Theoretical study of beam quality improvement in spatially modulated broad area edge-emitting devices

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Broad area (BA) lasers and amplifiers are robust, compact and highly efficient devices for generation of high power beams. These beams, however, suffer from a poor spatial and temporal beam quality. The stabilization and shaping of the optical beams in BA devices can be achieved, for example, by injection of the optical beam at some angle to the longitudinal axis [1], by the external optical feedback from the corresponding off-axis mirror [2], or by special geometry of the device [3].

In the present study we discuss how an introduction of longitudinal-lateral periodic structures [4] on the electrical contact can also help to improve the quality of the amplified beam in BA amplifiers or of the generated beam in BA lasers. A considered spatially periodic structure of the electrical contact is such that the longitudinal and lateral periods d_z and d_x are related by the factor $Q=2(d_x)^2n_b/(d_z\lambda_0)\approx 1$, where λ_0 and n_b are central wavelength and background refractive index in semiconductor, respectively. A scheme of such BA amplifier is shown in Fig. 1.

In contrast to our previous work [4] which was based on the linear approximation of the BA amplifier equations, in the present study we investigate impact of the periodic structure of electrical contact to the performance of the more advanced nonlinear model of the BA devices [3]. This model is based on the 2+1-dimensional traveling wave equations governing the spatio-temporal dynamics of slowly varying complex amplitudes of the counter-propagating optical fields, which are coupled to induced polarization equations and diffusive carrier rate equations.

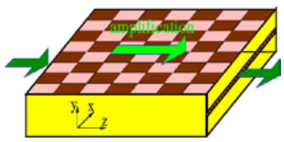

Fig. 1 Scheme of periodically modulated amplifier.

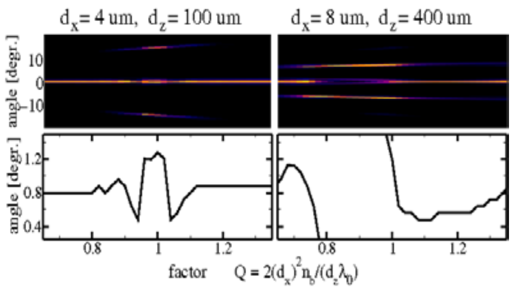

Fig. 2 Simulated beam propagation in BA amplifier for different values of Q. Top: mapping of the normalized far fields. Bottom: full width at the half maximum of the central far field lobe.

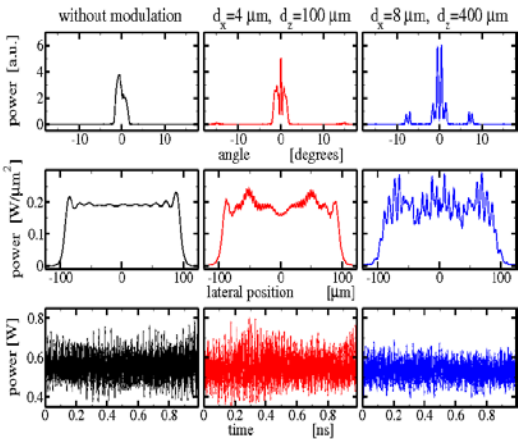

Fig. 3 Simulated optical fields in BA lasers with modulation factor Q=1.04. Top: time averaged far fields. Middle: time averaged near fields. Bottom: intensity of emitted fields. All parameters except of non-vanishing facet reflectivity and twice smaller injected current are as in Fig.2.

In Fig. 2 we show how a proper selection of factor Q in BA amplifier allows shaping of the far field of the amplified beam. One can see, that once Q is slightly larger than 1, the central lobe of the far field can be compressed. In our work we investigate an impact of the device length, the size of the spatial periods, and the index and gain modulation contrast on this far field compression. Finally, by Fig 3 we demonstrate similar beam shaping effect in periodically modulated BA lasers. Even though the laser emission is not stable, here, once again, we can observe a significant compression of the time averaged far fields.

References

[1] M. Radziunas, K. Staliunas, "Spatial rocking in broad area semiconductor lasers", EPL **95**, 14002 (2011)
[2] A. Jechow et al., "Stripe-array diode-laser in an off-axis external cavity: theory and experiment", Optics Express, **17**(22), 19599 (2009).
[3] M. Spreemann et al., "Measurement and Simulation of distributed-feedback tapered Master-oscillators power-amplifiers", IEEE JQE **45**, 609 (2009)
[4] R. Herrero et al., "Beam shaping in spatially modulated broad area semiconductor amplifiers", Opt. Lett. **37**(24), 5253 (2012)

978-1-4799-0594-2/13/$31.00 ©2013 IEEE