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Effect of Quantum Dots Density and temperature on Quantum Dot Laser Characteristics

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Abstract

Detailed theoretical study of the effects of surface density of quantum dots on the dynamics of quantum dot lasers (QDLs) is given. Temperature dependence of the threshold current density, confined level occupancy, internal loss coefficient, optical confinement layer (OCL), characteristic temperature and lowest excitation energy with the variation of internal loss constant component, root mean square of relative QD–size fluctuations, mean size of QDs and optical confinement factor are studied.

Keywords: Quantum dot lasers, Surface density of QDs, GaInAsP/InP laser, Characteristic temperature.

تأثير كثافة النقاط الكمية و الحرارة على خصائص ليزر النقطة الكمية

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الخلاصة

في هذا البحث قدمت دراسة نظرية مُفصّلة لتأثيراتِ الكثافةِ السطحيّةِ للنقاطِ الكَمّيةِ على حركيات ليزرِ النقطةِ الكَمّي. تم دراسة إعتماد درجةِ حرارة على كثافةِ تيار العتبةَ و معامل الخسارةِ الداخليةِ، طبقة الحجزِ البصريِ و درجة الحرارة المميزة و أوطأِ طاقة إثارةٍ على كل من مركبة الخسارةِ الداخليةِ الثابتةِ و معدل الجذرِ التربيعي لحجمِ التراوحاتِ في النقطةِ الكَمّيةِ النسبي و معدل حجم النقطةِ الكَمّيةِ وعامل الحصر البصري.

1. Introduction

Quantum dot (QD) semiconductor lasers are of particular interest due to certain advantages over the conventional semiconductor quantum well lasers viz. narrow gain spectra, significant low threshold currents and weak temperature dependence. As a consequence of quantum confinement in all the three dimensions the energy spectra of electrons and holes are discrete in QDs. Transitions between electron and hole levels are analogous to those between the exactly discrete levels of individual atoms. According to this reason, the behavior of structures with QDs have generated much interest as a new class of artificially structured materials with tunable energies through varying the compositions and sizes of discrete atomic-like states that are ideal for use in laser structures.Internal optical losses are present in all types of semiconductor lasers. Such losses affect the laser operating characteristics, increasing their threshold current density and decrease its differential efficiency [1, 2]. As a result of lower values of optical confinement factor in these lasers the effect of internal loss in stronger in comparison with bulk semiconductor lasers [1] . Several mechanisms can contribute to the internal loss viz. 1st; free carrier absorption in the optical confinement layer (OCL) and in the cladding layers, 2nd; inter-valence band absorption, 3rd; carrier absorption in the quantum confined active region itself, and 4th; scattering at rough surfaces and imperfections of the waveguide[1]. The key characteristics of a semiconductor laser are the light-current. The current