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Turn-on Dynamic of Field and Photon-Assisted Polarization in InGaAs/GaAs QD Laser with wavelength of 1.3 μm

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Abstract

With using master equations model of quantum dots (QDs) laser theory by C. Gies and his colleagues (2007), we have added a new factor to the s-shell population's equations to take into account the retardation procedure in the turn-on dynamics. The addition has led to theoretical results nearly in isomorphism with experimental data. We are presented a theoretical simulation of the turn-on dynamics of InGaAs/GaAs semiconductor QD laser output lasing with CW wavelength of 1.3μm at room-temperature including the photon-assisted polarization contribution.

الخلاصة

من خلال أستخدام نموذج المعادلات الرئيسية لنظرية ليزر النقاط الكمية (QDs) للباحث جيز و مشاركيه (٢٠٠٧) ، أضفنا معامل جديد الى معادلات تعداد طبقة-s للأخذ بنظر الاعتبار أجراء التأخير في حركيات بدء التشغيل. تؤدي هذه الأضافة الى نتائج نظرية مقاربة للبيانات العملية. قدمنا محاكات نظرية لحركيات بدء التشغيل في ليزر النقاط الكمية نوع InGaAs/GaAs بطول موجي 1.3 μm عند درجة حرارة الغرفة تتضمن أسهام الأستقطاب المصاحب للفوتون.

Introduction

Consider lens-shaped InGaAs/GaAs QDs grown in the Stranski-Krastanow growth mode [Peter Michler (2003), Todd Steiner (2004), Chun-Hua Yuana, et. al. (2006), and Swati Ramanathan (2007)]. In this process a thin film of a few nanometer thicknesses called wetting layer (WL) is formed between the QDs and the substrate. The QDs and the WL constitute a coupled system with common electronic states. Typical dimensions of the QDs are 25nm base diameter and less than10nm in height [Martin J. Stevens, et. al. (2006)]. The geometry of this kind of QDs allows for a description within the effective mass approximation, where free carrier dispersion with effective masses for electrons and holes is assumed. One can consider the first two confined shells of such a system, which are denoted by s and p according to their in-plane symmetry. The s-shell is only spin degenerate, while the p-shell has additional angular- momentum two-fold degeneracy [T. R. Nielsen, et. al. (2004)].The spectrum of the potential well introduces a splitting into sub bands with a spacing that depends on the strength of the axial confinement, although the term sub band is somewhat misleading for the QD case, as these possess only a discrete spectrum due to the additional in-plane confinement [T. Feldtmann, et. al. (2006)].

The discrete states are located energetically below a quasi –continuum of delocalized states, corresponding to the two-dimensional motion of carries in a WL. While, the localized states exist only below the quasi-continuum states of the WL [Emmanuel Rosencher , et. al. (2004), M. Lorke, T. R. Nielsen, et. al. (2006), and Voicu Popescu, et. al. (2009)]. In Fig.1, a schematic diagram of the energy levels of the coupled QD−WL system is shown. Further details of the QD model are discussed in Ref.[T. R. Nielsen, et. al. (2004)]. Strictly speaking, the localized states and the WL states are solutions of the single-particle problem for one common confinement potential and must, therefore, form an orthogonal basis [Peter Michler (2003), Todd Steiner (2004), T. R. Nielsen, et. al. (2004), and Paul Harrison (2005)]. In this work, we focus on modulation of the laser theory model for semiconductor QDs in