

# Solid State laser

## Nd:YAG laser

Nd: YAG laser is a neodymium based laser. Nd stands for Neodymium (rare earth element) and YAG stands for Yttrium Aluminum Garnet ( $Y_3 Al_5 O_{12}$ ) .

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## Nd (Neodymium) – YAG (Yttrium Aluminium Garnet) LASER

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## Principle:

The active medium Nd: YAG rod is optically pumped by Krypton flash tubes. The Neodymium ions ( $\text{Nd}^{3+}$ ) are raised to excited levels. During the transition from meta stable state to ground state, a laser beam of wavelength  $1.06 \mu\text{m}$  is emitted.

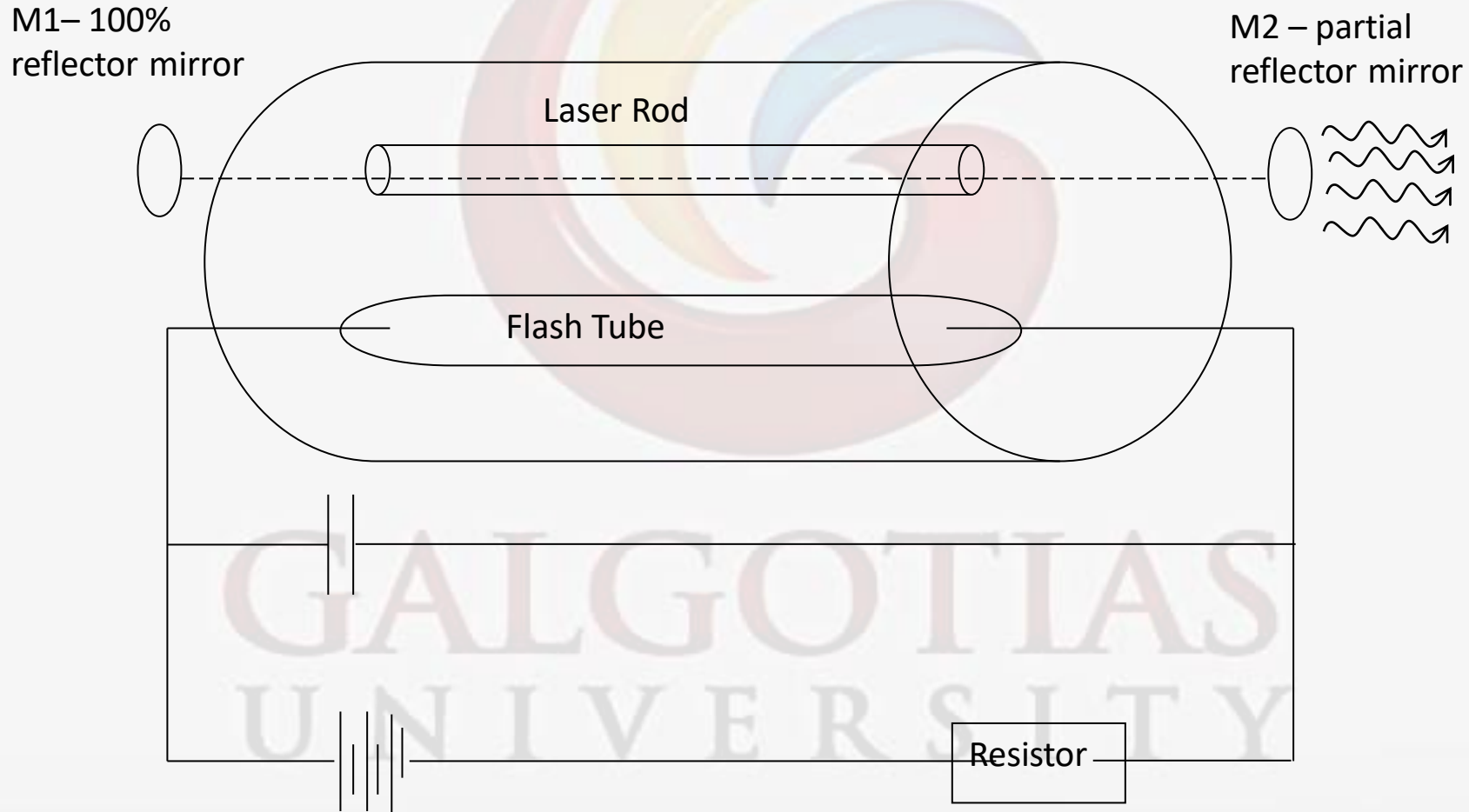
## Construction:

A small amount of Yttrium ions ( $\text{Y}^{3+}$ ) is replaced by Neodymium ( $\text{Nd}^{3+}$ ) in the active element of Nd: YAG crystal.

This active element is cut into a cylindrical rod. The ends of the cylindrical rod are highly polished and they are made optically flat and parallel. This cylindrical rod (laser rod) and a pumping source (flash tube) are placed inside a highly (reflecting) elliptical reflector cavity.

The optical resonator is formed by using two external reflecting mirrors. One mirror ( $M_1$ ) is 100% reflecting while the other mirror ( $M_2$ ) is partially reflecting.

## Construction: Block diagram of Nd-YAG laser



## Working:

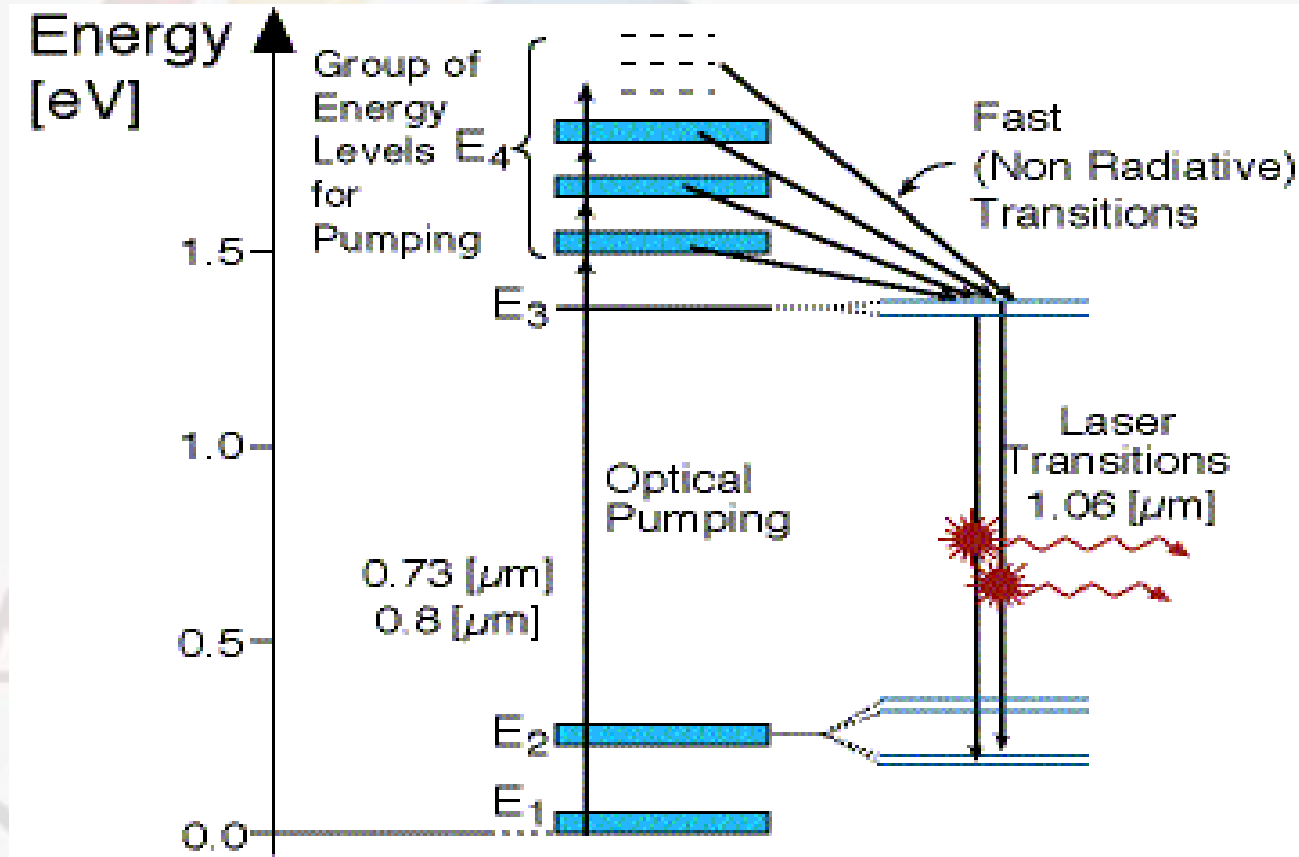
When flash lamp is energised it gives out radiations

Nd<sup>3+</sup> ions get excited to higher energy levels by absorbing 0.73  $\mu\text{m}$  and 0.80 $\mu\text{m}$  from the input radiations.(white light)

Nd<sup>3+</sup> ions can stay for a duration of about  $10^{-8}$  sec.

These ions undergo non-radiative transitions to reach the metastable state E<sub>3</sub>.  
Laser output of wavelength 1.06  $\mu\text{m}$  is obtained from E<sub>3</sub> to E<sub>2</sub> transition.

## Energy Levels of Neodymium ions in a crystal



## Characteristics:

1. Type: It is a four level solid state laser.
2. Active medium: The active medium is Nd: YAG laser.
3. Pumping method: Optical pumping is employed for pumping action.
4. Pumping source: Xenon or Krypton flash tube is used as pumping source.
5. Optical resonator: Two ends of Nd: YAG rod is polished with silver (one end is fully silvered and the other is partially silvered) are used as optical resonator.
6. Power output: The power output is approximately 70 watt.
7. Nature of output: The nature of output is pulsed or continuous beam of light.
8. Wavelength of the output: The wavelength of the output beam is  $1.06\mu\text{m}$ (infra-red)

## Advantages:

1. It has high energy output.
2. It has very high repetition rate operation
3. It is much easy to achieve population inversion.

## Disadvantages:

The electron energy level structure of  $\text{Nd}^{3+}$  in YAG is complicated.

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## Applications:

- Material processing, such as drilling,, cutting and welding steel and super alloys.
- Medical applications(hair removal, and treatment of minor vascular defects) for soft tissue surgeries in the oral cavity
- In manufacturing as a means for engraving, etching, or marking a variety of metals and plastics.
- The most common laser used in laser designators and laser rangefinders.

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## References:

1. K. Thyagarajan, A. K. Ghatak, Lasers: Theory and Applications. New Delhi: Macmillan India Ltd.
2. B. B. Laud Lasers and Nonlinear optics (2ndEdn.). New Delhi: New Age international (P) Limited.
3. L. Allen, Essentials of Lasers. Oxford: Pergamon Press.
4. L. V. Tarasov, Laser Physics. Moscow: Mir Publisher