EPJ Web of Conferences **243**, 13003 (2020) https://doi.org/10.1051/epjconf/202024313003
EUROPHOTON 2020

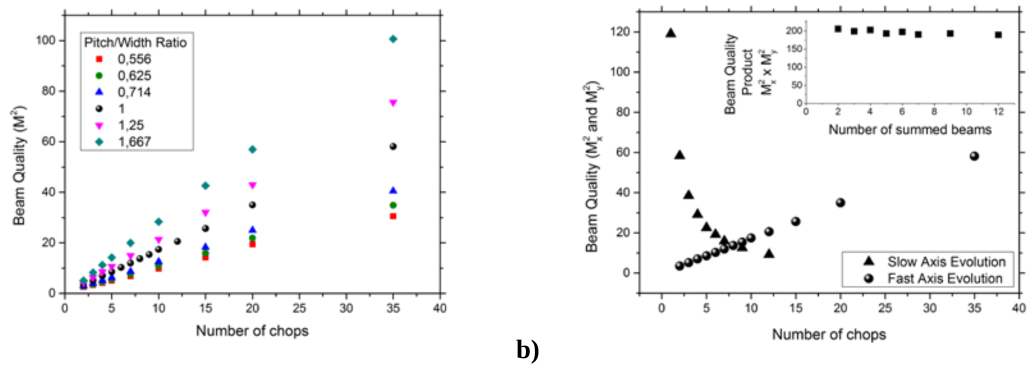
Beam-Shaping Optimization of the diode bar end-pumped laser

Lyuben S. Petrov, Kamen Velev, Kaloyan Georgiev, Ivan Buchvarov
Physics Department, Sofia University, 5 James Bourchier Blvd., BG-1164 Sofia, Bulgaria

Nowadays diode laser bars with theirs compact design, energy scaling by increasing the number of emitters as well as easy adjustment of the wavelength by temperature makes them basic elements for high-power solid-state laser pumping. A single diode bar is a monolithic linear array which can emit near infrared laser radiation from tens up to few hundreds of watts of power in CW or QCW mode, respectively. However the beam profile of a single diode laser bar is highly asymmetric in slow and fast axis and beam-shaping techniques are used to adapted beam-parameter products in both axes [1]. However, at present no easy theoretical procedure has been developed to optimize the operation of the beam-shaping device used for the specific laser bar.

In this paper we proposed a method of optimization of a laser bar beam-shaping device (BSD), using of a model of off-axis multiple Gaussian beam propagation. The method has been used to design and experimental demonstration of the specific beam-shaping device [2]. It chops the incident laser beam into a specific number of beams and then redirects and repositions these beams, so that they emerge from the beam shaper stacked on top of one another. The optimization procedure shows that for each specific bar (the number of emitters, their width and pitch there is an optimum number of the beam “chops”. We view each chop in vertical direction (Fast axis) as an individual Gaussian beam and the resulting shaped beam as a sum of offset Gaussian beams. In horizontal direction (Slow axis) the beam is determined by the parameters of the laser diode: emitter width, pitch and number of emitters, which is modified by the number of chops. As such the more chops there are the less Gaussian beams are summed for the Slow axis beam (“number of emitters”/”number of chops”).

The propagation of the beam then is calculated using a generalization of the ABCD matrix law which allows for the beam to be off axis [3]. The beam is propagated through a lens and then the beam quality is numerically measured. The evolution of the quality of the resulting shaped beam in the vertical direction (Fast axis) as a function of the number of chops is shown on fig. 1 a), where the ratio, of the pitch (distance peak to peak between two neighboring beams) to the beam width, is varied to show the changes for different beam shaper and laser diode configurations. We have established numerically that if the ratio Pitch/Width is constant so is the M^2.



a) b)

Fig. 1 a) Shows the evolution of the beam quality with the increase of the number of Gaussian beams summed. b) Shows the M_y^2 (Fast axis) evolution depending on the number of chops (Gaussian beams summed, on the same graph is shown the evolution of the M_x^2 (Slow axis), but the number of chops shows how much of all the emitters are used (“all emitters”/”number of chops”). As an inset the product of both axis Beam Quality is show.

In \Fig.1 b) we show how the optimum amount of chops can be chosen for the beam shaper. The pitch/width ratio we have chosen is 1, under which the losses from the beam shaper increase dramatically. For the laser diode the simulations are based on a Jenoptik JOLD-225-QPFN-1L, who’s M_x^2 we have measured and is around 127 and has 37 emitters. The brightness of the beam is proportional to the whole system beam quality which is defined by the product of the M^2 factors of both axes, which is shown as an inset in Fig. 1 b). We can see that it stays more or less the same, so no optimization can be performed there. Based on our simulations the optimum number of chops, to achieve symmetric beam quality for this system, should be around 8.

References

[1] F. M. Dickey and T. E. Lizotte, Laser Beam Shaping Applications, 2nd ed., (CRC Press, 2017)
[2] W. A. Clarkson, D. C. Hanna, "Two-mirror beam-shaping technique for high-power diode bars," Opt. Lett. 21, 375-377 (1996)
[3] A. A. Tovar, L. W. Casperson, "Generalized beam matrices: Gaussian beam propagation in misaligned complex optical systems," J. Opt. Soc. Am. A, Vol. 12, No. 7 (1995)