CO_2, nd:YAG & Fiber lasers – which is right for me?

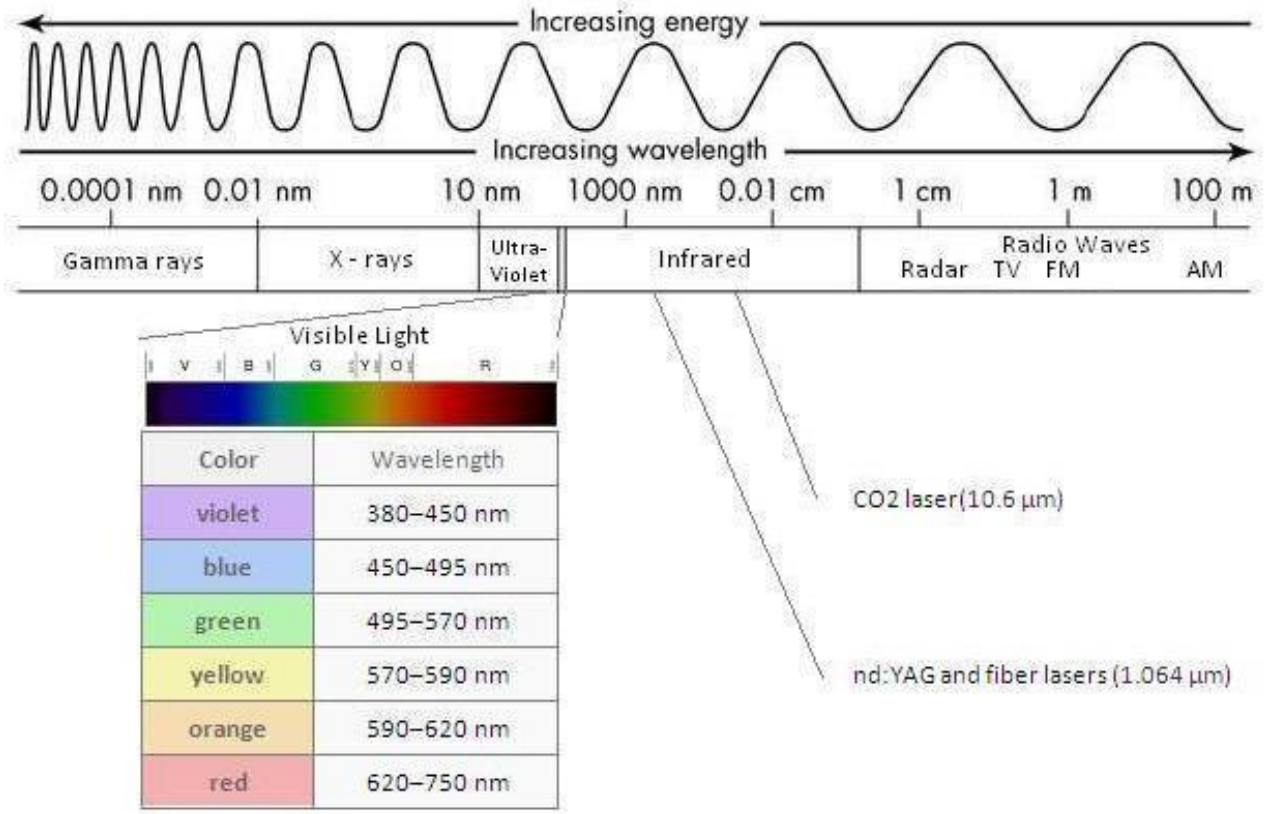
With so many options on laser marking systems available today it is not surprising that many people get confused with which is the most suitable to their application. Many people don't even know that the term "laser", is actually an acronym – Light amplification by stimulated emission of radiation – which explains the process by which a laser beam is created. The basic theory of this is simple. A gain medium (the material that is used to create the laser light), is excited using either light or electrical energy to generate photons (the laser light). All of this is happening in a closed cavity, with a completely reflective mirror at one end, and a semi reflective one at the other. When the light bouncing around inside gains enough energy, it escapes through the semi-reflective mirror.

These high energy photons are then focused to a small spot (much like you did at school when you used a magnifying glass to focus the sunlight to burn things!). If it is a vector laser, this beam is deflected and directed using a pair of mirrors (X and Y deflection). This guide will help you understand the capabilities of the 3 most common lasers available in the market today:

- A CO_2 laser: the Carbon Dioxide gas sealed inside the laser (along with some other gases – most commonly nitrogen, and helium) is pumped (excited / heated up) using electrical energy (DC, AC or RF) which creates the stream of photons.
- An Nd:YAG laser: the neodymium-doped yttrium aluminium garnet ($Nd:Y_3Al_5O_{12}$) is pumped using a lamp or diode to emit the stream of photons.
- A Fiber laser: a glass fiber doped with a rare earth ion – most commonly ytterbium (Yb^{3+}) – is diode pumped and the photons generated are reflected down the fiber towards the deflecting mirrors.

What are the differences?

The basic differences between the nd:YAG / Fiber and CO_2 Lasers is the wavelength of the beam that it produces. The light emitted from a laser sits within the Invisible Light - Infrared region of the electromagnetic spectrum, as shown in the image below.



Color	Wavelength
violet	380–450 nm
blue	450–495 nm
green	495–570 nm
yellow	570–590 nm
orange	590–620 nm
red	620–750 nm

10^3 nm = 1 µm

The light of the YAG and fiber lasers are emitted at a wavelength that is precisely 10 times smaller (1.064 µm) than that of a CO_2 laser(10.6 µm).

This smaller wavelength also means that if the Nd:YAG/Fiber and CO_2 lasers were used in the same application (with the same set-up). The Nd:YAG/Fiber would have a much smaller spot size and consequently, mark with a better resolution.

What difference does this make?

These wavelengths determine which laser should be used for each application, as the material to be marked will have different absorption capabilities (of the light at different wavelengths). If a material can absorb the light, then it can be affected by it.

Which one should I use for metal?

Most metals are highly reflective and therefore, an Nd:YAG or Fiber laser would be most suited.The wavelength being much shorter means there will be less reflection of the beam on the surface, therefore less loss of energy and consequently easier working of the metal. The metal absorbs more of the light energy that changes its physical properties.

Which one should I use for non – metal?

Organic materials such as wood, acrylics, plastics, fabrics, and transparent objects are better suited to the CO_2 as the wavelength is longer and has more latitude. However the Nd:YAG and Fiber lasers can be used to mark some non-metals too. But if the object is transparent (eg. glass) then the YAG / Fiber laser light will pass through it without marking it.

Material	YAG laser marker	CO2 laser marker
Plastic	○	○
Metal	○	○ (Stainless steel only)
Transparent object (glass, plastic)	×	○
Ceramic	○	○

Laser markers can produce alpha-numeric characters, bar codes, serial numbers, logo's, artwork and other graphic images using a non-contact thermal process.

Is there an easy way of knowing which would be most suitable?

Ideally, a sample of the material would have to be tested , but generally think of CO_2 for Organic and YAG and its derivatives (Fiber, nd:YAG .. etc) for Non Organic materials.

Okay, I have decided to go for either a nd:YAG or Fiber laser, what are the differences??

- The nd:YAG uses a lamp or a diode pack (array) to excite the gain medium - these require more electrical power and wear out (and are very costly to replace). They, also produce a lot of heat and require more heat dissipation (some water cooled – most now use heat-sinks and thermo-electric cooling systems)
- The fiber lasers use many single emitter diodes that are cheaper to run, and will last the lifetime of the fiber. The mean time before failure is greater than 50,000hrs
- The fiber laser is more stable at all power levels.
- The light source with a fiber is completely sealed all the way to the marking head. This stops dust and particle contamination and enables longer working distances between the control unit and marking head. It also reduces any leakage and therefore increases the efficiency of the laser beam.
- The fiber laser “boots up” a lot quicker.
- The fiber laser has less replacement parts (such as resonator mirrors, crystals, fluids and filters)

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