22nd May, 2024 LEC-17 Wednesday

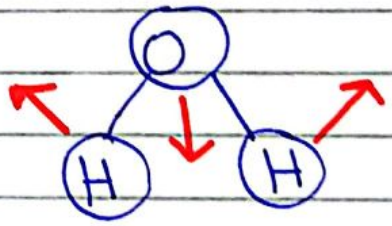
Molecular Gas Lasers

(1) CO_2 Lasers:-

Molecular gas lasers have molecular energy levels (vibrational and rotational) and the transitions between these levels gives us lasers.

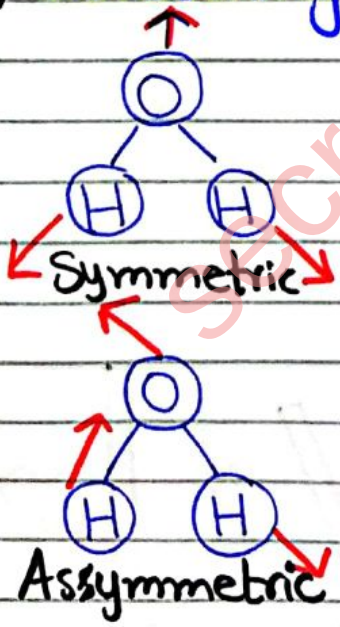
They are relatively easy to construct as compare to other lasers.

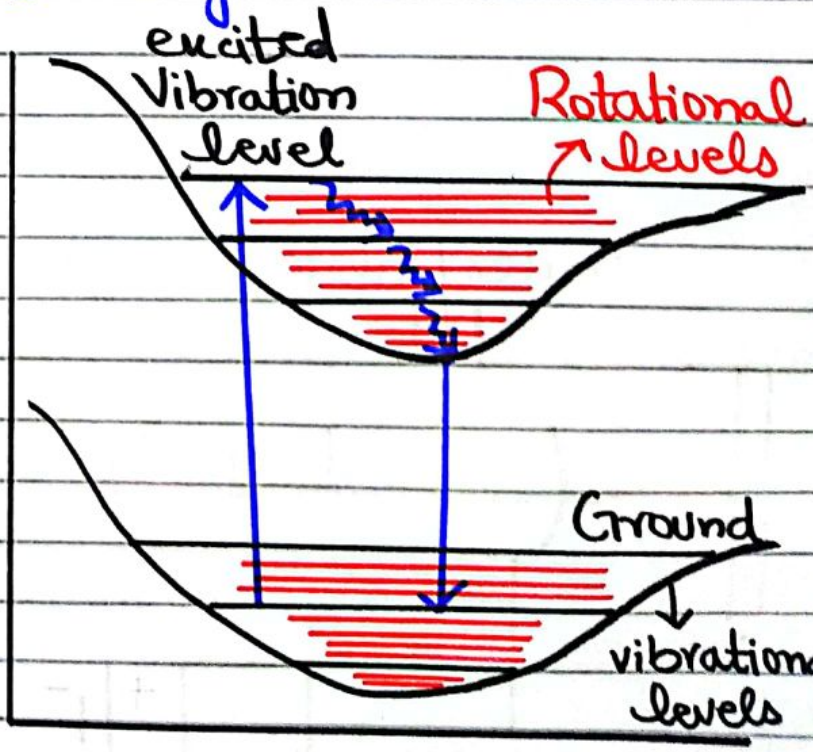
We have studied vibrational and rotational level before,



Types of Vibrations

(1) Stretching (2) Bending



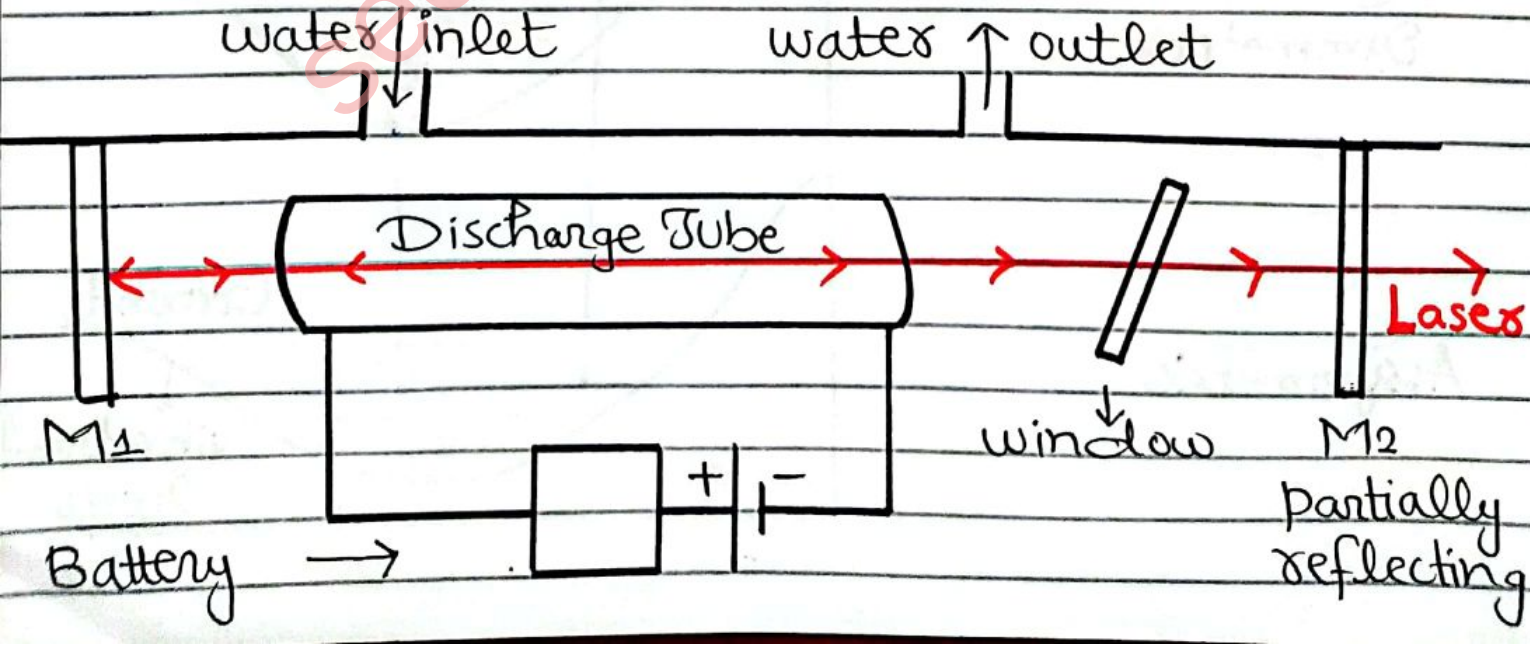


Lasing Medium:-

CO_2 is a type of gas lasers that uses CO_2 as the lasing medium. They are powerful and efficient lasers which are operated through **electrical discharge**. Nitrogen and Helium are used to support

$$CO_2 : N_2 : He$$
$$1 : 4 : 5$$

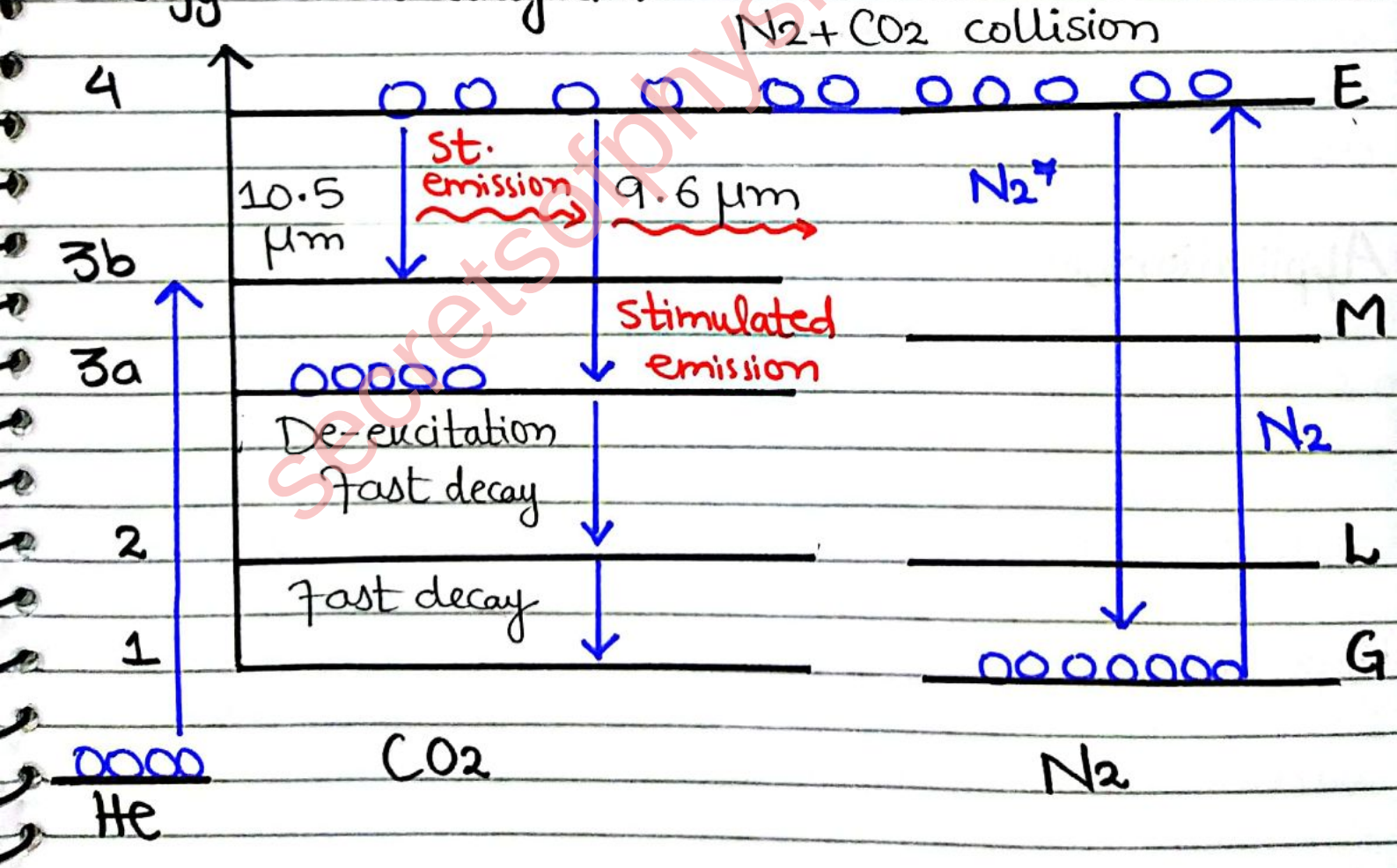
Construction:- We have a discharge tube having CO_2, N_2 and Helium in the ratio 1 : 4 : 5. The discharge tube is connected by an external battery. At both ends we have mirrors, one partially reflecting while other is fully reflective. Water inlet and outlet is used for cooling of the laser cavity. We also have a window on one side of the cavity.



Working:- Initially N_2 atoms goes to excited state and becomes N_2^*. The excited atoms would produce electrons due to discharge. The N_2^* atoms would collide with CO_2 atoms in the ground state. N_2^* gives energy to CO_2 and comes back to ground state.

$$N_2 + e \rightarrow N_2^* \rightarrow N_2^* + CO_2 \rightarrow N_2 + CO_2^* + \Delta E$$

Energy-level diagram



* N_2 From ground level gains e^-s and becomes excited from there, they collide with the CO_2 atoms and after completing their lifetime, they goes to Metastable state 3a or 3b.

* Lasing occurs in 4-3a (9.6 μm)
4-3b (10.5 μm)

* At the same time Helium atoms goes to the meta-stable state, there the only function of Helium atoms is de-excitation of the CO_2 atoms. The CO_2 atoms comes to the lower and ground state by fast decay.

Applications:-

If we have Nd:YAG and CO_2 laser in continuous mode, then CO_2 would be more efficient.

It is used in industries, commercial use and cutting and drilling and in medical applications.

Power:- It's power is in the range 1W to 10KW
It's wavelength is large and easily absorbed by water, ceramic, tissues of human body.

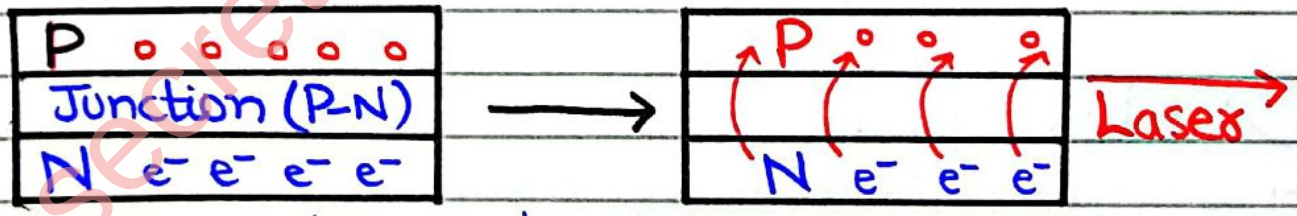
SEMICONDUCTOR LASER

(Also known as laser diodes)

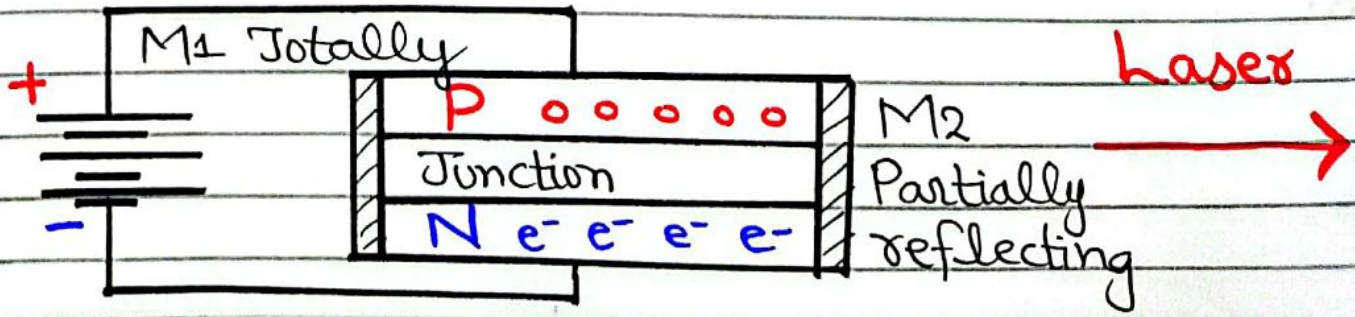
SemiConductors include:- Silicon, Germanium, Zinc oxide (ZnO), Helium Arsenide, Indium phosphide etc.

Semiconductor laser, also known as diode laser, is a type of laser that uses a semiconductor material as the gain medium.

Operating Principle:- These lasers operates on the principle of stimulated emission in a semiconductor which is typically made of **Gallium Arsenide (GaAs)**. When a current is applied to the semiconductor junction, electrons and holes **recombine** releasing photons and generating coherent light.



Some semiconductors emit photons on recombination. Not all do that. So we need to provide external energy for the recombination.



Applications:-

→ They are used in telecommunications (optical communication system).

→ Used in range finding, LIDAR.

→ They are also used in medicines.

Advantages:-

1. They are compact in size and light weight.
2. They are highly efficient and have low power consumption.
3. They can be easily modulated making them better in optical communication.

Disadvantages:-

1. They are temperature sensitive
2. They have limited power output.
3. Light is not fully coherent