# Beam Shaping in Spatially Modulated Broad Area Semiconductor Amplifiers


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Broad area semiconductor (BAS) laser are relevant high conversion light sources despite that the spatial and temporal quality of the emitted beam is relatively low due to the absence of a natural transverse mode selection mechanism [1]. To overcome this serious drawback different solutions have been incorporated in the design, such as external gratings, external injection spatially modulated injection or distributed feedback. In addition, in BAS lasers a modulation instability (or Bespalov-Talanov instability) can occur due to nonlinear focussing, leading to filamentation effects and deteriorating the spatial quality of the laser emission. In absence of cavity mirrors, planar semiconductor structures can act as light amplifiers undergoing however analogue disadvantages.

In the present work, we study a simple and effective new mechanism to improve the spatial beam quality of a planar semiconductor amplifier configuration. We consider a two-dimensional modulation, which can feasibly be realized by a periodical grid of electrodes for the electrical pump of the semiconductor, as illustrated in Fig. 1.a. The main result obtained is that such a micro-modulation of the spatial pump profile on a spatial scale of the order of several wavelengths, can indeed lead to a substantial improvement of the spatial quality of the amplified beam on a large spatial scale, see Fig. 1.b. The quantitative analysis of the spatial filtering is performed by numerical integration of a paraxial propagation model derived from [2,3], and on analytical estimations. Previous studies of wave propagation in media with spatially modulated Gain/Loss (GL) profiles show that a periodic modulation of GL on a wavelength scale can lead to particular beam propagation effects, such as self-collimation, spatial (angular) filtering, or beam focalisation [4]. In those works a purely GL modulation has been considered; however, in semiconductor media due to the linewidth enhancement factor, *h*-factor, a periodical spatial pump distribution causes a combined Gain and refraction Index Modulation (GIM). Hence, the aim of the present paper, performed under realistic parameters and conditions, is to demonstrate how the angular spectrum of the radiation from a spatially modulated GIM BAS amplifier becomes narrower while propagating and being amplified. The study predicts that the normalized beam quality factor – $M^2$ factor– can reduce almost to unity indicating that the BAS amplifier output becomes perfectly Gaussian for even strongly random initial input beam profiles, for a single-pass propagation length on the order of millimeters, see Fig. 1.c. Beyond the present report, this new technique could be implemented to improve the spatial quality of emission of BAS lasers.

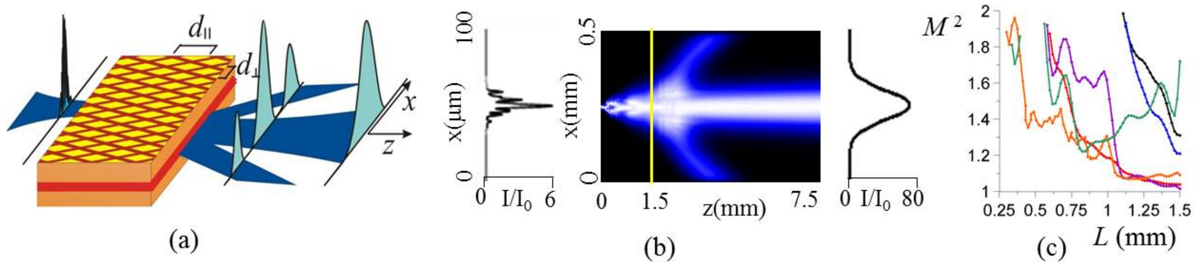


**Fig. 1** a) Illustration of modulated pump with fish-net electrodes on a semiconductor amplifier structure with longitudinal and transverse periodicities $d_\perp$ and $d_{||}$. b) A low spatial quality incident beam is amplified in propagation, while its spatial structure being progressively improved. A part of the radiation is, however, lost in sideband components. c) The output beam quality factor $M^2$ as a function of the amplifier length $L$ for an initial beam with $M^2 = 5.07$ . The different colors correspond to different geometrical factors $Q = 0.8$ (black), 0.9 (blue), 1.0 (red), 1.1 (purple), 1.2 (orange), 1.3 (green), where $Q = 1$ corresponds to resonance.

## References


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