(1.) Explain the construction and components of a Laser? Briefly explain about the working of Ruby Laser?

Ans:-

/* Laser is an acronym of "Light Amplification by Stimulated Emission of Radiation". Laser light is entirely different from the ordinary light in the case of intense brightness, high coherence & chromaticity.

A laser has mainly three components.

[Draw figure, Page No: 180, Text book]

1. Energy Source:-

Energy from the source is used for the initial excitation of atoms. It is used for attaining population Inversion.

2. Lasing Medium or Active medium

It is placed in between two reflecting mirror. ~~One mirror is perfectly silvered and the other is partially silvered~~. The medium exists in solid, liquid & gaseous phase.

3. optical cavity:-

It consists of two mirror M1 & M2. One mirror is perfectly silvered. Other one is partially silvered. The photons emitted during stimulated emission undergoes shuttling process between the two mirror and finally emerges through partially

silvered end as lased beam. */

Ruby laser

[Draw figure, page No. 181 of Text book]

It is a three level solid state laser. Ruby is Al_2O_3. since Aluminium & oxygen atoms are inert Ruby is dopped with 0.05% chromium oxide (Cr_2O_3).

Ruby rod exist acts as cylindrical rod. one end is polished and silvered which acts as perfect reflector (100%). The other end is partially silvered. The two ends acts as optical cavity. The ruby cylinder is placed in a cylindrical glass tube. It is surrounded with Xenon flash tube. It supplied the energy for population inversion.

[Draw Energy level diagram, Page No. 182 of Text]

When light is incident chromium ion absorbs of light of wave length $4200\,A^0$ ($G_1 \rightarrow E_2$) and $6000\,A^0$ ($G \rightarrow E_1$) and excited to level E_1 & E_2. The states E_1 & E_2 are of short life time of the order of 10^{-9} s. So Cr^{3+} ions Jumps to Metastable state M which has longer life time. At this stage population Inversion is achieved. As a result a lased beam of $6943\,A^0$ is emitted.

During the next flash of lamp the process (2).
continued again. over heating is controlled by the circulating Liquid Nitrogen over the tube.

Applications

(1) used to study matter & quality of material
(2) used in spectroscopy
(3) used in remote sensing
(4) used for Laser drilling, cutting, trimming etc.

Advantages	Disadvantages
(1) Efficiency can be increased by cylindrical reflectors	(1) output is not continuous
(2) Long life time at narrow line width.	(2) production of high temperature.
	(3) Large input energy is required for operation.

(2) Explain the construction & working of He-Ne Laser?

[As introduction write the components of Laser given along with Ruby laser]

[Draw figure, Page No. 15H of Text book]

It involves four level pumping Mechanism. mixture of He & Ne acts as the Lasing Medium. when a discharge is passed through gas ionisation takes place. Negative ions are accelerated to anode and positive ions are accelerated towards cathode. These accelerated

electrons collides with He atoms which is lighter than Ne atoms.

[Draw figure, Page No: 185 of Text book]

Working of He-Ne laser :-

1) The He atoms from F_1 are excited to levels F_2 & F_3
2) The He atoms now collides with Ne atoms and then deexcited to ground level
3) That is Ne atoms are excited to levels E_6 & E_4. They are metastable states having same energy as F_2 & F_3.
4) Successive collisions increases the population in E_4 & E_6 and finally population inversion takes place.
5) Photons emitted during ~~stimulated~~ spontaneous emission stimulates Ne atoms and emission takes place ~~to~~ from E_6 to E_5, E_6 to E_3 and E_4 to E_3.
6) During stimulated emission from E_6 to E_3, a laser beam of 6328 A^0 is emitted. It is in visible region.
7) During the emission from E_6 to E_5 a laser beam of 3.39 Mm emitted. It is in far infra red region.
8) During the emission from E_4 to E_3 a laser beam of 1.15 Mm is emitted in the far infra red region.
9) Finally the Ne atoms produces spontaneous emission of wavelength 6000 A^0 and reaches level E_2.

10) The Ne atoms at level E_2 collides with walls of tube and reaches ground state. (5)

(3) Explain the working of Neodymium Laser?
[Nd:Yag Laser]

[Draw, figures, Energy level diagram from page No. 187 & 188 of Text]
[write Introduction from Ruby laser]

The active medium is an Nd:YAG rod. In this YAG ($Y_3Al_5O_{12}$) is dopped with neodymium ions. Neodymium ions replaces yttrium ions because they have same size.

The length of rod is 1m and it's diameter is from 1/4 to 6 mm. The tube is placed at one of the focus of two elliptical reflectors. A Krypton flash tube is placed at the other focus of the elliptical reflectors. one reflector is fully silvered and the other reflector is partially silvered. The rod is placed in a glass Jacket. It is filled with a coolant to avoid excess heat.

① When Krypton arc lamp is switched on Nd ions are excited to upper levels E_H.

② The life time in E_H is small so it undergoes non-radiative transition to level E_3.

③ population Inversion is achieved between E_2 & E_3 and spontaneously emitted photon for lasing action.

④ The photon undergoes shuttling process between the two reflectors and finally emits through the partially silvered end.

⑤ The wavelength of output beam is 1.06 μm.

[write uses & Advantages from page No: 185 of Text book]

(4) Explain the working of semiconducted Laser?

[write the components of Laser as introduction - given along with Ruby laser]

Semiconducted laser is a solid state laser.

Principle :-

The LED light is incoherent. It can be converted to coherent by using suitable material and by proper biasing.

When a forward biased condition is applied to a heavily doped PN Junction diode electrons & holes are injected to the depletion layer.

① The energy band diagram of unbiased pn Jc shows that a part of conduction band and comple part of valence band is filled with electrons.

② The Fermilevel E_{Fn} is lies with in the conduction band and E_{fp} lies inside the valence Band.

③ At thermal equilibrium Fermilevel are uniform across the Junction. The region ABC is filled with electrons and region DEF is filled with holes.

④ When a forward biased condition is applied a current passess through the diode. The electrons from P region are injected to N region. The fermilecel split up and rises in the N region.

⑤ Similarly Number of holes in p region increases and Fermilecel E_{fp} fall down.

⑥ At this stage the size of region ABC & DEF increases. At a particular stage DEF becames just below ABC. The current flowing at this stage is called "Threshold current".

(7) The forward biasing acts as a pumping agent.

(8) When current becomes equal to the threshold current, photons emitted stimulate the electrons to jump to valence band. It produces stimulated emission.

(9) The photon undergoes shuttling between polished faces and Coherent emission takes place.

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(5) Explain Induced absorption, Spontaneous emission & stimulated emission. Derive the relation connecting Einsteins coefficients? [Essay Question]

[Refer Text & Note book] [Draw figures page No: 178]

(6) Define population Inversion? [5 Mark Question]

(7) Explain pumping & different types of pumping Mechanisms [2 Marks Qn]

(8) Explain Holography? How we can Record & Reconstruct Hologram? [Draw figures in the page No: 199 & 200 of Text]

[5 mark Qn]

(9) Explain the principle of Holography? [2 mark]