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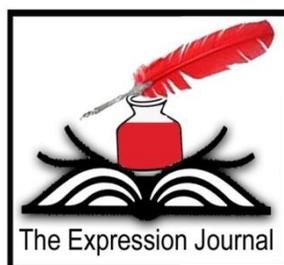
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TYPES, USES AND SCOPES OF LASER TECHNOLOGY: A REVIEW OF KEY MARKET TRENDS WITH PROS AND CONS

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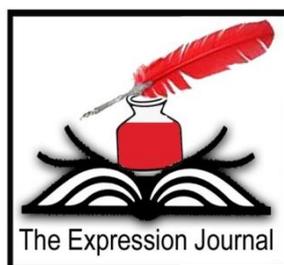
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Abstract

India is one of the fastest growing countries and much scientific growth and technological developments can be witnessed in every walk of human life. Among all these, laser technology is also a significant section that has emerged as a huge demand in India in the present context. A laser is a machine that emits an amplified single-colour source of light with spatial coherence that propagates over long lengths. Some crystals or gasses are also used so that only a single colour of light may be produced. These gasses emit light when energized. Specific mirrors are also used so that light may be amplified. The full form of “Laser” is “Light Amplification by Stimulated Emission of Radiation.” It is seen that the laser light travels in a single direction and it does not spread like a bulb, CFL tube or torch light. If there are more than one light, then also these lights travel parallel. Thus, a laser is a narrow beam or optical bandwidth of collimated light that does neither weaken, nor does it spread like other sources of light such as a mercury lamp or tungsten lamp. Most spectacularly, a high nick of directional monochromatic nature is also associated with these light beams. It is based on the principle of stimulated emission from excited atoms or ions within an amplifying medium and interaction of electromagnetic radiation with matter that causes the spontaneous process of absorption and spontaneous emission. Laser technology is being used in many industries, organizations and health institutions at the large scale. Painless laser technology has become more popular in the 21st century. The present paper is an attempt to see the types, uses and future scopes of laser technology keeping in view the market demands, emerging trends and challenges.

Keywords

Laser Technology, Scientific Revolution, New Era, Industries, Market Trends, Scopes, Advantages, Disadvantages, Painless Treatment, Challenges.



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I. INTRODUCTION

In the couple of years, India has to undergo several scientific breakthroughs which will never be forgotten even after many years. Every year brings challenges like omicron, Covid pandemic and many more natural disasters which are generally controlled only by new innovations and research in the domain of science. In the last two years, Covid-19 vaccine, malaria vaccine for kids, James Webb Telescope, new discoveries on the Mars, CRISPR gene editing injected into blood, closer than ever to finding ET, species of early humans, most powerful quantum processor, discovery of artificial titanium heart, etc. Among many more scientific developments, “Laser” (rarely written as L.A.S.E.R.), an acronym for “Light Amplification by Stimulated Emission of Radiation” is a wonderful invention in the history of human civilization because it is very beneficial for us.



Image 1

It was presented by Albert Einstein in 1917 and it was coined by Gordon Gold in 1957. The term usually means laser *oscillators*, but sometimes it includes devices with laser amplifiers, which are called Master Oscillator Power Amplifier (MOPA). It must be noticed that the nonlinear devices like Raman lasers and optical parametric oscillators also produce light that resemble with the lights of laser, but in fact, these are not lasers. A laser emits light on the small spots where high intensity is required. Material is also required for that purpose and there should be multiple or more than three energy levels. At least one metastable level is also required for it because it has a long life time and the active material can produce beam lights. This active material may be in any state.

The principle of the laser is also important to understand the functioning of the laser. To produce laser beams, atoms should be brought into an excited state. When it enters from excited state to ground state, laser beams must be produced. These radiations should be in the same direction. It means their angle; phase, frequency and direction should be the same. Lasers have a very narrow optical bandwidth whereas other sources of light such as lamps and torches have a broad optical spectrum. Though it cannot be ignored that there are many broadband lasers also among them ultrafast lasers can be put. It depends upon the person whether the laser light is to be emitted alternatively in ultrashort possessor continuously from microseconds down to a few femtoseconds.

Theodore Maiman demonstrated the first pulsed lamp-pump ruby laser in 1960 and the helium-neon laser and first diode laser were invented. There were few key persons before it such as Arthur Schawlow, Nikolay Basov, Charles Hard Townes, and Alexander Prokhorov who had also worked on lasers and masers. MASER (Microwave Amplification by Stimulated Amplification of Radiation) was invented by the Townes' group in 1953. It was used for some time but later the laser took its place. There are many new scientific developments in the field of lasers. In laser technology, a wide range of optical components are used such as Laser mirrors, laser crystals, tunable optical filters, polarizers and Faraday isolators.

II TYPES OF LASERS

There are many varieties of lasers and we can do its classification from different perspectives. However, keeping in view the different types, lasers can be put into the following categories:

i) Solid State Lasers

In these types of lasers, solids are used as laser mediums. Generally glasses or crystalline materials can be used for that purpose. Ions are generally used as impurities into the host materials and it can be a crystalline or a glass. Doping is a process in which the impurities are added. Erbium (Eu), terbium (Tb), cerium (Ce), etc. impurities can be added which are called Dopant. Ruby laser was the first solid-state laser. It cannot be denied that it is not used as it is still used in some applications. A ruby crystal is generally used in it. In these types of lasers, only light sources of energy such as flash lamps, flashtubes, laser diodes or arch lamps are particularly used. Semiconductor lasers cannot be put into this category as these types of lasers have physical processes and are electrically pumped.

ii) Gas Lasers

In the gas lasers, electric current is released through a gas inside the laser medium so that laser light can be emitted. Generally a helium-neon gas mixture is used as a source of gas in it. Apart from it, carbon dioxide lasers (CO₂ lasers), argon ion lasers, carbon monoxide lasers (CO lasers), nitrogen lasers, hydrogen lasers, excimer lasers, etc. also can be used. The type or quality of gas can better define the wavelength of a laser light. High reflector, anode, glass tube,

cathode, output coupler, DC power supply, etc are the main components of the gas lasers. Gas lasers are generally used when laser light is needed at long coherence lengths with a high beam quality which other lasers fail to provide. Mixture of gasses is used and it is stored in a glass tube and then it acts as a laser medium. This laser works on the principle of converting electrical energy into the light energy and the light beam remains at $1.15 \mu\text{m}$.

iii) Liquid Lasers

In these lasers, liquid is kept as a laser medium. In these lasers, light supplies the energy to the laser medium. There are many examples of a liquid laser and a dye laser is also its perfect example. An organic dye is mixed with a solvent in a dye laser. Laser light is generated through the liquid solvents in these types of lasers.

iv) Semiconductor Lasers

These lasers are very important these days and that's why these play a vital role in our everyday life because these lasers are not very costly, consume the least energy as compared to other lasers and have a compact size also so that the portability of these lasers is very easy. These lasers are known as laser diodes also. These lasers are quite distinct from solid state lasers. In solid state lasers light energy is used while in the semiconductor lasers, electrical energy is used.

v) Fiber Lasers

In fibre lasers, it is seen that active gain medium is an optical fibre that is doped with some rare elements which are found in earth such as, ytterbium, neodymium, erbium, dysprosium, praseodymium, holmium and thulium. This laser remains full of advantage as compared to other lasers in some cases. In this laser, the light is generated by an inherently flexible medium and it easily delivers the light at the focused point. It is used for multiple purposes such as welding, cutting, folding of polymers and metals. Apart from this, this laser is also used in medicine, material processing, telecommunications, spectroscopy, and directed energy weapons. This laser has active regions for several kilometres and it has a high optical value. It is designed as a double clad fibre in which a fibre core is used and a double cladding both inside and outside. This index consists of three concentric layers in the form of a single-mode fiber. In this way, a large amount of power is propagated and generally pump lights are used in this stimulation process.

Every technology and pros and cons. Likewise the laser technology is beneficial to human beings and simultaneously it has some disadvantages also.

III. ADVANTAGES OF LASER TECHNOLOGY

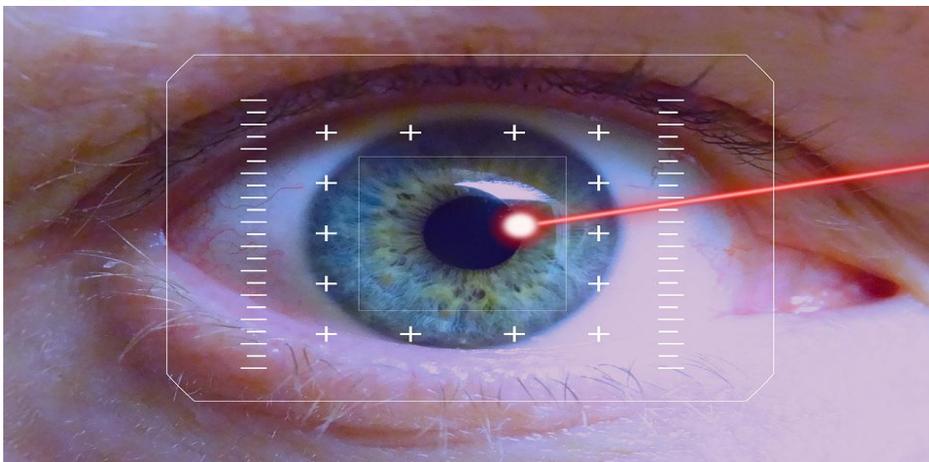


Image 2

So far as its advantages are concerned, it is a drug free and almost pain free therapy. It has helped a lot improve the health and mental well-being of millions of people in the world. It is in more practice in the developed countries. The most interesting point of the laser technology is that there is no need for anaesthesia for the patients as it is a drug-free and pain free technology. So there are no risks that the patient will get addicted to overdoses of the painkillers or anaesthesia. Patients feel comfortable and relaxed with this therapy. Due to laser treatment, eye patients can see well without wearing glasses or application of contact lenses. There is no worry that the glasses will be broken or misplaced.

This therapy has versatility because effective treatments have many common physical concerns such as neck pain, lower back pain, arthritis, muscle spasm and strain, neuropathy, ligament sprains, etc. it is a customizable therapy having adjustable power output and multiple wavelengths and it has practitioners who take care of the needs of their prospective patients.

It is not a single use therapy that can be used for the treatment of only one disease. In fact, it is used to treat multiple diseases. It has long-lasting results and further improvements are being done on the laser therapy to make it more useful, cheap and absolutely pain free for the human beings and gradual developments are being done on it since the 1960s. However, this technology pays off well because it attracts more and more customers and patients and helps the doctors' practice grow.

There is a high level of accuracy that results in consistent quality. Minh Quang Chau observes that "Industrial lasers are the main types of lasers used in industry such as material processing, machine manufacturing, metal cutting by laser or engraving on all materials. Most of lasers are applied in manufacturing and industry. Use the power level from medium (several tens of W) to high power level (several kW) to process metal or nonmetallic materials" (Chau, 2019: 19).

Due to laser technology, work has become very easy because these are very easy to operate and there are no design limitations. Further, there are no post processing requirements in this technology. Lasers do not do any environmental pollution and thus, these are environment friendly also. Work is also done with high speed and ultra best quality which gives ultimate satisfaction to the person concerned.

IV. DISADVANTAGES OF LASER TECHNOLOGY

There are disadvantages of laser technology also. This technology is highly expensive and the bourgeois and the labour class people cannot afford its treatment because the medical practitioners or doctors have to buy laser machines at the high costs. Another disadvantage of the laser technology is that some insurance policies do not cover the harm done by the laser therapy. In such cases, if any, the patients have to face difficulty.

Safety protocol is also properly maintained. Though the practitioners have proper knowledge of the laser machine, they have to undergo a necessary training before allowing them to operate any device. These devices can prove harmful because sometimes strong wavelengths may affect patients' bodies and that's why they have to get proper training for it.

This device is getting very costly due to the high price of the machines. Many people complain that they are not able to see properly during the night. Thus, laser treatment of the eyes has bad night vision. The results are not good for some old people and they have to need glasses spp. It permanently weakens the cornea and it increases the risk for rupture.

V. LASER MARKET TRENDS IN INDIA



Image 3

This section attempts to shed light on the main laser market trends, developments and drawbacks that shape and affect the Indian laser Market. The most significant growth of the laser is seen in the automotive sector where the work of sheet metal cutting is being done with laser technology. There are many automotive hubs in India such as Manesar, Bangalore, Pune, Ahmedabad etc. where more than 80% metal-cutting-work is done with the lasers. It is also used for the diamond processing units in Surat where approximately 12000 lasers are used. In the wake of COVID-19, to ensure safe transportation and manpower, new technology is in huge demand. The fibre laser cutting machine has made the work easy because it has a dynamic operating power and it allows the beam focus. However, there is dominance of the Chinese manufacturers such as Bodor Laser, Han's Laser, HSG Laser, and several others and there are Indian distributors of lasers such as Laser Lab Delhi, Laser Technologies Mumbai, and around 30 more other Indian distributors of Chinese cutting machines.



Image 4

Apart from the automotive sector, laser technique is in huge demand in the steel manufacturing units. The Indian Institute of Welding (IIW) reports that the consumption of almost 90% done through welding where also laser technology remains much beneficial. The World Steel Association in April 2022 reported that India is one of the top 10 steel producing countries in the world and it has increased the steel output in the first quarter of 2022 as compared to the same quarter of 2021 and produced 31.9 million tone steel with an annual growth of 5.9 and it was not possible without the laser technology.

Laser technology is also in huge demand in the medical and electrical industries where precise micro cutting is needed. In both of these sectors, mainly fibre lasers are used. In the electrical industries, the narrow sheet-cutting and finishing is only possible with the laser technology. Laser technology has brought a revolution in the medical world where it has proved like another god because it has made the treatment painless and drugless

VI. RECENT DEVELOPMENTS IN LASER TECHNOLOGY

Some significant changes have been made in the past couple of years. It is the fact that all the smartphones, computers, laptops and LED screens also cannot work without the impact of lasers. Many initiatives have been witnessed in recent years. Just in May 2020, Samsung and South Korean telecom provider, SK Telecom jointly launched the Samsung Galaxy: A Quantum. Satellite based lasers are also helpful in supplying environmental data to us. A huge technology push will also be introduced with the photonics integration. Now ultrafast material processing has become ultra-short laser pulses (USP) and it takes less than a picosecond.

A scientist has created a completely automated laser based technology in January 2022 from which the expensive parts such as rotor blades, moulds, and other aviation parts have been removed. Now only minor human support is needed at the time of any technical glitch.

Bharat Fritz Werner Ltd (BFW) and m2nxt (a BFW subsidiary), issued the PHOTON 4000G Laser-Directed-Energy-Deposition (L-DED) machine in April 2022. This machine was manufactured in India and it has worldwide supply now.

Lumibird, one of the European laser technology pioneers, also launched the Lumibird Medical India in Mumbai in June 2022. It has a customary and standard range of ophthalmic lasers, ultrasonography platforms, and tools to detect and later for the treatment of a dry eye. The company has planned to increase its revenues related to Ellex goods and Quantel Medical throughout India.

Furthermore, in the same month, Bharat Fritz Werner Group has introduced, the Photon 1000H and Photon 1000R, the first Laser-Directed Energy Deposition (L-DED) equipment that is driven by the Meltio in India. It has robotic versions in hybrid mode.

VII. CONCLUSION

Thus, it can be stated that laser technology has emerged as a blessing for human society. In the sixty years of development, a large scale research has been carried out and many developments have taken place. We generally see that the laser is a wonderful invention to sort out the medicinal diagnosis and the treatment of many diseases so that substantial growth of human society may continue unabated. Many research projects have been completed on laser technology and still there is a further scope for further improvements so that this technology may be more beneficial for the human beings.

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