing of InAs QDs at relatively high temperatures a combination of ripening and InAs decomposition happens. The size and chemical composition of QDs can be tuned without formation of defects [1].

We present a growth study of multilayer stacks of InAs QDs embedded in InGaAs and GaAs matrices to investigate the influence of QD density on the performance of solar cells.

All samples were grown by molecular beam epitaxy in a Riber Compact 21T system equipped for arsenide growth. A schematic drawing of the device structure is shown in Fig. 1. Ten layers of InAs QDs embedded in a InGaAs/GaAs matrix were deposited on a n-type GaAs layer and covered by a p-type GaAs layer to form a pin structure.

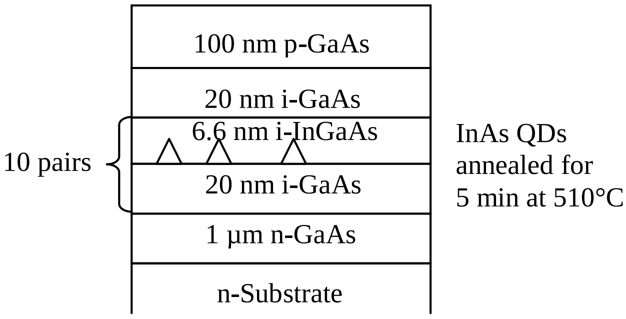

Fig. 1. Device structure.

An annealing procedure for each QD layer is introduced to tune the QD density. However, we

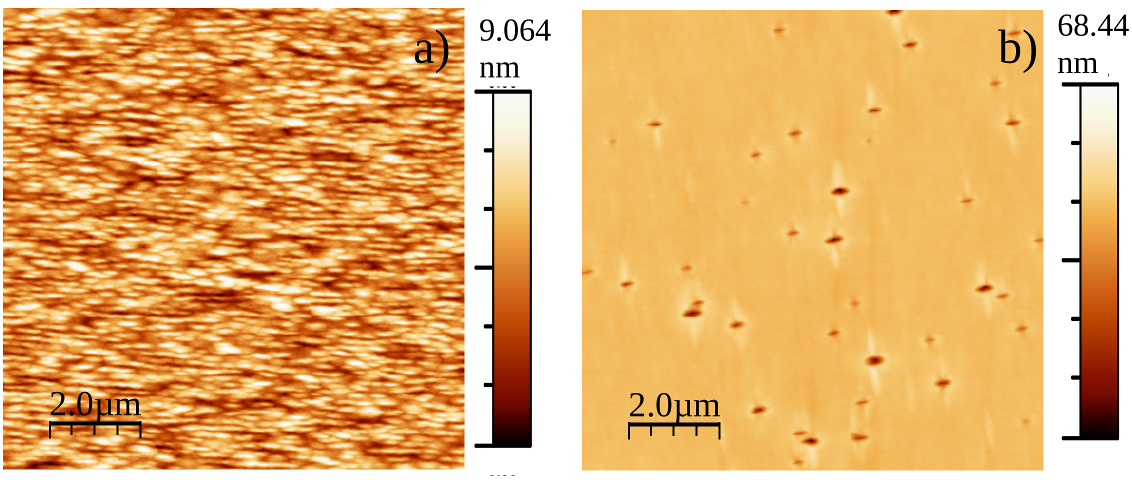

Fig. 2. AFM images of surfaces, a) without in-situ annealing, b) with annealing

found that annealing of each InAs QD layer deteriorates the device surface, as shown in atomic force microscope (AFM) images in Fig. 2, where dips on the surface are visible, while the surface of as grown devices is flat. A possible explanation is a combination of In segregation from QD and desorption of In forming dips on the surface.

It was suggested previously in literature, that a thin AlAs capping layer can suppress In segregation in single InAs QD layers[2].

To understand the influence of such a thin layer, we fabricated multilayer stacks with InAs QDs covered by one monlayer AlAs. AFM images, as shown in Fig. 3, indicate that the density and the size of dips are reduced. This suggests that the application of a thin AlAs capping layer also works in multilayer stacks.

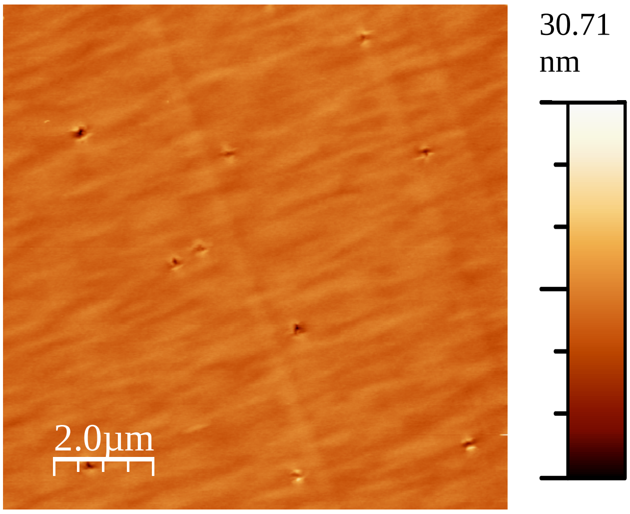

Fig. 3. AFM images of device surface with AlAs layers

References

[1] D. Z. Hu, A. Trampert, and D. M. Schaadt, J. Crystal Growth 312, 447 (2010).
[2] T. Kawai, H. Yonezu, Y. Ogasawara, D. Saito, and K. Park, J. Appl. Phys. 74, 1770 (1993).

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