Exp. No. 2
P-I Characteristics of Laser Diode (LD)

Aim of experiment

In this experiment, we study and measure the P-I characteristics of laser diode, which used in optical fiber communication as a light source.

Apparatus

1. Laser Diode has a wavelength of 1550 nm a maximum output power of 2mW continues wave. The laser diode is integrated in the Controller LDS 1200.
2. Laser Diode has a wavelength of 980 nm a maximum output power of 100 mW continues wave. The laser diode is integrated in the Controller LDS 1200.
3. InGaAs - PIN photo detector.
4. Si - PIN photo detector.
5. Optical Power meter
6. Oscilloscope
7. IR converter screen 800-1200 nm.

Theory

The role of the optical transmitter is to convert an electrical input signal into the corresponding optical signal and then launch it into the optical fiber serving as a communication channel. The major component of optical transmitter is an optical source. Fiber-optic communication systems often use semiconductor optical sources such as light-emitting diodes (LEDs) and semiconductor lasers because of several inherent advantages offered by them. Some of these advantages are compact size, high efficiency, good reliability, right wavelength range, small emissive area compatible with fiber core dimensions, and possibility of direct modulation at relatively high frequencies [1].

The operating characteristics of semiconductor lasers are well described by a set of rate equations that govern the interaction of photons and electrons inside the active region. The *P–I* curve characterizes the emission properties of a semiconductor laser, as it indicates not only the threshold level but also the current that needs to be applied to obtain a certain amount of power. A typical current Vs optical output power is shown in Fig.(1).

For currents underneath the laser threshold, the spontaneous emission is dominant. Stimulated emission is responsible for the strong increase above the laser threshold. The threshold current can be determined by the point of intersection of the extrapolated characteristic lines of the initial and of the lasing working mode. The rounding of the characteristic line is the result of spontaneous emission. It also is the cause for the oscillation of several modes next to the threshold. At higher currents, the mode spectrum becomes more and more clean.

In other words, below the threshold current the optical output power of the laser is essentially zero, any photon emissions are due to spontaneous transitions in the laser's semi-conducing material. Once the applied current crosses the threshold, value the output power rises considerably. The slope of the current Vs power curve above the threshold is a measure of how good the laser is at converting electrical power to optical power otherwise known as the external quantum efficiency.

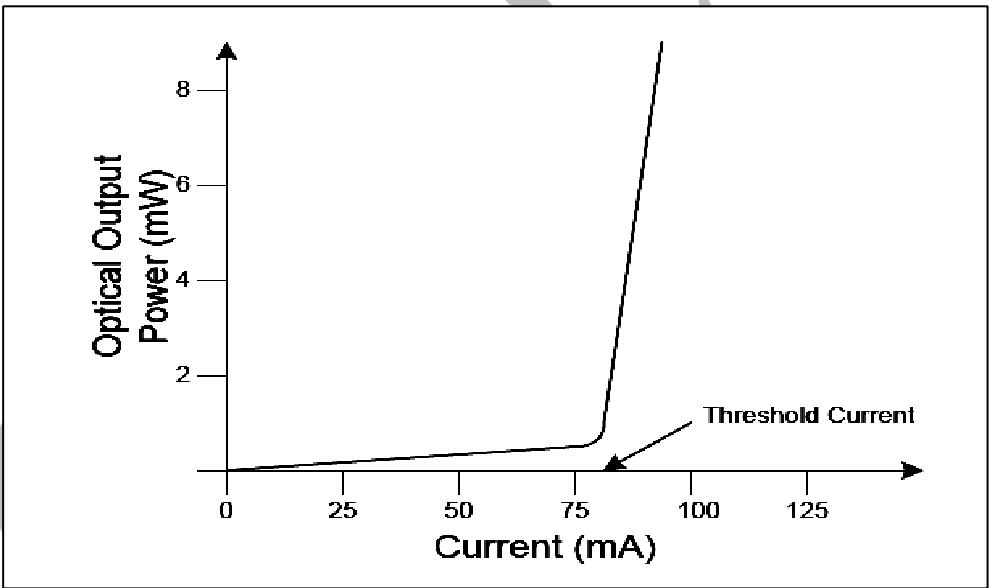
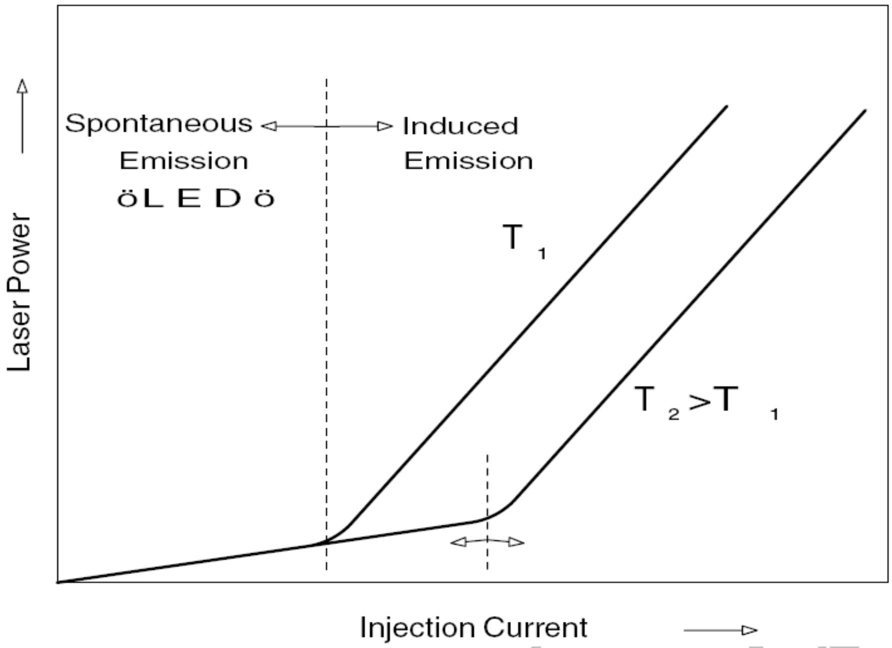


Fig.(1): Typical laser diode response plot

The laser performance degrades at high temperatures. The threshold current is found to increase exponentially with temperature, i.e.,

$$I_{\mathrm{th}}(T) = I_0 \exp(T/T_0)$$

The strong dependence of the current and the output power on the temperature are typical for a semiconductor shown in figure below.



The wavelength increases with increasing temperature. The reason for this is that the refractive index and the length of the active zone, respectively the resonator, increase with increasing temperature. Beyond a certain temperature, the mode does not fit anymore into the resonator and another mode, which faces conditions that are more favorable, will start to oscillate [2].

A similar behavior is observed for the variation of the injection current and in consequence for the laser output power. Here the change in wavelength is mainly the result of an increase in the refractive index, which again is influenced by the higher charge density in the active zone. A higher output power provokes also a higher loss of heat and an increase in temperature of the active zone.

Procedure

6. Connect the optical fiber to the 1550nm laser diode which integrated in the controller LDS 1200.
7. Connected second end of optical fiber to the InGaAs - PIN photo detector
8. Connect the photo detector to the BNC socket ‘Photo Diode Input’ at the rear panel of the controller LDS 1200. Then connect an oscilloscope or a digital voltmeter to the BNC socket ‘Photo Diode Output’.
9. Switch on the controller LDS 1200 by its main switch at its backside. After a few seconds of self-testing, the unit is ready for use.
10. Switch on the laser diode by turning the key switch at the front of the controller to the ‘On’ position.
11. Change the injection current in steps and record the voltage of photo diode as in table below.

I_{LD}(mA)	0								
V_{PIN} (V)									

I_{LD}(mA)									
V_{PIN} (V)									

12. Switch on the modulation of the laser diode. Then select modulation type is triangle.
13. Connect one channel of the oscilloscope to the modulator output BNC socket and the Photo diode output BNC socket to the second channel of the oscilloscope.
14. Display and optimize two signals on the oscilloscope, then switch oscilloscope to XY mode.
15. Plots curve on the graph paper.
16. Repeat steps (1-10) for 980 nm laser diode.

Discussion

1. Comment on your results
2. Why we use the laser diode in optical communication rather than the other types of laser?
3. Explain the relation between the injection current and temperature and output power.
4. Discuss the operation of the laser diode with constant wavelength operation.
5. Why the wavelength increased with increase temperature?

References

1. Govind P. Agrawal," Fiber-Optic Communication Systems", John Wiley & Sons, Inc, 2002.
2. User Manual , "EXP-12: fiber optics", MEOS Com.
3. User Manual , "Laser Education Kit CA-1920 Wavelength Division Multiplexing ", MICOS Com., Germany.