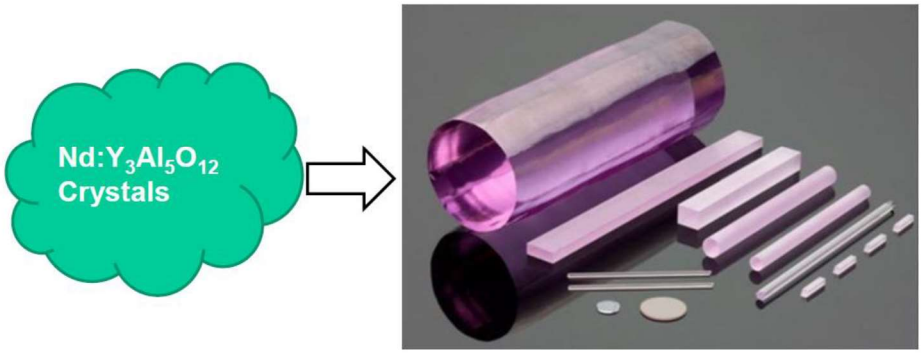
Nd:YAG Laser

Dr Rajeshkumar Mohanraman
Assistant Professor Grade 1
School of Advanced Sciences
VIT Vellore

Nd:YAG laser **Solid state laser**

Neodymium-doped Yttrium Aluminum Garnet

Chemical composition $Nd:Y_3Al_5O_{12}$



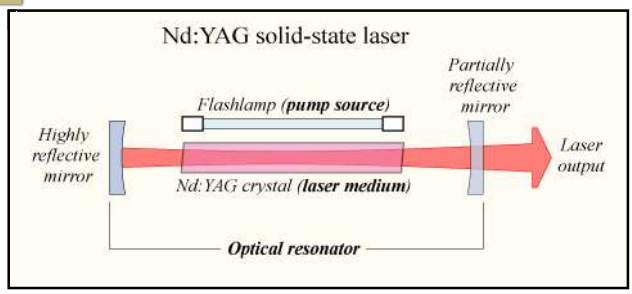
Called as "doped Insulator laser"

Nd:YAG laser

❖ Ruby ($Cr:Al_2O_3$) was the 1st solid state medium laser developed by T.H. Maiman in 1960. 4-level laser. Pure material acts as host and the dopant acts as guest material responsible for lasing action.

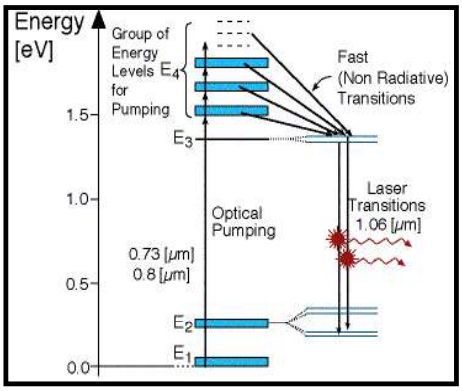
- Neodymium doped Yttrium Aluminum Garnate ($Y_3Al_5O_{13}$).
- It is the most popular type of solid state laser.
- Here, Y^{+3} ions in YAG crystal are partially replaced by Nd^{+3} ions.
- The crystal atoms do not participate in the lasing action but serve as a host lattice in which the active centers (Nd^{+3}) reside.

Construction



- Nd: YAG laser is made up of **elliptical cylindrical reflector.**
- One end is fixed with focus **krypton lamp acting as pumping device**.
- Other focus is silvered – flash from the krypton lamp after reflection concentrate at YAG rod placed at the other end.
- Ends of the laser rod is polished with silver to achieve the resonance mechanism of lasing action

Working of Nd:YAG laser



- **Optical pumping excites** the Nd^{+3} ions from the ground state energy E_1 to higher energy level E_4 and above by absorbing radiations of wavelengths **800 nm and 730 nm** respectively.
- The transition from **higher energy levels to E_3 is a non-radiative** transition.
- **E_3 is a metastable state** and upon continuous excitation, **population inversion of Nd^{+3} ions is achieved between the metastable state E_3 and E_2.**

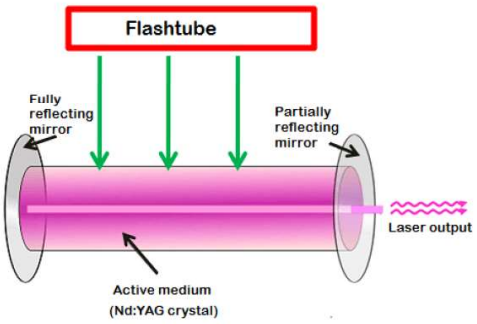
- Any of the spontaneously emitted photon will make the excited Nd^{+3} ions to undergo a transition between E_3 to E_2 state producing coherent stimulated photons.
- As a result the **transition $E_3 \rightarrow E_2$ yields a coherent laser beam of wavelength 1064 nm.**
- The Nd^{+3} ions then make a transition **$E_2 \rightarrow E_1$ which is a non-radiative transition**.

Applications:

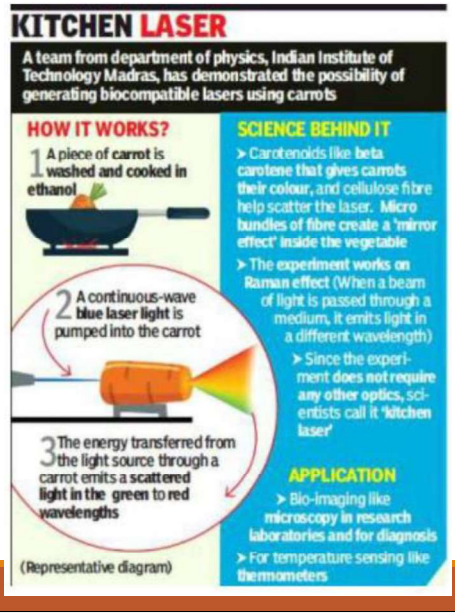
1. Widely used in material processing such as drilling, cutting, etching, welding, surface hardening etc.
2. In military for range finding and target destination.
3. In medical field for cateract surgery, gall bladder surgery anointd to treat gastrointestinal bleeding.

Nd:YAG laser Principle

The Nd ion has many energy levels and due to optical pumping these ions raised to excited levels. During the transition from metastable state E_3 to lower energy state E_2, the laser beam of wavelength 1064nm emitted.



In A First , IIT Madras Researchers Generate Lasers From Carrots



Uses of Lasers

- Due to their properties of coherence, high intensity and high monochromaticity, lasers prove to be useful in almost all fields of the society.

- In general, they are widely used for scientific, military, medical and industrial purposes.

Scientific Uses of Lasers

- ❖Spectroscopy
- ❖Heat treatment
- ❖Weather
- ❖Lunar laser ranging
- ❖Photochemistry
- ❖Laser scanner
- ❖Laser cooling
- ❖Nuclear fusion
- ❖Microscopy

Military Uses of Lasers

- ❖Directly as an energy weapon
- ❖Defensive countermeasures
- ❖Disorientation
- ❖Guidance
- ❖Firearms

Industrial Uses of Lasers

- ❑ Lasers are used in a vast variety of areas in the industry, but the most important applications of lasers include cutting, welding and drilling.
- ❑ Other uses include laser pointers, engraving, OLED display manufacturing, 3D laser scanners, etc.

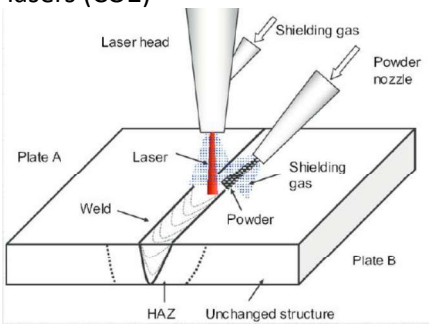
Welding

❖Two metals are placed in contact, and the area around the point heated until the metals are fused together.

❖Type of laser used: solid state (Nd:YAG and ruby) and gas lasers (CO2)

❖Advantages of using lasers:

- ❑No physical contact
- ❑Heating is localised
- ❑Dissimilar metals can be weld
- ❑Controlled Atmosphere
- ❑Can be used in inaccessible regions



❖Examples: Curved contours of automobiles. CO2 laser can also be used to weld plastic films.

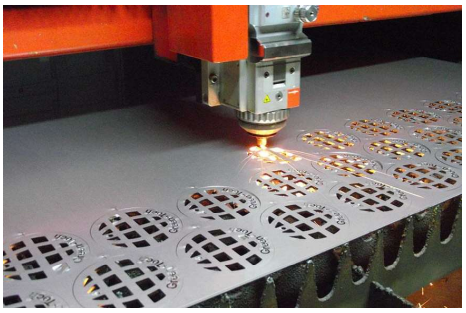
Cutting

❖The aim is to vaporise quickly and produce narrow heat affected zone with minimum distortion

❖Types of laser used: CO2, Nd:YAG

❖Advantages of using lasers:

- ❑ Minimal mechanical distortion and thermal damage
- ❑ No contamination
- ❑ Complicated profiles
- ❑ Easy automation



❖Examples: Paper, cloth, plywood, glass, ceramics, aerospace industries

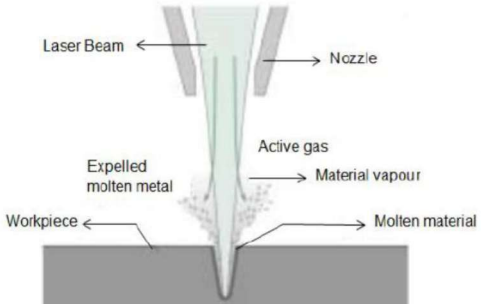
Drilling

❖ Creating thru-holes, by repeated pulses of focused laser energy. Each pulse lasts for 0.0001 - 0.001 seconds.

❖ Types of laser used: CO2, Nd:YAG, Copper Vapour Laser (CVL)

❖ Advantages of using lasers:

- ❑ Non-contact, so physical drill bit needed
- ❑ High precision
- ❑ Faster process
- ❑ Drilling hard materials is possible



❖ Examples: baby bottle nipples, aircraft engine turbine blade, nozzles