Lab #9

Light Source Characteristics: Laser Diode Properties

Thorlabs L670P005 670-nm Laser Diode (5mW)

1. Summary of measurements

Threshold current and efficiency

1. Measure the laser diode output power vs. drive current at two different temperatures.

Beam properties

2. Use the camera to measure the divergence angle of the beam for both the parallel and perpendicular directions.
3. Measure the polarization state of the output light.

Spectral properties

4. Measure the output spectrum when the diode is below threshold, at threshold, and operating at the rated current above threshold.
5. Measure the output spectrum at 35^{o}C and at 5^{o}C, when operated at rated output current. Describe the temperature dependence of the output wavelength.

2. New Equipment

For this lab we will be using the laser diode driver and thermoelectric cooler controller. Instruction on their use will be provided in class. The Optical Spectrum Analyzer also is new if you did not use it in the LED lab.

3. Introduction

Laser diodes are perhaps the most important light source found in electro-optical systems. They have high brightness, good efficiency, low cost and can be directly modulated to impress information on the light beam. Laser diodes are found in everything from laser printers to long-haul communication systems.

In this lab we will investigate several features of a Thorlabs L670P005 670-nm laser diode, including output power vs. current, spatial beam properties, spectral properties and temperature dependence.

Laser diodes are rather sensitive devices! You must use care when handling these lasers to be sure that you are grounded to your workspace so you don't kill the device with a static shock. In Montana the air is drier in the winter, and static is very much a problem. A few precautions to observe when handling the laser diode packages:

1) Don't exceed maximum ratings found in the data sheet
2) Use a grounded wrist strap, or remain in contact with the metal tabletop when connecting or disconnecting the cable from the LD.
3) Don't touch the LD package window glass.
4) **Don't look into the beam!!**

4. Measurements

The diode is mounted on a temperature controlled platform, and a 4.5mm focal length asphere is used to collimate the beam. Verify collimation before beginning your experiments. You can adjust the collimation by rotating the threaded lens holder (you'll need a spanner wrench to do this).

Threshold current and efficiency

1. At room temperature (25^{o}C) measure the output power of the laser diode vs. drive current. Plot your results. From a linear fit to the active region of the curve, calculate the threshold current and slope efficiency. What is the quantum efficiency of the laser diode? At the rated power of 5 mW, what is the wall plug efficiency?
2. Measure the output power vs. drive current at 5^{o}C, and calculate the threshold current for this temperature. Plot your results on the same axes as the results of the measurement made at 25^{o}C.

Beam properties

3. Use the camera to measure the divergence angle of the beam for both the parallel and perpendicular directions. Remember the collimation lens has *f*=4.5mm. What is the ratio of perpendicular to parallel divergence angles? This parameter is often referred to as the "beam ellipticity" (not to be confused with a polarization state). From these divergence angles, calculate the size of the laser mode at the waist. What is the brightness of the laser at the waist?
4. Is the beam polarized? Determine the polarization direction relative to the far field beam shape and the percent polarization (ratio of the light power with dominant polarization to the total light power). Measure the polarization below threshold and above threshold, and discuss any differences.

Spectral properties

5. Measure the room temperature output spectrum when the diode is below threshold, near threshold, and operating at the rated current above threshold. Describe what you see. What is the length of the laser cavity? How good is the side-mode suppression when lasing near the rated current?
6. Measure the output spectrum at 35^{o}C and at 5^{o}C, when operated at rated output current. Describe the temperature dependence of the output spectrum. Does the output wavelength tune smoothly with temperature? What is the range of temperature tuning you can achieve with 30^{o}C temperature range?