3.5 TYPES OF LASERS

Lasers can be divided into gas lasers, solid state lasers and liquid lasers according to the active medium used.

Gas Lasers:

Gas Lasers can be further divided into neutral atom, ion and molecular lasers, whose lasing mediums are neutral atoms, ions or gas molecules respectively.

1. Helium –neon Laser.
2. Carbon dioxide laser

1. Helium –Neon Laser.

Helium-neon (He-Ne) laser is a kind of neutral atom gas laser, the common wavelength of a He-Ne laser is 632.8 nm, it is tunable from infrared to various visible light frequencies. He and Ne are mixed according to certain percentage, pumping is by DC electrical discharge in the low pressure discharge tube. First He atom is excited. Because Ne atom has an energy level very near to an energy level of He, through kinetic interaction, energy is readily transferred from He to Ne, and Ne atom emit the desired laser light. The typical power of He- Ne laser is below 50 mW, it is widely used in holography, scanning, measurement, optical fiber communication, etc. It is the mostpopular visible light laser.

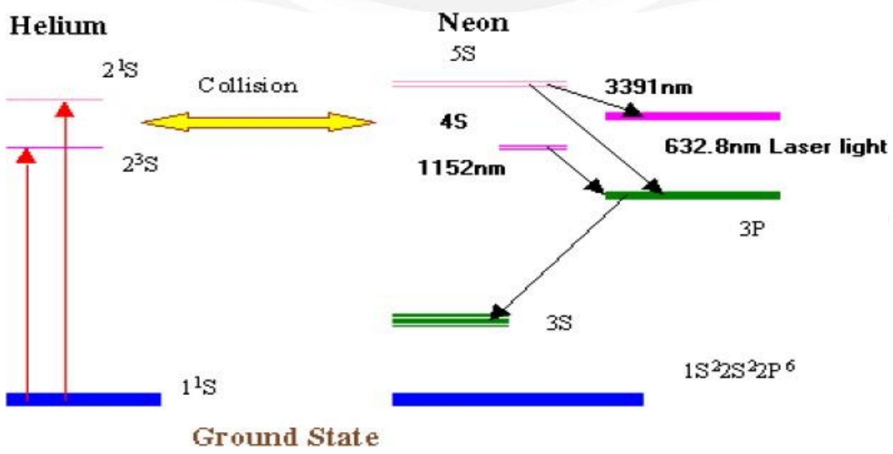

Figure 3.5.1 Helium Neon Laser

[Source: "Optical Fibre Communications" by J.M.Senior, Page:422]

2. Carbon Dioxide laser

Carbon dioxide laser is a typical molecular gas laser, it emits laser light at a wavelength of 10.6 m m, its beam power ranges from several watts to 25 kW or even to 100 kW, so CO2 laser is widely used in laser machining, welding and surface treating. For this reason, let's investigate it in detail. The active medium of CO2 laser is a mixture of CO2, helium and nitrogen gases, the approximate constitute is CO2:N2:He::0.8:1:7. Pumping is realized by AC or DC electrical discharge. First most of the electrical discharge energy is absorbed by nitrogen gas, only a small part of the energy is Absorbed by CO2 molecules directly which raise them from ground state (000) to upper state (001). Large amounts of CO2 molecules collide with the nitrogen molecules and gain the excitation energy. Once excitation is achieved, the CO2 molecules at (001) state will give out energy and jump to lower energy state (100) or (020), thus giving out laser light at frequency 10.6m m or 9.6 m m respectively. The remaining decay from state (100) to (010), (020) to (010) or (010) to ground state (000) will dissipate energy in the form heat instead of light.

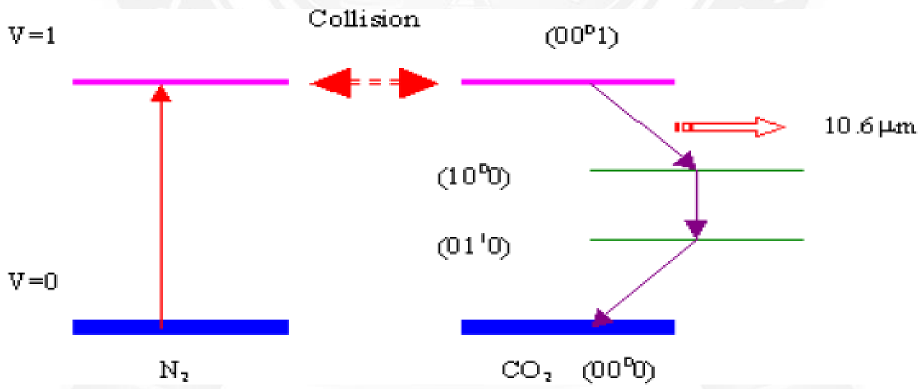

Figure 3.5.2 Carbon Dioxide Laser

[Source: "Optical Fibre Communications" by J.M.Senior, Page:424]

Solid Lasers

In solid state lasers, ions are suspended in crystalline matrix to generate laser light. The ions emit electrons when excited, the crystalline matrix spread the energy among the ions. The first solid state laser is ruby laser, but it is no longer used because of its low efficiency. Two common solid state lasers are Nd:YAG lasers and Nd:glass lasers, there structures are very similar. Both use krypton or xenon flash lamps for optical pumping.

For Nd:glass lasers, the glass rod has the advantage of growing into larger size than YAG crystals, but the low thermal conductivity of glass limits the pulse repetition rate of Nd:glass laser. So Nd:glass lasers are used in applications which require high pulse energies and low pulse repetition rates. It is suitable for hole piercing and deep keyhole welding operations.

YAG crystal has a higher thermal conductivity than glass, so the thermal dissipation in Nd:YAG laser cavity can be improved, operation power can be up to several hundred watts in continuous mode, and high pulse rates (50kHz) can be reached. YAG is a complex crystal of Yttrium-Aluminium-Garnet with chemical composition of Y3Al5O12, it is transparent and colorless. About 1% Nd3+ ions are doped into the YAG crystal, the crystal color then changed to a light blue color. The wavelength of Nd:YAG laser is 1.06m m.Solid state lasers are widely used in laser machining.

Liquid Lasers

Liquid Lasers use large organic dye molecules as the active lasing medium. These laserscan lase in a wide frequency range, i.e. they are frequency tunable. The spectral range of dyes covers infrared, visible and ultraviolet light. Pumping is by another pulsed/continuous laser, or by pulsed lamp. These lasers are used in spectroscopic investigation and photochemical experiments.

Semiconductor Lasers.

PN-junction Laser: A semiconductor laser is a specially fabricated pn junction device (both the p and n regions are highly doped) which emits coherent light when it is forward biased. It is made from Gallium Arsenide (GaAs) which operated at low temperature and emits light in near IR region. Now the semiconductor lasers are also made to emit light almost in the spectrum from UV to IR using different semiconductor materials. They are of very small size (0.1 mm long), efficient, portable and operate at low power. These are widely used in Optical fibre communications, in CD players, CD-

ROM Drives, optical reading, laser printing etc. p and n regions are made from same semiconductor material (GaAs). A p type region is formed on the n type by doping zinc atoms. The diode chip is about 500 micrometer long and 100 micrometer wide and thick. the top and bottom faces has metal contacts to pass the current. the front and rare faces are polished to constitute the resonator

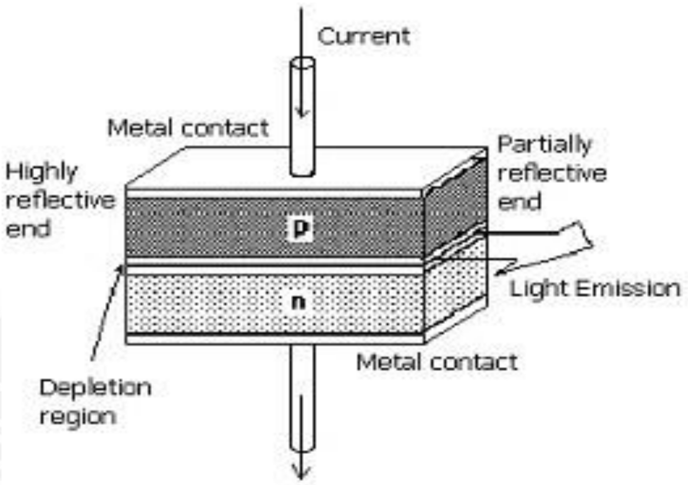

Figure 3.5.2 Semiconductor Laser

[Source: "Optical Fibre Communications" by J.M.Senior, Page:431]

When high doped p and n regions are joined at the atomic level to form pn-junction, the equilibrium is attained only when the equalization of fermi level takes place in this case the fermi level is pushed inside the conduction band in n type and the level pushed inside the valence band in the p type When the junction is forward biased, at low voltage the electron and hole recombine and cause spontaneous emission. But when the forward voltage reaches a threshold value the carrier concentration rises to very high value. As a result the region "d" contains large number of electrons in the conduction band and at the same time large number of holes in the valence band. Thus the upper energy level has large number of electrons and the lower energy level has large number of vacancy, thus population inversion is achieved. The recombination of electron and hole leads to spontaneous emission and it stimulate the others to emit radiation. Ga As produces laser light of 9000 Å in IR region.

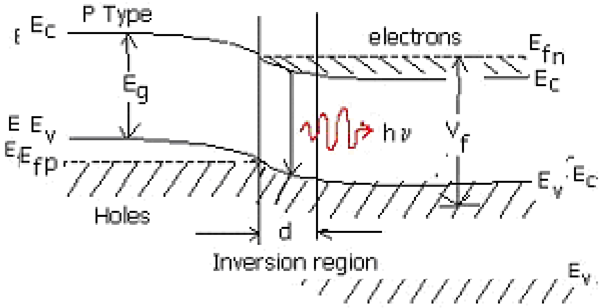

Figure 3.5.1 **Energy Level Diagram of Semiconductor laser**

[Source: "Optical Fibre Communications" by J.M.Senior, Page:428]