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Comparative analysis of optical confinement in ternary and quaternary GaAs-Based quantum wells using GaAs and GaAsP Barriers

Abstract:

In this work, we investigate the optical confinement characteristics of GaAs-based quantum well (QW) structures for long-wavelength optoelectronic applications. Both ternary ($\text{Ga}_{1-x}\text{In}_x\text{As}$) and quaternary ($\text{Ga}_{1-x}\text{In}_y\text{N}_{1-y}\text{As}$) quantum wells are studied, with emission wavelengths of 1216.44 nm and 1310.02 nm, respectively. Two types of barrier materials are considered: GaAs and GaAs_{1-z}P_z, while the cladding layer is fixed as $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$. The optical confinement factor (Γ) is numerically analyzed as a function of emission wavelength, barrier width, and effective refractive index, for both single quantum well (SQW) and multiple quantum well (MQW) configurations. The results show that Γ decreases with increasing wavelength and barrier width, particularly in MQW structures. Structures with GaAs barriers provide stronger confinement than those with GaAsP, due to higher refractive index contrast. Additionally, although the quaternary GaInNAs wells exhibit a slightly higher intrinsic refractive index than the ternary GaInAs ones at the same Ga composition ($x = 0.2829$), the longer emission wavelength of GaInNAs (1310.02 nm) leads to a lower confinement factor. This highlights the complex interplay between material composition, refractive index, and wavelength in determining optical confinement. These findings emphasize the importance of careful structural and material design to optimize confinement in GaAs-based quantum well lasers for long-wavelength applications.

Biography

Fatima is a Senior Lecturer at Tahri Mohammed University of Béchar (Algeria) and a researcher in the Laboratory of Physics and Semiconductor Devices (LPDS). She has specialized in the field of lasers and electronics throughout her academic and research career. She obtained her Engineering degree (Ingénieur) in Electronics in 2004, with a focus on laser systems, followed by a Magister degree in 2009 in the same field. In 2017, she earned a PhD in Electronics, with a dissertation on quantum well laser sources. In 2021, she received her Habilitation (HDR), recognizing her ability to supervise doctoral-level research in laser and optoelectronic technologies. From 2011 to 2017, Fatima served as an Assistant Lecturer at Tahri Mohammed University of Béchar. Since 2017, she has held the position of Senior Lecturer, teaching electronics and laser-related subjects to undergraduate and Master's students. She has authored numerous scientific publications in peer-reviewed journals and specialized collections in the fields of lasers and electronics. Her research continues to contribute to the advancement of optoelectronic devices, semiconductor physics, and laser technologies.