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Transient characteristics of the InGaP–Ga As–InGaAs–GaAs transistor laser

Md Ahsan Habib · Saeed Mahmud Ullah · Shahida Rafique

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Abstract Transient characteristics of the InGaP–GaAs–InGaAs (quantum well)-GaAs transistor laser are studied. Rate equations are numerically solved to obtain the response of current density and photon density. Expression of resonance frequency f_r is obtained by solving the rate equations analytically. It has been found that the f_r increases with decreasing spontaneous carrier lifetime and with increasing value of the bias current density.

Keywords Transistor laser · Quantum well · Switching · Resonance frequency

1 Introduction

Transistor laser (TL) marks a great advance in semiconductor device research because the TL monolithically integrates the functionality of laser and bipolar transistor (Holonyak and Feng 2006). In TL a thin quantum well (QW) is inserted in the base region of a Heterojunction Bipolar Transistor. The injected carriers in the base are captured by the QW, in which a population inversion occur leading to stimulated emission (Feng et al. 2005; Faraji et al. 2009). Light emission occurs from a facet of a Fabry Perot (FP) cavity in a direction perpendicular to the direction of flow of base charges (Feng et al. 2005). In Zhang and Leburton (2009) transient characteristics of the TL analyzed but no analytical equation for resonance frequency was developed. In this current paper rate equations are analytically solved to obtain the relaxation oscillation and oscillatory optical output of InGaP-GaAs-InGaAs (QW)-GaAs TL model. An equation for oscillation frequency is derived and the variation of it with the spontaneous emission lifetime in the QW, τ_{qw} and bias current density is studied. Response to a current density step function is also calculated numerically.

The following coupled rate equations have been used to depict the TL activity (Zhang and Leburton 2009; Bhattacharya 2005):

Md. A. Habib (✉) · S. M. Ullah · S. Rafique
Department of Applied Physics, Electronics and Communication Engineering
University of Dhaka, Dhaka, Bangladesh
e-mail: ahsantonmoy2007@yahoo.com