Opt Quant Electron (2013) 45:87–96
DOI 10.1007/s11082-012-9605-9

One-dimensional numerical analysis of transistor lasers

Guanghui Xu · Changtong Huang · Qiang Liu · Ruiyou Liu · Guangyue Chai · Zigang Duan

Received: 13 January 2012 / Accepted: 13 July 2012 / Published online: 26 July 2012

Abstract We demonstrate one-dimensional numerical analysis of transistor lasers (TLs). The high frequency performances of TLs and laser diodes (LDs) are compared. The charging time definitions of the TL and LD are given. The TL has a larger bandwidth and a shorter rise time than the LD due to the shorter charging time in the former. We find that the bandwidth decreases and the eye diagram of 40 Gb/s is degraded with increasing base region width of the TL. Finally, compared with the TL, the bandwidth reduction of LDs at high injection currents is due to a narrower small-signal response for the virtual states carrier density to the modulation current ratio.

Keywords Transistor laser · Modulation response · Numerical method · Charging time

1 Introduction

As a new type of opto-electronics device, a transistor laser (TL) integrates the functionalities of a transistor and a laser, and draws great attention in recent years (Holonyak and Feng 2006). Compared with conventional laser diodes (LDs), the main advantages of the TLs are as follows: simultaneously outputting an optical signal and an electrical signal with a single input electrical signal; being either voltage-modulated or current-modulated; being three-terminal operation that enables novel applications; having an enhanced modulation bandwidth (Feng et al. 2006; Shi et al. 2008; Duan et al. 2010; Taghavi and Kaatuzian 2010). Especially, its great potential for high frequency operation may break the bandwidth bottleneck of LDs.

There have been several important theoretical works about high frequency characteristics of TLs (Feng et al. 2007; Faraji et al. 2009; Shi et al. 2011; Zhang and Leburton 2009; Then et al. 2010; Shirao et al. 2011). However, some questions are still not clear to date. For example, it is contradictory that TLs and LDs have the same formula for the transit time, because

G. Xu · C. Huang · Q. Liu · R. Liu · G. Chai · Z. Duan (✉)
Key Laboratory of Optoelectronic Devices and Systems of the Ministry of Education and Guangdong Province, Shenzhen University, Shenzhen 51806, China
e-mail: zgduan@szu.edu.cn