



AN-03 LASER EMISSION AND FOCUSING

Our single-emitter products feature a single, wide emission stripe. The stripe is typically between 50um and 300um wide, and is not divided or segmented. The emission is nominally uniform over this width, but the profile of the near field of the stripe does typically have some random variation over its width on the order of 30%. This “wide” direction of a high-power laser diode is sometimes referred to as the “parallel” direction, since it is parallel to the laser diode P-N junction. It is also sometimes called the “slow axis”, since the divergence of the light in this direction is lower. In this wide, or slow axis, the laser is highly multimodal. There can be 50 or more overlapping optical cavity modes lasing. So the laser far-field pattern is an irregular overlapping pattern of these many modes. The distribution of power among the various optical modes is unstable and can change with temperature, drive current, aging, and optical feedback (reflected light). Thus, the laser far-field pattern is also typically unstable, even though the total laser output power is stable to within a few percent.

The angular divergence of the light from the laser in the slow axis is typically between 5 and 8 degrees FWHM (Full Width to Half Max). The divergence in the slow axis usually changes with drive current. When the laser is only slightly above threshold, the divergence is typically lower, around 5 degrees FWHM. At full operating power, the divergence generally increases to 7 or 8 degrees (in some cases up to 10 degrees). The angular intensity profile of the slow axis far-field is usually something like an irregular “top-hat” distribution. But because of the many overlapping optical modes, there is usually a significant intensity variation (peaks and valleys) of about 50%.

To model the slow axis for light focusing or imaging calculations, the emission should be treated as an incoherent source, and classical lens formulas should be used. Gaussian optical calculations do not apply because the light in the slow axis is highly multimodal. For example, if using a lens to focus the beam to a spot or into an optical fiber, apply the lens focal length, and the image and object distances to calculate the resulting magnification (or reduction) of the stripe width. It is impossible to focus the slow-axis light to a diffraction-limited spot.

It is sometimes useful, for the purposes of a rough first-order approximation, to model the product of emitter width and NA (numerical aperture) as a constant. Take, for example, a 100 um stripe emitter with an NA of 0.07 (8° full width). If a lens were used to focus the slow axis to a 50um spot, the NA of the light at the focused spot would be about 0.14.

In the other (orthogonal) direction of a high-power laser diode, the situation is completely different. This axis is variously referred to as the “narrow” direction, the “perpendicular” direction, or the “fast axis”. In the fast axis, the laser light is emitted from a narrow waveguide 1~2 um in width and is single spatial mode in character. Gaussian optics can be applied to beam focusing calculations on this axis. Light in the fast axis diverges more than that in the slow axis due to diffraction, with a typical FWHM angular divergence of 25-40 degrees. This corresponds to an angular divergence of 42-68 degrees if defined by the 1/e² full width. The angular intensity profile in the fast axis is close to a true Gaussian distribution.

The fast and slow axes of a high-power laser diode have very different characteristics. Therefore, beam collimation or focusing often requires cylindrical lenses in the system to preferentially focus one axis differently from the other.

