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Efficiency Improvements in AlInGaN-delta-AlGaN quantum wells for deep-ultraviolet emission

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Ultraviolet (UV) photonic devices such as laser diodes (LDs) and light-emitting diodes (LEDs) have drawn great interest in many applications including lighting, optical storage, and purification. From a theoretical viewpoint, III-nitride (III-N) semiconductors can be good candidates for UV photonic application because of its band gap which may cover a wide wavelength range of ultraviolet (UV) to visible red. The (Al,Ga,In)N multiple quantum wells (MQWs) are extensively used as active region for deep UV wavelengths. These structures are characterized by the existence of both spontaneous and piezoelectric polarization arising from the lack of lattice-matched substrate. The polarization-induced internal electric field causes charge separation which leads to reduction in TE-polarized spontaneous emission radiative recombination rate (Rsp) and TE-polarized optical gain (GTE). One of the challenges for high efficiency UV lasers is the need to reduce this internal electric field. We present here a comprehensive analysis of structure based on III-N quaternary QWs as an alternative for high efficiency deep-UV lasers using the 8x8 wurtzite k.p Hamiltonian matrix to calculate the energies band structures and the wave functions by taking into account the valence band anisotropy mixing, the interband interaction and the spontaneous and piezoelectric polarization. Simulation of lasers performance are realized using matlab genetic algorithm. Our proposed design is optimized by adjusting the (Al,In) content and thickness of the sublayers of staggered AluInvGa1-u-vN/AlxInyGa1-x-yN-delta-AlxGa1-xN QWs surrounded by quaternary AlInGaN for peak emission wavelengths at 229 nm. since TE-polarized optical gain peak intensity larger than such achieved by conventional AlInN-delta-GaN-based QWs.

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