EMISSION HOMOGENEITY OF InGaAs/GaAs QUANTUM WELL STRUCTURES WITH DIFFERENT BARRIER PATTERNS

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Indium gallium arsenide (InGaAs) is a III–V semiconductor alloy with a tunable bandgap from 1.425 eV (GaAs) to 0.36 eV (InAs) at room temperature [1], and, combined with its high electron mobility [2], serves as a key material in modern semiconductor technologies. InGaAs is commonly grown epitaxially, enabling precise control over composition and layer thickness. However, lattice mismatch with GaAs substrates can generate strain-induced defects, which degrade device performance [3]. These issues are particularly important in multilayered structures, which are widely used in applications such as lasers and heterostructure field-effect transistors (HFETs), where the optical response of individual layers is often indistinguishable. By employing photoluminescence (PL) measurements with excitation sources of different wavelengths, the contributions of individual layers can be separated, enabling a depth-sensitive and more precise analysis of both structural and optical characteristics.

In this work, three types of InGaAs/GaAs multiple quantum well (MQW) structures were investigated, each differing in barrier thickness and indium composition. The samples were grown by molecular beam epitaxy (MBE) on semi-insulating GaAs (100) substrates. The first structure featured 7 nm GaAs barriers between twelve QWs. The second comprised six QW pairs with alternating 7.3 nm and 119 nm GaAs barriers. The third retained the same ordering as the first structure while increasing the barrier thickness to 119 nm. The indium content ranged from 18.3% to 25.6%. PL measurements were performed using a WITec Alpha 300S confocal microscopy system, with optical excitation provided by four continuous-wave lasers emitting between 405 and 662 nm.

A theoretical model, based on known optical constants [4], was applied to estimate light penetration depth and transmission through the multilayered stacks. These predictions were experimentally validated using PL measurements at varying excitation wavelengths and power levels. Key parameters - including contrast, emission center of mass deviation, and spectral broadening - were analyzed to assess excitation behavior.

The results revealed that narrow barrier structures exhibited increased emission from a larger structural volume and greater spectral broadening with rising excitation power, whereas wide barrier structures maintained more stable emission characteristics due to limited light penetration imposed by the thicker barriers. These findings will be further investigated by evaluating the excitation threshold for QWs in different MQW structures, enabling a direct comparison between the different excitation conditions in the grown samples, giving a further insight into the reasoning behind previously observed trends.

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