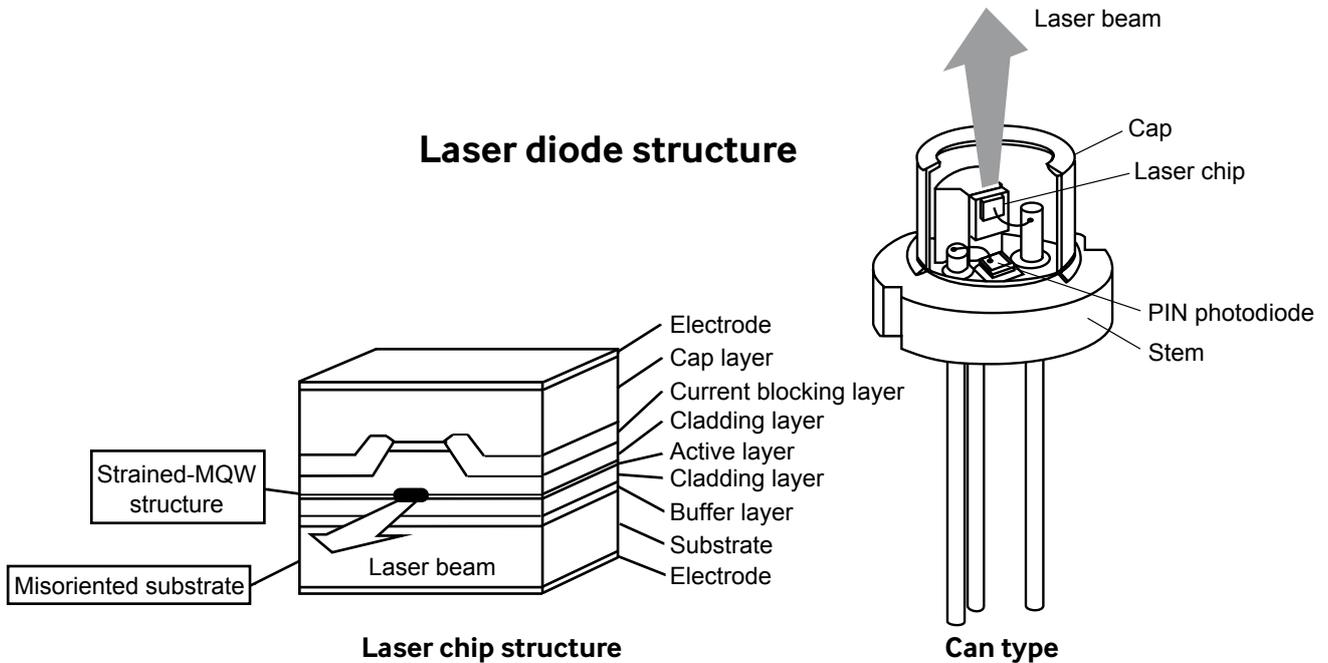




# Laser Diode Characteristics and Definitions

# What is a Laser Diode?

The term laser is an acronym that stands for “Light Amplification by Stimulated Emission of Radiation”



A laser diode, similar to a light emitting diode (LED), is comprised of a junction between two semiconductors (one positive, one negative). This junction is known as a p-n junction. These semiconductors are incredibly small, made of very thin slices of semiconducting material, and are very carefully manufactured so as to create a perfect p-n junction.

Lasers are monochromatic, meaning that they have only one frequency. For a laser to function, many photons of light of the same frequency must all travel in the same direction, causing them to constructively interfere with each other, which increases the amplitude of the light. In a laser diode, the light is emitted because there are both electrons, in the positive substance, and holes (the absence of electrons) in the negative substance. When the positive substance is charged, the electrons in the positive substance jump to fill the holes in the negative substance. When the electrons jump, they lose energy in the form of photons, which are light quanta. These photons are all produced simultaneously. Because all the electrons jumped down to fill holes in a certain semiconducting material, all of the photons are of the same frequency and direction. This causes a laser beam to form and come out through the lens of the laser diode.

Because laser diodes have to be operated at such a high current density, and have a very low forward resistance when lasing action occurs, they are at risk of destroying themselves due to thermal runaway. Their operating light density can also rise to a level where the end mirrors can begin melting.

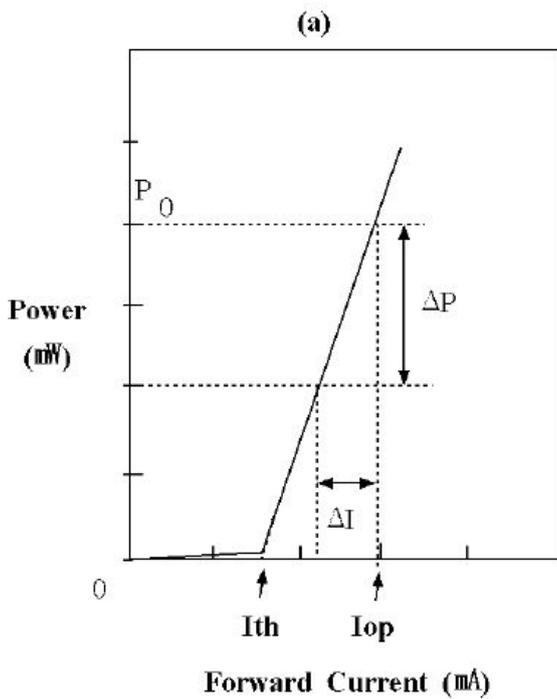
This means that not only must a laser diode's current be regulated by a constant current circuit rather than a simple series resistor, but optical negative feedback must generally be used as well to ensure that the optical output is held to a constant safe level. To make this optical feedback easier, most laser diodes have a silicon PIN photodiode built right into the package, arranged so that it automatically receives a fixed proportion of the laser's output. The output of this monitor diode can then be used to control the current fed through the laser by the constant current circuit, for stable and reliable operation.

The diagram above shows a typical horizontal type laser chip mounted in its package, with the monitor photodiode mounted on the base stem below it so the diode receives the light output from the rear of the laser chip.

# Laser Diode Characteristics and Definitions

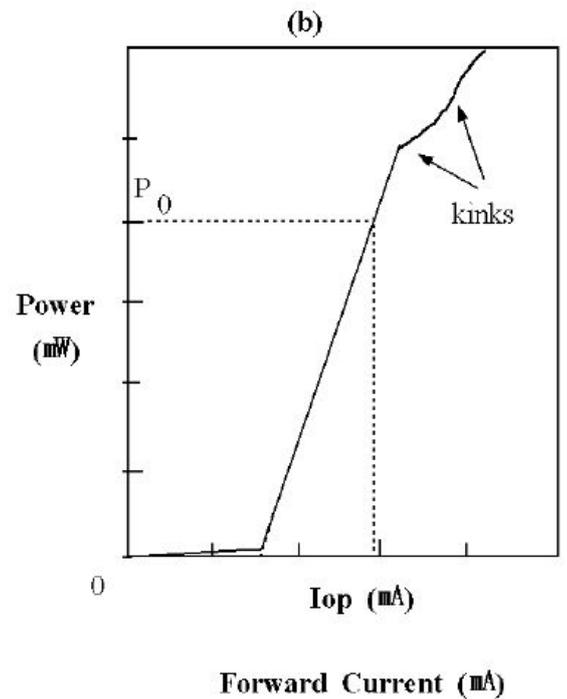
ITEMS	SYMBOLS	
Output Optical Power	Pop	Maximum allowable instantaneous light power in pulse or CW mode. Up to this output level there are no kinks in the light-current curve.
Operating Current	Iop	The forward current through the LD which necessary for the LD to produce its specified typical optical output power.
Operating Voltage	Vop	The forward voltage across the LD by forwarding operating current.
Wavelength	$\lambda_p$	The wavelength of the laser spectral line with the greatest intensity.
Watt-Ampere/ Slope/ Efficiency	SE	The value of the incremental change in the laser beam power for an incremental change in forward current above the threshold current.
Monitoring Current	I <sub>m</sub>	The monitoring photodiode current is proportional to LD laser output power/ at a specified reverse bias voltage.
Threshold Current	I <sub>th</sub>	The forward current value at which the LD begins to produce laser output.
Laser Beam Divergency/ In Horizontal Plane	$\theta_{  }$	The laser beams full angular at the half-maximum intensity (FWHM), measured in horizontal plane/parallel to the LD p-n junction plane.
Laser Beam Divergency/ In Vertical Plane	$\theta_{\perp}$	The laser beams full angular at the half-maximum intensity (FWHM), measured in vertical plane/perpendicular to the LD p-n junction plane.
LD Reverse Voltage	V <sub>r</sub>	Maximum admissible reverse bias voltage, which may be applied to the LD without damaging.
PD Bias Voltage	V <sub>rb</sub>	Maximum admissible reverse bias voltage, which may be applied to the monitoring PD without a damage.
Operating Temperature	T <sub>opr</sub>	Range of the case temperature within which LD may be safely stored.
Storage Temperature	T <sub>stg</sub>	Range of the ambient temperature within which LDM may be safely stored.
Forward Current	I <sub>f</sub>	Current through the forward biased LD.
Forward Bias Voltage	V <sub>f</sub>	Laser diode voltage by an applied forward bias.

LASER DIODE OPTICAL POWER OUTPUT vs. FORWARD CURRENT

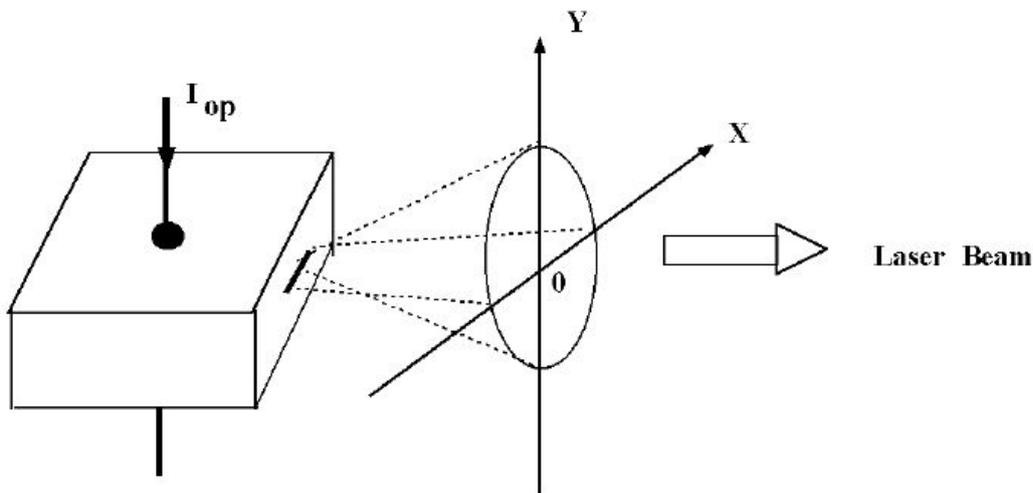


$$SE = \frac{\Delta P}{\Delta I}$$

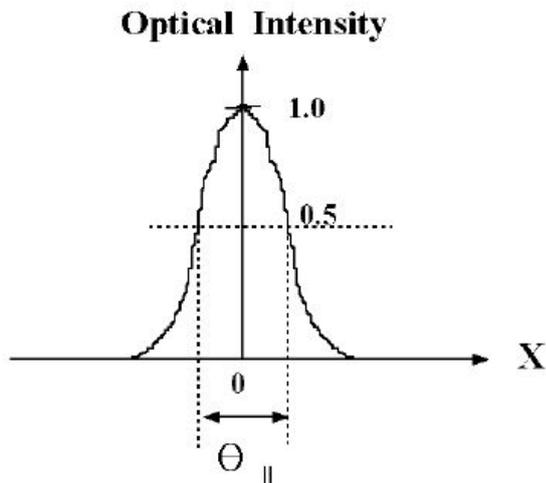
[ If  $\geq I_{th}$  ]



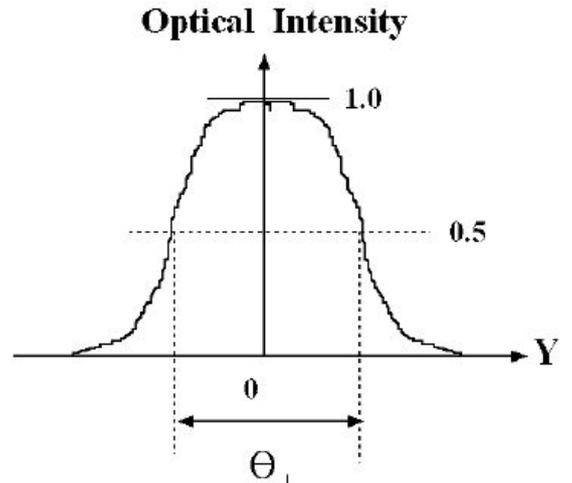
LASER DIODE OUTPUT BEAM DIVERGENCY / FAR FIELD PATTERN



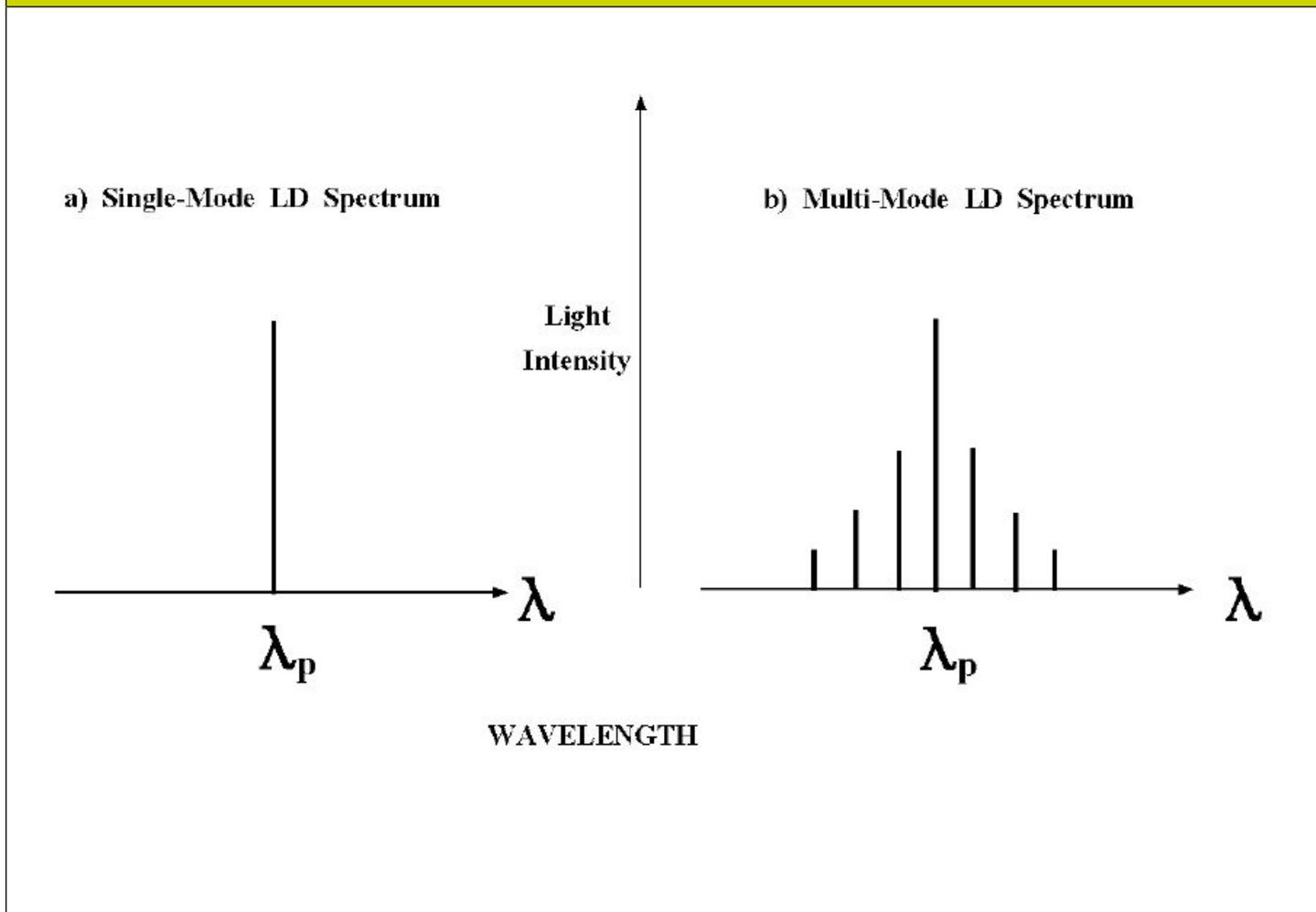
a) Laser Beam Divergency in Parallel Plane



b) Laser Beam Divergency in Vertical Plane



## LASER DIODE OUTPUT SPECTRUM CHARACTERISTICS

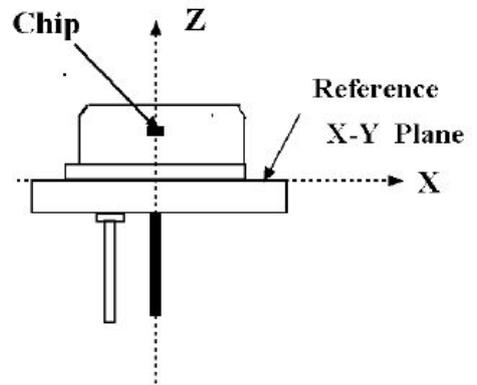
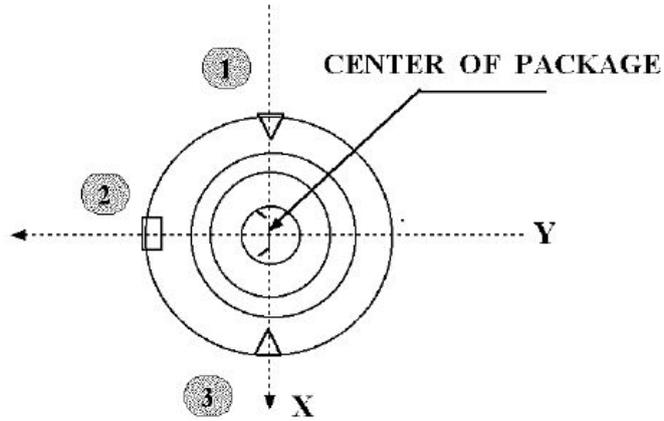


## Some Important Reference Characteristics and Items

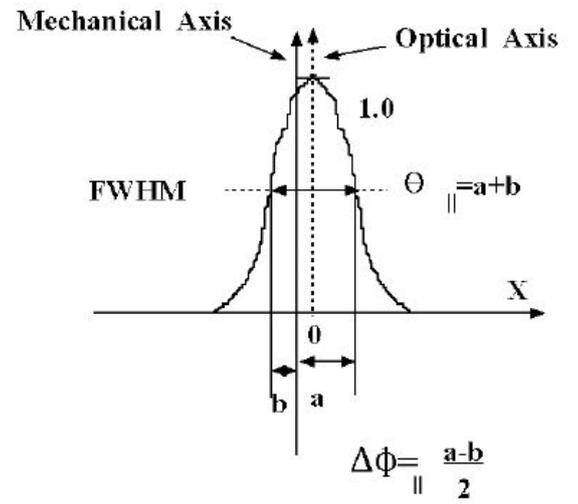
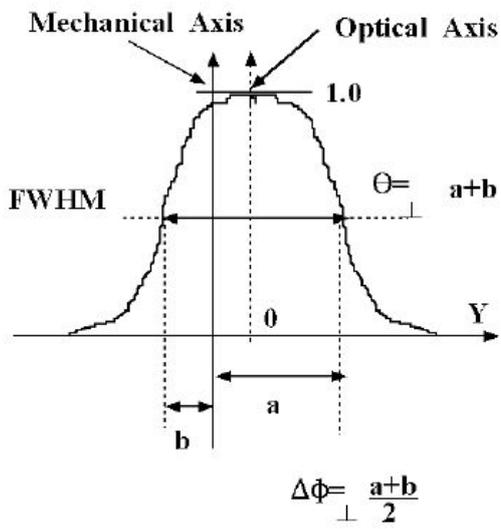
ITEMS	SYMBOLS	
Radiation Angle Deviation in Horizontal Plane	$\Delta\phi_{\parallel}$	The deviation of the optical axis of the laser beam from the mechanical axis of the package, measured parallel to the p-n junction plane.
Radiation Angle Deviation in Vertical Plane	$\Delta\phi_{\perp}$	The deviation of the optical axis of the laser beam from mechanical axis of the package, measured perpendicular to the p-n junction plane.
Monitoring Photodiode Bias	$V_{\text{bias}}$	Allowable reverse bias for the monitor photodiode.
Monitor Photodiode Dark Current	$I_{\text{D}}$	The current through the reverse biased monitor photodiode when the laser is not emitted and without any illumination to photodiode.

LASER DIODE PACKAGE REFERENCE POINTS

LD PACKAGE TOP VIEW



Optical Intensity



# Precautions for Use

## 1. Absolute Maximum Ratings

Do not exceed, even momentarily, the maximum ratings.

When laser diode is driven in excess of the maximum ratings, it causes not only instant breakdown or deterioration but also considerable reduction in reliability.

a) Laser diode may be damaged by surge current generated at power on-off operation.

Check on the transient characteristics of power supply to make sure that such surge current does not exceed the maximum ratings.

b) The maximum ratings are specified by case temperature at 25°C. Design should be made well to work with temperature. As temperature goes up, power dissipation as well as maximum light output power is reduced.

## 2. Soldering Conditions

Maximum temperature is set at 260°C and soldering time is within 3.0 seconds and minimum clearance of 1.6mm from the root of a lead is necessary.

## 3. Prevention of breakdown due to static electricity or surge current

Laser diode may be adversely affected by static electricity and surge current and, consequently causes breakdown of element and reduction of reliability unless the following cares are taken :

a) Power supply, installation and measuring equipment should be grounded.

A noise filter or noise-cut transformer is to be provided to power supply input utilized.

b) During operation, working clothes, hats and shoes should be static-protected when in use.

Also, a workman body should be static-protected by use of an earth-band or the like and grounded through high resistance

(500kW-1MW).

c) A soldering iron should be grounded to protect laser diodes from voltage leak.

d) Any container for carriage and storage should be static-protected.

e) Avoid using laser diodes at a place where high frequent surge current may be generated as an inductive electric field gives breakdown or deterioration. (Avoid being placed around fluorescent grow lamp, for example).

## 4. Package Handling

a) Package must not be cut off, reworked nor deformed. Do not hold the cap of laser diode tight, otherwise it may bring about cracks onto the window glass.

b) Do not touch the surface of the window glass.

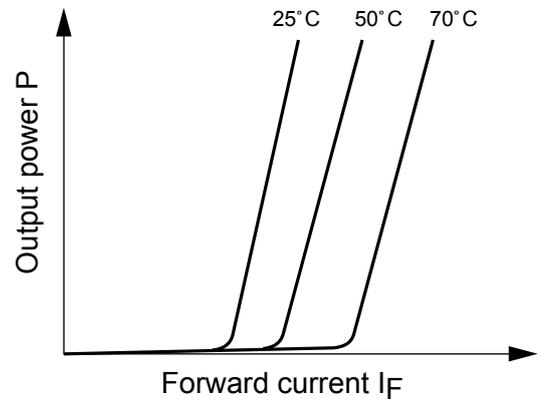
Any scratch or contamination may result in reduction of optical characteristics.

c) Remove small contaminations on the surface softly using a cotton stick with a small amount of methyl alcohol.

# Precautions for Use

## 5. Temperature Characteristics

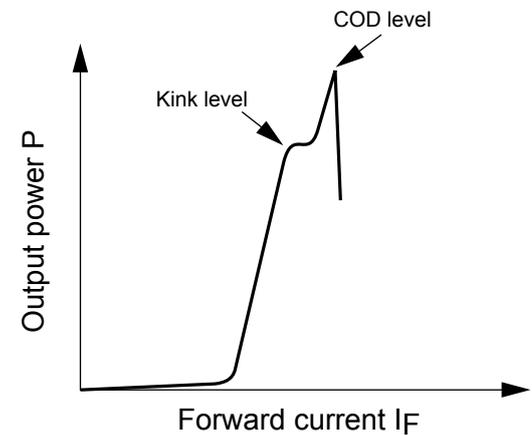
Laser characteristics (wavelength, operating current) vary with temperature, and variation is more extreme at shorter wavelength. We recommend installing an APC circuit to maintain a constant output because operating current varies significantly with temperature. By the same token, laser reliability can be improved by designing products based on their heat release characteristics. Since laser reliability falls off steeply at a higher temperature, never allow the case to exceed the operating temperature range given in specifications while a laser is in use.



Temperature characteristics of I-L curves

## 6. COD (Catastrophic Optical Damage) Level

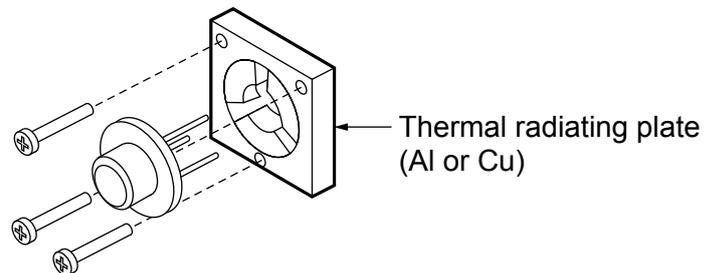
If current is flowing into the forward direction and output continues to rise following a kink or other deviation, then the laser eventually reaches facet breakdown (COD) level where the crystal at the facet melts due to the high optical density. Special care must be taken in the handling of red lasers because they may continue to oscillate with a low power of 2 to 3mW even after occurring facet breakdown. There are several ways to tell whether an element is damaged or destroyed, such as through a far field pattern or an increase in the operating current. The life of a laser is significantly curtailed once the element is damaged, so special care must be taken to avoid not only exceeding current when adjusting the output, but surge like static electricity as well.



Output power vs. Forward current (P-I<sub>F</sub>)

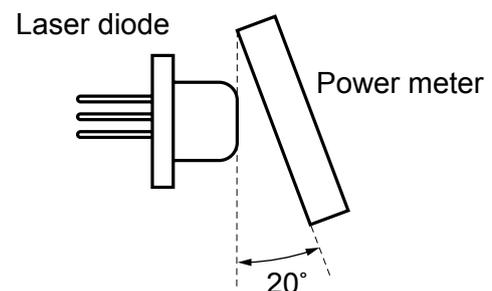
## 7. Thermal Radiation

Make sure that a thermal radiating plate (W30' L30' t5mm) made of aluminum or some other high thermal conducting materials is mounted to laser diode. The reliability of laser diode is closely linked to junction temperature, so reliability rapidly declines at a higher temperature. Do not overlook thermal radiation.



## 8. Measuring Light Output Power

Use a light power meter to measure light output power of laser diodes. When measuring with APC drive, set a power meter at an angle as shown in the right figure so that a photodiode in a laser diode is not exposed to reflected light from the power meter.



# Laser Safety

The output light from laser diode is visible or invisible, and harmful to a human eye. Avoid looking at the output light of laser diode directly or even indirectly through a lens while oscillating. When an optical axis is to be adjusted to a laser beam and outer optical systems, a laser beam should be observed through an infrared TV camera or other equipment. Particularly when the light is collimated or focused through a lens, safety glasses should be worn and care should be taken to absolutely protect human eyes from the directly entering beam.

**CAUTION- - THE USE OF OPTICAL INSTRUMENTS WITH THIS PRODUCT WILL INCREASE EYE HAZARD.**

Refer to IEC 825-1 and 21 CFR 1040. 10 - 1040. 11 as a radiation safety standard as to laser products.



For further information about any of our products please contact your local distributor or you can contact Global Laser in the UK. Your Local Distributor Is:



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