Sintec Optronics Technology Pte Ltd
10 Bukit Batok Crescent #07-02 The Spire Singapore 658079
Tel: +65 63167112 Fax: +65 63167113

# Nd:YAG Lasers

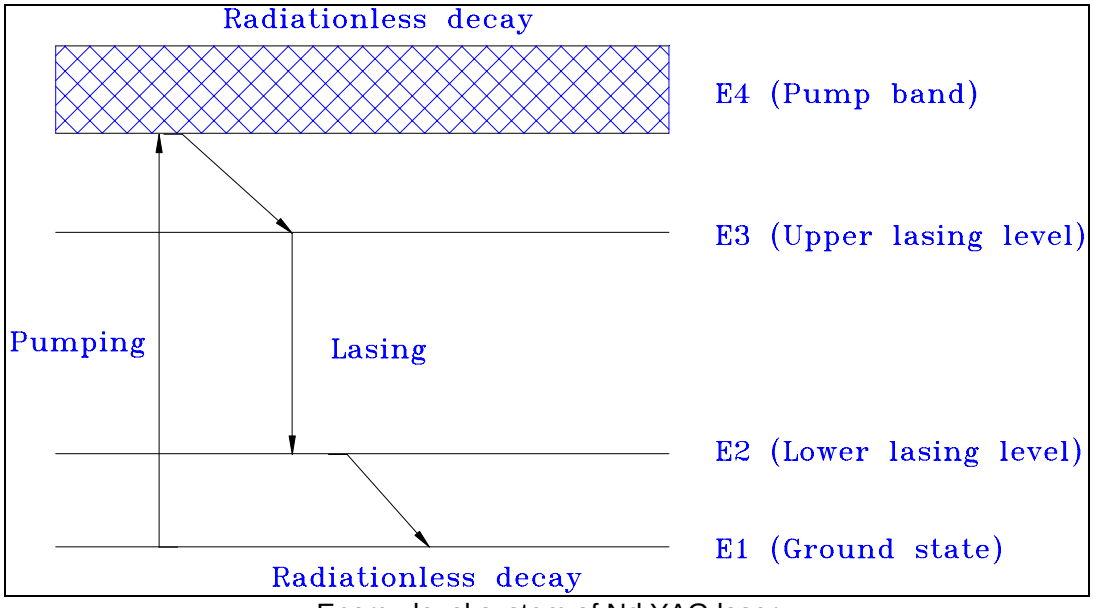
The first demonstration of laser action by T. H. Maiman was achieved in 1960 using ruby ($Cr^{3+}$:$Al_2O_3$). In 1960, L. F. Johnson and K. Nassau demonstrated the first solid-state neodymium laser, in which the neodymium ion was a dopant in calcium tungstate ($CaWO_4$). Elias Snitzer demonstrated the first neodymium-glass laser at American Optical that same year. However, it took another three more years before today's best choice of neodymium host for most commercial applications - yttrium aluminium garnet (YAG) - was demonstrated as a laser material by J. E. Geutic, H. M. Marcos, and L. G. Van Uitert. Solid-state lasers are now important candidates in laser applications, e.g. material processing, laser precision measurement, laser spectroscopy, laser medicine, and laser chemistry.

Compared to other lasers, the solid-state lasers have the following advantages:

(1) Various operation modes: The solid-state lasers can operate in CW, pulsed, Q-switched, and mode-locked modes to obtain high average power, high pulse repetition rate, high pulse energy, and high peak power. The average power of 4 kW has commercially been achieved with modular construction YAG lasers. The peak power of $10^{13}$ - $10^{14}$ W has also been obtained.
(2) Wavelength diversity: More than 100 solid-state materials can produce laser beams. Most of these beams range in the visible and near infrared regions of the electro-magnetic spectrum. The UV wavelengths have also been achieved by harmonic generators due to the advent of new non-linear materials and high beam quality obtained from diode-pumped lasers. Significant progress has been made in the development of tuneable solid-state lasers.
(3) Convenient optical delivery system: Laser beams produced by some solid-state lasers can be delivered with optical fibre, which makes lasers more flexible and applicable in dangerous or difficult-to-access processing environments.
(4) More compact and lower maintenance compared to high power $CO_2$ lasers and excimer lasers.

**Principle of operation**

The following figure shows the energy-level diagram of a Nd:YAG laser. Lasing is dependent on the rapid transitions from the lower lasing level to the ground state by radiationless transition. When the rod temperature is low, these transitions will occur at a high rate. Hence, lasing efficiency depends mainly on cooling efficiency. Higher output powers can be achieved by having lower operating temperature. This explains why cooling systems are generally operated at temperatures just above the threshold of this effect.

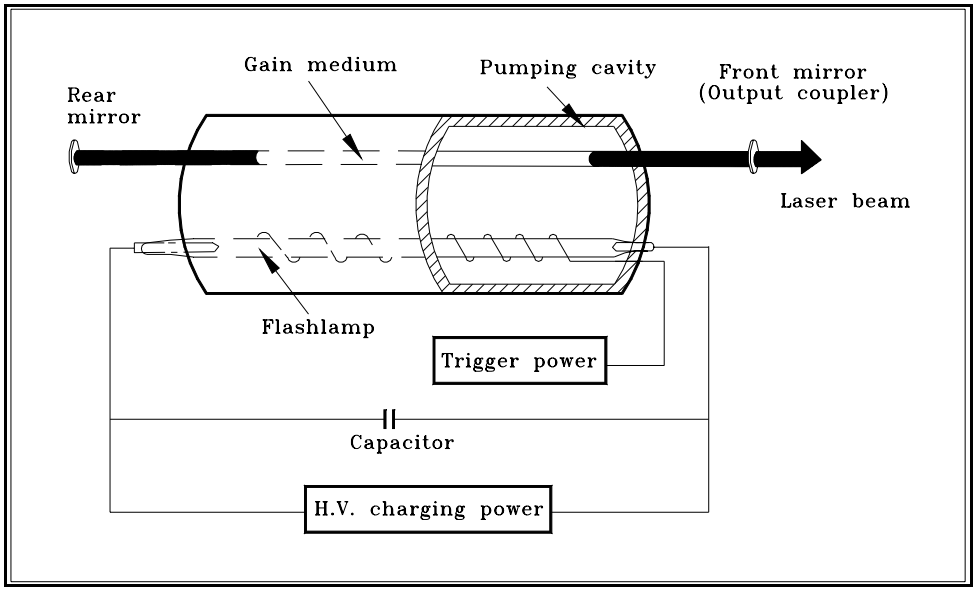


Energy level system of Nd:YAG laser

In the laser pumping cavity, Nd:YAG crystals are excited by absorbing light from a krypton flash lamp. The crystal absorbs light energy in two 730 - 760 nm and 790 - 820 nm pumping bands which are provided by the krypton lamp. This causes the molecules in the crystal to excite to the E4 pump band shown. The molecules radiate heat in the E4 to E3 transition and the E2 to E1 transition. Subsequently, this heat has to be removed by cooling the crystal rod.

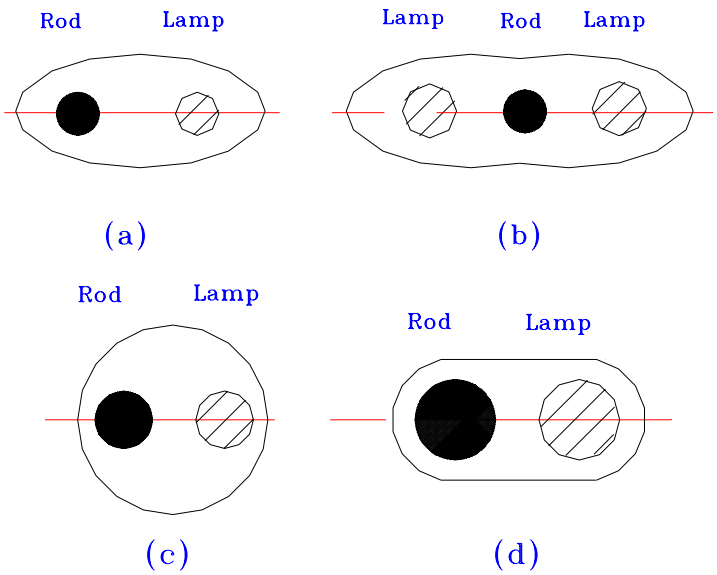
**Basic Construction of Solid-state Lasers**

A typical solid-state laser usually consists of a gain medium, a pumping cavity, an optical resonator, a cooling system and a power supply, as shown in Figure 2. The gain medium is placed in a gold-plated elliptical cross-section pumping cavity. Inside the cavity is an elliptical space with the rod (gain medium) at one focus of the ellipse and a flashlamp at the other focus. Ideally, all the light emitted by the lamp is coupled into the rod by the cavity. The optical resonator consists of two mirrors mounted separately from the lasing medium. The cooling system is necessary since most of the light energy from the lamp is lost as heat.




Basic construction of a solid-state laser

One of the most important elements in solid state lasers is pumping cavity. It, besides providing good coupling between the pumping source and the absorbing active material, is also responsible for the pump density distribution in the laser element which influences the uniformity, divergence, and optical distortion of the output beam. Depending on the shape of the active material and the type of pumping source used, pumping geometries can be broadly divided into systems in which the active material is side-pumped, end-pumped, or face-pumped. The following figure shows some of the typical pumping cavities.




Typical pumping cavities
(a) Single ellipse (b) Double ellipse (c) Circular cylinder (d) Close-wrap

Among the pumping cavities, the elliptical cavities have been most extensively discussed in the development of solid state lasers. In this configuration, a linear lamp and a laser rod, possibly with different radii, are placed at the foci of an elliptical cylinder, as shown in the above figure.

The laser material is shaped into a cylindrical rod whose ends are round and polished to be plane parallel. When the rod is placed between two mirrors facing each other, and is strongly irradiated by an intense light source around it, laser is emitted. To minimise cooling problems, YAG rods with smaller diameter are usually used. The rod ends are usually anti-reflection coated for the Nd:YAG wavelength of 1064 nm. The rod ends are held in place and sealed by O-rings recessed in the ends of the rod holders to protect them from the pump lamp light.

## 1. Integrated Lamp-pumped CW Nd:YAG Lasers


Imported key components used in our lasers result in high stability, good beam quality & low maintenances and low cost man-power results in low prices of our lasers.

The integrated laser typically consists of a laser head (pump chamber with YAG rod & lamp and laser resonator) and a cabinet with built-in lamp driver. There is also enough space inside the cabinet to mount a Q-switch driver, an electrical controller for the marking machine's control, and an industrial computer. The YAG-CW series of lamp-pumped CW Nd:YAG lasers are suitable for a wide range of precision marking, cutting, engraving, trimming, micro-machining, instrumentation and medical applications in the electronics, medical, automotive and fine mechanics markets.

| | YAG-CW-50 | YAG-CW-100 |
|---|---|---|
| Laser type | Lamp-pumped CW Nd:YAG lasers | |
| Laser wavelength | 1064 nm | |
| Laser power | 50W | 100W |
| Beam diameter | 3mm | 6mm |
| Beam mode | Multi-mode ($TEM_{00}$ mode available upon request) | |
| Output stability | ±3% | |
| Cooling method | Closed water cooling | |
| Power requirements | 380VAC, 5KVA | 380VAC, 8KVA |
| Dimension | Laser head: 920x160x175 mm<br>Power supply: 1060x560x600 mm | |
| **Option: AO Q-switch element** | | |
| Q switching frequency | 1-50 kHz | |
| Pulse width | Min. 140ns | |
| Peak power | 30kW | 45kW |
| **Option: laser chiller** | | |
| Cooling capacity | 4.0kW @ 20°C | 5kW @ 20°C |

**Typical Applications：**

Laser marking；
Laser medicine；
Laser trimming；
Laser cutting;
Laser welding.

## 2. Integrated Lamp-pumped CW Nd:YAG Lasers for Deep Engraving

The laser is specially designed for deep engraving on metals. The laser can output long pulse width & high power energy, also can output short pulse width & high peak power for the deep engraving of different materials. Through the application of new technology, the peak power is around 10 times compared to the traditional lasers, reaching 300kW. High beam quality and high conversion efficiency make the laser the best choice for deep engraving applications. The engraved depth can reach 5mm.

The laser can be used in deep engraving of parts of automotive and motors, hardware tools, stainless steel products, medical parts, clock and watch, industrial bearing, mould. The materials to be engraved include copper, brass, aluminum, alloy, stainless steel etc.

| | |
|---|---|
| Maximum average laser power | 100W |
| Maximum peak laser power | 300KW |
| Laser wavelength | 1064nm |
| Maximum engraving depth | ≥5mm depending on materials |
| Input electricity | 380V/50Hz 4.5KW |

**Engraved samples**


Tool steel

Brass

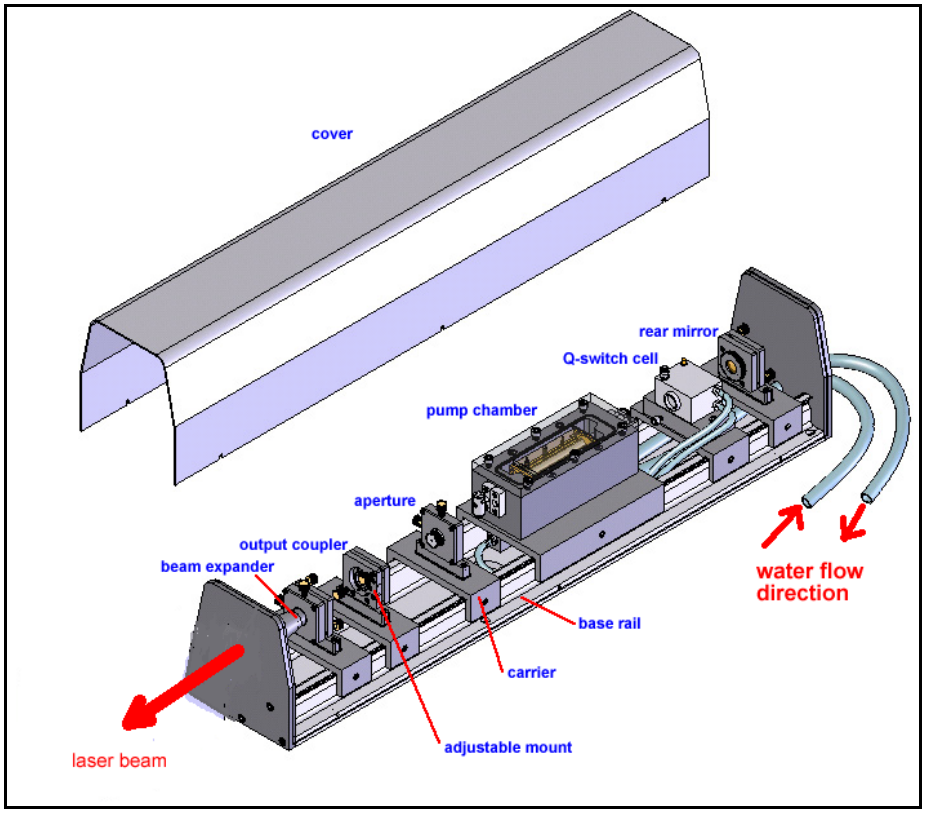
## 3. OEM CW Lamp-pumped Nd:YAG Lasers

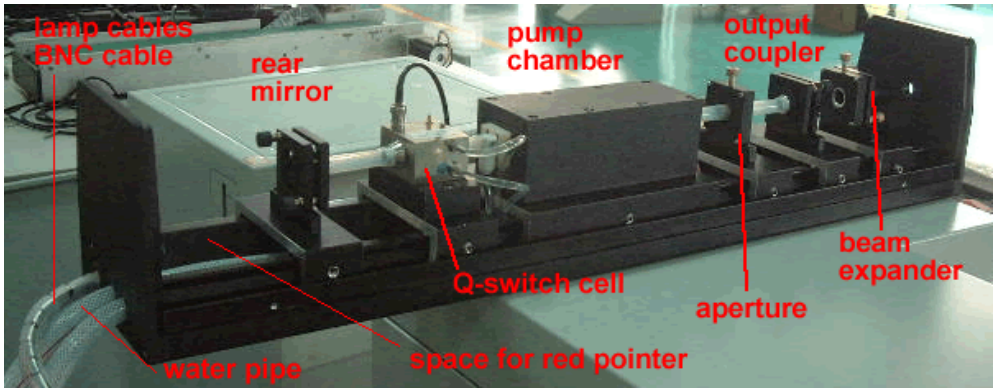
For OEM users or laser integrators, we can provide OEM and system integrators with a range of high performance components and sub-assemblies of Nd:YAG laser at more attractive prices. These components and sub-assemblies include laser head (pump chamber, Nd:YAG rod, lamp, laser resonator, optional Q-switch cell, aperture and beam expander), lamp driver and optional Q-switch driver and chiller.

| | YAG-CW-50OEM | YAG-CW-100OEM | YAG-CW-200OEM | YAG-CW-300OEM |
|---|---|---|---|---|
| Laser type | Lamp-pumped CW Nd:YAG lasers | | | |
| Laser wavelength | 1064nm | | | |
| Laser power | 50W | 100W | 200W | 300W |
| Beam diameter | 4mm | 5mm | 7mm | 8mm |
| Beam mode | Multi-mode ($TEM_{00}$ mode available upon request) | | | |
| Output stability | ±3% | ±3% | ±3% | ±3% |
| Cooling method | Closed water cooling | | | |
| Electricity | 380VAC, 5kW | 380VAC, 5kW | 380VAC, 10kW | 380VAC, 16kW |

**1. Laser Head**

A laser head consists of base rail, pump chamber with Nd:YAG rod & lamp, output coupler and rear mirror, front plate, rear plate, and cover. Options include aperture, AO Q-switch cell and beam expander.



**2. Q-switch Driver**

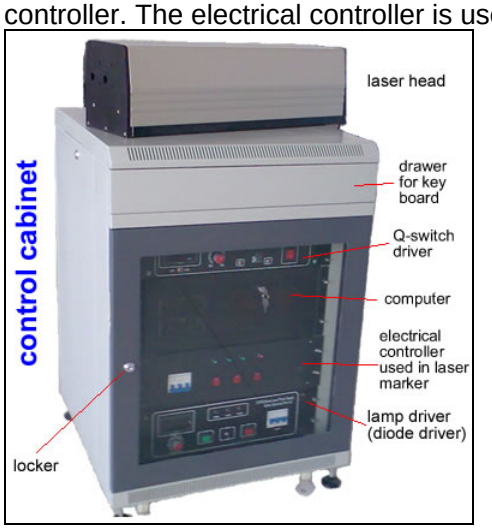

The panel is standard 19 inch.

**3. Lamp Driver**

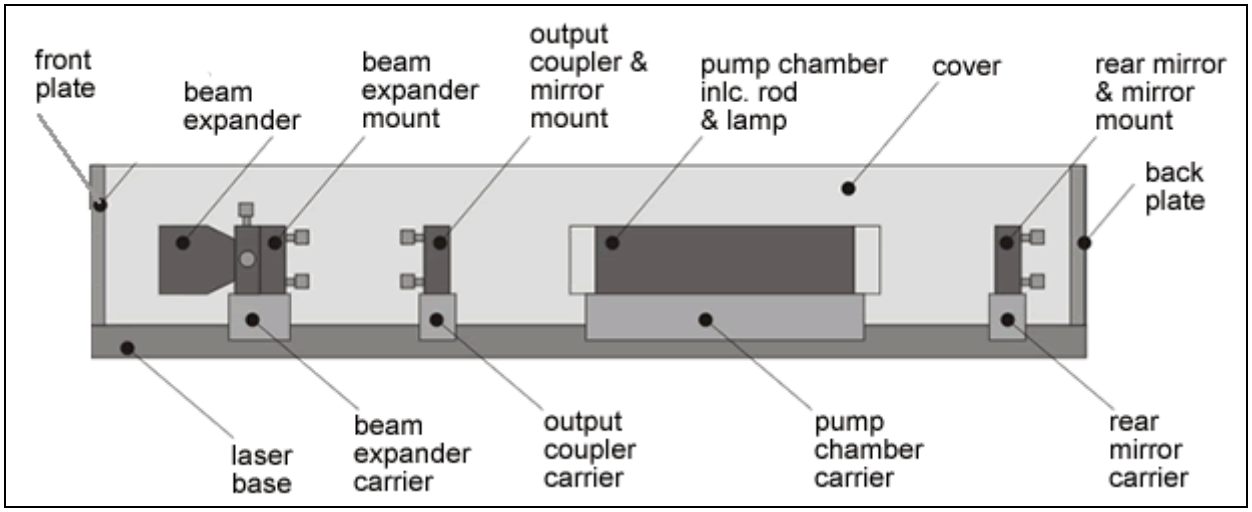
The panel is standard 19 inch.

**4. Control Cabinet**

Used to mount key board, Q-switch driver, computer, lamp driver (or diode driver) and electrical controller. The electrical controller is used in YAG laser markers.



## 4. OEM CW Lamp-pumped Nd:YAG Laser Heads




If you have good experience on CW lasers, you may just buy laser heads as follows:

**Integrated lamp-pumped CW Nd:YAG laser head (50W)**

- laser head, including pump chamber BPQT-97, Nd:YAG rod 3x120mm, lamp ST5166, rear mirror & mirror mount MM-20, output coupler and mirror mount MM-20, optional beam expander BEST-1064-3-2 & beam expander mount BEM22x0.75, laser base & cover, back and front plate, all carriers.
- The above items are assembled and tested.

**Integrated lamp-pumped CW Nd:YAG laser head (75W)**

- laser head, including BPQT-97, Nd:YAG rod 4x120mm, lamp ST5166, rear mirror & mirror mount MM-20, output coupler and mirror mount MM-20, optional beam expander BEST-1064-3-2 & beam expander mount BEM22x0.75, laser base & cover, back and front plate, all carriers.
- The above items are assembled and tested.

**Integrated lamp-pumped CW Nd:YAG laser head (100W)**

- laser head, including gold-coated pump chamber BPQT-117, Nd:YAG rod 4x140mm, STK-8x125x270-5x10, rear mirror & mirror mount MM-20, output coupler and mirror mount MM-20, optional beam expander BEST-1064-3-2 & beam expander mount BEM22x0.75, l laser base & cover, back and front plate, all carriers.
- The above items are assembled and tested.

## 5. Lamp-pumped Q-switched Green Nd:YAG Lasers

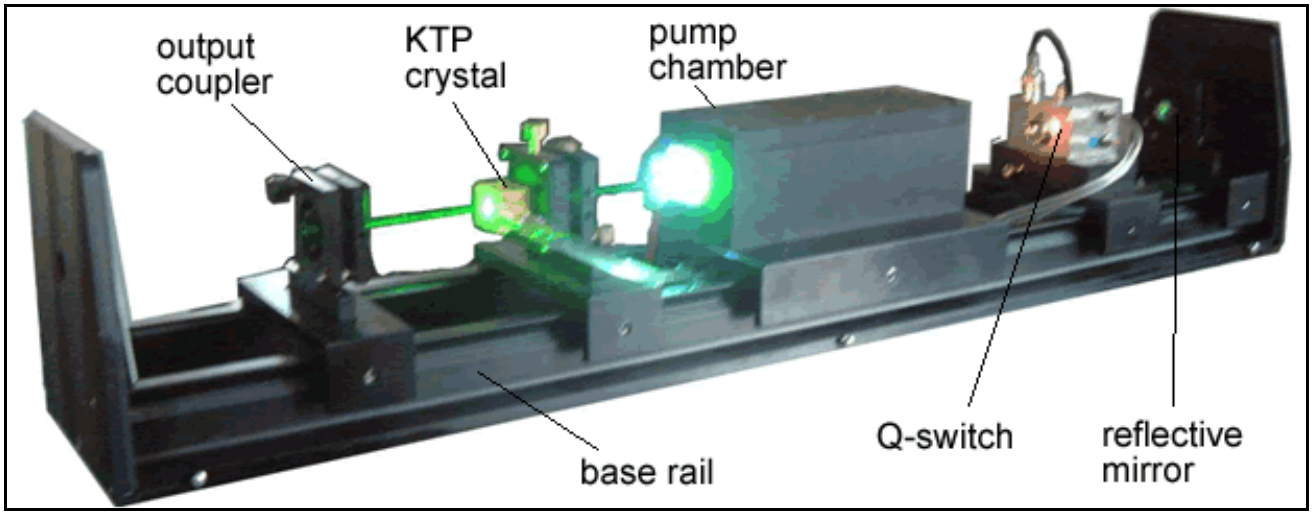
Imported key components used in our lasers result in high stability, good beam quality and low maintenances.

The laser typically consists of laser head (pump chamber, second harmonic crystal, Q-switch and laser resonator), control cabinet (Q-switch driver, lamp driver & electrical control box) and chiller. The green Nd:YAG lasers are suitable for a wide range of precision marking, cutting, trimming, micro-machining, instrumentation and medical applications in the electronics, medical, automotive and fine mechanics markets.

| Model | SHG-LP-05 |
|---|---|
| Laser type | Lamp-pumped Nd:YAG laser |
| Laser wavelength | 532nm |
| Laser power | 5W |
| Beam diameter | 3mm |
| Beam mode | Multi-mode |
| Q-switch element | AQ Q-switch |
| Pulse repetition rate | Max. 50kHz |
| Min. pulse width | Min. 140ns |
| Output stability | ±5-7% |
| Cooling method | Closed water cooling |
| Power requirements | 380VAC, 6.5kVA |


**Typical Applications：**

1. Laser marking;
2. Laser medicine;
3. Laser trimming.



## 6. Integrated Lamp-pumped Pulsed Nd:YAG Lasers


The flashlamp-pumped pulsed Nd:YAG laser typically consists of laser head (pump chamber and laser resonator), switching power supply, control & closed water cooling system. The YAG-P series of flashlamp-pumped pulse Nd:YAG lasers are suitable for a wide range of precision welding, cutting and drilling applications in the electronics, medical, automotive and fine mechanics markets. The maximum output average power can reach 500-600W.

**Technical Data:**

| Model | YAG-P-50 | YAG-P-100 | YAG-P-200 |
|---|---|---|---|
| Laser type | Flashlamp-pumped pulse Nd:YAG lasers | | |
| Laser wavelength | 1064nm | | |
| Laser beam diameter | 3mm | 4mm | 6mm |
| Laser power | 50W | 100W | 200W |
| Laser energy | 15J | 25J | 50J |
| Pulse width | 0.1-10ms (others available upon request) | | |
| Pulse repetition rate | 1-200Hz (others available upon request) | | |
| Cooling | Closed water cooling system | | |
| Power requirements | 3-phase, 380VAC, 6KVA | 3-phase, 380VAC, 8KVA | |
| Dimension of laser head | 900×180×180mm | | |
| Options | Laser chiller, optical beam delivery, XY table, XYZ table | | |

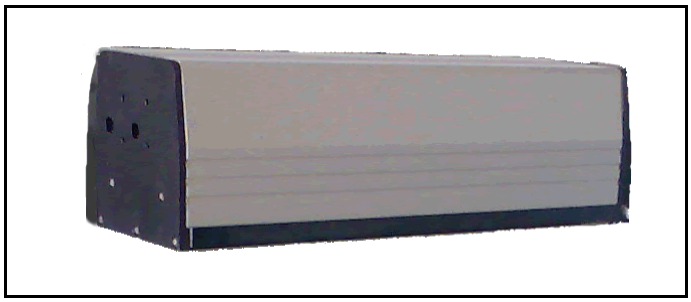
For OEM users or laser integrators, we can provide OEM and system integrators with a range of high performance components and sub-assemblies at more attractive prices. These components and sub-assemblies include laser head (pump chamber, Nd:YAG rod, lamp, laser resonator, optional aperture), lamp driver and chiller.

**Typical Applications:**

Laser cutting, welding & drilling of metals and components such as stainless steel, aluminium alloy, containers, electronic guns, lithium battery, fiber coupler etc.

**Application notes:** based on our experience, ceramic chambers are better used in welding machines and gold-coated chambers are better used in cutting machines.

## 7. OEM Lamp-pumped Pulsed Nd:YAG Lasers



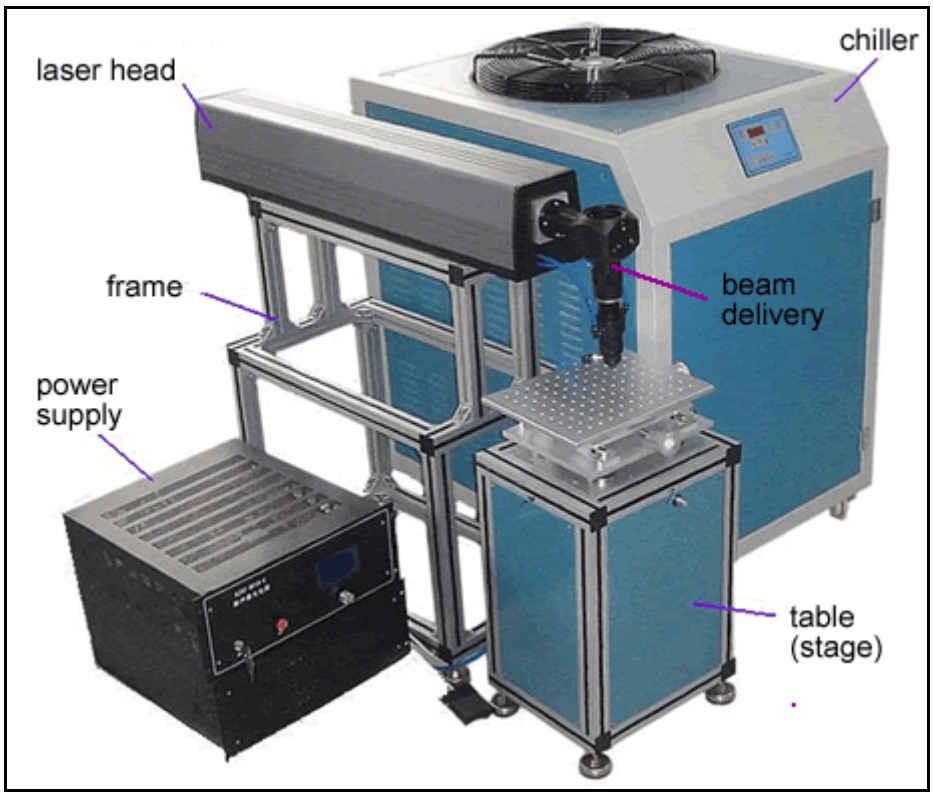
Laser head

Laser driver (power supply)

For OEM users or laser integrators, we can provide you with a range of high performance components and sub-assemblies at more attractive prices. The OEM pulsed laser consists of a laser head (pump chamber, Nd:YAG rod, lamp, laser resonator, optional aperture and optional beam expander), a lamp driver (power supply) and an optional chiller. These lasers can be used for laser welding and cutting.

| Model | YAG-P-100OEM | YAG-P-200OEM | YAG-P-350OEM | YAG-P-500OEM |
|---|---|---|---|---|
| Laser type | Flashlamp-pumped pulse Nd:YAG lasers | | | |
| Laser wavelength | 1064nm | | | |
| Laser beam diameter | 4mm | 6mm | 8mm | 8mm |
| Laser power | 100W | 200W | 350W | 500W |
| Pulse width | 0.1-10ms (others available upon request) | | | |
| Pulse repetition rate | 1-300Hz (others available upon request) | | | |
| Cooling | Closed water cooling system | | | |
| Power requirements | 3-phase, 380VAC | | | |
| Dimension of laser head | 900×180×180mm | | | |

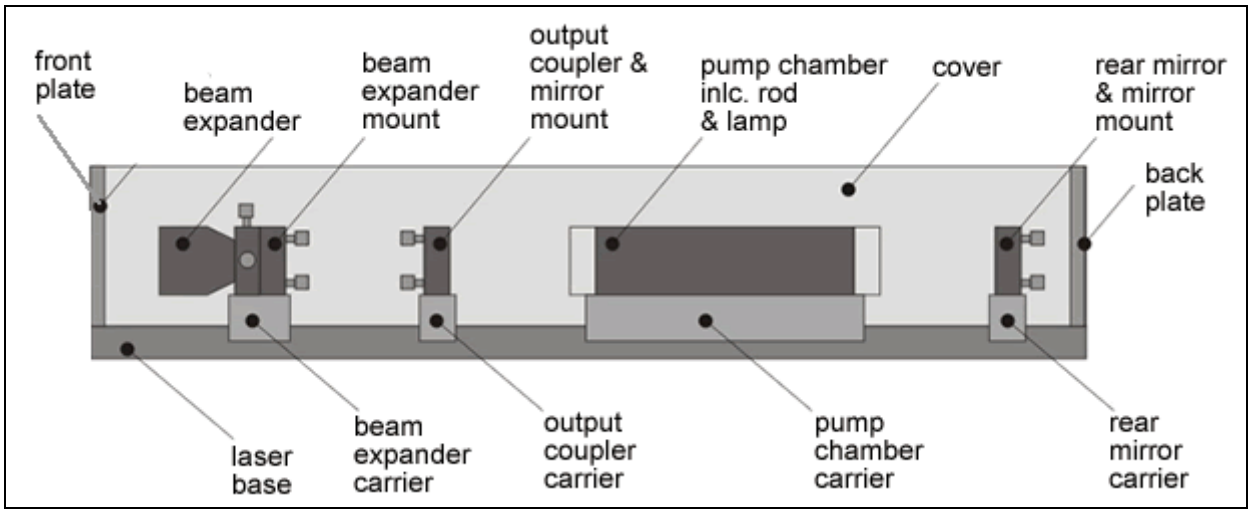
The customer can use these OEM lasers to develop its own laser welding or cutting systems by adding beam delivery, frame, chiller and relevant motorized or hand-adjustable tables as shown in the following picture.




**Application notes:** based on our experience, ceramic chambers are better used in welding machines and gold-coated chambers are better used in cutting machines.

## 8. Pulsed Lamp-pumped Nd:YAG Laser Heads

For OEM or laser system integrators, we can provide you with a range of high performance laser heads. The OEM pulsed laser head consists of pump chamber, Nd:YAG rod, lamp, laser resonator, optional beam expander, all mirror mounts, carriers and all mechanical parts (front and back plate, laser base & cover). The laser head has been assembled and tested at our factory.




**Integrated lamp-pumped pulsed Nd:YAG laser head (100W to 150W)**

- laser head, including pump chamber BPQJA-100 or BPQT-117, Nd:YAG rod (6x110mm or 6x140mm), lamp STX-8x100x250-5x10, rear mirror & mirror mount MM-20, output coupler and mirror mount MM-20, optional beam expander BEST-1064-3-2 & beam expander mount BEM22x0.75, laser base & cover, back and front plate, all carriers.
- The above items are assembled and tested.

**Integrated lamp-pumped pulsed Nd:YAG laser head (200W to 250W)**

- laser head, including pump chamber BPQJB-130 or BPQT-130D, Nd:YAG rod (6x140mm or 6x150mm), 2pcs lamps STX-8x130x280-5x10, rear mirror & mirror mount MM-20, output coupler and mirror mount MM-20, optional beam expander BEST-1064-3-2 & beam expander mount BEM22x0.75, laser base & cover, back and front plate, all carriers.
- The above items are assembled and tested.

**Integrated lamp-pumped pulsed Nd:YAG laser head (350W to 400W)**

- laser head, including pump chamber BPQJB-150 or BPQT-142D, Nd:YAG rod (7x165mm), 2pcs lamps STX-8x140x290-5x10, rear mirror & mirror mount MM-20, output coupler and mirror mount MM-20, laser base & cover, back and front plate, all carriers.
- The above items are assembled and tested.

**Integrated lamp-pumped pulsed Nd:YAG laser head (450W-500W)**

- laser head, including rail & base, ceramic pump chamber BPQT-150D, front and rear mirror with mount, front plate, rear plate, cover
- The above items are assembled and tested.

**Integrated lamp-pumped pulsed Nd:YAG laser head (500W-600W)**

- laser head, including rail & base, ceramic pump chamber BPQT-170D, front and rear mirror with mount, front plate, rear plate, cover
- The above items are assembled and tested.

**Application notes:** based on our experience, ceramic chambers are better used in welding machines and gold-coated chambers are better used in cutting machines.

# Cutting Results using 500W Pulsed Nd:YAG Laser

For reference only!

| Material | Thickness （mm） | Max. Cutting Speed （mm/min） | Min. Linewidth （mm） | Assistant Gas | Remark |
|---|---|---|---|---|---|
| Stainless steel | 0.5 | 3000 | 0.15 | Oxygen | Cutting will reduce 20% using nitrogen |
| | 1 | 1500 | 0.15 | | |
| | 2 | 900 | 0.25 | | |
| | 3 | 600 | 0.3 | | |
| | 4 | 300 | 0.4 | | |
| | 5 | 180 | 0.45 | | |
| Mild steel | 1 | 2000 | 0.12 | Oxygen | Cutting will reduce 20% using nitrogen |
| | 2 | 1200 | 0.15 | | |
| | 3 | 900 | 0.25 | | |
| | 4 | 800 | 0.3 | | |
| | 5 | 700 | 0.4 | | |
| | 6 | 600 | 0.45 | | |
| Brass | 0.5 | 420 | | Oxygen | |
| | 1 | 300 | | | |
| | 2 | 200 | | | |
| | 3 | 120 | | | |
| Aluminum | 0.5 | 320 | | Oxygen | |
| | | | | | |