InAs Quantum Dots with Emission Wavelength of 1.38 μm Grown by Molecular Beam Epitaxy on GaAs Substrates

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The increasing demand for faster, more efficient communication and facial recognition technology drives the development of photon sources that are compatible with existing infrastructure and highly cost-effective.

In this study, we explore the extension of quantum dot (QD) wavelength on GaAs substrates, which is a cost-effective alternative to conventional InP substrates used for vertical cavity surface emitting lasers (VCSELs). We report on the fabrication of high-quality InAs/InGaAs quantum dots-in-a-well heterostructures using molecular beam epitaxy on GaAs substrates with a room-temperature photoluminescent (PL) emission wavelength of 1380 nm. The Indium (In) composition in the In1-xGaxAs capping layer plays a critical role in reducing the lattice mismatch and strain during QD growth. The experimental analysis reveals that an In composition of 0.14 in the In1-xGaxAs capping layer exhibits a strong PL emission peak at 1310 nm with a narrow spectral full width at a half-maximum of 29 meV. Adjusting the V/III ratio of InAs QDs to 10% results in uniform dot size distribution. The Atomic Force microscopy (AFM) revealed minimized large coalescent dots with an average dot diameter of 57 nm and a high dot density of 6.8 x1010 cm-2. To reduce In-Ga intermixing between the InAs QDs and the InGaAs capping layer, antimony (Sb) soaking process was employed on the QD surface. This process elongated the PL emission wavelength to 1380 nm at room temperature. This study provides insights into optimizing quantum dot-in-a-well heterostructures, laying the groundwork for surface-emitting quantum dot lasers with long emission wavelengths on GaAs substrates.