Lattice registration and allocation of strain in (211)B InAs/GaAs quantum dot superlattices

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Transmission electron microscopy (TEM) techniques were employed to shed light to the structural features and strain properties of piezoelectric InAs quantum dots (QDs), showing extensive potential for single photon emission and photon entanglement. QDs were grown by plasma-assisted molecular beam epitaxy, either on the surface or buried in (211)B GaAs, over a 40x period (1.5 nm AlAs)/(2.3 nm GaAs) superlattice. Regardless their location, QDs exhibit a pyramidal anisotropic shape, elongated along the [-111] direction, with a base-aspect-ratio ranging from 1.2 to 1.4.
Lattice registration and allocation of strain in the InAs/GaAs QDs superlattice were explored by Moiré fringe analysis, fast Fourier transform (FFT) of high-resolution TEM (HRTEM) images, Bragg filtering of the interfacial area and geometrical phase analysis (GPA). Uncapped QDs were almost relaxed due to the introduction of misfit dislocations at the InAs/GaAs interface. Residual elastic strain decreased from the base to the apex area of the QDs that exhibited the strain-free lattice values. Conversely, HRTEM imaging showed full in-plane registration of the buried QDs without any associated line defects, implying fully strained nanostructures. Indium chemical composition maps of the buried QDs, constructed assuming a plane-stress condition and Vegard's law validity, showed possible Ga segregation in the initial stages of growth and a gradual increase of the In content from the base of the QDs towards pure InAs at their apex region (Figure 1).

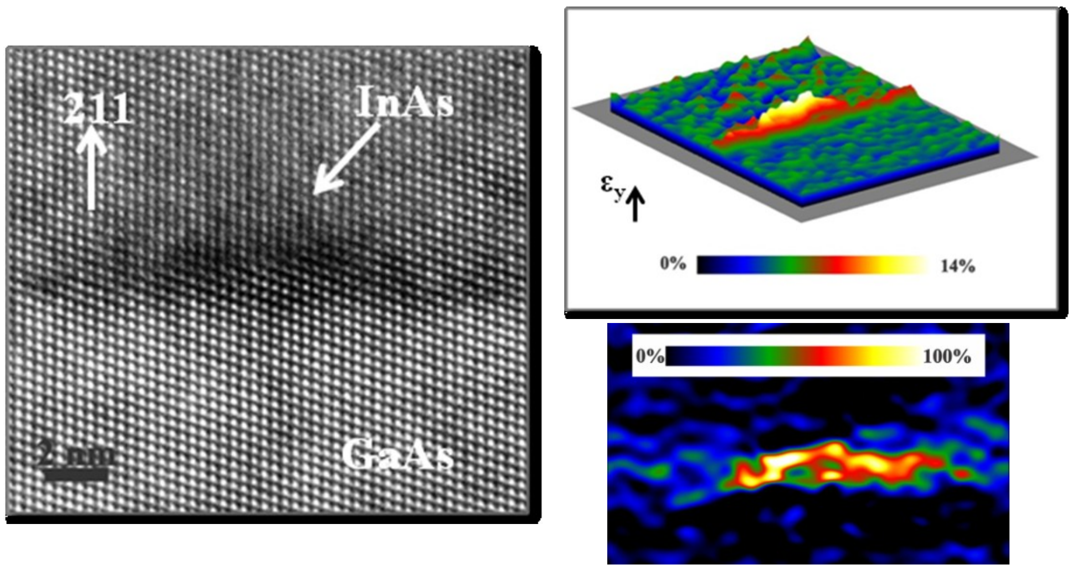

Figure 1. HRTEM image of a buried InAs QD in the [0-11] projection, and the corresponding GPA strain and In chemical composition maps along the growth direction.

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