AL- Mustaqpal University
Science College
Dep. Medical physics

Medical physics
Third Stage

Lec 8

Types of laser

م . م علي سـلمان حمادي

Lasers are classified into 6 types based on the types of medium used in them, and they are:

- Solid-state lasers.
- Gas lasers.
- Liquid lasers.
- Semiconductor lasers.
- Chemical lasers.
- Metal-vapour lasers.

Lasers are light beams so powerful that they can travel miles into the sky, and they can also cut through the surfaces of metals. Today lasers find applications in various fields and there are different types of lasers with numerous applications.

Solid-State Lasers

The solid-state laser is a type of laser where the medium used is solid. The solid material used in these lasers is either glass or crystalline materials.

Working of Solid-State Laser

Glass or crystalline materials used in a solid-state laser are used as impurities in the form of ions along with the host material. Doping is the term used for The dopants that are used in this type of laser are terbium (Tb), erbium (Eu), and cerium (Ce) which are rare earth elements. The host materials are ytterbium-doped glass, neodymium-doped yttrium aluminium garnet, neodymium-doped glass and sapphire. The most commonly used host material is neodymium-doped yttrium aluminium garnet.describing the process of addition of impurities to the substance.

Application of Solid-State Laser

- The drilling of holes in the metals becomes easy with these lasers.
- The push-type solid-state lasers are used for medical purposes such as for endoscopy.
- They find application in the military and are used in the target destination system.

Advantages of Solid-State Lasers

- These lasers have casts that are economical.
- The construction of a solid-state laser is simple.
- The output can be both continuous and pulsed.
- There is very less or zero chance of material in active medium going waste.
- The efficiency of these lasers is high.

Disadvantages of Solid-State Lasers

- The output of solid-state lasers is not high.
- The divergence of this laser is not constant and varies between 1 milliradian to 20 milliradians.
- There is a power loss in the laser due to heating of the rod.

Gas Lasers

Gas lasers have an active medium made up of one or more gases or vapours. These lasers are classified as:

- Atomic gas lasers which is He-Ne laser
- Molecular gas lasers which is CO_2 laser
- Ion gas lasers that are Argon laser

A gas laser is a laser in which an electric current is discharged through a gas to produce coherent light. The gas laser was the first continuous-light laser and the first laser to operate on the principle of converting electrical energy to a laser light output.

Types of gas laser

Gas lasers using many gases have been built and used for many purposes. Carbon dioxide lasers, or CO_2 lasers can emit hundreds of kilowatts at 9.6 μm and 10.6 μm, and are often used in industry for cutting and welding. The efficiency of a CO_2 laser is over 10%.

Carbon monoxide or "**CO**" lasers have the potential for very large outputs, but the use of this type of laser is limited by the toxicity of carbon monoxide gas. Human operators must be protected from this deadly gas. Furthermore, it is extremely corrosive to many materials including seals, gaskets, etc.

Helium–neon (HeNe) lasers can be made to oscillate at over 160 different wavelengths by adjusting the cavity Q to peak at the desired wavelength. This can be done by adjusting the spectral response of the mirrors or by using a dispersive element (Littrow prism) in the cavity. Units operating at 633 nm are very common in schools and laboratories because of their low cost and near-perfect beam qualities.

Liquid Lasers

Liquid lasers are also known as dye lasers. This is a type of laser in which liquids are used as an active medium. The active material used in the liquid laser is known as a dye and the commonly used dyes are sodium fluorescein, rhodamine B and rhodamine 6G.

Working of Liquid Laser

The active medium in this laser type is organic dye and the solvent used for dissolving the dye is either water, alcohol, or ethylene glycol. The dye is pumped to the capillary tube from the storage tank. This dye leaves the tubes with a flash lamp. The output beam then passes through a Brewster window to the output coupler which is a 50% reflective mirror. The output wavelength can vary to a wide range and the maxim output possible is 618 nm.

Application of Liquid Laser

- These lasers are commonly used for medical purposes as a research tool.

Advantages of Liquid Lasers

- The efficiency is greater by 25%.
- The wavelengths that are produced can be of varied ranges.
- The diameter of the beam is less.
- The beam divergence ranges between 0.8 milliradians and 2 milliradians, which is comparatively lesser than other lasers.

Disadvantages of Liquid Lasers

- These lasers are expensive.
- Tuning a laser to one frequency requires the use of a filter which makes it more expensive than other laser types.
- It is difficult to determine which element is responsible for lases.

Semiconductor Lasers

The semiconductor laser is a type of laser that is small in appearance and size. The operation of this laser is similar to **LED** but the characteristics of the output beam are of laser light. The manufacturing of semiconductor used in semiconductor diode is done uniquely.

Working of Semiconductor Laser

- The active material used in a semiconductor laser is gallium arsenide and therefore, the laser is also known as Gallium Arsenide Laser.
- The working of a semiconductor laser is similar to the **PN** diode in forward biased condition. The **PN** material is connected to the DC power supply with the help of the metal contacts. The semiconductor laser is also known as the Injection Laser because the current is injected into the junction between **P** and **N** material.

Application of Semiconductor Lasers

- This laser is a transmitter of digital data naturally as the laser can be pulsed at different rates and pulse widths.
- These lasers find applications in optic cable communication.

Advantages of Semiconductor Lasers

- They find many applications due to their small size and appearance.
- These lasers are economical.
- There is no use of mirrors.
- The power consumption is low.

Disadvantages of Semiconductor Lasers

- The divergence of the beam is more than 125 to 400 milliradians which is greater than other laser types.
- The output beam has an unusual shape as the medium used is short and rectangular.
- The working of this laser type is dependent on the temperature.

Chemical lasers

Chemical lasers are powered by a chemical reaction and can achieve high powers in continuous operation. For example, in the hydrogen fluoride laser (2.7–2.9 μm) and the deuterium fluoride laser (3.8 μm) the reaction is the combination of hydrogen or deuterium gas with combustion products of ethylene in nitrogen trifluoride.

Chemical lasers are powered by a chemical reaction permitting a large amount of energy to be released quickly. Such very high power lasers are especially of interest in various industries. Further, continuous-wave chemical lasers at very high power levels, fed by streams of gasses, have been developed and have some industrial applications.

Metal-vapor lasers

Metal-vapor lasers are gas lasers that typically generate ultraviolet wavelengths. Helium-silver (HeAg) 224 nm, neon-copper (NeCu) 248 nm and helium-cadmium (HeCd) 325 nm are three examples. These lasers have particularly narrow oscillation linewidths of less than 3 GHz (500 femtometers).

The Copper vapor laser, with two spectral lines of green (510.6 nm) and yellow (578.2 nm), is the most powerful laser with the highest efficiency in the visible spectrum.

Discussion

1. How are lasers classified?

A) By size

B) By power

C) By medium ✔

D) By shape

E) By color

2. Medium of solid-state lasers?

A) Gas

B) Dye

C) Solid ✔

D) Chemical

E) Plasma

3. Common dopant in solid-state lasers?

A) Sodium

B) Terbium ✔

C) Neon

D) Oxygen

E) Hydrogen

4. Host material in Nd:YAG laser?

A) Glass

B) Silicon

C) Yttrium aluminium garnet ✔

D) Gallium arsenide

E) Sapphire

5. Medical use of solid-state lasers?

A) Welding

B) Endoscopy ✔

C) Surgery

D) Cutting steel

E) Astronomy

6. Efficiency of solid-state lasers?

A) Low

B) Very low

C) High ✔

D) Medium

E) None

7. Main disadvantage of solid-state lasers?

A) No output

B) Expensive

C) Heating loss ✔

D) Toxic

E) Fragile

8. Active medium of gas lasers?

A) Solid

B) Dye

C) Gas ✔

D) Liquid

E) Plastic

9. Example of atomic gas laser?

A) CO2

B) He-Ne ✔

C) Argon

D) Copper

E) HF

10. Example of molecular gas laser?

A) He-Ne

B) Argon

C) CO2 ✔

D) Copper

E) Sodium

11. Example of ion gas laser?

A) CO2

B) Helium

C) Argon ✔

D) Sodium

E) HF

12. Efficiency of CO2 lasers?

A) 2%

B) 5%

C) 10% ✔

D) 50%

E) 100%

13. Dangerous gas laser type?

A) Argon

B) Helium

C) CO ✔

D) CO2

E) Ne

14. Wavelength of He-Ne laser?

A) 325 nm

B) 510 nm

C) 633 nm ✔

D) 1064 nm

E) 578 nm

15. Liquid lasers are also called?

A) Ion lasers

B) Solid lasers

C) Dye lasers ✔

D) Metal lasers

E) Argon lasers

16. Example of dye in liquid lasers?

A) Oxygen

B) Rhodamine ✔

C) Sodium

D) Argon

E) Copper

17. Solvent used in dye lasers?

A) Water ✔

B) Oil

C) Gas

D) Plasma

E) Air

18. Max output of liquid laser?

A) 325 nm

B) 633 nm

C) 618 nm ✔

D) 510 nm

E) 1064 nm

19. Active medium of semiconductor lasers?

A) Nd:YAG

B) Argon

C) Gallium arsenide ✔

D) Rhodamine

E) Helium

20. Another name for semiconductor laser?

A) Dye laser

B) Injection laser ✔

C) Argon laser

D) CO2 laser

E) Solid laser

21. Major use of semiconductor laser?

A) Welding

B) Optic communication ✔

C) Cutting

D) Endoscopy

E) Surgery

22. Beam divergence of semiconductor laser?

A) 1–2 mrad

B) 20 mrad

C) 125–400 mrad ✔

D) 0.5 mrad

E) 50 mrad

23. Power source of chemical lasers?

A) Sunlight

B) Battery

C) Chemical reaction ✔

D) Electricity

E) Heat

24. Example of chemical laser?

A) He-Ne

B) Argon

C) HF laser ✔

D) CO laser

E) Nd:YAG

25. Copper vapor laser wavelength?

A) 325 nm

B) 633 nm

C) 510 & 578 nm ✔

D) 1064 nm

E) 224 nm

26 . Application of solid-state laser?

A) Drilling metals ✔

B) Cutting glass

C) Tattoo removal

D) Data storage

E) Printing

27. Medical use of solid-state lasers?

A) Surgery

B) Endoscopy ✔

C) Welding

D) Barcode scanning

E) Holography

28. Military use of solid-state lasers?

A) Welding

B) Range finding

C) Targeting ✔

D) Cutting

E) Surgery

29. Advantage of solid-state lasers?

A) Cheap ✔

B) Heavy

C) Toxic

D) Fragile

E) Slow

30. Disadvantage of solid-state lasers?

A) High efficiency

B) No heat loss

C) Heating of rod ✔

D) Perfect beam

E) Large output

31. Application of CO2 lasers?

A) Welding ✔

B) Endoscopy

C) Data transfer

D) Holograms

E) Surgery

32. Use of He-Ne laser?

A) Cutting

B) Drilling

C) Lab demos ✔

D) Welding

E) Endoscopy

33. Gas laser efficiency (CO2)?

A) 2%

B) 5%

C) 10% ✔

D) 50%

E) 100%

34. Main disadvantage of CO lasers?

A) Weak output

B) Expensive

C) Toxic ✔

D) Fragile

E) Large size

35. Advantage of gas lasers?

A) Cheap

B) Good beam ✔

C) Portable

D) No cooling

E) Small size

36. Application of liquid (dye) lasers?

A) Industry

B) Research ✔

C) Welding

D) Data storage

E) Barcode

37. Medical use of dye lasers?

A) Endoscopy

B) Tattoo removal ✔

C) Welding

D) Cutting

E) Drilling

38. Advantage of liquid lasers?

A) Low cost

B) Small beam ✔

C) Toxic-free

D) No cooling

E) Simple design

39. Disadvantage of liquid lasers?

A) High efficiency

B) Expensive ✔

C) Cheap filters

D) No toxicity

E) Large output

40. Application of semiconductor lasers?

A) Welding

B) Optical fiber ✔

C) Endoscopy

D) Surgery

E) Cutting metals

41. Another application of semiconductor lasers?

A) Data transfer ✔

B) Tattoo removal

C) Welding

D) Targeting

E) Drilling

42. Advantage of semiconductor lasers?

A) Small size ✔

B) Toxic

C) Heavy

D) Expensive

E) Complex

43. Another advantage of semiconductor lasers?

A) High cost

B) Low power

C) No mirrors ✔

D) Large divergence

E) Fragile

44. Disadvantage of semiconductor lasers?

A) Stable beam

B) Temp sensitive ✔

C) Perfect shape

D) Strong output

E) Simple design

45. Another disadvantage of semiconductor lasers?

A) Wide beam ✔

B) Cheap

C) High efficiency

D) Small divergence

E) Easy cooling

46. Advantage of chemical lasers?

A) Very high power ✔

B) Cheap

C) Low power

D) Simple design

E) Small size

47. Application of chemical lasers?

A) Industry ✔

B) Tattoo removal

C) Endoscopy

D) Data storage

E) Holography

48. Disadvantage of chemical lasers?

A) Low power

B) Toxic gases ✔

C) Cheap

D) Fragile

E) Small

49. Application of metal-vapor lasers?

A) Ultraviolet output ✔

B) Tattoo removal

C) Welding

D) Endoscopy

E) Barcode

50. Copper vapor laser color?

A) Blue

B) Red

C) Green & yellow ✔

D) Purple

E) Orange