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Review about Semiconductor Laser

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Abstract:

The pulse of a laser beam can be likened to a military battalion as all soldiers advance. In consistent, regular steps, while an ordinary lamp radiates light in irregular, scattered light waves, it does not have the energy of a laser, so it is like people in the street, each of them facing a different direction than the other. However, by using crystals of suitable materials (such as ruby red) of high purity, it is possible to stimulate their production of light rays of one color. (i.e., of one wavelength) and also of one wavelength, then the waves match each other - by being reflected several times between two mirrors inside the laser crystal, so they become like soldiers in a battalion - The waves are organized, have constructive interference, and emerge from the device with the desired high energy, for the button, A laser or light amplification by stimulated emission of radiation is a device that emits light through a photonic amplification process based on the stimulated emission of electromagnetic radiation. Its photons are equal in frequency and identical in wave phase, where they constructively interfere between, Its waves are transformed into a high-energy optical pulse that is highly coherent in time and space, with a very small angle of departure, which is something that cannot be achieved using techniques other than radiation stimulation.

Introduction

They take streams of single light rays in a pattern, that is, in a pattern, and they emit elegant dazzles in certain situations. An anhazard device is used to create luminous patterns such that they can be collected in an anther, and their energy is released. With it, I will create you, adjacent to the illuminated patterns, and you will end up flying.

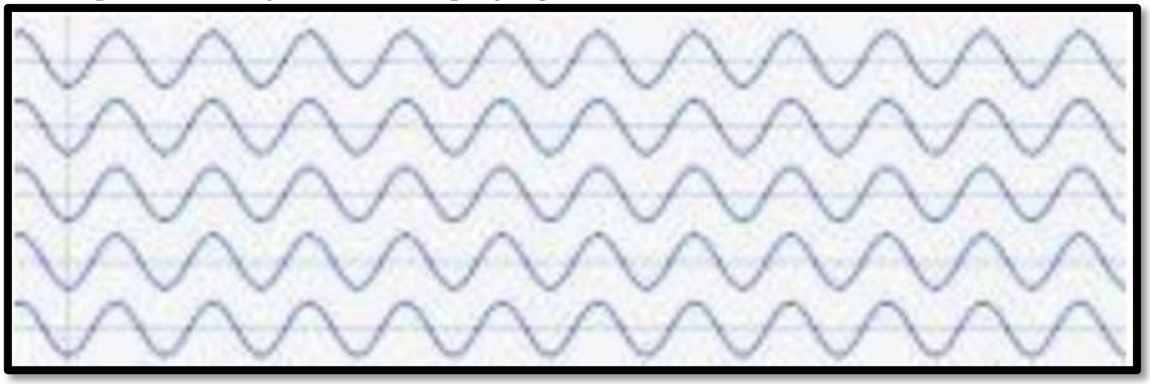
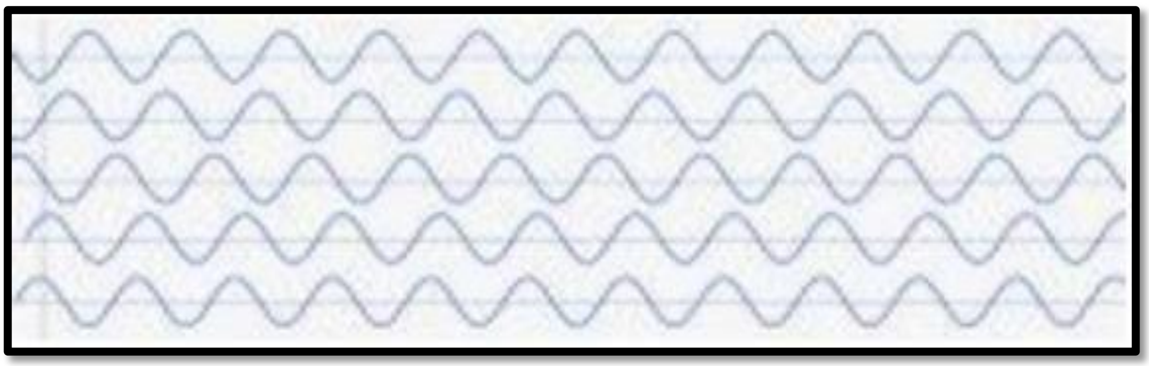
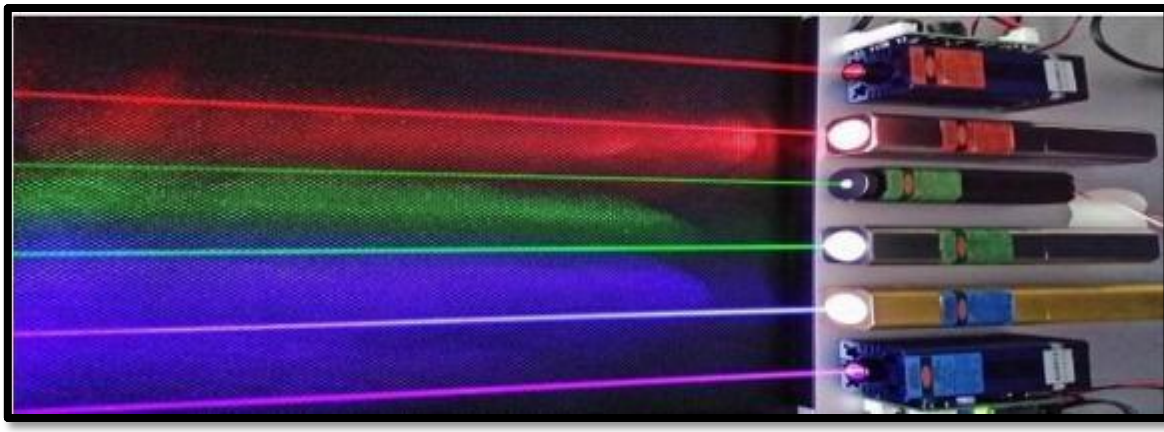


Figure (1_1) Waves in the same phase, (as in a laser)



(Like the light emitted from an ordinary lamp) Figure (1_2)

The pulse of a laser beam can be likened to a military battalion as all soldiers advance. In consistent, regular steps, while an ordinary lamp radiates light in irregular, scattered light waves, it does not have the energy of a laser, so it is like people in the street, each of them facing a different direction than the other. However, by using crystals of suitable materials (such as ruby red) of high purity, it is possible to stimulate their production of light rays of one color. (i.e., of one wavelength) and also of one wavelength, then the waves match each other - by being reflected several times between two mirrors inside the laser crystal, so they become like soldiers in a battalion - The waves are organized, have constructive interference, and emerge from the device with the desired high energy, for the button, A laser or light amplification by stimulated emission of radiation is a device that emits light through a photonic amplification process based on the stimulated emission of electromagnetic radiation. Its photons are equal in frequency and identical in wave phase, where they constructively interfere between, Its waves are transformed into a high-energy optical pulse that is highly coherent in time and space, with a very small angle of departure, which is something that cannot be achieved using techniques other than radiation stimulation. The first laser was built in 1961 by Theodor Harold Maiman at Hughes Research Laboratories, building on theoretical work by Charles Hard Towns and Arthur Leonard Shaolo. Because of its high capacity and a very small breakthrough, the button rays are used in several areas, the most important of which is the measurement, such as the small distances, or the cabinet is very accurate, and it is also used in the production of heat for the work of the makers and in the surgeon And with.



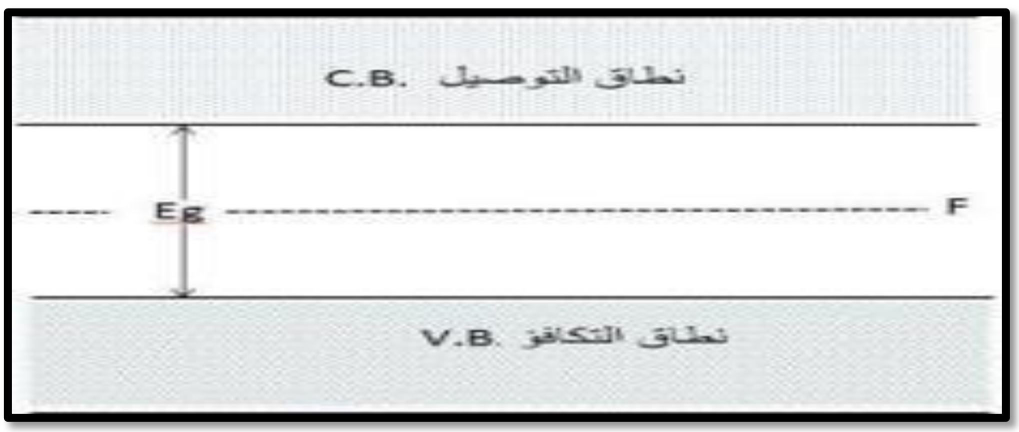
The semiconductor laser is one of the most popular sources of medium-power lasers and is used in many

- Fields and exists in different spectra.

Laser work: - The laser contains an optical wave detector, an internal cavity, two mirrors between which the laser beams can travel, and an amplifying medium, usually made of, The crystal is used to magnify the laser light, and without this medium, the laser light will become weaker every time it is used. That is, he loses part of his energy.

The amplification medium requires an external power supply in the form of optical pumping or electrical current, such as a semiconductor laser, in order to effectively amplify the waves. Characteristics of the laser beam: Laser rays differ from traditional light sources in that they have many distinctive properties, the most important of which are: Cohesion -: The electrons in traditional light sources move naturally over time, and are characterized by having different energies, frequencies, and wavelengths. Laser beams emit the same energies, frequencies, and wavelengths. Direction -: All photons in a laser travel in the same direction, so the laser light is focused in the same direction. Only one direction, and the width of the laser beam is narrow, meaning it can travel long distances Without dispersing its energy or changing its direction. Monochrome -: Therefore, the wave is different Photons emitted by ordinary light have wavelengths, All photons have a wavelength, Different colors, while lasers have one, Have colours which makes them monochromatic. High intensity: Laser rays are characterized by their high intensity, thousands of times greater than the intensity of ordinary light, as a result of the fact that laser rays flow in only one direction, while ordinary light rays . It spreads in different directions types of laser: Gas laser: It is a laser in which the resonator contains a gas such as helium and neon. Carbon dioxide gas has wavelengths in the infrared range and is used in cutting solid materials due to its high energy. Sable laser (dye laser): It is a laser whose active medium is a sable, in which organic dyes are dissolved in ethyl alcohol. The discovery of the sable laser led to solving some of the problems facing scientists in several fields such as medicine, mechanics, and communication. etc. After the scientist Iman published the first article on the discovery of the solid ruby laser, attention turned to the discovery of other effective media for laser generation, such as gaseous and liquid media. Solid-state laser: It is a laser that is produced by a material or mixture of solid materials such as ruby or a mixture of aluminum, ytrium, and neodymium. It is called the blazer, Abbreviation and its wavelength is in the infrared region (TAG). Diode laser or LED laser, Semiconductor laser, sometimes called it, It is based on semiconductor materials and is characterized by a very small size and power consumption (compared to other types). Therefore, it has become widely used in all applications, and precision devices up to a capacity of 1000 milliwatts. It is found in CD, DVD, and Blu-ray devices, laser printers, and precision measuring tools for distances and lengths, and optical devices and pens Laser toys come in many colours, including red, green and blue. Semiconductor laser:

A semiconductor is a crystalline solid in which the individual atoms form a periodic lattice whose electrical conductivity coefficient is much lower than that of metals. They differ from the solid ionic crystals used in solid-state lasers in the way they represent energy levels and thus the pumping mechanism and the process of light emission. The energy levels in a semiconductor represent a general characteristic of the internal characteristics of the crystal lattice as a whole, and it is not possible to speak of the energy level of an individual atom or molecule or an individual ion in a semiconductor. The conductor or ion embedded in its crystal. This is in addition to the fact that the semiconductor laser differs from the solid-state laser in most of its physical and geometric characteristics, the most notable of which is the difference in size. The largest dimension in a semiconductor laser does not exceed (1 mm). Also, the physical properties of the semiconductor are related to the operation of the laser, which changes with external conditions. Such as pressure and temperature differ from those properties and conditions of change for ionic crystals or glass in a solid-state laser. Energy levels: Figure (2-1) shows the energy level diagram for an example semiconductor (pure crystal), which is energy bachnadr.acterized by the presence of two broad energy bands separated from each other by a forbidden (Gap) whose width (Eg) These two bands are called the valence band (VB) and the conduction band (CB). Each of them consists of a dense number of energy states and does not express the possibility of the electron being present at an energy level (E) and in the equilibrium state according to Maxwell’s statistics - Rather, it is given in terms of the Fermi-Dirac distribution and by the function (E(f) which is given by the following relationship:



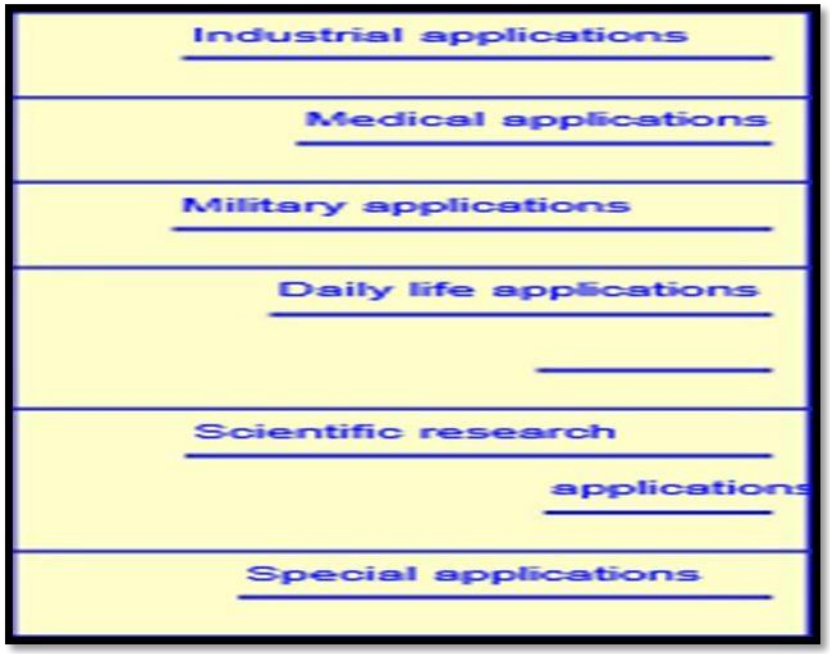
Energy levels of a semiconductor, for example, Figure (1-2)

F is the energy of the Fermi level and is located within the gap range. T represents the absolute temperature. This level is characterized by the following considerations: At absolute zero, T=0 and values of E<F., That is, for the conduction band, it is f=0, and the values of E>F are f=1, meaning that this level represents the border between completely empty energy levels and completely filled energy levels at absolute zero. The conduction band is completely empty of electrons and the valence band is completely filled with them. At this temperature, the semiconductor acts as an electrical insulator, At a temperature higher than absolute zero (T<0), some electrons are in a band like this conduction, leaving behind (positive) electron gaps in the valence band, and accordingly, It becomes possible for electrical fire to flow between the two ranges. perfect, as for a scampered picture is absolutely

A simple diagram that describes the energy levels of a real, crystal may include additional energy levels due to the presence of crystal defects such as impurities, gaps, and dislocations. The presence of impurities in the crystal determines the number of particles that act as current carriers (electrons and holes), which is why they are of great importance in the process of reverse rehabilitation and thus stimulated emission. In general, impurities can be classified into the following types: Donor impurities, whose, Near the conduction zone and susceptible impurities are planes, energy levels generally fall, Their energy is usually near the valence banad and finally for impurities whose energy levels, Flie deep in the band gap. The first two are important as both are deliberately implanted. The resulting crystal is a negative type (n-type) or positive type (p-type) of semiconductor. In many applications, the semiconductor is treated with impurities of both types, where the donor atoms are spread in one part of the crystal and the acceptor atoms are spread in the other part, and the joining area between them is called the junction (np). Reverse rehabilitation and electric pumping: For the purpose of achieving reverse rehabilitation, a number of electrons must be pumped into the conduction region and the electron gaps in the valence region must be increased. When an electrical voltage is applied in the forward direction of the junction, that is, by connecting the negative type (n) to the negative pole of the source, the current carriers move towards the junction and combine there, and this results in an emission that has the characteristics Stimulated Emission: To compare with the work of previous types of lasers, the semiconductor that is operated with a forward voltage is in a state of thermal equilibrium because of the flow of a large current through the junction, which makes the junction area far from the state of equilibrium. In this case, the Fermi-Dirac distribution principle cannot be applied to this region. Stimulated absorption and emission in a semiconductor: When the LED is connected to a forward potential difference (V) approximately equal to e/E, the electric field, as shown in Figure (0), will shift the position of the Fermi level in each type of crystal by an amount given by the relationship: The use of forward voltage also causes the injection of current carriers (electrons in the conduction region in the n-type, and the gaps in the valence region in the p-type) in two opposite directions towards the junction region and thus they are joined in a narrow layer called (the depletion layer) from which the required rays are emitted. The energy levels shown in the two types p & n, which are not in thermal equilibrium with each other, can be explained as follows: In each range, a relative thermal equilibrium is quickly established, and the electron distribution can then be described. The energy levels in each band have a state called (quasi-Fermi levels) and are expressed by the Ferm-Dirac function: It can be treated as a level of equilibrium In this case, the meeting will be a Fermi distance for the stimulated transition. When an electron fuses with a positive hole, the total energy is released as a photon

$$h\ddot{y}=E2-E1 \quad (5)$$

whose frequency is given according to the Planck equation, that is: 1E & 2E represent the energy of the electron in the initial and final state, respectively. An electron in the initial state can also absorb a photon and advance to the conduction band. Since the general laws of emission and absorption of electromagnetic radiation apply to the rays emitted by coalescence at the semiconductor junction, Emission is expected to occur Stimulus whenever a photon is released. Q: Under what conditions does the emission rate exceed the absorption rate in the junction area with a gain that can cross the threshold? The rate of absorption and emission depends on the number of photons present in the resonator on the Einstein transmission coefficient B. The stimulated emission rate is also proportional to the product of the probability of the electron being present in the upper level and the probability of not being present in the lower level, while the absorption rate is proportional to the probability of the electron being present in the lower level and the probability of it being present in the lower level. It is not present at the upper level, so in order to obtain stimulated emission, the time rate of stimulated emission must exceed that of absorption, that is, it must be: This requires that fv>fc from equations (4&3) results in: Fc-Fv>E2-E1=hÿ (7) Since (1E2-E) is not less than Eg, it is: Fc-Fv>Eg (8)This inequality is equivalent to the inverse qualification condition in other types of lasers. Device description: np, in which the shaded regiFoonr thfoersmemsicaonmduoctdoer bl u(tFtoinguwirteh t2he-1ju)nrcetiopnresenting the depletion layer. The most commonly used media of this type is cadmium arsenate (GaAs), and in general The valve is small in size and thickness material is thicker, within 1 µm, of thTehdeeapcletitvioen zone that forms (µm 0.1), as for the other dimensions of the valve, the length does not exceed within, Very small, The width is not more than 1 mm, but the thickness does not exceed 0.5 mm. The crystal is cut so that its two surfaces are parallel and its other surfaces are perpendicular to each other, and on a surface rough to resduuccheas an opposite pair of its surfaces on both sides, and the other pair is left, The junction, eliminates unwanted bright reflections, and the two glossy surfaces do not need to be coated with a reflective layer to make a Fabry-Perrot mirror. The refractive index of the semiconductor is high (for a GaAs crystal, it is about 3.6), and thus the reflectivity of the final surfaces (semiconductor - .air) is about 35%. This piece of the double is fixed On a solid metal base to form an electrode, Due to diffraction, the laser beam occupies the junction area, and the outgoing beam has a relatively large diffraction. Also, the threshold current density of the semiconductor laser with a homogeneous junction is relatively high. At room temperature. This density decreases rapidly with a decrease in this temperature condition because the amount (fv1-(fc) increases with the decrease in temperature, while the amount (fc1-(fv) decreases with its decrease. Thus, the gain increases as the temperature decreases. As a result, the homogeneous junction semiconductor laser works. continuously (CW) except at high temperatures (stable pH). This difficulty was overcome by using a design that included a heterogeneous junction pair where it was possible to operate This design lasers continuously at room temperature and also at a lower threshold current density. In the case of pulsed operation. For pulsed operation of a semiconductor laser, an electric field is applied across the medium in the form of a pulse with an energy approaching the energy of the gap, and the current across the junction increases non-linearly with the applied voltage until this approaches the energy of the gap, where you notice the rays emanating from all directions and their overall spectrum. Broadband (infrared in the range 830-840 nm) and the emitted rays change with the change in the junction current, and the length of the emitted wave depends on the concentration of impurities and the electrical current. A maximum power of watts can be obtained from a GaAs valve when it is pumped and the maximum value exceeds (ko In a pulsed manner and at high Watt temperatures at room temperature, while running it continuously gives a power between (5-10 m) W is in the same degree. The output of the semiconductor laser covers a wide range of wavelength, which ranges between 30 - 0.7 µm. The most important model of this type of laser is the GaAs laser, and 10% is therefore considered a type of laser with a rate of Its efficiency is relatively 11 (Hz) high, and its high efficiency is explained by its operation, as well as the bandwidth of its beam oscillations: 10) in closed form, and the GaAs laser is one of the most important sources used in optical communications, which uses optical fibers as its transmission medium. The life of the LED is also used in a number of important applications that require a long optical light (10 hours), There is a constant power (such as reading and scanning operations) and a source of radiation located in the radiation area infrared. There are other semiconductor materials that are important in the operation of this type of laser, such as lead salts, which oscillate in the medium and far range of the infrared spectrum, and their emission can be very narrow, which is why their importance lies in the study of infrared spectra. Red, especially for studying high resolution spectra, Laser applications: Lasers have very many applications in various fields of life, and it is not possible in this lecture to cover the entire topic. We will shed light on the most important of these applications, and this field will be enriched by writing about it, but under the heading of physical explanations, scientific articles , or student graduation research. Laser uses can be divided into six basic sections, which are as follows:



3-1 Industrial applications

The laser has been used in industrial applications since its first discovery in 1961, especially in measurements and arrangement of optical devices, pumping tubes, power lines, and measuring devices. It has been used in the field of manufacturing, such as cutting, welding, melting, and evaporation, in the manufacture of integrated electronic circuits, in engraving on glass, and others.

3-2 Medical applications

Lasers have entered into many medical applications. Therefore, these applications are divided either according to the type of treatment, such as laser applications in surgery, dentistry, or ophthalmology. They are also divided according to the type of laser used in medicine, such as the carbon dioxide laser, the nitrogen laser, or the excimer laser, and they are divided into Sometimes it depends on the nature of the treatment, such as surgical applications, blood vessel welding, or diagnosis. The last division is more commonly used. To understand laser applications in medicine, the relationship between laser rays must be studied. Different types of living cells. This relationship depends on the characteristics of the laser in terms of its wavelength, intensity, and shape when it falls on the object to be treated. The wavelength can be changed by changing the type of laser, and the intensity of the beams can be controlled by controlling the laser illumination time and the pumping power used, while the shape of the laser beam is controlled by the focusing lenses used. If we consider that the energy of laser rays is in the range of 0 watts, then by changing the wavelength it is possible to control the nature of the relationship between the laser and living cells. Lasers that operate in the far ultraviolet region kill living cells such as RNA and DNA. A laser that operates in the near ultraviolet region causes a reaction, Chemically with cell components. The laser that works in the nanny ray area causes a thermal effect on the cells because they absorb the laser energy. Laser treatment has many characteristics, including the lack of blood loss as a result of the cut. The laser pulses are short in time, which makes the patient not feel pain. The use of the laser gives the doctor a clear view of the area he is treating due to the lack of mechanical tools that the doctor uses for a mentioned wound in the patient's body. It does not require any events, and therefore the patient can leave the hospital as soon as the anesthesia effect wears off. The laser can also be controlled by a computer, which means extreme accuracy in the operation. Among the medical fields in which laser is used for treatment are: Treat the eye. General Surgery. Ear, Nose and Throat. Dentistry. Skin. Illnesses, The digestive system, colon, and rectum. Plastic surgery. Women disease. Urology surgery, Urine. Oncology. Orthopedics. Neurosurgery. Veterinarian - Veterinarian. the heart, And blood vessels.

3-3 Military applications

Since the discovery of the laser, much of the research related to its development has been for use in military fields. This research is often very secret and is not revealed until years later. Among these applications, we mention the use of lasers in targeting, its use in remote detonation or directing missiles, in tracking the target regardless of its speed and its ability to change its direction, and in the weapons of the so-called Star Wars, as well as in neutralizing the opponent's electronic devices and blinding him.

In the following example, we explain the idea of using lasers to guide missiles, where the drone directs pulses of non-targeting laser rays at the target, and receivers installed on the guided missiles track the pulses reflected from the target until they hit it. This technology is highly accurate, taking advantage of the straight laser beam, the speed of laser propagation, and the ability to control the pulses, which are a code of zeros and ones that the computer guiding the missile understands.

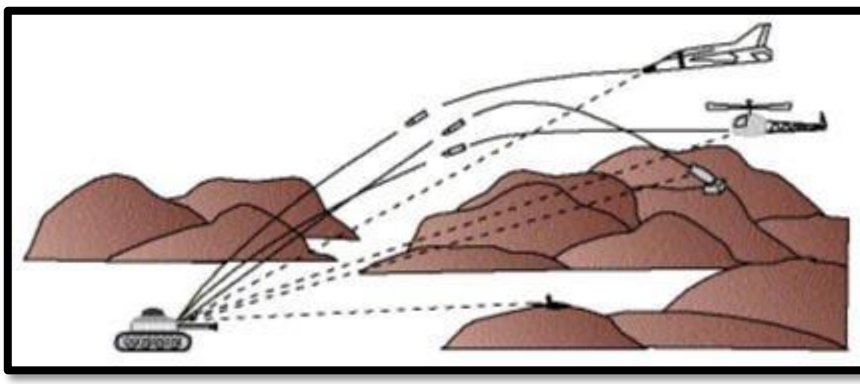


Figure (3-1)

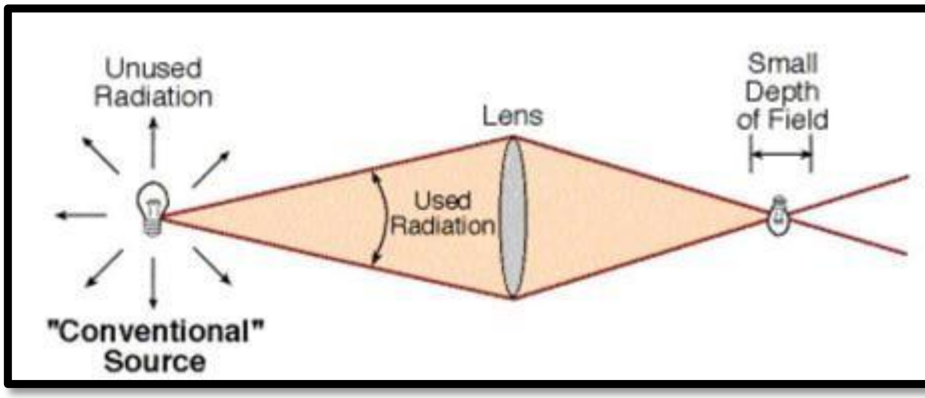
3-4 Applications for daily life

The laser has many applications in the field of daily life uses, and these applications are divided as Follows

CD-ROMs are the medium used to store information	Laser applications at home
Laser printer A means of storing information The broken computer	Laser applications at work
Bar code reader, holographic sign	Laser applications in commerce
Fiberglass used in space communications	Laser applications in communications
Laser shows at events, celebrations and holidays 3D photography exhibitions	Laser applications in entertainment

Here we must explain a characteristic that distinguishes the laser beam from other ordinary light sources, which is the depth of the laser's focus field, and the following figure explains this term.

In the case of focusing ordinary light rays using a lens, the depth of focus of the rays does not exceed only a millimeter.



The depth of focus of the laser beams reaches approximately 51 cm, if not more, and this gives a wide scope for applications in which the laser must be moved.

3-5 Scientific research applications

There is rarely any scientific research, whether in the field of physics, chemistry, geology, or biology, except that the laser is used as a basic tool in this research, and among its applications in scientific fields, we mention the

following: Spectroscopic analysis Laser (inertial) fusion, Very short pulses (Femtothek 01-05) Subject, Cooling atoms with a laser, studying the interaction of electromagnetic radiation with. Each of the previous topics needs a book to explain, and I have mentioned them here for your information.

3-6 special applications

This is an advanced application and there is no room for a detailed explanation at this stage. Among these applications we mention the following: Energy transfer in space, They are space stations for human use and rely on lasers to supply them with the necessary energy by directing laser beams from the ground to the space station.

Laser gyroscope, It is a device used to maintain orientation in space, Fiber laser, These are applications that rely on laser generation in glass fibers without the need to use electrical energy for the pumping process.

Conclusion

The current study, which is an analytical study, dealt with the characteristics and physics of the semiconductor laser (diode laser), in terms of design and electrical characteristics of the laser resonator based on the standing wave principle. Note that the current and optical lasers. Modern and traditional techniques were reviewed in a design that can work on the traveling wave principle, The Fabry-Pirot resonator is replaced with a resonator with four mirrors and unidirectional operation. Approved studies have shown the effectiveness of the vertical surface emission laser, Laser cavity vertical emitting compared to conventional side-emitting laser edge, Laser emitting. However, the first type fails to maintain a constant degree of polarization when the operating temperature and the bias current level change. It is superior to the traditional laser in terms of . narrow beam amplitude at mid-intensity. Both types are used in various application fields, including optical communications, optical sensors, optical signal scanners, laser disc readers, etc. It is possible to make continuous improvements to the performance of these types of lasers by adopting multiple techniques based on external flexible design. A laser with a narrower beam or a wider beam can be designed for the application to be harnessed.

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