CO_2 Laser:

Principle:

The Nitrogen atoms are initially raised to excited state. The Nitrogen atoms delivers the energy to CO_2 molecule. Then, transition takes place between the vibrational energy levels of the CO_2 atoms and hence laser beam is emitted.

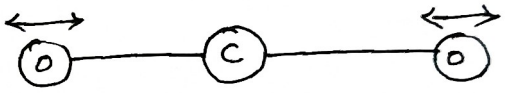
Fundamental modes of vibration of CO_2 molecule:

There are three fundamental modes of vibration.

1. Symmetric Stretching mode
2. Bending mode
3. Asymmetric Stretching mode.

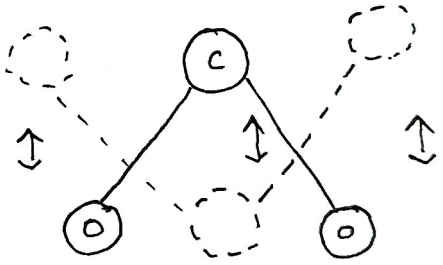
1. Symmetric Stretching mode:

In this mode, carbon atom is at rest. Both oxygen atoms are moving away or approaching the fixed carbon atom simultaneously along the axis of the molecule.



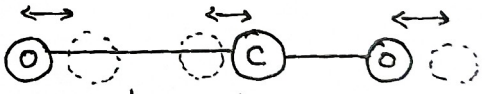
2. Bending mode:

In this mode, both oxygen atoms and carbon atom vibrate perpendicular to molecular axis.



3. Asymmetric Stretching mode:

In this mode, oxygen atoms move in one direction while carbon atom moves in the opposite direction.



Construction:

It consist of a quartz discharge tube of 5m long and 2.5cm in diameter. The tube is filled with the gas mixture of CO_2, N_2 and He with pressure level of 0.33 : 1.2 : 7 mm of Hg.

In the gas mixture

(i) CO_2 – Active center

(ii) N_2 – Helps to transfer the CO_2 laser molecules to higher energy level

(iii) He – Helps to depopulate the CO_2 molecules in lower energy level.

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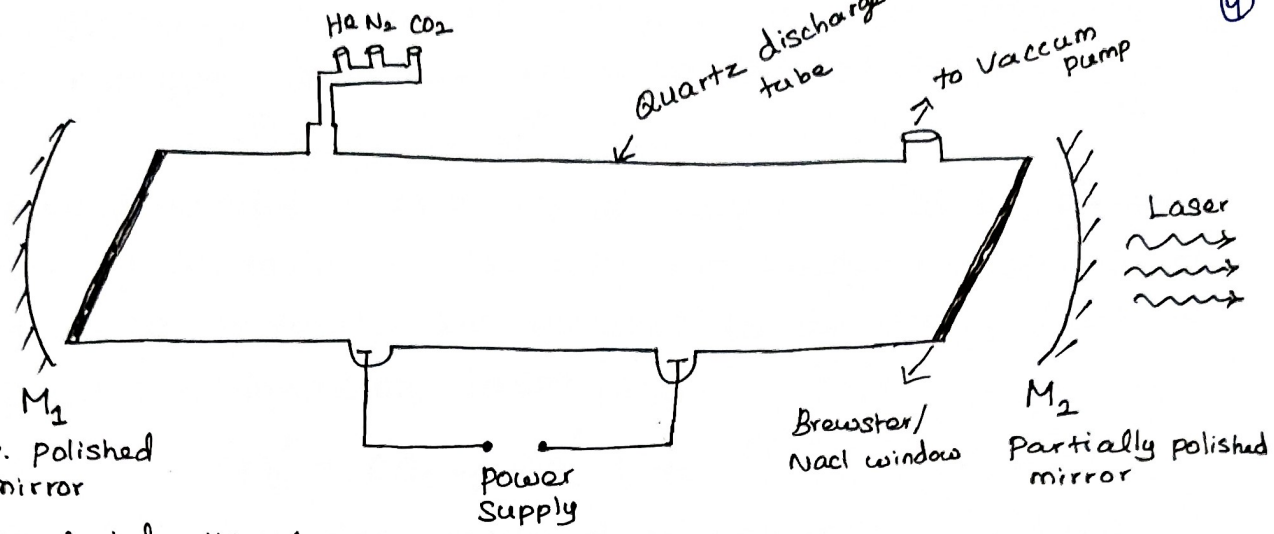
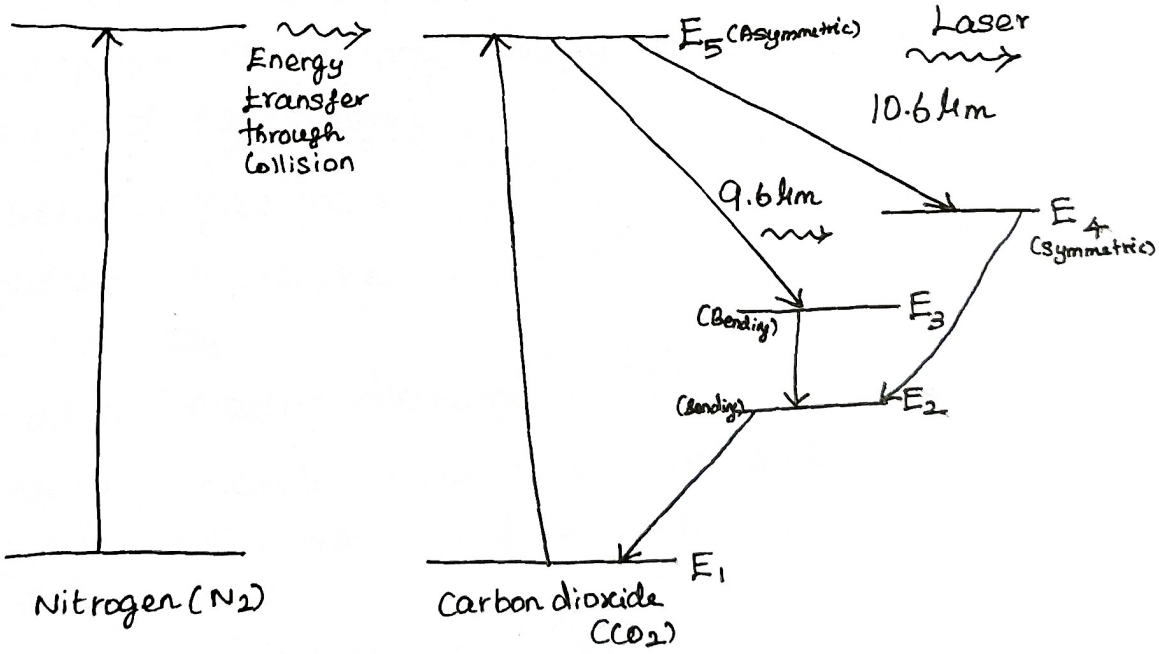


The terminals of the discharge tube are connected to D.C. power supply. At the ends of the tube Brewster windows are placed. So that the laser light generated is plane polarized. The optical resonator is formed with two concave mirrors. They are either Si mirror coated with Aluminium (or) Metallic mirror coated with gold. The output power can be increased by increasing the diameter of the tube.

Working:



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(i) The discharge is passed through the tube first. The Nitrogen atoms are rised to excited state.

$$e^* + N_2 \Rightarrow N_2^* + e$$

(ii) Excited energy level of N_2 is very close to E_5 energy level of CO_2 molecule. So resonant energy transfer takes place. CO_2 molecules are excited to E_5 energy level and population inversion takes place.

$$N_2^* + CO_2 \rightarrow CO_2^* + N_2$$

(iii) When the transition takes place between E_5 to E_4 10.6 μm Laser beam is emitted.

(iv) Similarly, when transition takes place between E_5 to E_3, 9.6 μm Laser beam is emitted.

(v) Normally 10.6 μm transition is more intense than 9.6 μm transition

(vi) $E_4 \rightarrow E_2$ (or) $E_3 \rightarrow E_2$ non-radiative transition takes place after emitting the laser radiation.

(vii) Now, we can find all the CO_2 molecules are in Energy level E_2.

(viii) He gas is used to remove excess energy from the CO_2 molecules and depopulate them from Energy level E_2 to E_1.

Characteristics of CO_2 Laser:

(i) Type : Molecular gas laser

(ii) Active medium : CO_2, N_2, He

(iii) Active center : CO_2

(iv) Pumping method : Electric discharge

(v) Optical resonator : Metallic mirror coated with gold (or) Si mirror coated with Al.

(vi) power output : 10KW

(vii) Nature of o/p : Continuous (or) pulsed.

(viii) o/p wavelength : 9.6 μm (or) 10.6 μm.

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Advantages:

1. Simple Construction
2. out put is pulsed (or) Continuous
3. Efficiency is high.
4. Output power is high.
5. The output power can be increased by increasing the dimensions of the discharge tube.

Disadvantages:

1. To avoid oxygen and carbon monoxide contamination fresh gas can be pumped inside the discharge tube.
2. The operating temperatures plays an important role in the output power of the Laser.
3. The corrosion may occur at the surface of the discharge tube.
4. It is invisible Laser light. Accidental exposure may damage eyes.

Applications:

1. CO_2 Laser is used in material processing, welding, drilling, cutting, soldering etc.,
2. It is suitable for open air communication.
3. It is used in Remote Sensing
4. It is used in the treatment of liver and lung diseases.
5. It is used in neurosurgery and general surgery
6. It is used to perform microsurgery and bloodless operations.

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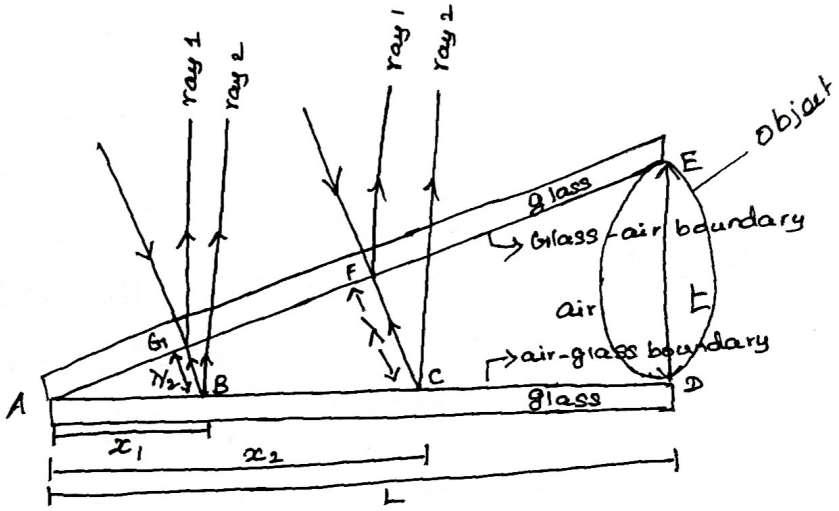
Theory of airwedge and experiment:

Principle:

A thin wedge of air film formed by two glass plates on each other with contact at one edge and separation by a thin material at the opposite edge is known as airwedge.

Theory



When light falls on wedge shaped air film, it gets reflected partially from the glass-air boundary at the top of the air film. The other part of the incident ray transmitted through the air film and gets reflected from the air-glass boundary. The wedge angle is very small, and the rays reflected from the two bounding surfaces interface constructively (or) destructively producing bright and dark fringes.

Let us consider the points G1 and F. They are $\lambda/2$ and λ distance away from the point A. Ray 1 and ray 2 are reflected from top and bottom of the air film. So they have varying path difference. The ray 2 travels more distance than ray-1. Ray-2 undergoes a phase change of π at air to glass boundary due to reflection.

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Let consider the triangles ΔABG & ΔADE

$$\frac{x_1}{\lambda/2} = \frac{L}{t}$$

$$x_1 = \frac{L}{t} \times \frac{\lambda}{2} \quad ; \quad \boxed{x_1 = \frac{L\lambda}{2t}}$$

Let us consider the triangles ΔACF & ΔADE

$$\frac{x_2}{\lambda} = \frac{L}{t}$$

$$\boxed{x_2 = \frac{L\lambda}{t}}$$

The fringe width β = distance between any two constructive or destructive fringes (bright (or) dark)

Fringe width $\beta = x_2 - x_1$

$$\beta = \frac{L\lambda}{t} - \frac{L\lambda}{2t}$$

$$\boxed{\beta = \frac{L\lambda}{2t}}$$

L-is length of the object ; λ – wave length of the light used.
t- thickness of the material.

Experiment:

Two optically plane glass plates are placed one over the other. one end is tied by means of a rubber band. A thin wire is inserted in the another end between the plates. Now, a wedge shaped air film is formed between the two glass plates.

The light from the Sodium vapour lamp is allowed to fall on the 45° glass plate. The light rays are then reflected downwards and are fall on the airwedge arrangement.

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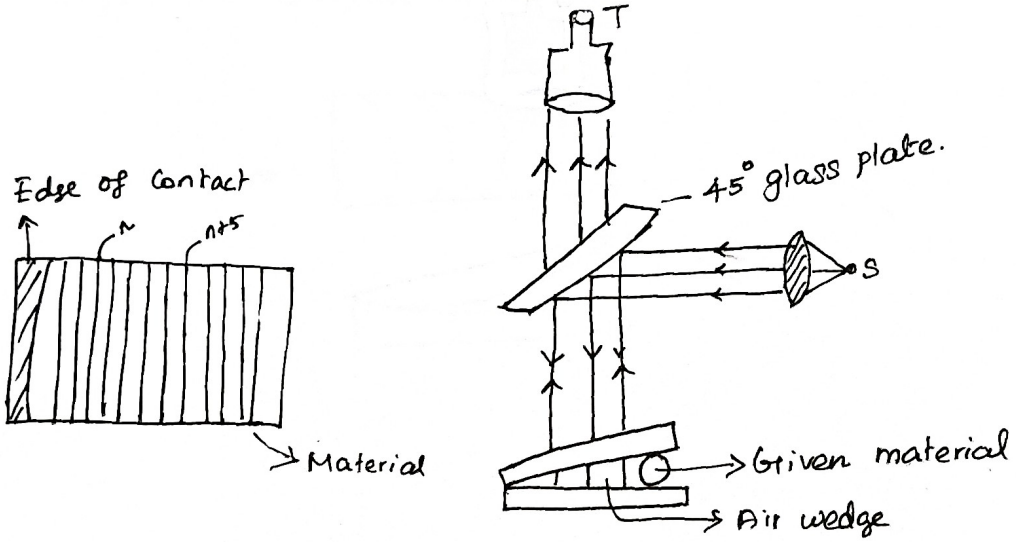
Large number of interference fringes were formed due to interference between the reflected wave from top and bottom surface of the film. The microscope is moved across the fringes using the horizontal transverse screw and the readings are taken for every successive 5 fringes. The width of every 20 fringe is calculated and the width of one fringe is calculated. The mean of this gives fringe width (B)

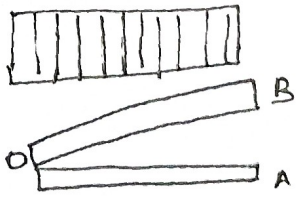


S. No	order of the fringes	Microscope reading	width of 10 fringes	Band width B
	n n+5 n+10 ⋮ n+40			

Testing of flatness (surfaces)

The surface OB which is to be tested is placed in contact with optically flat glass plate OA, and forming an air wedge.

(i) If the fringes are of equal thickness, than the surface OB is said to be flat.



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