Introduction to Diode Laser Assemblies

Diode laser assemblies comprise, at a minimum, a semiconductor diode laser and beam-conditioning optics. In addition to these two basic elements, assemblies may include thermoelectric coolers (TECs), dc power supplies, and ac-to-dc converters, along with a variety of other options and accessories. To understand why these additional components are needed, it is necessary to understand the basic characteristics of the diode laser itself.

OUTPUT POWER

The output power from a diode laser is a function of both the current supplied to the diode junction and the temperature of the junction itself. Since the current through the diode generates heat at the junction, these two factors are highly interrelated. Typical relationships for output power, forward current, and junction temperature are shown for a generic diode laser in the figure below.

AVAILABLE WAVELENGTHS

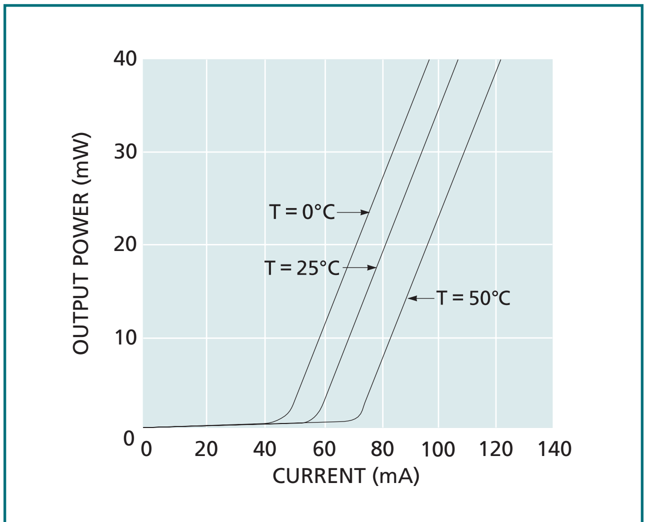
The basic diode lasers used in our assemblies are available in a wide range of wavelengths and output powers, ranging from 635 nm to 1550 nm and from 5 mW to 200 mW, respectively. Due to space considerations, only a small number of the lasers we offer are listed in this catalog. If you have a special requirement, do not hesitate to call your nearest Melles Griot sales office.

TEMPERATURE DEPENDENCE

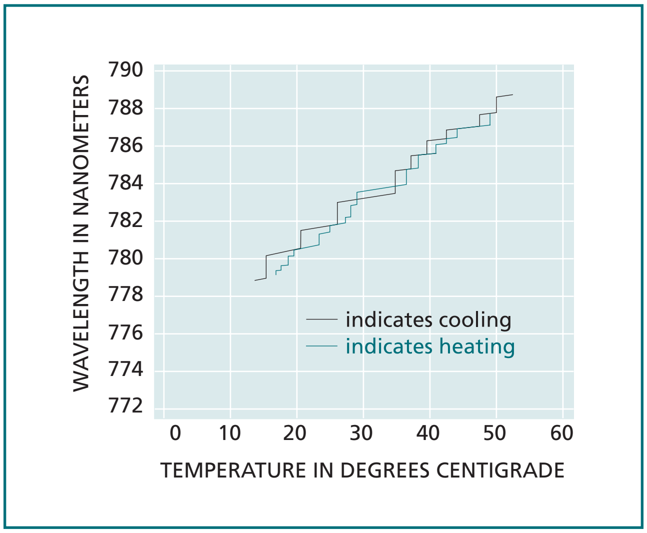
In addition to the dependence of output power on junction temperature, wavelength also exhibits a marked temperature dependence and can vary several nanometers over a 20ºC change in temperature, as can be seen in the figure below. Wavelength variation is not a smooth function of temperature but occurs in abrupt jumps, called mode hops. Between mode hops, wavelength change can be as little as 0.05 nm/ºC, with an average change in wavelength of 0.3 nm/Cº over a large temperature range. The marked dependence of both power and wavelength on junction temperature illuminates the importance of either maintaining a constant junction temperature through thermoelectric cooling or maintaining output power with automatic power control (APC).

TRANSVERSE MODE AND EMISSION ANGLES

The emission from a diode laser generally is TEM_{00} (Gaussian), but the emission angles are typically 10 degrees and 30 degrees parallel and perpendicular to the laser junction, respectively–with variability up to 25 percent from component to component. This illustrates the importance of matching collimating optics to each individual diode when making an assembly.



Output power vs. current at constant temperature



Dependence of wavelength on temperature

LONGITUDINAL MODE STRUCTURE

Below a defined threshold point, the diode laser will usually exhibit a spectral width of several nanometers with several longitudinal modes operating simultaneously—similar to a light-emitting diode (LED). Above threshold, spectral width is reduced to a fraction of a nanometer with a single longitudinal mode. If multimode behavior persists above threshold, the most common cause is optical feedback from light reflected back into the diode laser.

POLARIZATION

Diode lasers are linearly polarized with a nominal 100:1 extinction ratio in the direction parallel to their junction. This ratio varies with operating current, proximity to threshold and the f-number of the collimating lens.

LIFETIME

Lifetimes in excess of 50,000 hours at room temperature are not uncommon for most low-power visible and near-infrared diode lasers. In general, operating life doubles for every 10ºC reduction in operating temperature and halves for every 10ºC increase. Current transients caused by inappropriate drive circuitry and electrostatic discharge (ESD) are the two primary causes of diode laser mortality.

BEAM DELIVERY METHODS

The two most common methods of delivering a diode laser beam are free-space optics (conventional lenses) and optical fibers. The free-space approach has been used extensively for scientific and industrial applications, and single- or multielement glass lenses, as well as molded plastic optics, provide relatively good optical performance at a reasonable price.

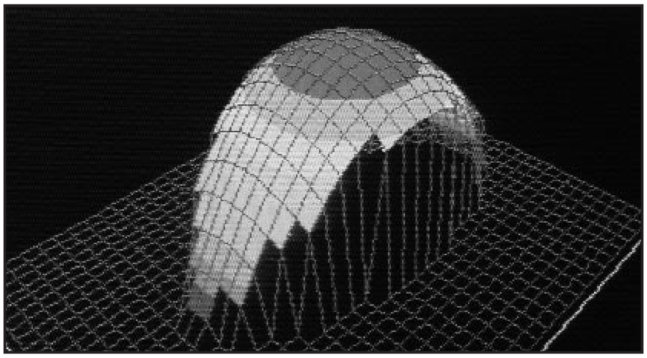
Fiber-coupled diode laser assemblies, however, result in an optical beam quality that is far superior to that produced by bulk collimating and beam-shaping optical systems. Transmission through the fiber can eliminate high-order spatial modes and result in a diffraction-limited, circular output that is truly Gaussian and free from astigmatism. A drawback of these assemblies is optical efficiency. Single-mode fibers typically transmit from 20 percent to 40 percent of the available light for visible wavelengths and up to 75 percent for infrared wavelengths. Multimode fiber bundles can transmit more than 70 percent of the available visible light, but with a reduction in mode quality.

Benefits of free-space beam delivery

- High optical efficiency for greater output power
- Good beam quality–adequate for many high-volume applications
- Compact size for easy integration into most optical systems
- Low cost — an economical approach

Benefits of fiber-coupled diode lasers

- Diffraction-limited beam that is circular, anastigmatic, and can be focused to the theoretically smallest spot size or propagated over hundreds of meters while maintaining a clean uniform beam shape
- Consistent beam size from unit to unit (traditional diode-laser beams will vary by as much as 25% in size)
- Remote beam delivery over several meters possible without loss of optical power or degradation of beam quality.



Typical elliptical diode laser wavefront profile

DIODE LASER DRIVERS

For a comprehensive selection of diode laser drivers, see Chapter 46, *Laboratory Diode Laser Drivers*. For information on custom driver boards and integrated OEM diode laser assemblies, please contact your nearest Melles Griot sales office.