Tailoring single-mode DFB laser with integrated passive feedback section for direct modulation applications

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Directly modulated semiconductor lasers are of great interest for low cost transmitter applications in short reach optical data transmission systems. Recently it was shown theoretically [1] and experimentally [2], that a two section *passive feedback laser* (PFL) consisting of an active DFB and a passive integrated feedback (IFB) sections can demonstrate a suitable performance under direct current modulation at 40 Gb/s rate (see Fig. 1). In contrast to solitary DFB lasers, the interaction of longitudinal *compound cavity* modes of this PFL can imply an enhancement of the modulation bandwidth. The required neighbouring mode in the PFL is excited by a sufficiently high properly delayed and phase tuned optical feedback into the active DFB section. The feedback control is realized by the IFB section [1].

In the present work, we discuss the main requirements on the active DFB section of the PFL. Our discussion is based on the numerical simulations and analysis of the Travelling Wave (partial differential equation) model of multisection semiconductor lasers. For illustration, we consider the PFL with the same passive IFB section, but with different types of the index- or gain-coupled gratings in the active DFB section (see top part of Fig. 2).

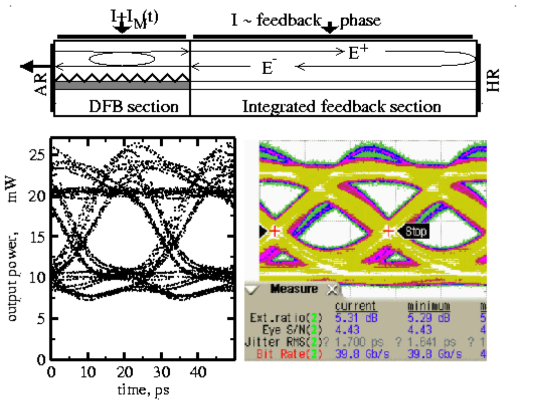

Fig. 1 Top: scheme of a PFL, consisting of an anti-reflection coated DFB- and high-reflection coated IFB sections. Bottom: eye diagrams of simulated (left) and measured (right) response of the PFL to a PRBS current modulation (NRZ).

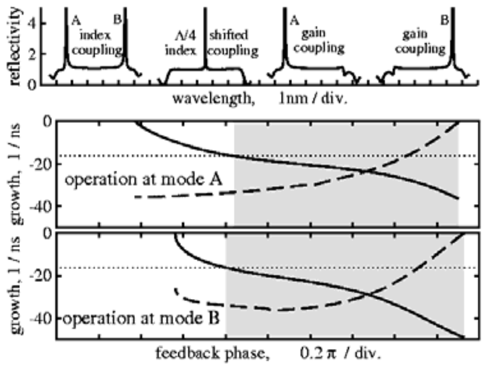

Fig. 2 Top: reflectivity spectra of considered DFB sections. Bottom: growth (negative damping) of RO (solid) and mode interaction (dashed) resonances of the *stable* cw state in dependence on the field feedback phase. Dotted: growth of the RO resonance in solitary DFB laser. Shading: the RO damping is improved.

Our analysis has shown the best performance of the PFL when the DFB section satisfies a series of requirements. First, directly modulated laser should clearly show a single mode emission without mode hopping even under relatively high feedback. This condition is challenging for DFB lasers having a uniform index grating where the exchange between different stop-band side modes is possible (see upper-left diagram of Fig. 2). Second, the damping of slow relaxation oscillations (ROs) in the solitary DFB laser should be as strong as possible. A properly adjusted optical feedback can improve this damping (compare thick solid and thin dotted lines within shaded regions in Fig. 2), what allows to exploit the dominant fast mode-interaction resonance and to achieve an appropriate operation of the PFL. Third, the DFB laser modes should be sufficiently sensitive to the optical feedback. Only in this case the feedback strength caused by the passive IFB section is large enough to excite for an appropriate operation needed neighbouring compound cavity mode. This condition is related to linewidth of the resonance peak in the reflectivity spectrum of the DFB section (see top of Fig. 2) and is hard to achieve for a standard quarter wave shifted DFB grating. Finally, we have compared PFLs operating at the shorter (mode A in Fig. 2) and at the longer (mode B in Fig. 2) wavelength side of the stop-band. We have found, that the long wavelength modes guarantee a better damping of the slow ROs, and, therefore, cause a better performance of the direct modulated PFLs (compare thick solid curves in lower panels of Fig. 2).

References

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