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Experimental and numerical study of Distributed-Bragg-Reflector tapered lasers

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Abstract We report results on experimental and numerical investigations of the output characteristics of edge-emitting distributed Bragg reflector tapered diode lasers emitting around 980 nm. The experimental results are well described by the Traveling Wave model which is extended by a parametrical heating model. Dynamic instabilities occur due to different thermally induced refractive index changes.

1 Introduction

High-power diode lasers having a nearly diffraction-limited beam and emitting at a single frequency are required for many application, e.g. frequency conversion [1, 2], laser display technology [3, 4], direct material processing [5], and pumping of fiber lasers and fiber amplifiers.

Several groups presented such high-power systems [6, 7] based on tapered laser devices [8], which promise a good beam quality and high output power at the same time. However, these setups are not compact and thus limited in their applicability. The most promising approaches that combine all mentioned requirements in a monolithically integrated device are Distributed-Feedback (DFB) [9] or Distributed Bragg Reflector (DBR) [10, 11] tapered Master-Oscillators (MO) Power-Amplifiers (PA) and DBR tapered lasers [12]. During recent years, the optical output power of DFB MOPAs [13] as well as DBR tapered lasers [14, 15] has been increased towards the 10 W level.

Due to the finite reflectivity of the front facet monolithically integrated MOPAs show compound cavity effects that lead to a dynamically instable behavior of the device. That can be overcome by a reduction of the front facet reflectivity to values smaller than $R = 10^{-5}$. However, this is associated with high technological efforts. In [16] we investigated a dynamic model for a DFB MOPA device based on traveling wave equations. Using this model we were able to describe and explain some of the spatial and spectral features of the device. We reported some conclusions on how to improve the device by reducing the dynamic instabilities [17].

In this paper we experimentally and numerically investigate a DBR tapered laser. DBR tapered lasers promise a better performance and stability. Due to an increased front facet reflectivity of $R_f = 1\%$ the whole cavity section is involved in a more stable lasing process which is additionally less sensitive to feedback effects from external optical components. Furthermore, the manufacturing process is much simpler because a surface grating can be employed which is defined simultaneously with the ridge waveguide structure [18]. Thus, only a single epitaxial step is necessary instead of a complicated two-step epitaxial process.

The paper is organized as follows. The device structure and fabrication process are described in Sect. 2. In Sect. 3 the experimental results concerning optical output power, spectral behavior, and beam quality are presented. Section 4 contains the mathematical model and a discussion of the simulation parameters used to investigate the laser dynamics. Simulation results are presented and discussed in Sect. 5 and conclusions are given in Sect. 6.

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