

Types of laser

There are many types of lasers and also many criteria according to which we can divide them. We most often divide them according to **the active environment** into:

- solid
- semiconductor
- gas
- liquid
- plasma
- free electron lasers

In another method of division, **the time mode** of its operation can be taken into account. In this case, we distinguish:

- continuous
- impulsive
- quasi-continuous

Other types of division methods include, for example, division according to the number of energy levels (2, 3 or more levels), the wavelength of the emitted radiation (infrared lasers, lasers in the visible light region, ultraviolet lasers, and X-ray lasers) or according to the method of pumping energy (optically, electrically, chemically, thermodynamically or nuclearly).

Division by active environment

Solid state lasers

The active medium is crystalline or amorphous insulators with an admixture of suitable ions. Excitation is usually optical. These lasers can work in different modes and under different operating conditions, are stable, and require little maintenance. Their radiation has wavelengths in the infrared and visible light range. The best-known representative is the ruby laser, whose active medium is a synthetic ruby crystal. It was from the ruby rod that Maiman managed to obtain the first laser beam of red light.

[1] The neodymium laser is the most widely used today. It emits infrared radiation or green light and has applications in various fields, especially in medicine. It is used in the treatment of vascular nevi, because its radiation is scattered little in the tissue and thus penetrates deeper, up to a depth of 2 to 6 mm, where it causes coagulation necrosis. The laser can coagulate arteries up to 2 mm in diameter and veins up to 3 mm in diameter.[2]

The type with neodymium glass is also widely used, which can be made in virtually any size and can produce very strong radiation. In the pulse mode, it is able to reach a power of up to 106 MW within 10-12 s, therefore it is considered a source of laser excitation of a thermonuclear reaction.

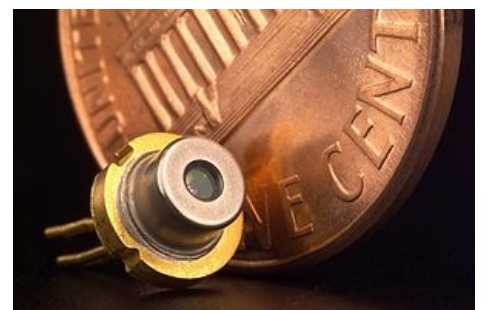


Solid state laser (Nd-YAG)

Semiconductor lasers

The principle of operation of this type of laser is similar to others, in particular the creation of a population inversion, which ensures the dominance of stimulated emission over absorption. Inversion is usually realized by injecting electric current, into the diode, the forward voltage induces the injection of a pair of carriers into the junction region, where they recombine for stimulated emission. A semiconductor injection laser is also called **a laser diode (LD)**, which is similar to **a light-emitting diode (LED)**. In both diodes, the energy source is the electric current injected into the PN junction.[2]

However, the radiation emitted by LEDs is generated by spontaneous emission, while that of LDs is generated by stimulated emission. Its advantages are small dimensions, high efficiency, and integrability with electronic components. Semiconductor lasers operate at wavelengths from near ultraviolet to far infrared. Output powers reach 2W. In general, they are among the most widely used lasers, they are mainly used in **telecommunications**, and **computer technology**, but also in **medicine**.



A laser diode in a case, for size comparison with a dollar cent

Gas lasers

The active gaseous environment can be made up of atoms, ions, or molecules. Gas lasers operate in a very wide range of wavelengths in continuous or pulsed mode. Their excitation is mostly by means of an electric discharge in a rarefied gas, optical excitation is rarely used. Gas lasers have a homogeneous active environment that ensures their excellent parameters. The disadvantage is relatively small performance. The most common types include the red glowing **helium-neon laser**, **argon**, or **helium-cadmium** (red-orange, green and blue radiation). The CO₂ infrared laser is the most widely used in industry and medicine.

Molecular gas lasers

For example, the CO₂ infrared laser belongs to this category. These lasers show high efficiency and can emit a lot of energy. Moreover, they can work on most molecular transitions in the infrared region. By using high energies and focusing beams, a "**laser scalpel**" can be obtained for non-contact tissue cutting.

Excimer lasers

Excimer lasers are the most important gas lasers for the ultraviolet region. They exist only in excited electronic states (in the ground state, their components repel each other). Their radiation has a minimal absorption depth in the tissue, therefore they enable the removal of microscopic layers of tissue. This fact is used especially when performing precise microsurgical procedures with minimal damage to the surroundings. In ophthalmology, the ArF laser is most often used for photorefractive keratectomy. The interaction of excimer radiation with the target tissue is based on the principle of photodecomposition. During this process, molecules/clusters of them are pulled out of the target tissue.



Diabetic retinopathy laser surgery-NEI

Liquid lasers

Liquid lasers work with chelates, and their advantage is undoubtedly the ability to occupy an unlimited volume and perfect homogeneity. Most often, the active medium is an aqueous or alcoholic solution of an organic dye. We refer to these lasers as **dye lasers** and are used in spectroscopy and information technology. They are tunable and the wavelength of the laser radiation can be continuously changed. The chosen dye affects the spectrum of emitted light, so here are a few examples: Polymethine dyes generate radiation in the red to infrared range (700-1500 nm), xanthene dyes work in the visible spectrum (400-500 nm) and scintillator dyes in the ultraviolet part of the spectrum (< 400 nm). Pulsed dye lasers shining at a wavelength of 540-577 nm, which corresponds to the absorption maxima of hemoglobin, are of great importance, as they lead to the selective destruction of blood vessels without affecting the surrounding tissues.

Plasma X-ray lasers

Achieving laser activity in the X-ray part of the electromagnetic spectrum is very difficult, which is why lasers of this type began to be created relatively recently. The active medium can be, for example, a carbon target irradiated with a CO₂ laser in pulse mode. These lasers have enormous energy, which can be used to create plasma or vaporize hard-to-melt metals (tungsten, tantalum). They can also be used in the holography of cell structures, the preparation of semiconductor chips, and X-ray microlithography.

Free electron lasers

Lasers with free electrons, or FEL (free electron laser), use a magnetic field, which is formed by a periodic system of magnets of alternating polarity. The active environment is a bundle of relativistic electrons that move in a magnetic field. Electrons are not bound to atoms, but they are not completely free either, because their movement is influenced by the magnetic field. The wavelength of the emission can be tuned over a wide range by changing the energy of the electrons in the beam and by changing the period of the magnetic field. Depending on the specific design, FELs can emit radiation with wavelengths from the ultraviolet to the far infrared region of the electromagnetic spectrum.

Lasers in medicine

Laser systems usable for medical purposes have undergone intensive development in the last decade. Currently, most modern devices are equipped with a control computer, which makes therapeutic procedures much easier and more efficient. The vast majority of laser devices used in medical work are in the optical region of the electromagnetic spectrum. Optimum use of laser radiation requires clarification of the mechanisms of action of radiation of different wavelengths on biological tissue. In general, when radiation and tissue interact, it is necessary to consider the parameters of the radiation – the wavelength and power of the source, as well as the size of the irradiated area and the exposure time. The parameters of the irradiated tissue are no less important. The choice of a laser for certain applications in medicine is related to the requirements for the resulting therapeutic effect and to the different mechanisms of action of individual types of lasers on biological tissue.

Links

Related articles

- Laser
- Laser diode
- Phototherapy

Sources

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