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Molecular beam epitaxial growth and properties of InAs quantum dots in asymmetric (Al)GaAs matrices.

Currently, one of the most outstanding advances in cutting-edge science is the self-assembly of quantum dots (QDs), a promising process in the field of nanotechnology. These nanostructures restrict the degrees of freedom of electrons, phonons, and photons, allowing the creation of optical and electronic devices with exceptional characteristics.To achieve devices with the unique properties offered by QDs,it is essential to successfully stack multiple layers of the barrier/QDs/barrier structure vertically. This project focused on understanding and controlling the morphological characteristics of InAs quantum dots, such as their shape, size, and spatial distribution, analyzing the biaxial strain (εxx) based on theoretical understanding from numerical simulations [1].In this work, the growth of InAs QDs in asymmetric (Al)GaAs matrices using the MBE technique was analyzed.Experiments were conducted with systematic variations in growth parameters (GP) such as temperature, deposition rate, and matrix composition. Before encapsulation of the QDs, the GPs were adjusted until reaching an InAs nano average island density, height and base of 5x10^10 cm^-2, 5nm and 40 nm, respectively. Better spatial distribution of QDs conduced to low noise photoreflectance spectra,where a transition close to 1.12eV was observed attributable to the quantum electron confinement of the QDs. These QDs were later capped with GaAs, Al(30)Ga(70)As and Al(40)Ga(60)As. When covering the QDs the rate of flattening of the surface strongly depends on the concentration of Al, as analyzed by reflection high-energy electron diffraction (RHEED) patterns. On this respect, several encapsulation models are proposed in this work. It is noteworthy that in spite of the intrinsic roughness of the QDs containing samples, high resolution x-ray diffraction pattens showed uniform Pendellösung fringes through which heterostructure properties were attained.Furthermore, computational simulations and theoretical models were developed to support the experimental results and provide a deeper understanding of the growth and formation mechanisms of QDs in asymmetric (Al)GaAs matrices.

Keywords

MBE, self-assembly, QDs, numerical simulations, encapsulation

Reference

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