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Research Article

Implementation of crimson ray in techno world

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Abstract

A groundbreaking advancement in laser technology, the ruby laser has transformed a number of industries, including scientific research and medical. The synthetic ruby crystal serves as the laser medium for this solid-state laser. In 1960, Maiman created the first successful laser, the ruby laser. One of the rare solid-state lasers that emits visible light is the ruby laser. It produces light with a wavelength of 694.3 nm, which is deep red. The three key components of a ruby laser are the optical resonator, pump source, and laser medium. A single cylinder-shaped ruby crystal serves as the active medium or laser medium in a ruby laser. The host sapphire (Al2 O3), which is doped with trace amounts of chromium ions (Cr 3+), makes up the laser medium (ruby) in a ruby laser. Its distinctive qualities, such as its narrow spectral line width and high power output, have made it possible for it to be widely used in a variety of fields, including materials processing, spectroscopy, dermatology, and ophthalmology. Ruby is a dynamic programming language that is open source and primarily object-oriented, however it also supports functional programming. Ruby is notable for its emphasis on developer efficiency and its easily readable syntax. Because of its dependability, affordability, and ease of use in certain applications, the Ruby laser remains relevant even in the face of emerging newer laser technology. The ruby's thermal characteristics are favorable. A solid-state laser that employs a synthetic ruby crystal as its gain medium is called a ruby laser. On May 16, 1960, Theodore H. "Ted" Maiman of Hughes Research Laboratories created the first functional laser, a ruby laser. Deep red, coherent visible light pulses with a wavelength of 694.3 nm are produced by ruby lasers. The average pulse length of a ruby laser is around one millisecond.

Keywords: *Actinidia chinensis; Actinidia deliciosa; Pseudomonas syringae* pv. *Actinidiae;* quality

Introduction

A solid-state laser that employs a synthetic ruby crystal as its gain medium is called a ruby laser. On May 16, 1960, Theodore H. "Ted" Maiman of Hughes Research Laboratories created the first functional laser, a ruby laser. Deep red, coherent visible light pulses with a wavelength of 694.3 nm are produced by ruby lasers. The typical pulse length of a ruby laser is around one millisecond.

The stimulated emission principle, initially put forth by Albert Einstein in 1917, provides the foundation for how a ruby laser works. The laser is a concentrated beam of light that is produced when the chromium ions in the ruby crystal are stimulated by the light from the flash tube and release their own light. The idea behind the gadget was a "optical maser," a maser that could function in both the visible and infrared portions of the spectrum. The first visible light laser to come after the early microwave masers was the ruby laser. It is a solid-state laser that emits red light with a wavelength of $\lambda 0$ = 694.3 nm.

By reflecting red and absorbing green and blue, chromium gives the ruby rod its red hue. High power operations including welding, cutting, drilling, and molding are among its uses. There must be two energy levels in the active amplifying medium. Levels of doped ions function as meta stable states. Stimulated emission requires pumping or carrier inversion.

High energy flash light excitation is used to accomplish this. optical feedback by the use of an external mirror or an electro-optic crystal. Here, ruby rods are irradiated with flash lamps to create population inversion. It is composed of a noble gas-filled quartz tube. For more efficient carrier pumping, several unique ruby laser types use helical type flash lamps. The stability of this high-power laser system depends on the water coolant.

Flash light intensity is dependent on a number of variables, including gas pressure, gas type, tube diameter, applied voltage, and capacitor size. Very high-power light output can be achieved when using a ruby laser in pulse mode. To put it briefly, flash lights are used for pumping, and lasers work in the pulsed area.

Advantage of Ruby Laser

They are frugal.
In comparison to CO2 lasers, ruby lasers have a smaller beam diameter.
The He-Ne laser type has a higher output power than the ruby laser.
Since rubies are solid, there is no possibility of wasting any active medium material.
The output of a ruby laser is quite powerful, ranging from 104 to 106 watts. The wavelength of this object is 6943 Angstroms.
Holography, industrial cutting, and welding are all done with ruby lasers.
They are referred classified as class-I lasers because of their modest output power. As a result, kids use them as toys. They can also be utilized as a piece of art and decoration.

Disadvantage

The pumping source for the ruby laser needs to be high-power.
Maintaining the population inversion is challenging since the ground state is the terminal of laser action. This feature contributes to the low efficiency of ruby lasers.
The laser emission happens as microsecond-long bursts rather than continuously.

Ruby lasers also have crystallographic imperfection-related flaws.
Until at least half of the ground state electrons have been excited to the meta stable state, there is no discernible stimulated emission in the ruby laser. Compared to other lasers, this one's optical cavity is shorter.

Applications

Range finding was one of the early uses for the ruby laser. Before the more effective Nd: YAG rangefinders were introduced ten years later, military rangefinders were using ruby lasers with spinning prism q-switches by 1964. The primary usage of ruby lasers was in research. The ruby laser is especially well-suited to excite laser dyes radiating in the near infrared, and it was the first laser to optically pump tunable dye lasers. Because of their poor efficiency and low repetition rates, ruby lasers are rarely used in industry.

Since diamond's broad absorption band (the GR1 band) in the red is precisely matched by Ruby's powerful beam, one of the primary industrial applications is drilling holes through diamond.

With the development of improved lasing media, the use of ruby lasers has decreased. They are still employed in many applications that need for brief bursts of red light. Using ruby lasers, holographers worldwide create holographic portraits up to one meter square in size. The red 694 nm laser light is chosen over the frequency-doubled Nd: YAG green light at 532 nm, which frequently needs numerous pulses for big holograms, due to its high pulsed power and good coherence length.

In order to find lining vulnerabilities, several non-destructive testing labs utilize ruby lasers to make holograms of huge items, including airplane tires. In the tattoo and hair removal industry, alexandrite and Nd: YAG lasers are replacing ruby lasers, which were once widely utilized.

Systems for laser metalworking that drill holes in hard materials. Frequency doubling into the UV spectrum using high-power equipment. Holographic camera systems with a long coherent length and high brightness. Medical laser systems for cosmetic dermatology and tattoo removal. Q-switched system with high power.

Design

In order to accomplish a population inversion, a ruby laser typically consists of a ruby rod that needs to be pulsed with extremely high energy, typically from a flashtube. The rod is frequently positioned between two mirrors to create an optical cavity that causes stimulated emission by oscillating the light generated by the ruby's fluorescence.

Ruby is one of the few solid-state lasers that emits light in the visible spectrum. It has an extremely small line width of 0.53 nm and a rich red color, lasing at 694.3 nm.
A solid state laser with three levels is the ruby laser. A synthetic ruby rod serves as the active laser medium (also known as the laser gain/amplification medium), and it is powered by

optical pumping, usually a xenon flashtube. Ruby has a relatively long fluorescence lifetime of three milliseconds and very broad and strong absorption bands in the optical spectrum at 400 and 550 nm.

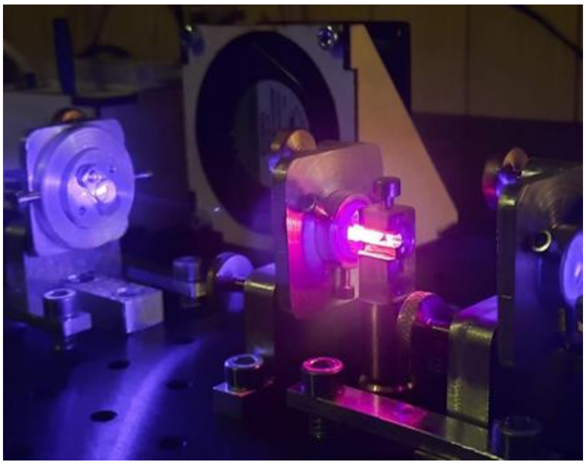

Fig. Ruby laser

Construction

Ruby is an aluminum oxide (Al2O3) crystal in which chromium ions (Cr3+) partially replace aluminum ions (Al3+). This is accomplished by doping the melt of purified Al2O3 with trace amounts of chromium oxide (Cr2O3).

Depending on their concentration, these chromium ions give the crystal a pink or red hue. A single pink ruby crystal with 0.05% (by weight) chromium is used to make laser rods. The laser action does not involve Al2O3. All it does is serve as the host.

The ruby crystal has a cylindrical shape. Ruby crystals typically have a diameter of 0.5 to 2 cm and a length of 2 to 30 cm. The rod is encircled by liquid nitrogen to cool the device because the laser generates an extremely high temperature when it operates.

Active medium or active Centre

In ruby crystals, chromium ions serve as active centers. Thus, the laser is created by chromium ions.

Pumping source

The pumping source is a xenon-filled helical flash lamp. A xenon flash light is used to illuminate the ruby crystal. In order to accomplish population inversion in ruby lasers, optical pumping is utilized.

Optical resonator system

Ruby crystal ends are ground, polished, and flattened. To obtain the output, one end is partially silvered and the other is fully silvered. The two polished ends so function as a set of optical resonators.

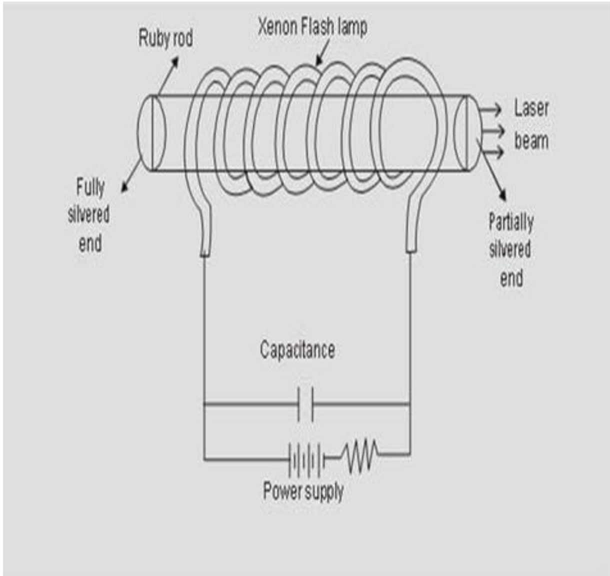

Fig. Construction of Ruby laser

Working

Ruby is a laser system with three levels. Assume that there are three levels: E1 and E2, as well as E3 and E4. The ground level is denoted by E1, the meta stable level by E2, and the bands by E3 and E4. Due to their near proximity, E3 and E4 are regarded as a single level.

A xenon flash light with a ruby crystal inside is coupled to a capacitor that releases several thousand joules of energy in a matter of milliseconds. In the ground state, chromium ions absorb some of this energy.

The chromium ions are thus elevated to energy levels within the bands E3 and E4 via optical pumping. We refer to this process as stimulated absorption. Absorption of radiation with wavelengths of about 6600 angstroms and 4000 angstroms, respectively, results in the shift to bands E3 and E4. Pumping levels are another name for the levels that fall inside the E3 and E4 bands.

The laser gain medium is the stimulated emission of photons that happens in a laser when an electronic transition from a higher energy state to a lower energy level takes place. To create an output, some light is let to flow through the partially reflecting mirror while the majority of the light is reflected off it.

The totally reflecting mirror reflects all of the light. Coherent visible light is the electromagnetic ray that a ruby laser produces. It employs a ruby rod that needs to be pumped with a lot of energy. The goal of this is population inversion.

Components of Ruby Laser

Ruby crystal

Flash tube

Resonator

Ruby Crystal

After absorbing light from the flash tube, the chromium ions in the ruby crystal transition to an excited energy state. A particular wavelength of light, in this example a deep red light with a wavelength of 694.3 nanometers, is released when they return to their natural state.

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Fi**g. Ruby Crystal**

Flash Tube

The energy needed to excite the chromium ions is provided by this component. When electricity is run through it, it surrounds the ruby rod and emits a bright light.

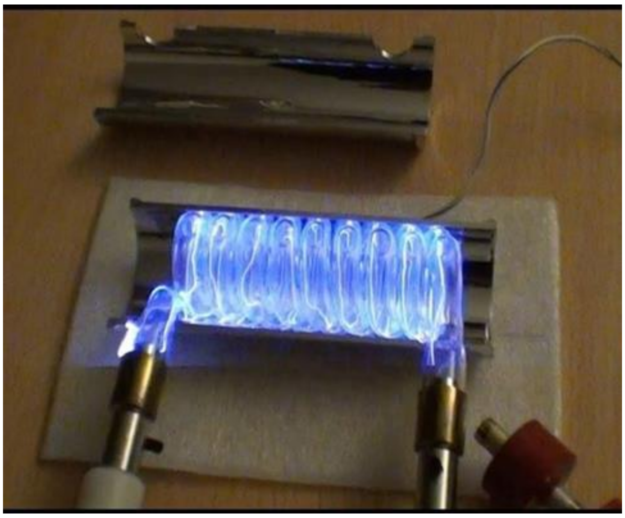

Fig. Flash tube

Two mirrors are placed at either end of the ruby rod in this section of the laser equipment. While the other mirror is slightly reflecting, letting some light in, the first mirror is entirely reflective. The laser beam is formed by this fleeing light.

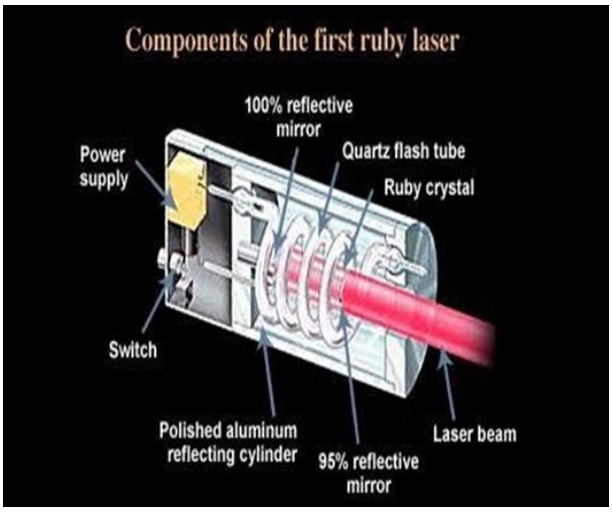

Fig. Components of Ruby laser

Energy Level of Ruby Laser

Let us consider three levels of energy with E1, E2, and E3 with N number of electrons where E1 < E2 < E3.

E1 is the ground state.

E2 is the metastable state.

E3 is the high-energy state.

Only a small percentage of electrons are found in the E2 and E3 states at first, with the majority being in the E1 state.

As the laser medium absorbs light energy, the electrons begin to accumulate energy and move from the E1 state to the E3 state. Since the pump state E3 has a very limited lifespan, its electrons do not remain there for very long.

They release energy when they fall into E2. Compared to E3, E2 has a far longer lifespan. The electrons in E2 eventually drop into E1. Photons are released as a result, a phenomenon known as stimulated radiation emission.

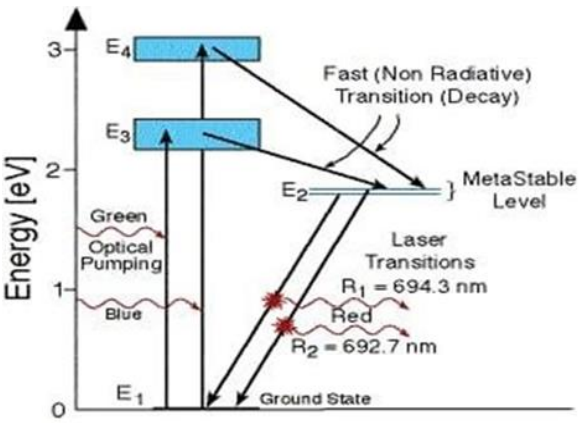

Fig. Energy level of Ruby laser

Achievement of Population Inversion

When excited Cr3+ ions interact with the crystal lattice, they lose some of their energy and decay to the Meta stable state E2. As a result, the change from excited states to Meta stable ones is non-radiative, meaning that no photons are released. Chromium ions will remain in E2 for a longer period of time because it is a meta stable state. As a result, the number of chromium ions in the E2 state continues to rise, while the number in the E1 ground state continues to fall as a result of pumping. Consequently, compared to ground state E1, there are more chromium ions in an excited state (meta stable state). As a result, between states E2 and E1, the population is inverted.

Circuit diagram

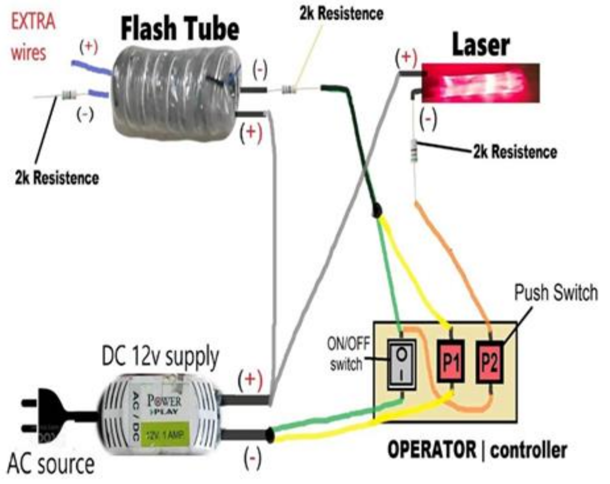

Fig. Connection of ruby laser

Transmittance of Ruby Laser

Ruby's transmittance in near-infrared and optical wavelengths. Take note of the small absorption band at 694 nm, which matches the ruby laser's wavelength, as well as the two large blue and green absorption bands. A portion of the light at the lasing wavelength is also absorbed by rubies. It is necessary to pump the full rod length, avoiding any dark sections close to the mountings, in order to overcome this absorption. The dopant, which is made up of chromium ions suspended in a synthetic sapphire crystal, is the active ingredient in rubies. All of the radiation absorption and emission is caused by the dopant, which typically makes up only 0.05% of the crystal. Typically, synthetic rubies are either pink or red, depending on the dopant concentration.

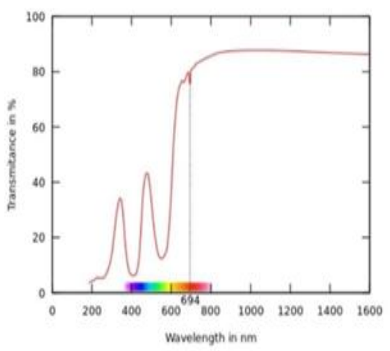

Fig. Transmittance of Ruby laser

How Does Ruby Laser Works in Different Field

Selective thermolysis is the basis for the operation of the Q-switched ruby laser (QSRL), which is employed in dermatological applications. The process of creating intense laser beams in brief bursts is known as Q-switching. At a wavelength of 694 nm, the active medium (a ruby crystal) allows for high output energy (100–200 MW) at incredibly brief pulse periods (20–80 nanoseconds).

The target structure, also known as a chromophore, absorbs a greater amount of the chosen laser light wavelength than the surrounding tissue. The target structure's thermal relaxation time, or the amount of time it takes for the target to cool by 50% of its peak temperature following irradiation, is longer than the laser energy pulse duration.

The influence of thermal energy is guaranteed to be restricted to the target structure and not to the surrounding tissue thanks to this reduced pulse duration. Ruby laser light may be absorbed, transmitted, or reflected when it strikes the skin. Since the targeted targets (chromophores) transform absorbed energy into thermal energy (heat), which kills the sick cells, absorbed energy is mostly to blame for the clinical effect. Hemoglobin, melanin, and tattoo ink are the skin chromophores that the ruby laser often targets; each has a distinct laser light absorption spectrum. When energy meant for the target chromophore is non-selectively diffused and absorbed by nearby tissues and structures, complications arise.

Hair Removal in Hypertrichosis (Excessive Body Hair)

In order to maximize light delivery into the reticular dermis and minimize damage to the epidermis, the beam was guided into an actively cooled "hand piece" using an articulated arm. To enhance beam coupling into the skin and create a convergent beam at the skin's surface, a planoconvex sapphire lens with a focal length of about 20 mm was utilized rather than air as an external medium.

Before, during, and after each laser pulse, the sapphire lens was cooled to 4°C to allow heat conduction from the epidermis. Before each laser pulse was given, the cold sapphire lens's convex surface was pressed firmly against the skin.

A laser energy meter (model 351, Scientech, Boulder, Colo) was used to measure the energy of the pulses that were discharged into the atmosphere.

The ruby laser (694 nm wavelength, 3 MS pulse duration, energy fluence 46.5 J/cm2) has been investigated as a hair extraction (epilation) technique in the non-Q-switched mode for people with hypertrichosis.

Hair follicles are exposed to light pulses, which results in hair loss and a decrease in new hair growth. Depending on the body, different percentages of hairs are removed throughout a session; generally speaking, areas with thinner skin, like the armpits and bikini area, respond better than areas with thicker skin, such the back and chin.

Usually, three or more treatments are needed to permanently suppress hair growth. Every four to eight weeks, treatments are repeated. For people with Fitzpatrick types I to III and maybe light-colored type IV skin, the laser treatment is often ineffective for light-colored (blonde/grey) hair but helpful for dark-colored (brown/black) hair. Patients with darker or tanned skin should continue with great caution because the laser can also eliminate pigment in healthy skin, leaving behind white regions. Following the surgery, patients should stay out of the sun and apply a broad-spectrum sunscreen with an SPF of 50 or higher.

Tattoo Removal

The ink or color used has a significant impact on how sensitive the tattoos are to Q-switched ruby laser treatment. Ruby laser treatment works effectively on blue and black tattoos because they absorb the red laser light quite well. Green tattoo paints vary in their reactivity. Generally speaking, tattoos that are red or yellow don't react well to the ruby laser. The Q-switched ruby laser outperformed the Q-switched Nd:YAG laser (1064 nm, 10–20 nanoseconds, 3.0 mm spot size, 5–10 J/cm2) and Q-switched alexandrite laser (755 nm, 50–100 nanoseconds, 3.0 mm spot size, 6–8 J/cm2) in at least one research when it came to clearing blue/black tattoos.

The typical Q-switched ruby laser parameters for tattoo removal are fluence 4–10 J/cm2, wavelength 694 nm, pulse 25–40 nanoseconds, and spot size 5.0 mm. For amateur tattoos to be completely removed, four to six treatment sessions spaced three weeks apart are required. Professionally done (machine pierced) tattoos typically take more treatment sessions (about 6–10 sessions) to completely remove because to their higher pigment density. Particularly, patients with skin types IV–VI react to the ruby laser more slowly than patients with light skin. This is because a large amount of the laser light is absorbed by the epidermal melanin, which is found above the tattoo ink.

Ink molecules are selectively destroyed by laser treatment, which is subsequently taken up by macrophages (immune cells) and eradicates

Side Effects of Ruby Laser Treatment

Side effects from ruby laser treatment are usually minor and may include:

Pain during treatment (reduced by contact cooling and if necessary, topical anesthetic)

Redness, swelling and itching immediately after the procedure that may last a few days after treatment.

Rarely, skin pigment may absorb too much light energy and blistering can occur (laser burn). This recovers without specific treatment.

Changes in skin pigmentation. Sometimes the pigment cells (melanocytes) can be damaged leaving darker (hyperpigmentation) or paler (hypopigmentation) patches of skin. Generally, cosmetic lasers are less likely to result in these effects in people with lighter rather than darker skin tones.

Bruising affects up to 10% of patients. It usually fades on its own.

Bacterial infection.

Transition to Human Use

The first clinical experience in humans was using the ruby laser to treat malignant gliomas, performed by Rosomoff and Carroll in 1966. To avoid thermal damage to adjacent brain matter, low energy pulses were used, and physicians did not try to respect the tumors. However, the laser radiation induces some areas of radiation necrosis. Stellar et al. were the first in the world to use the continuous-wave CO_2 laser to try to resect a recurrent glioblastoma multiforme in a human in 1969. They were able to partially excise the tumors without causing any damage to the surrounding structures.

Achievement of Laser

Through spontaneous emission, some of the chromium ions will return to E1 by releasing photons. A photon has a wavelength of 6943 Å. As it passes through the ruby rod, if it is traveling parallel to the crystal's axis, it is reflected back and forth by the rod's silvered ends, stimulating the other excited ions and causing them to release a new photon that is in phase with the stimulating photon.

As a consequence, the reflections will cause stimulated emission, which will then cause the stimulated emitting photons to be amplified. The laser transition is this stimulated emission. By stimulating the chromium ions, the two stimulated photons will expel more photons, increasing the total to four and so forth. Photons multiply as a result of this process being done repeatedly. A very strong and narrow red light beam with a wavelength of 6943 Å appears through the partially silvered end of the ruby crystal when the photon beam is strong enough.

Since the laser beam is attained between these levels, E2 is the upper laser level and E1 is the lower laser level in the energy level diagram. Therefore, a three-level laser system is what the ruby laser falls under.

Output

The ruby laser produces pulses with an output wavelength of 6943 Å and an output power of 10 watts, with the option to increase power from 4 to 10 watts or 6 watts.

Conclusion

As the first functional laser ever developed, the ruby laser has left a lasting impression on the history of science and technology.Notwithstanding its drawbacks, it created a whole new realm of opportunities that resulted in the creation of numerous laser technologies that have revolutionized a variety of fields, including industry, health, and communication. Although more advanced and effective lasers have been created over time, the ruby laser's status as a pioneer in this area highlights its significance in our technical legacy.

The first visible light laser to come after the early microwave masers was the ruby laser. It is a solid-state laser that emits red light with a wavelength of $\lambda 0$ = 694.3 nm. By reflecting red and absorbing green and blue, chromium gives the ruby rod its red hue.

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