Beam Shaping in Spatially Modulated Broad Area Edge-Emitting Semiconductor Lasers

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Edge-emitting broad area (BA) semiconductor lasers are robust, compact and highly efficient devices for the generation of high power beams. The spatial and temporal quality of these beams, however, is rather weak. To improve the beam quality in such BA lasers, we propose to intrinsically introduce a two-dimensional gain and index modulation (GIM) on the semiconductor media, with appropriate longitudinal and lateral periods. This modulation can be realized, e.g., by the periodic structuring of the electrodes.

Recently, we have theoretically analyzed the lateral (angular) shaping of the emitted beam in GIM BA *amplifiers* [1,2]. We have shown that the narrowing of the central radiation component occurs for GIM amplitudes and geometries characterized by a geometry factor $Q = 2\Lambda_{\perp}n/\lambda_0\Lambda_{\parallel}$ (n: background refractive index, $\Lambda_{\parallel}$: longitudinal period, $\Lambda_{\perp}$: perpendicular period, λ_0: central wavelength) slightly larger than unity. Figure 2, for example, shows the simulated angularly shaped beam and the dominant radiation peak dependence on Q.

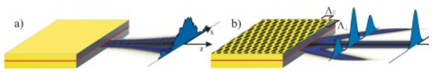

Fig. 1 Schematic illustration of conventional (a) and GIM (b) edge-emitting BA lasers.

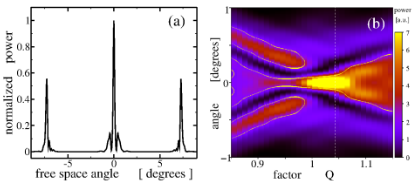

Fig. 2 Shaping of the far fields in GIM BA amplifier with $\Lambda_{\perp}$= 8 μm and $\Lambda_{\perp}$= 400 μm for Q=1.04 (a) and for varying Q≈1 (b).

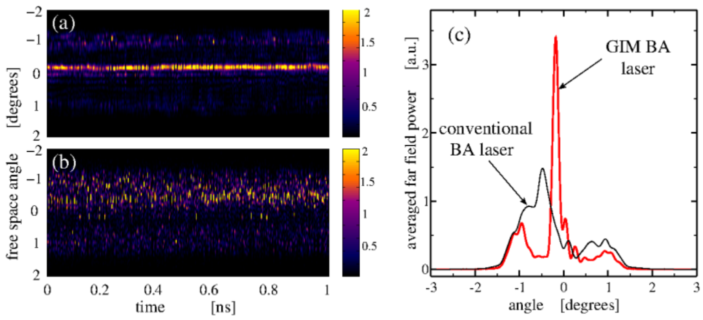

Fig. 3 Simulated evolution of the far fields in GIM [Q = 1.02] (a) and conventional (b) BA lasers. The corresponding time averages are shown in (c).

In the present work, we concentrate our attention on the performance of GIM BA lasers. In contrast to amplifiers, lasers are not restricted to single-pass but the beam experiences multiple round-trips, and this is expected to enhance the angular filtering action. On the other hand, the field evolution and frequency band in lasers is defined by multiple self-excited optical modes (which imply temporally irregular broadband radiation), but not by the evolution and frequency of the field injected into the amplifier. The comparison between simulated radiation of the conventional and GIM BA lasers is provided in Fig. 3(a,b). While in both cases the radiation is non-stationary and irregular, one can clearly see a substantial stabilization of the emission by the GIM. Moreover, Fig. 3(c) evidences that the time-averaged far field is much more regular and narrower for the GIM than for the conventional BA laser. Additional control on the emission bandwidth could be achieved combining GIM and distributed Bragg reflectors or distributed feedback laser concepts.

In this study, we have used the 2+1 dimensional dynamical traveling wave approach [3]. According to this model, the traveling wave equations governing the spatio-temporal dynamics of the counter-propagating optical fields are nonlinearly coupled to the diffusive rate equation for the carrier density. In order to speed up the computations, our model equations were solved using multilevel parallel distributed computing. Comparable calculations on a single PC system take nearly 100 times longer.

References

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