Engineering Physics

(PHY1701)

Dr. B. Ajitha

Assistant Professor
Division of Physics
VIT University
Chennai, India
ajitha.b@vit.ac.in

Module-7: Optoelectronic Devices & Applications of Optical fibers

Contents

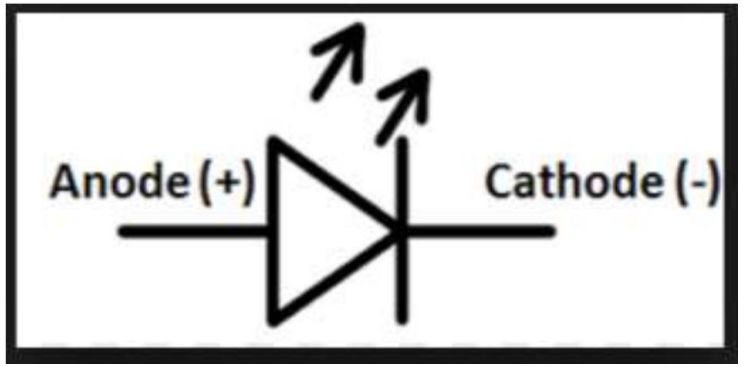
- Introduction to Semiconductors,
- Sources-LED & Laser Diode,
- Detectors, Photodetectors- PN & PIN (AG 209, 235, 238),
- Applications of fiber optics in communication, and
- Endoscopy*

*: Self Study

❖ Introduction to Fiber Optics, Ajoy Ghatak and K. Thyagarajan, Cambridge University Press, 2010 (AG)

LASER DIODE

- LASER stands for Light Amplification by Stimulated Emission of Radiation.
- A laser diode is an electronic device, which converts electrical energy into light energy to produce high-intensity coherent light.
- Laser diode is very small in size and appearance.
- It is similar to a transistor and has operation like LED but it emit coherent light.
- The material which often used in Laser diode is the gallium Arsenide (GaAs).
- It is also called injection laser diode.
- It work on forward biasing.

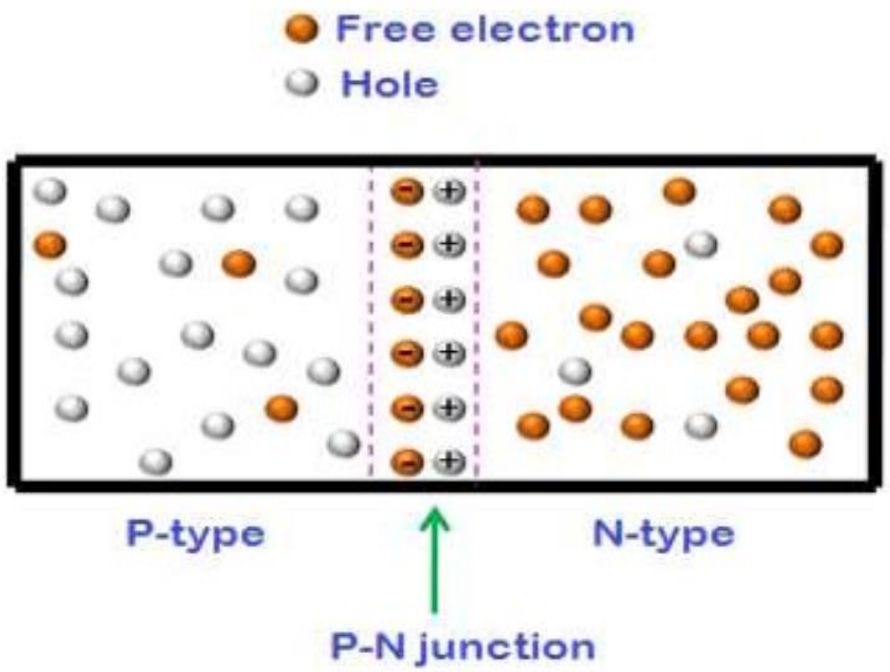


LASER DIODE CONSTRUCTION

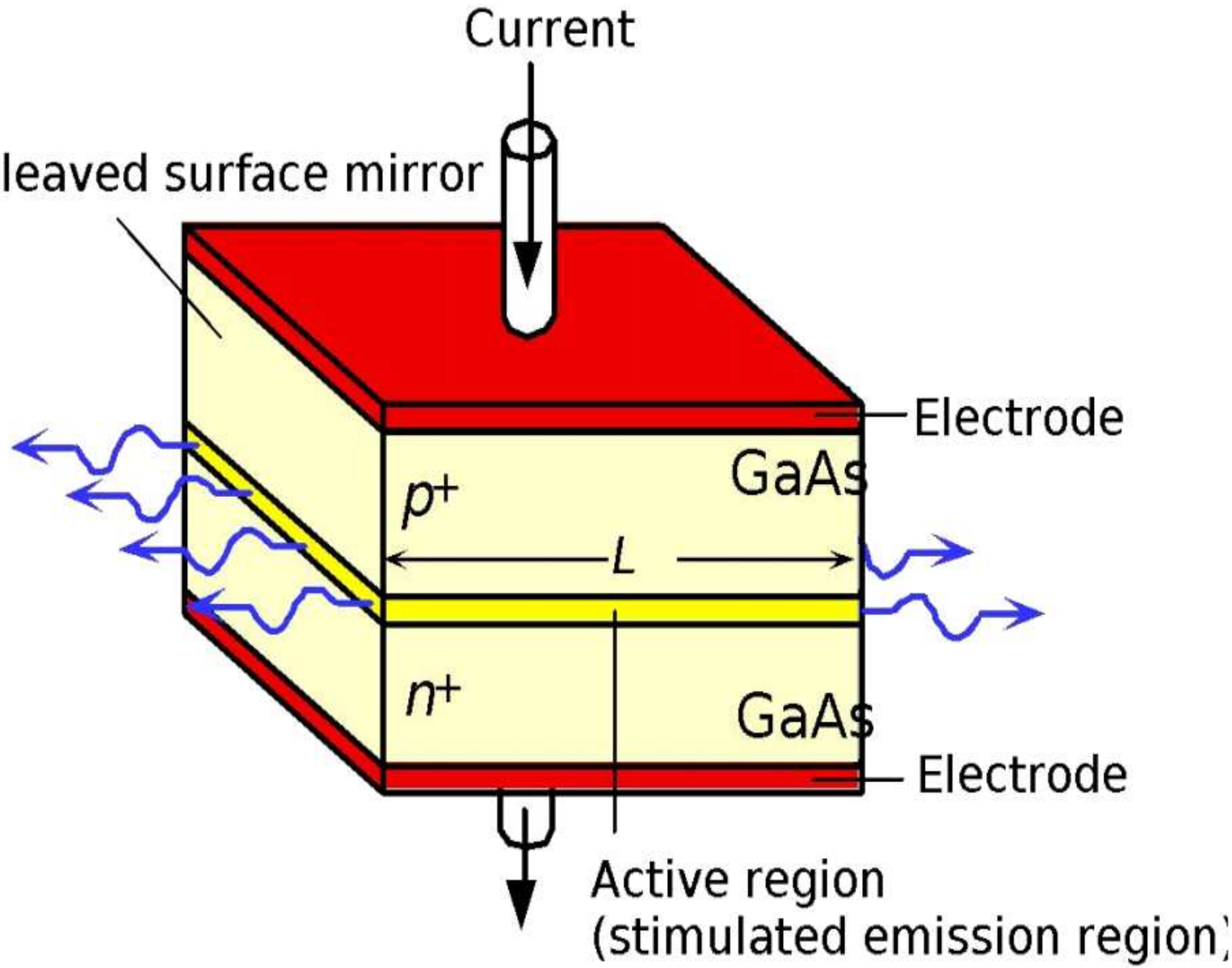
- The laser diode is made of two doped gallium arsenide layers. One doped gallium arsenide layer will produce an n-type semiconductor whereas another doped gallium arsenide layer will produce a p-type semiconductor. In laser diodes, selenium, aluminum, and silicon are used as doping agents.

P-N junction

- When a p-type layer is joined with the n-type layer, a p-n junction is formed. The point at which the p-type and n-type layers are joined is called p-n junction. The p-n junction separates the p-type and n-type semiconductors.



LASER DIODE CONSTRUCTION



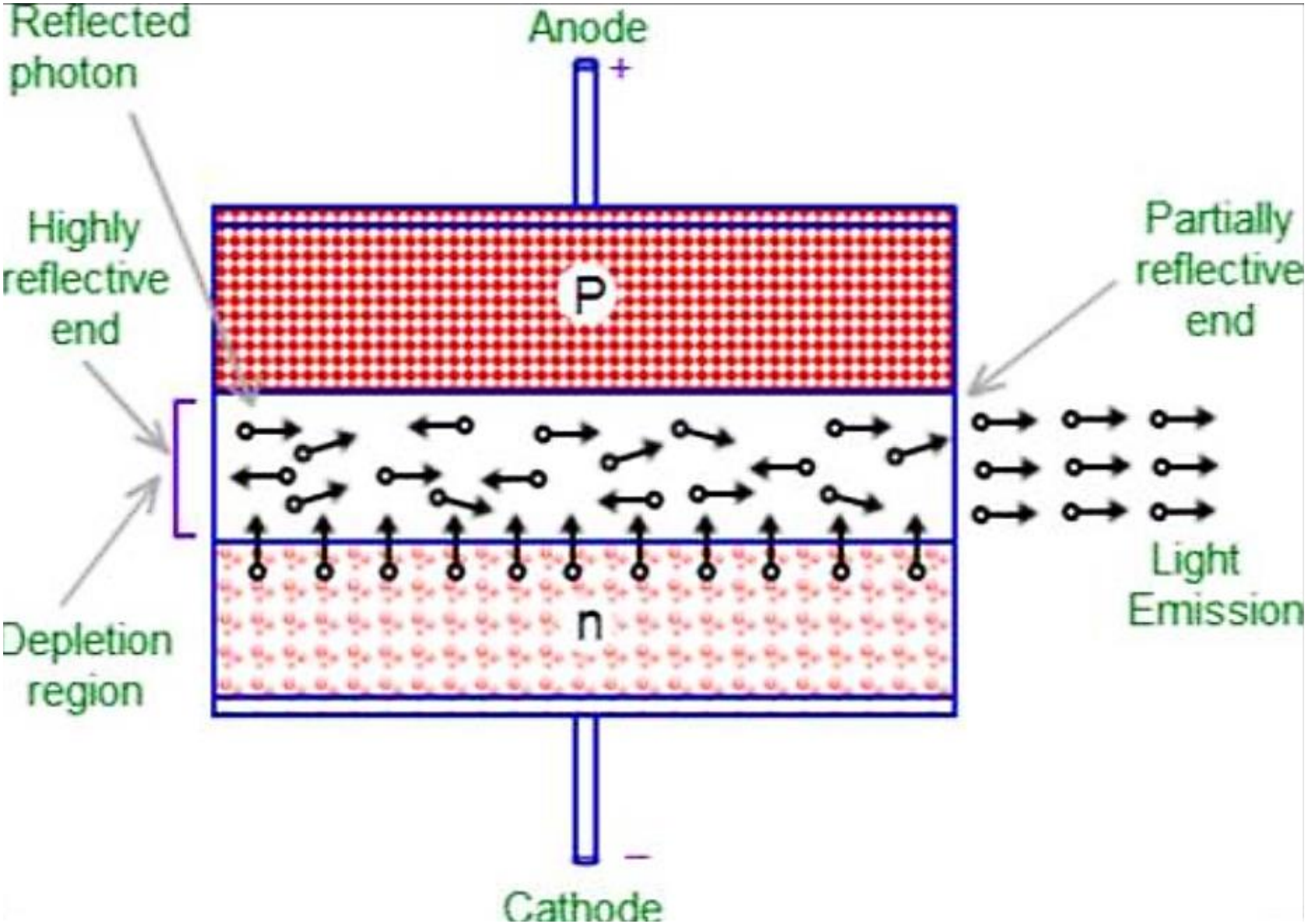
LASER DIODE WORKS

- When DC voltage is applied across the laser diode, the free electrons move across the junction region from the n-type material to the p-type material.
- In this process, some electrons will directly interact with the valence electrons and excites them to the higher energy level whereas some other electrons will recombine with the holes in the p-type semiconductor and releases energy in the form of light. This process of emission is called spontaneous emission.
- The photons generated due to spontaneous emission will travel through the junction region and stimulate the excited electrons (free electrons).
- As a result, more photons are released. This process of light or photons emission is called stimulated emission. The light generated due to stimulated emission will moves parallel to the junction.

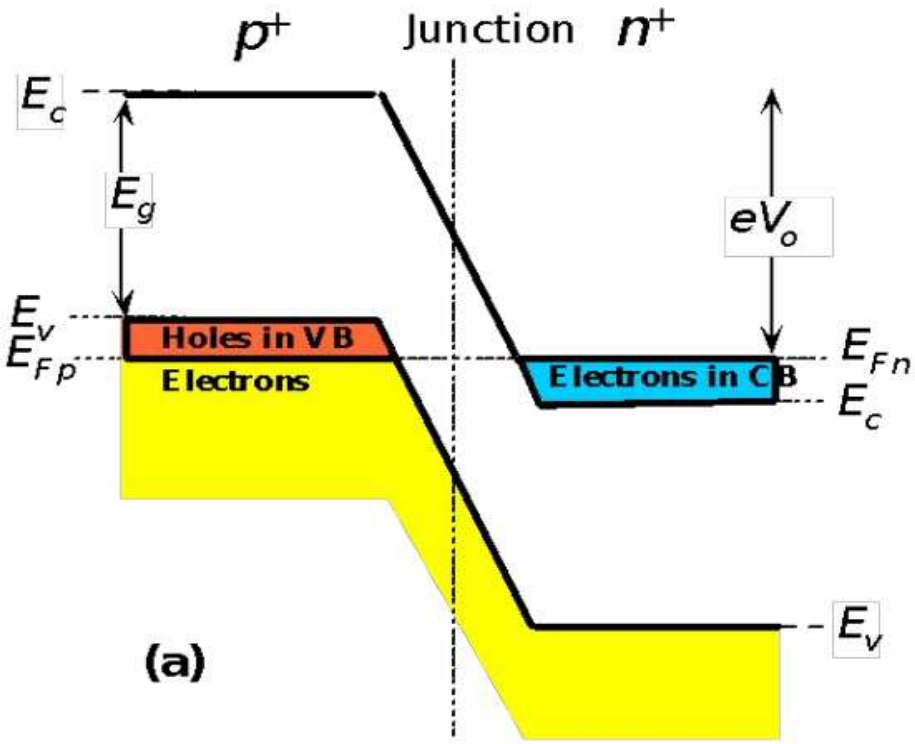
LASER DIODE WORKS

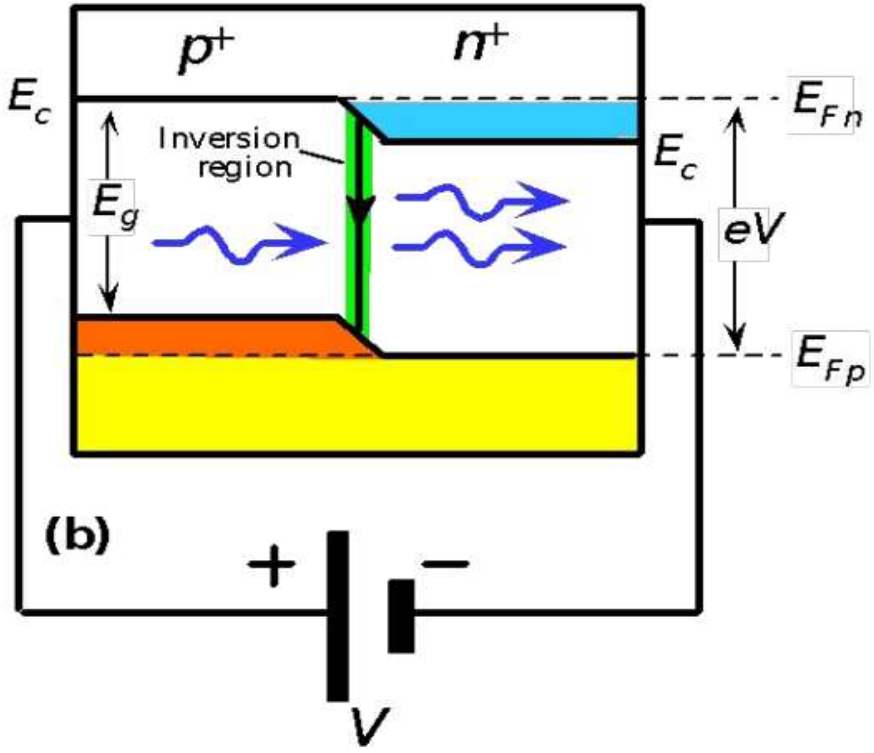
- The two ends of the laser diode structure are optically reflective. One end is fully reflective whereas another end is partially reflective.
- The fully reflective end will reflect the light completely whereas the partially reflective end will reflect most part of the light but allows a small amount of light.
- The light generated due to the stimulated emission is escaped through the partially reflective end of the laser diode to produce a narrow beam laser light.
- All the photons generated due to the stimulated emission will travel in the same direction. Therefore, this light will travel to long distances without spreading in the space.

FORWARD BIASED LASER DIODE



ENERGY BAND DIAGRAM OF LASER DIODE



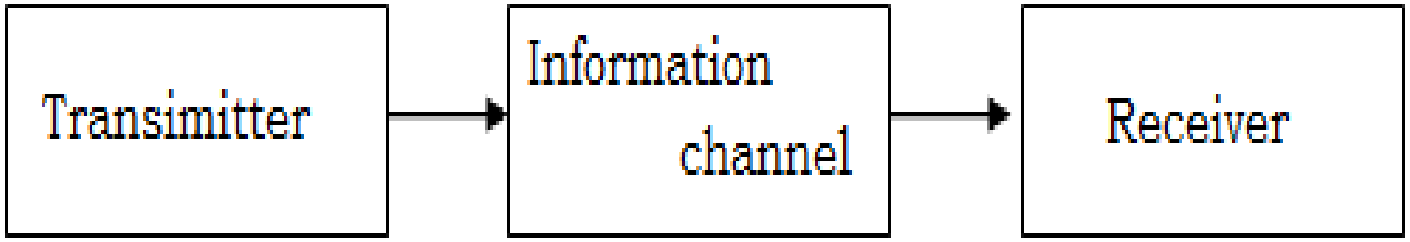


ADVANTAGES and DISADVANTAGES

- ✓ Simple construction
- ✓ Lightweight
- ✓ Very cheap
- ✓ Small size
- ✓ Highly reliable compared to other types of lasers.
- ✓ Longer operating life
- ✓ High efficiency
- ✓ Mirrors are not required in the semiconductor lasers.
- ✓ Low power consumption
- ➢ Not suitable for the applications where high powers are required.
- ➢ Semiconductor lasers are highly dependent on temperature

Fiber Optic Communication Systems

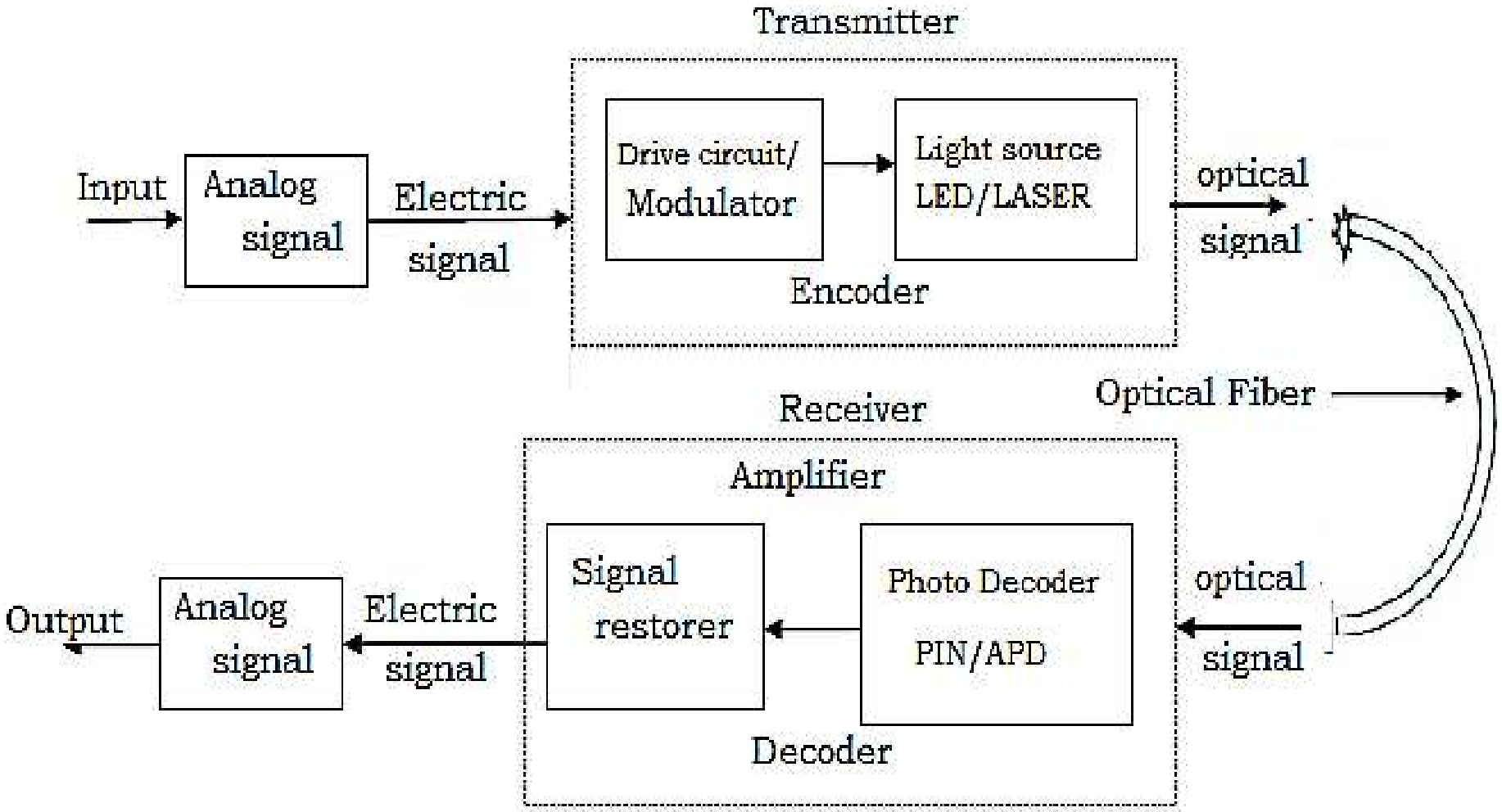
An optical communication system consists of three important parts. They are 1. Transmitter 2. Optical fiber 3. Receiver



The Information signal source

The Information signal source may be voice, music, video signals etc. which is in the analog from to be transmitted is converted from analog signal to electrical signal.

Block Diagram of Optic Communication Systems



Transmitter

The transmitter consists of a drive circuit and a source. The drive circuit transfers the electrical input signal into digital pulses and the light source converts that in to optical pulses. The light source usually used is LED. Here the electric pulse modulate the intensity of the light source and are focused on to the optical fiber.

Optical fiber

It acts as a waveguide and transmits the optical pulses towards the receiver by the principle of total internal reflection.

Receiver

The photo detector is a receiver which receives the optical pulses and converts it into electrical pulses. Further the signals are amplified by an amplifier. These electrical signals are decoded. i.e converted from digital to analog signals. Thus the original electrical signal is obtained, in analog form, with the same information.

In this way information is transmitted from one to other end.