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Low parasitic carrier reservoir of AlGaN-based DUV-LED via controlled-polarization step-graded superlattice electron blocking layer for high luminescence lighting

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Abstract
Achieving high luminescence intensity of deep-ultraviolet light-emitting diode (DUV-LED) is generally performed through the implementation of electron blocking layer (EBL) on the chip's epilayers. However, the issue of parasitic carrier reservoir that originated from the uncontrolled piezoelectric field polarization has restricted the performance of DUV-LED by reducing the radiative recombination in the active region. This work reports on the numerical computation analysis of the DUV-LED with different types of EBL designs which are reference EBL, conventional superlattice EBL and step-graded superlattice EBL. The analysis of the DUV-LED focuses on the band diagram, carrier concentration at the EBL interfaces, current density of the carrier in the active region, radiative recombination rates, and luminescence spectrum. Remarkably, it is found that the DUV-LED step-graded superlattice EBL provides the polarization-controlled band diagram and emits 272 nm UVC-wavelength in which it is superior in performance compared to the other structures, specifically in terms of its radiated intensity. The parasitic electron and hole reservoir have been reduced by 30% and 60%, respectively. The luminescence intensity was also enhanced by 11% compared with the reference EBL and the IQE obtained by the DUV-LED with step-graded superlattice EBL is 50.12%. © 2024 IOP Publishing Ltd.

Author Keywords
aluminium gallium nitride; deep-ultraviolet light-emitting diode; electron blocking layer; luminescence; parasitic carrier reservoir; polarization

Index Keywords
Aluminum alloys, Aluminum gallium nitride, Carrier concentration, Electrons, Gallium nitride, III-V semiconductors, Light emitting diodes, Luminescence, Ultraviolet radiation; Active regions, Deep ultraviolet, Deep-ultraviolet light-emitting diode, Electron blocking layer, Luminescence intensity, Parasitic carrier reservoir, Parasitics, Performance, Ultraviolet light emitting diodes, Ultraviolet light-emitting diodes; Polarization

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4

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