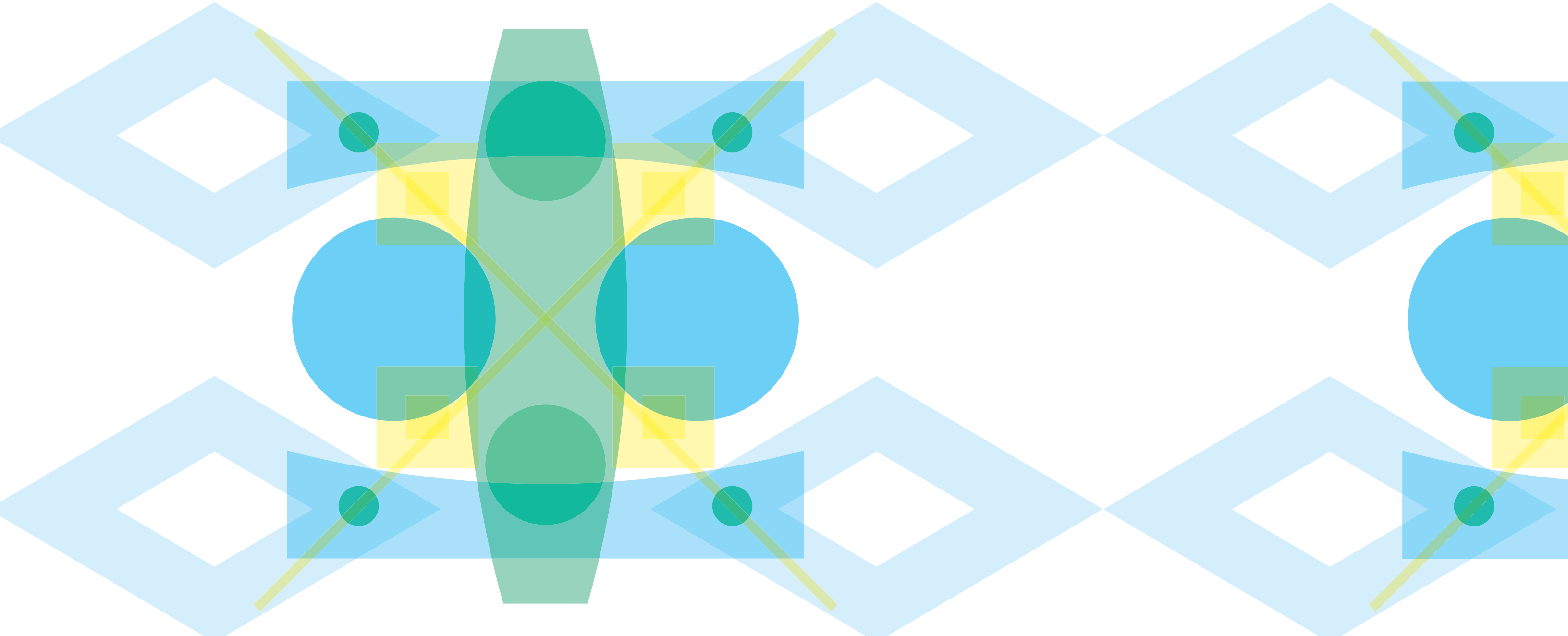

Slow Axis Collimators for Laser Diodes

Diode laser technology is advancing at a breathtaking pace as suppliers add new wavelengths and improve output power. For all their improvements, laser diodes still present one big challenge to the system designer: their output is inherently asymmetric. Their divergence in one plane is greater than in the other. Whether looking to incorporate single diode lasers or diode bars, system designers must condition the beams to compensate for the asymmetry. FISBA's family of beam conditioning optics provides an easy and efficient solution. The family consists of three independent beam shaping elements. The fast axis collima-

There are two alternatives for diode laser bar coupling into a fiber. Upper picture: Fast axis collimator (FAC), FISBA Beam Twister™ array, slow axis collimator (SAC) and focusing lens. Lower picture: Fast axis collimator (FAC), slow axis collimator array and focusing lens.

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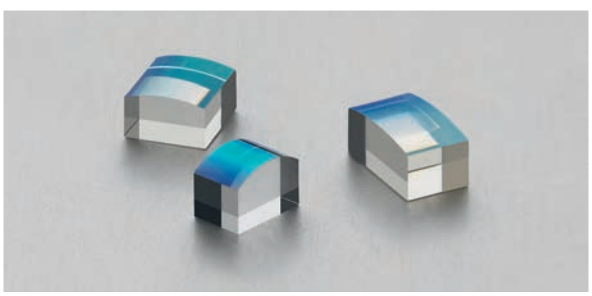
tor, FAC, is a precision-engineered acircular cylindrical lens that collimates the high-divergence output axis of a laser diode or diode bar. The FISBA Beam Twister™, FBT, is a micro optic that rotates each individual beam axis by ninety degrees. The final element of the solution is the slow axis collimator, or SAC.

SACs are cylindrical lenses designed to collimate the smaller divergence angle and leave the beam undisturbed in the fast axis. SACs are available as single-diode micro optics or in array form, fabricated for diode bars of a given pitch. For many applications, such as coupling into a fiber, the optimum solution after FA collimation is a FISBA Beam Twister™ -SAC combination, which produces a symmetric beam, leading to fiber coupling efficiencies as high as 80 percent or higher.



Slow Axis Collimator (SAC) for single emitters

The Challenges of Laser Diodes

Laser diodes are compact, flexible, responsive light sources available in a wide range of output wavelengths. The emitting area of an individual diode is a rectangular active region, with a vertical short side and a horizontal long side. At the emission facet of the diode, the beam is elliptical, typically about 1 micrometer in the vertical direction and a few tens of micrometers in the horizontal direction.

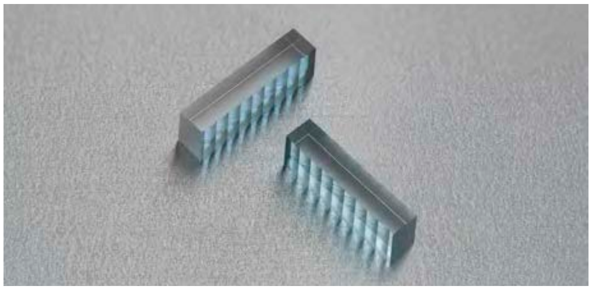
The beam spreads out after it exits the emitter, but the divergence angle is asymmetric. In the horizontal direction – the plane of the longer side of the emitter – the divergence angle is typically about 6 to 10 degrees. That's defined as the slow axis. In the vertical direction the divergence is often somewhere in the range of from less than 15 degrees to more than 40 degrees. That's the fast axis.

The diode output is also astigmatic. That is, the beam waist – the effective source location – is different in the two axes. In the fast axis, the waist is just inside the emitting facet, while the beam waist in the slow axis is a few micrometers further within the diode.

These three asymmetries – in initial beam dimension, in divergence angle, and in beam waist location – don't present an issue for every potential application. For those applications, however, that look to combine the output from different diodes to create a single effective source of higher power, it's essential that each separate diode output be shaped identically. Where the output is to be fiber-coupled, the challenge is even more significant: the fiber input is symmetric, and any asymmetry in the combined beams leads directly to loss when coupling into an optical fiber.

Diode Bars

The output power of a laser diode is limited by the effective carrier density, which, in turn, puts a limit on the height of the active area. To get more power, then, the width of the active area is increased, creating a diode bar. The diode output then consists of a horizontal array of separate emitting areas, each with the three asymmetries discussed above. This is where SAC arrays provide their value.

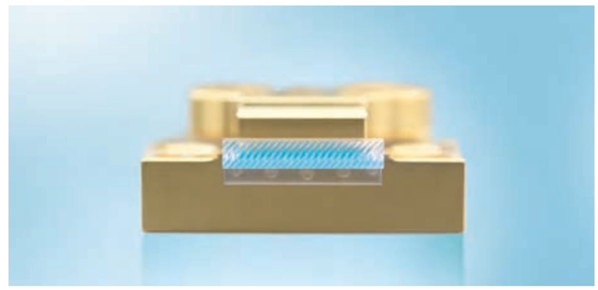


Slow Axis Collimation (SAC) array

Each individual element of the SAC array collimates the slow axis of the diode output. The array consists of a strip of SACs fabricated as a single monolithic micro optic designed for a given emitter pitch. The SAC array converts the daunting problem of shaping each individual emitter beam in the bar with the much easier task of performing one alignment to collimate the divergence in the slow axis for all the individual emitters.

For many applications, the goal is to combine the beams from individual emitters into one more powerful beam. Once the beams are combined, the system will use traditional optics to form and direct the beam. Without proper beam shaping, the asymmetries in the initial diode sources will propagate through the system, making it impossible to use traditional optics to direct and focus the beam. A combination of an FAC and SAC combines the individual beams so they can be manipulated as if the source was a single laser.

The FAC and SAC together do not eliminate all asymmetries: the beam parameter product (BPP) in the two axes are not equal. The beam parameter product is the lateral dimension times the divergence in that same dimension. For many applications differences in BPP are not a problem, but for fiber coupling full beam symmetry is desired. That's where the FAC-BT-SAC combination provides an efficient solution. Efficiencies of fiber coupling with the FAC-BT-SAC can be 80 percent or higher.



FISBA Beam Twister™ (FBT) subassembly, consisting of Fast Axis Collimator (FAC) and Twister array

Systems Engineering

SACs and the other micro optics in the FISBA beam shaping family are available in a range of designs precision engineered to provide optimum efficiency for a given wavelength range. There are several configurations available, offering a selection of effective focal lengths to fit a wide variety of application needs. For the array elements, system designers can select from an assortment of emitter pitches to fit many commonly available diode bars.

Designers incorporating non-standard diode bars can consult with FISBA engineers to produce precision-engineered custom solutions to meet just about every possible need. FISBA's systems engineering expertise means we are prepared to produce SACs and other design components that will meet your needs, adjusting the pitch, effective focal length, back focal length, and central thickness to produce an effective and efficient beam-shaping solution for any laser diode problem.