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On the mechanisms of InAs quantum dots AlGaAs capping: strain, shape and intermixing.

Throughout the years the semiconductor nanostructures like the quantum dots (QDs) have taken relevance in the industrial and academic fields due to the electron confinement properties they uphold, allowing for the harvesting of a wide range of the solar spectrum in photovoltaic technology, giving the user superior versatility and efficiency on devices such as TV screens for vibrant colors, photodetectors with enhanced sensitivity, etc. To properly tailor the absorption range, the full control of the synthesis process by modifying their size, composition, and arrangement in multi stacked heterostructures should be propitiated. In this study we present a method to control the morphology of the QDs by encapsulating them in asymmetric composition AlGaAs/GaAs layers by Molecular Beam Epitaxy (MBE). For sake of guaranteed reproducibility in the experiment, it was verified that prior to the capping all the QDs grown on GaAs showed the same diffusion parameters, critical thickness, and pyramidal shapes with 50° vortex angle. When encapsulating in asymmetrical AlGaAs barriers the InAs lattice mismatch is nearly maintained for any Al composition (%Al) in the ternary alloy. Nevertheless, reflection high-energy electron diffraction (RHEED) patterns of the QDs revealed consistent changes on their shape to truncated and tip rounded pyramids. GaAs capping (0%Al) conduces to a sudden flattening of the surface in such a way that the faceted growth is lost at 1.2nm. On the contrary, for high %Al alloys capping the vortex angle progressively diminishes to 20°, and its observed up to 7nm. These results prove that despite the similar lattice mismatch, the surface diffusion tailored by %Al plays a key role when capping the QDs. Numerical simulations were run to explain the ternary alloy strain effect, accounting for the morphological shapes of the pyramids, and intermixing processes.

Keywords

Molecular Beam Epitaxy, QDs, Strain, RHEED, encapsulation

Reference

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