Journal of Babylon University/Pure and Applied Sciences/ No.(5)/ Vol.(20): 2012

Turn-on Dynamic with Nonlinear Carriers Scattering Rates in InAs/GaAs QD Lasers

R. M. Hassan, C. A. Emshary S. I. Easa

Dept. of Physics, College of Education, University of Basrah.

Abstract

Based on the relaxation oscillations theory in semiconductor lasers of Quantum dots (QDs) based on a microscopic approach by K. Lüdge et.al (2008) as a basic model used in this work. We introduce a new expression of nonlinear scattering rates by using the curve fitting functions. We can discuss the influence of different values of the QD density upon the dynamic of laser output in detail of our simulations results. By taking into account, we study the dependence of the carrier-carrier scattering rates on the injection current. We present a theoretical simulation of characteristics and the turn-on dynamics of InAs/GaAs semiconductor QD laser output lasing with pulse wavelength of 1.3μm at room-temperature.

الخلاصة

بالاستناد على نظرية تذبذبات الإسترخاء في ليزر النقاط الكمية ((QDs لشبه الموصل القائمة على رؤية مجهرية من قبل K. Ludge و مشاركيها (٢٠٠٨) كنموذج أساسي إستخدم في هذا العمل. نقدم صيغ جديد لمعدلات الاستطارة اللاخطية من خلال أستخدام دوال المنحنى الملائمة. يمكننا أن نناقش تأثير القيم المختلفة لكثافة QD على حركية خرج الليزر بشكل مفصل من خلال نتائج النظرية.. أخذت دراستنا بنظر الأعتبار اعتماد معدلات استطارة حامل - حامل على تيار الحقن. قدمنا محاكاة نظرية لخصائص و حركيات بدء التشغيل لفعل الليزر الناتج من ليزر النقطة الكمية QD لشبه الموصل نوع InAs/GaAs النبضي بطول موجة ١,٣μm عند درجة الحرارة الغرفة.

Introduction

The recent research is focused on some of the most important aspects of the QD laser dynamics: Such as, modulation dynamics of QD lasers in the relaxation time approximation, a study of quantum correlations in the optical emission [Christopher Gies et. al. (2007)], and a dynamical hierarchy for the population. The interaction of electrons in the injection pumped bulk regions, the quantum-well WL, and QDs in the gain regime is provided by relevant relaxation processes such as electron-electron and electron-phonon interaction [Peter Michler. (2003), Y. Fu et. al. (2009) and Massimo Rontani. (1999)]. Above threshold, a microscopic description of the dynamics of QD lasers would be required to describe the polarization and population dynamics of an inhomogeneous distribution of these states [Pter Blood. (2009) and Ian O'Driscoll et.al. (2010)]. A fully microscopic approach for all time and length scales of the dynamics of QD lasers is by far numerically too demanding.

In this work, we focus on the turn-on light field dynamics with nonlinear QD carrier scattering rates and the population dynamics induced by the interaction of the QD states with the temporally current modulated population reservoir of WL states. We focus on the dynamics of relaxation oscillations on a nanosecond timescale for current injection well above the laser threshold. In high excitation limit, electron-electron scattering provides the main interaction channel. A detailed comparison between experimental and theoretical data is given for a wide range of different pump currents or other control parameters.

Rate Equations Model

The rate equations models are a most of semiconductor QD laser models which was derived from what is known as semiclassical laser theory [Pierre Meystre et. al. (2007)]. This theory incorporates the classical electrodynamics that occurs within the laser as well as the quantum mechanics associated with the active material. The rate equations model (REM) for the electromagnetic fields in matter such, which is derived beginning with *Maxwell-Bloch equations* (MBE) and using the *slowly varying envelope* to