Laser diode model for beam shaping



Overview

In this work, we propose an innovative beam shaping method for the homogenization of the beam quality of six 8-bar diode laser stacks at wavelengths from 790 nm to 980 nm.

Key Takeaways

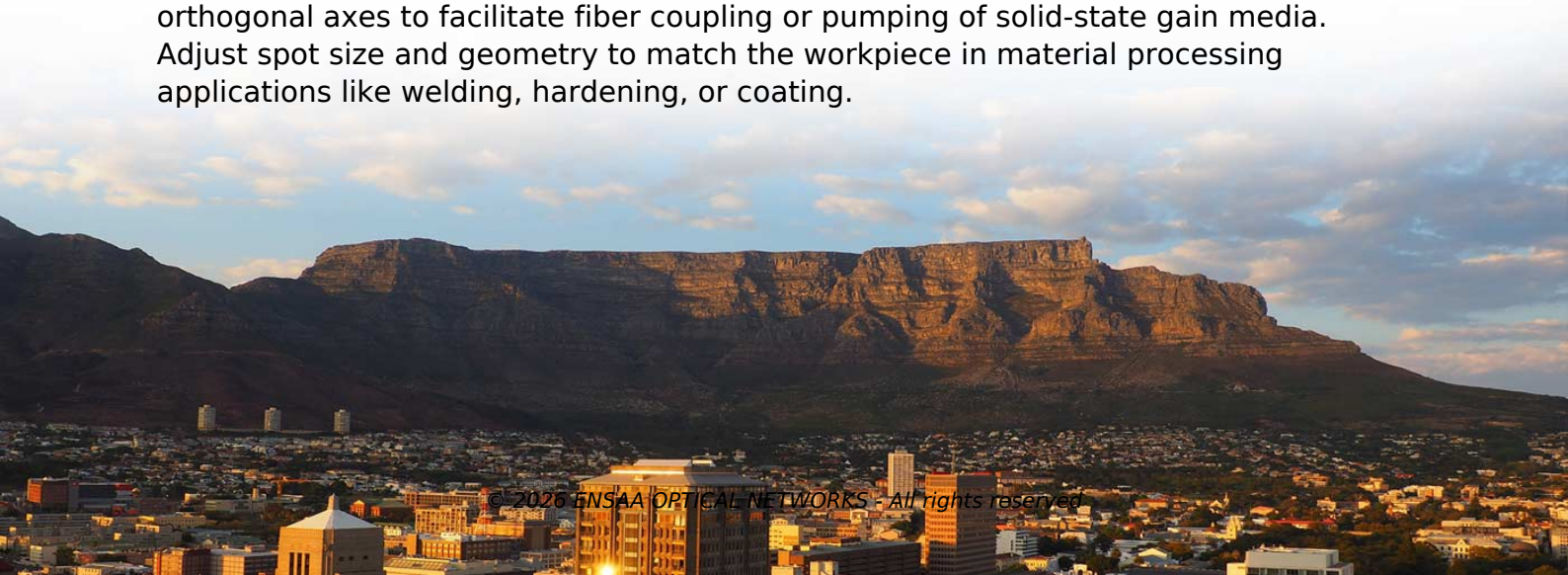
Laser diode beam shaping modifies the spatial profile of a laser beam to achieve desired intensity distributions, symmetry, and focus for specific applications.

Beam Characteristics of Laser Diodes

Laser diodes emit light from a PN-junction ridge waveguide, producing a highly divergent and often elliptical beam due to the asymmetric geometry of the cavity. The axis perpendicular to the junction (fast-axis) diverges more than the parallel axis (slow-axis), resulting in an elliptical beam profile. High-power diodes may use multiple emitters on a single bar, further complicating the beam shape.

Purpose of Beam Shaping

Beam shaping is essential to: Convert the natural Gaussian profile of a laser into a flat-top (top-hat) profile for uniform energy distribution. Symmetrize the beam along orthogonal axes to facilitate fiber coupling or pumping of solid-state gain media. Adjust spot size and geometry to match the workpiece in material processing applications like welding, hardening, or coating.



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Common Beam Shaping Techniques

Refractive and Micro-Optic Beam ShapersRefractive devices use lenses or mirrors to redistribute irradiance, converting Gaussian beams into flat-top profiles while preserving brightness. Micro-optical structures, such as prism arrays, achieve similar effects in compact devices.

Cylindrical Lenses

Focus or expand light along a single axis, useful for line generation, beam expansion, or symmetrization of diode outputs. Often used in combination to create thin lines or sheets of light for scanning or metrology. CollimatorsFast-axis collimators (FACs) and slow-axis collimators (SACs) are used to collimate laser diode bars along their respective axes, improving beam quality and symmetry.

Homogenizing Optics

Special lens and mirror systems ensure uniform energy distribution, critical for applications requiring precise and consistent irradiation. Motorized zoom optics can dynamically adjust spot size during processing.

Applications

Materials Processing: Flat-top beams improve cutting, welding, and ablation by providing uniform energy across the target area. Fiber Coupling: Symmetric beams allow efficient coupling into circular-core fibers. Medical and Scientific Uses: Line or sheet illumination for imaging, spectroscopy, or laser scanning.

Practical Considerations

Beam shaping increases system complexity and cost but enhances precision and efficiency. Customized coatings and high-quality optics can achieve >98% transmission and maintain beam uniformity down to micrometer scales. The choice of shaping method depends on laser type, power, wavelength, and application requirements.

In summary, laser diode beam shaping is a combination of optical design and component selection aimed at controlling beam profile, symmetry, and intensity distribution to optimize performance for specific industrial, scientific, or medical applications.

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Article Content

Laser Beam Shaping Overview

PDF file

A review on beam-shaping techniques for high-power and ... - Springer

In this study, we provide a succinct overview of the key beam shaping methods and highlight the important details and benefits of common fiber-coupled laser diode systems that mostly utilize for

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Beam-shaping design for multi-wavelength diode laser stack system ...

In this work, we propose an innovative beam shaping method for the homogenization of the beam quality of six 8-bar diode laser stacks at wavelengths from 790 nm to 980 nm. We

Beam Shapers – laser beam converter

Another kind of beam shaper is often used in conjunction with a high-power laser diode, for example with a diode bar, to make both its beam radius and beam

Multimode Fibers – optical glass fiber, large-core fibers,

Also, fiber-coupled high-power diode bars and diode stacks use multimode fibers, as their beam quality is far from diffraction-limited. Fiber coupling is useful because

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Asphericon a|TopShape TSM25-10-LDX-D-405 Beam Shaper

Can this beam shaper be used with pulsed lasers outside the 532 nm damage threshold specification? Yes—laser-induced damage threshold scales inversely with wavelength squared. At 405 nm, the

Evolase LDM-PS/NS Series Pulsed Laser Diode Modules

Overview The Evolase LDM-PS and LDM-NS series are compact, turnkey pulsed laser diode modules engineered for precision timing, high peak power, and spectral versatility in semiconductor

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Adjustable Mode Beam Laser Market in Asia-Pacific | Report

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Global 405nm Single Frequency Laser Market Size, Share, Growth

Future growth will be influenced by advances in laser beam shaping, adaptive optics, and AI-driven process control, which will enable higher throughput, finer feature resolution, and

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Precision blue laser welding head optimized for copper & aluminum. Features beam-shaping control, 450nm wavelength, and industrial thermal management for stable welding.

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Global Laser IR Illuminators Market Size, Share, Growth Trends ...

Advances in laser diode efficiency, thermal management, and beam shaping are expected to enable the development of ultra-compact, high-power IR illuminators that can operate

custom laser collimator lens Optical Single-Line Focus Collimating, IR ...

Felix Glass single-line laser collimating focus lens is a precision infrared optical glass component dedicated to laser diode beam processing. This lens integrates collimation and linear focusing

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Abstract In this paper, the research work of two-dimensional beam shaping and homogenization of high power laser diode (LD) stack by a rectangular waveguide is presented.

LaserStar FiberStar 7600 Series Manual Fiber Laser Welding

Overview The LaserStar FiberStar 7600 Series Manual Fiber Laser Welding Workstation is a precision-engineered, Class 1 enclosed laser system designed for high-reproducibility micro-welding of

Beam shaping for two-dimensional laser array by a computational model ...

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After shaping the laser light source with a luminous diameter of 1 mm, a circular and uniform spot is obtained at 100 m. For the point light source model, the divergence angle of 0.28° is

Beam Shaping Technique for 5-mm Fiber-coupled Laser Diode Bars

In this work, a simple beam shaping method is demonstrated for coupling a high-power semiconductor laser diode into multi-mode fiber optic using optical lenses.

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