OPTICA APPLICATA online
open access
A quarterly of the Institute of Physics, Wroclaw University of Technology
Wroclaw University of Technology
INSTITUTE OF PHYSICS

Optica Applicata 2005(Vol.35), No.3, pp. 579-589

Simplified modelling of photonic-crystal-confined vertical-cavity surface-emitting diode lasers

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Keywords

photonic crystals, vertical-cavity surface-emitting diode lasers (VCSELs), photonic-crystal-confined VCSELs, simplified VCSEL modelling

Abstract

In standard GaAs-based oxide-confined vertical-cavity surface-emitting diode lasers (VCSELs), their transverse single-fundamental-mode operation is limited to relatively low outputs. It is a direct consequence of small radial sizes of their active regions and strong real waveguiding effects induced by their oxide apertures. Photonic crystals applied in VCSEL designing in a way shown in the present paper enable a subtle waveguiding modification leading to a considerable increase in an output of the VCSEL single-mode operation. Unfortunately, the structure of a photonic crystal damages inside a VCSEL volume its axial symmetry, which makes rigorous simulation of its operation much more difficult. In the present paper, a simplified approach to physical (optical, electrical and thermal) phenomena taking place within VCSEL volumes equipped with photonic crystals is presented. Designing guidelines to obtain single-mode-operating photonic-crystal-confined VCSELs have been proposed. Various possible distributed-Bragg-reflector (DBR) output mirrors designed for various wavelengths have been analysed. From among them, GaN-based DBRs have been found to enable higher single-mode VCSEL outputs, especially for longer wavelengths.