

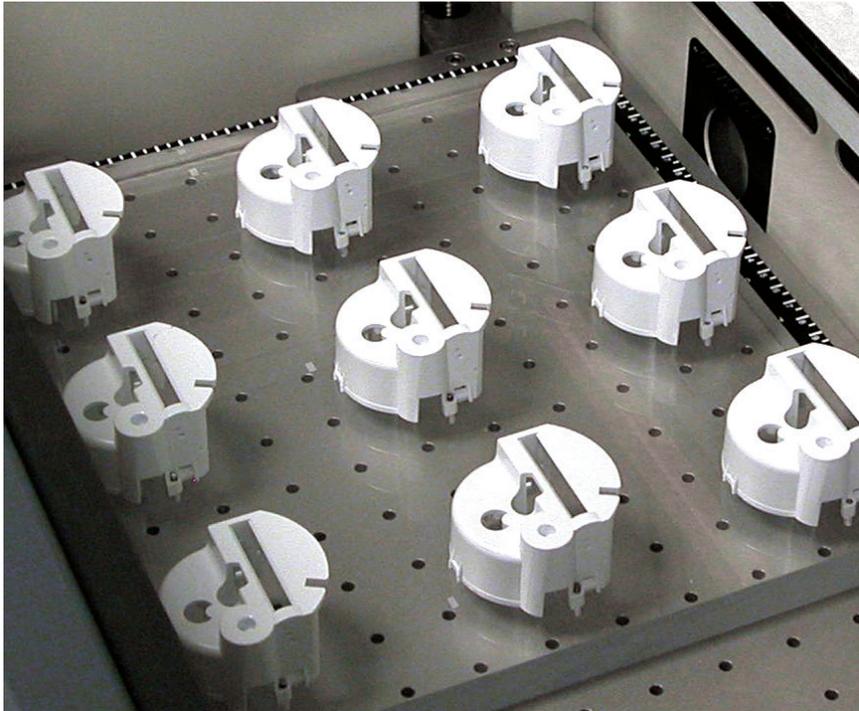


GUIDE FOR FIBER INDUSTRIAL ETCHING & MARKING



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INTRODUCTION

The fiber laser has been a great tool for our customers because it meets an entirely new set of needs. The ability to etch and mark so many types of industrial products means that you have the challenging task of determining how to best test the materials to show off how well the laser will work for a particular application.

To help you determine if a fiber laser system is right for your application, we've put together a short white paper which will:

- Provide you with a list of the most common compatible and non-compatible materials for the fiber laser source.
- Help you determine the correct printing parameters when etching different materials.
- Give you a quick reference guide when thinking about applications for the fiber laser system.

HOW FIBER LASERS WORK

The Short Answer:

The fiber laser source generates a laser beam by pumping intense diode light into the end of fiber optic cables that have been doped with ytterbium. The energy from the diode light is absorbed by the ytterbium in the fiber optic cables. The ytterbium then releases the energy in the form of photons that travel down the optic cables. The photons that leave the optic cables create the laser beam. The wavelength of light generated from a fiber laser is 1062 nm.

The Longer Answer:

The fiber laser source generates laser light by pumping intense diode light into fiber optics cables that are doped with the rare-earth element, ytterbium (Yb^{3+}), which is referred to as the medium or gain medium. As this diode light energy travels into the fiber optic cable, it energizes the electrons in the ytterbium and the ytterbium electrons go from a ground or stable state, to an excited state.

Essentially, all that is happening in this first step is that the electrons in the medium are absorbing and storing the energy that's coming from the external energy source (diodes). In the fiber laser (and also most YAG lasers these days and YVO lasers) the external energy source is a laser diode.

The electrons in the medium don't really want to store the external energy they've absorbed, so they emit the extra energy by releasing a photon (a quantum packet of light). Once a photon has been emitted by one electron in the medium it stimulates other excited electrons to also emit photons, creating a chain reaction where the absorption and emission of energy is at a constant rate. The photons travel through the optic fibers and some are released through the end of the fibers as the laser beam.

By continually pumping energy into a medium, that medium tries to shed the excess energy by emitting photons. The type of medium is important because different mediums absorb different types of energy (for instance, a CO_2 gas medium is not going to absorb the energy from a diode in a way that will make the CO_2 gas laser). Different mediums also emit different wavelengths of photons, and hence, the different properties of different wavelength lasers.

COMPATIBLE MATERIALS

Here is a list of the compatible materials that we have found work well with the fiber laser system:

<ul style="list-style-type: none"> • 17-4 PH stainless steel • 303 stainless • 4043 steel • 6061 Aluminum • ABS (black/white) • Aluminum, 6061 • Aluminum, yellow chromate • Bayer 2807 Makrolon polycarbonate • Bayers bayblend FR110 • Black/white ABS • Black/white polycarbonate • Brass • Brushed aluminum • Carbon fiber • Carbon nanotube • Ceramics, metal-plated • Clear coat anodized aluminum • Cobalt chrome steel • Colored Delrin (black/brown) • Compacted powder iron with iron phosphate coating • Copper • DAP- Diallyl Phthalate • Delrin, colored (black/brown) • GE Plastics polycarbonate resin 121-R • Glass filled PEEK • Glass filled Teflon • Hard coat anodized aluminum • Inconel metals (various) • Machine tool steel 	<ul style="list-style-type: none"> • Magnesium • Metal-plated ceramics • Molybdenum • Nickel plated 1215 mild steel • Nickel plated brass • Nickel plated gold • Nickel plated Kovar • Nickel plated steel • Nylon • PEEK, white • Polybutylene Terephthalate • Polycarbonate, (black/white) • Polycarbonate resin 121-R, GE Plastics • Polycarbonate, Bayer 2807 Makrolon • Polysulphone • Rynite PET • Santoprene • Silicon carbide • Silicon steel • Silicon wafers • Stainless steel 303 • Stainless steel 17-4 PH • Steel 4043 • Steel, machine tool • Various inconel metals (nickel-chromium super alloys) • White PEEK • Yellow chromate aluminum • Zinc plated mild steel
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If you have additional questions about these materials, please contact the Applications Lab at applications@epiloglaser.com.

NON-COMPATIBLE MATERIALS

Instead of providing a master list of non-compatible materials, we recommend experimenting using a broad range of settings and different techniques to draw your own conclusions. Many “non-compatible” materials will actually mark using the fiber wavelength of light and our endless range of adjustable settings. Whether the mark is desirable, provides enough contrast, or is acceptable for the intended application is all subjective.

Transparent polymers often won’t engrave using the fiber wavelength at standard polymer settings. The beam simply passes right through and marks the table. It is possible to get a mark on transparent polymers using metal engraving settings, but the results are typically less than stellar. The polymer’s pigmentation also plays a role in whether or not it will mark.

Black Delrin marks well, but white Delrin doesn’t mark as well.

Organic materials generally aren’t well-suited for the fiber laser system. Wood, clear glass, clear acrylic, leather and fabrics all tend to be transparent to the 1062nm wavelength.

Suggestions for marking less than ideal materials include:

- Oxidizers, paint fill and foils can help enhance the mark.
- Placing a metal plate under a transparent material will result in a mark. The fiber wavelength will pass through the material, mark the metal plate and reflect the beam back onto the bottom side of the transparent material.
- Consider using the Cermark or Thermark line of marking compounds as they can work with the fiber wavelength of light.
- In many cases, an alternative compatible material can be used.

TYPES OF MARKS

Terminology used when examining different types of marks:



Ablation: The process of ablation is the removal from the surface of an object by vaporization. You'll often hear of this process associated with etching an anodized material.



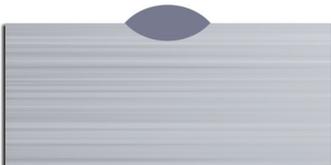
Annealing: This is the process of heating steel to a high temperature, creating a permanent oxide layer on the surface. The mark that results is a high-contrast mark created without changing the surface finish of the metal.



Color Changing: With some plastics, the laser radiation penetrates the plastic and is absorbed by the color pigments of the plastic. The pigments are chemically modified, resulting in a color change in the surface, without damaging the surface.



Engraving: The material is vaporized by the laser beam. The result is often a cone-shaped indentation due to the shape of the laser beam.



Foaming: Most commonly seen with plastics and sometimes stainless steel, foaming is when melting of the material occurs, producing gas bubbles that get trapped as the target material cools, producing an elevated result.

COMMONLY MARKED PRODUCTS

How do customers most often use a fiber laser for their business? Many enter the market with one application in mind for use with the laser, but quickly expand the laser's usage into a variety of different applications.

Barcoding and Serializing

A common use for the fiber laser is etching barcodes and serial numbers directly on parts and tools. The fiber laser provides a very high-quality mark that is easily read by barcode scanners. You can choose between one-dimensional codes, UPC codes, data matrix or any other type of code. When you are serializing parts, the laser is often used in conjunction with a jig that holds multiple parts in the laser and an entire table full of parts are serialized all in one engraving job without having to utilize a dedicated operator to switch out parts.

Placing Your Logo on Products

When your company is providing a high-end product, etching your logo directly on the part guarantees that your brand will always be immediately identifiable by the customer. Printed labels can be taken off the product, but your logo will be permanently marked on the product.

Customizing Products for Customers

Not only can you brand your parts, but you can also customize your product for your customer by etching their logo directly on products that you manufacture for them. When you are able to create a high-end etched logo on the product for your customer, it provides a service that your competitors may not be able to provide, and allows you up-sell to add the logo to the product.

These are only a few of the ways that customers are using fiber laser systems, but there are many more ways to utilize the laser that go beyond these categories as well.

HOW TO ENGRAVE WITH A FIBER LASER

Software Interface

Laser systems feature two main software interfaces:

- Proprietary Software
- Open Architecture Print Driver

Benefits of Proprietary Software:

- Guaranteed to work with the laser system regardless of updates.
- Features that are specially designed for processes that are associated with the laser.

Drawbacks of Proprietary Software:

- Tries to recreate functions that are better handled by professional software.
- Updates and bug-fixes are company dependent.
- Have to learn new software to operate the laser and spend time training new operators on how to run the software.

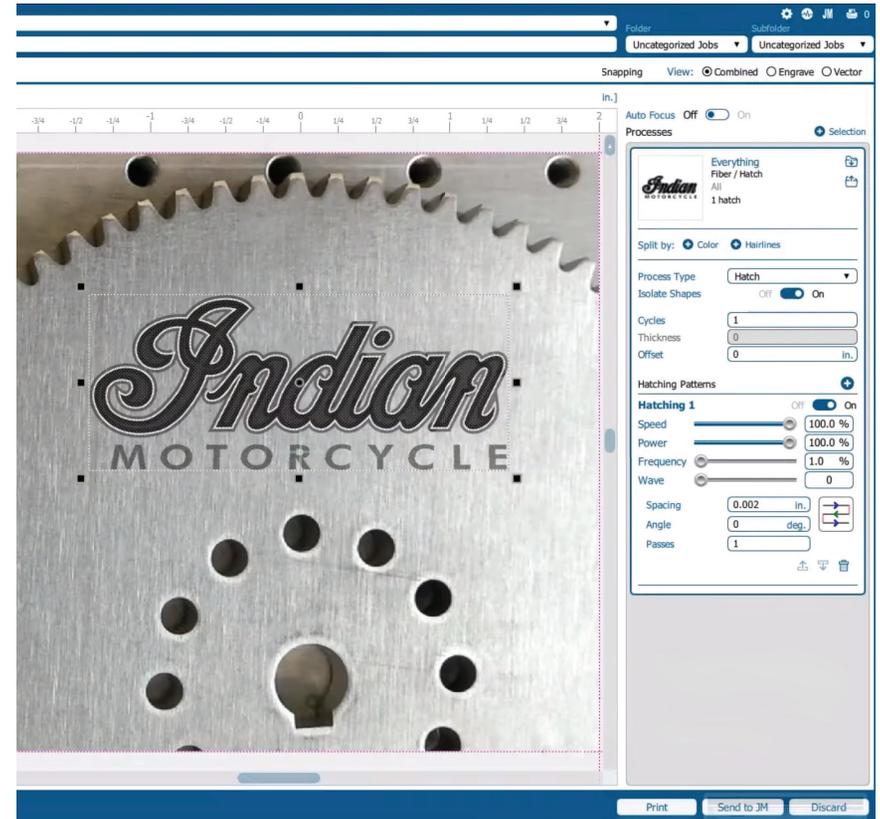
Benefits of Open Architecture Software:

- You are able to use the most commonly used software (AutoCAD, Illustrator, CorelDRAW, BarTender, etc.)
- Best-of-breed softwares are designed with better, more reliable features.
- Training is relatively simple using common software applications.
- Easier to get support on the software from experts who understand how it operates.

Drawbacks of Open Architecture Software:

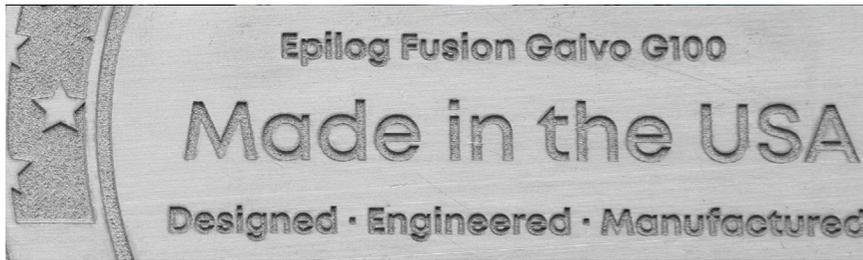
- Updates to software needs to be tested for operation with the system.
- Features are built into the print driver instead of the software itself.

Epilog's fiber laser systems utilize an open architecture software interface that works through a Windows®-based print driver. This allows users to create their laser files in a variety of software, such as AutoCAD, and print the file directly to the laser. All system configurations and settings are set in the print driver, including engraving resolution, frequency, focus, speed, power and more. We find this provides users with the easiest-to-use design capabilities combined with the design versatility of a variety of software choices.



Sending a File to the Laser

- To send a file to the laser, in the design software of your choice, prepare the file just as if you were going to print it to paper. Print the file to the Epilog Engraver.
- In the Laser Dashboard, select your material settings, line up your artwork with the camera, and print the file to the laser.
- At the laser select your file and press the start button.
- If you are engraving multiple items at one time, you can set up your page size to the size of the engraving table and duplicate your file across the entire page. You can also use a custom cut jig to hold multiple parts.



PROCESSING GUIDELINES

Processing fiber laser system applications isn't rocket science; however there are several tips and tricks to help provide the best possible results.

Tools:

A pair of calipers and a 7-10X loop.

Checklist:

Start by reviewing the system requirements and devising a game plan. What process are you looking to replace using a fiber laser? Is there a depth requirement? Is there an ideal cycle time? Consider the industry; how the part is used; the environment the part will be exposed to; and possible post-mark processing before deciding on a particular mark.

Base Settings:

Choose from the base settings we've provided in the manual for the most similar material. Start with small text on an inconspicuous area of the part.

Testing Multiple Marks:

As you test different settings, instead of moving the text/artwork around in your graphic design software, use the center positioning feature for quicker testing.

Reduce Browning of the Mark:

With any metal, bare or coated, too much power or too low of frequency will cause a color change (typically light brown at the surface). Minimize the color change by reducing the power or increasing the frequency.

REDUCE CYCLE TIMES

High Wattage=High Speed:

For metal applications, use the highest wattage available. Epilog Laser provides fiber laser systems with wattages ranging from 30 to 50 watts.

Lower the Resolution:

How important is a high resolution image for your application? Processing jobs at 400 dpi vs. 600 dpi can reduce cycle times by up to 30%, and processing at 300 dpi could mean half the cycle time.

Reduce White Space:

Orientate the parts to minimize engraving dead space (area where head travels, but has nothing to engrave).

Don't Use the Rotary:

If an option, run cylindrical parts as flat stock. Orientate the artwork to be inline going across highest point of part.

Horizontal Layout:

Horizontal text will engrave faster than vertical or curved text.

Start with a Higher Speed Setting:

Unless necessary, start with a higher speed setting. 40-60% speed with a frequency of 1-5% will likely yield the same results as 20-30% speed using 15-30% frequency.

Color Mapping:

Use the Color Mapping feature to save time by adjusting the order in which the objects engrave/mark.

Run Multiples:

Time studies using a mocked-up bed full of parts will confirm a reduction of individual times.



BE CREATIVE FOR BETTER RESULTS

The list of adjustable parameters is long, so get creative! Don't settle on just adjusting the speed/power/frequency.

Use Multiple Runs:

Run an etch pass, then use a second or third pass to clean up or polish the mark.

Outline the Mark:

Use a vector anneal outline around the text to really make it stand out.

Adjust the Focus:

For curved parts, focus between the high and low point.

Dither to Reduce Discoloring:

When running sensitive materials that quickly discolor, consider using the Dashboard dithering patterns (Jarvis/Stucki) or a 80% gray fill.

BEAM DELIVERY

Flying-Optic Beam Delivery

Systems Available: Fusion Edge 12 / Fusion Pro 24 / Fusion Pro 36 / Fusion Pro 48

What is it? A flying-optic system utilizes a series of moving mirrors in the x- and y-axis directions to engrave over a large work area.

Benefits: You can laser mark a large part up to 48" x 36" x 12.25" (1219 x 914 x 311 mm) or fill the entire table with smaller parts and let the laser engrave the entire table without a dedicated operator spending time changing out parts.

Galvo Beam Delivery

Systems Available: Fusion Galvo G100

What is it? A galvo system uses 2 rotatable mirrors moved by galvanometer drives for extremely high speed engraving.

Benefits: You can engrave your pieces in a fraction of the time of a flying-optic system, but are limited to a 6" x 6" (152 x 152 mm) work area.



FAQS ON FIBER LASER SYSTEMS

Q: What is the laser source of the fiber laser source?

A: The source is a fiber laser: a fiber optic cable that has been doped with ytterbium, a rare earth element.

Q: Is it the same as a YAG (yttrium aluminum garnate) laser?

A: It produces the same wavelength of light and same marks. YAG lasers require cooling and more maintenance.

Q: What is the wavelength of the fiber laser?

A: 1062 nm.

Q: Is the wavelength of light dangerous?

A: Yes, especially to the operator's eyes and will pass through common Lexan or glass materials. The viewing window has been impregnated with an organic compound that absorbs the fiber energy. If running the systems with the safety interlocks defeated, the user MUST wear special safety glasses containing the same impregnated compound.

Q: What is the power consumption?

A: The fiber laser systems pull the same wattage as our CO₂ systems: 8-10 amps on a 110 volt, and 4-5 amps on a 220 volt circuit.

Q: Why does Epilog Laser use a pulsed fiber laser source instead of a CW (continuous wave) in its flying optic systems?

A: We tested both types and found that pulsed lasers are much faster and produce a better mark in metal than CW lasers. Pulsing allows the laser energy to build up to many times the rated power before it's released in big bursts. Like a jackhammer. CW lasers produce a steady flow at the rated power. As you can imagine, the big, high-powered bursts of the pulsed laser penetrate hard, dense, metals, much more easily than the lower power, steady rate of a CW laser.

Q: What is the fiber laser beam spot size?

A: 0.00034" (.0086mm). The wavelength of light emitted is what mostly contributes to the small spot size. A fiber laser emits a wavelength of 1062nm (1.06microns), a CO₂ laser emits a wavelength of 10,600nm (10.6microns). A direct correlation is that the CO₂ laser emits a wavelength ten times greater than a fiber laser, thus the reason why the spot size of a CO₂ laser is ten times greater than the fiber laser.

Q: What is the max material height?

A: Flat Stock:

	Fusion Edge 12	Fusion Pro 24 & 36	Fusion Pro 48	Fusion Galvo G100
3" Lens	6"	9"	11.25"	F163: 10" F254: 6"

A: Standard Rotary:

	Fusion Edge 12	Fusion Pro 24 & 36	Fusion Pro 48
3" Lens	3"	6"	8.25"

A: 3-Jaw Chuck Rotary:

	Fusion Edge 12	Fusion Pro 24 & 36	Fusion Pro 48	Fusion Galvo G100
3" Lens	3"	6"	6"	F163: 4"

Q: How deep can it engrave into metal?

A: All metals can be engraved into with some depth; however, some metals are more amenable to depth engraving. Softer aluminum material will engrave with depth with only a few passes. A 2" x 2" (51 x 51 mm) image into hardened gun metal to a depth of 0.005" (0.127 mm), took over one hour to accomplish.

Q: How thick can the fiber laser cut?

A: We do not market the fiber laser as a cutting laser, however it can up to 0.012" (0.30 mm)

Q: Will it mark black oxide or similar dark metal parts?

A: Yes, the black oxide color will be removed to expose the lighter native metal color.

Q: Can Cermark/Thermark be used?

A: Yes, but CO₂ systems are a better fit with these metal marking compounds.



SUGGESTED MATERIAL SETTINGS

In the world of metals, the grade, type, hardness and chemical compositions are endless. Metal alloys are engineered for specific applications and have their own strengths and weaknesses. With such an unlimited selection, we've yet to come across a metal that proved to be incompatible with the fiber laser systems.

Below are general guidelines for most common metals. Settings will have to be adjusted based on wattage. For lower wattage fibers, use less speed and lower frequency. For higher wattages, use less power and higher frequency

Material	DPI	30 watt	50 watt
Aluminum (Anodized)			
Etching/ Marking	600 DPI	Speed: 40 - 50% Power: 100% Frequency: 1% Focus: +.06" to +07"	Speed: 50 - 60% Power: 100% Frequency: 1% Focus: +.06" to +07"
The contrast / brightness of marks achievable on the fiber laser are excellent and can often be much brighter than marks from a CO2 laser. Taking the fiber laser out of focus by +.06" - .09" broadens the beam and produces a very bright mark on anodized coating. Lower frequency and higher power settings help offset the change in focal point. Different grades of anodized & core aluminum alloy will affect how the final marks look.			
Aluminum (Bare)			
Etching/ Marking	600 DPI	Speed: 30 - 40% Power: 100% Frequency: 50 - 60% Focus: -.01" to +.01"	Speed: 40 - 50% Power: 100% Frequency: 50 - 60% Focus: -.01" to +.01"
Engraving aluminum will result in various shades of gray, not black. Fine tuning the settings can provide a bit more contrast but the range of applicable marks is very narrow. If the application calls for a black etch, consider using an oxidizer after engraving. Oxidizers are used most commonly if the aluminum has a protective coating (urethane, clear coat, clear anodized) covering the area that is not engraved. Deep metal engraving on aluminum can be done using multiple passes. Consider deep engraving and using a black epoxy/color fill. Although the marks on aluminum are not black like they are on steel, we have no difficulty getting 2D, UID barcodes to scan and verify.			
Brass			
Etching/ Marking	600 DPI	Speed: 30 - 40% Power: 100% Frequency: 5 - 20% Focus: 0	Speed: 40 - 50% Power: 100% Frequency: 5 - 20% Focus: 0
Laserable Plastic			
Etching/ Marking	600 DPI	Speed: 50 - 60% Power: 60-70% Frequency: 50% Focus: 0	Speed: 60 - 70% Power: 60-70% Frequency: 50% Focus: 0

Material	DPI	30 watt	50 watt
Stainless Steel			
Annealing	600 DPI	Speed: 7-12% Power: 100% Frequency: 1% Focus: +.08" to +.110"	Speed: 10 -15% Power: 100% Frequency: 1% Focus: +.08" to +.110"
Etching/ Marking	600 DPI	Speed: 30 - 40% Power: 100% Frequency: 1-5% Focus: -.01" to +.01"	Speed: 40 - 50% Power: 100% Frequency: 1-5% Focus: -.01" to +.01"
Polishing	600 DPI	Speed: 60 - 70% Power: 35-40% Frequency: 50 - 60% Focus: 0	Speed: 70 - 80% Power: 35 - 40% Frequency: 50 - 60% Focus: 0
Titanium			
Annealing	600 DPI	Speed: 7-12% Power: 100% Frequency: 1% Focus: +.08" to +.110"	Speed: 11-15% Power: 100% Frequency: 1% Focus: +.08" to +.110"
Etching/ Marking	600 DPI	Speed: 30 - 40% Power: 100% Frequency: 1-5% Focus: -.01" to +.01"	Speed: 40 - 50% Power: 100% Frequency: 1-5% Focus: -.01" to +.01"
Titanium and Ti alloys are highly amenable to marking at this wavelength. Similar to aluminum, a black mark from the etching process is difficult to achieve. Various shades of gray can be made, from very dark gray to light gray. Annealed marks can also be made on titanium materials using the same processing parameter described for stainless steel. Depending on the Ti alloy, marks of various colors can be achieved by changing the frequency values for 1% up to 100%. It is common to see red, blue, green, orange, yellows and purple marks, depending on the frequency selected.			

Material	DPI	30 watt	50 watt
Plated Metals			
Etching/ Marking	600 - 1200 DPI	Speed: 20-30% Power: 100% Frequency: 1-5% Focus: -.09" to -.100" +.09" to .100"	Speed: 30-40% Power: 100% Frequency: 1 - 5% Focus: -.09" to -.100" +.09" to .100"
Metals are often plated to assist with conductivity, to provide a protective coating against rust and elements and for aesthetic purposes. Plating thickness will depend on application and purpose. Most of the plated metals processed through the applications lab are electronic components (to enhance conductivity) and various fittings (protection against environment & rust). The typical plating thickness varies from .001" up to .005". Our recommended settings for general metal engraving works well for ablating through the plating; exposing the base metal. Ablating the plating will also provide high contrast. Using an oxidizer will enhance the look.			
Our recommended settings for polishing of metals are a good starting point where ablating through the plating isn't an option. This is likely the most common plated metal application as exposing the raw metal underneath will break continuity and / or expose the bare metal to rust and other elements. Note that the contrast of polishing of plated metals won't be as consistent or contrasting as a direct ablation. Multiple passes will help and end results will vary based on the metal used for plating, thickness of plating & size of mark. Our recommended settings for annealing will often work for plated metals where the plating has a thicker wall and material used has high levels of carbon or metal oxides.			
Powder Coating			
Etching/ Marking	600 DPI	Speed: 40 - 50% Power: 100% Frequency: 100% Focus: +.05" to .07"	Speed: 50 - 60% Power: 100% Frequency: 100% Focus: +.05" to .07"
Two to three passes are suggested (one pass to ablate the powder coating, 2nd or 3rd pass to polish up the metal underneath). A little less power, higher frequency and less focus adjustment will be required for the 2nd or 3rd pass, depending on the base metal. The idea is to ablate then polish. An alternative to running two or more passes is to run one pass and then use a common cleaner such as Simple Green or a citric-based cleaner with short, stiff bristle brush to scrub out the residual material remaining in the mark area. If using this technique, it may be necessary to raise or lower the marking table from around 0.07" to 0.10".			

ANNEALING & POLISHING OF METALS

Annealing Metals

Annealing can be done on most metals that contain high levels of carbon and metal oxides. These are generally, but not limited to, steel alloys, iron, titanium, cobalt, molybdenum, and chrome-plated iron/steel.

To anneal, you must use a slow rate of speed to heat and change the surface color of the material, but a higher wattage fiber laser system will help reduce the cycle times.



To change the surface color without penetrating the metal, the laser beam's focal point is crucial in achieving a dark mark. An annealed mark is accomplished with the focal point up (closer to) .070" to .110" (1.778 to 2.794 mm) or down (further away) -.060" to -.090" (-1.524 to -2.286 mm) from zero. Adjusting the speed, focus and frequency setting will vary the contrast of mark generally resulting in shades of blue, purple and black.

The frequency is the amount of laser power per pulse. The lower the frequency, the more burst of power is being applied. Because we're intentionally applying a broader beam of laser light to achieve an annealed mark, frequency is almost always set in the lower 1-5% range.

For best results, print at 600 dpi. 1200 dpi should be considered for metals that are more difficult to anneal, if there is inconsistent color change at the recommended settings, or when cycle times aren't a concern. The extra overlapping of pixels offered at 1200 dpi will assure a deeper, darker mark.

Polishing Metals

Polishing of metals is accomplished by quickly heating up the metal's surface, changing its color, resulting in a mirror-like finish. Polishing can be done on just about any metal including, but not limited to, raw alloys, heat-treated metals, plated metals and precious metals.

For a high-contrast mark, polishing is best done on darker, matte finish metals. Cleaning the surface prior to processing is recommended as oils, grease and other chemicals can affect the consistency and finish of the final marks.

As mentioned in the recommended base settings, dialing in the settings for a polished mark is the most difficult of the three most popular metal marking techniques. Speed, power and frequency play the biggest role.

- Speed is generally set on the high side, 50-100%, depending on wattage.
- The power is set in the 30-60% range, depending on wattage.
- Frequency is also set on the higher side, typically around the 50-100% range. A higher frequency setting equates to less power per laser pulse. Too strong of a laser pulse and the laser beam starts penetrating the metal instead of polishing, resulting in a dull or browning effect.
- Focus should be set at zero. Printing resolution is in the range of 300 to 600 dpi but is mostly done at 400 or 600.
- Start by determining your base speed, frequency and resolution setting. From there, select a power setting and start fine tuning by adjusting the power in 1% increments or decrements.

Precious Metals Note

Any rare metal alloy is deemed precious. As mentioned earlier, we've yet to come across a metal that could not be marked. This includes the rare "Grammium", metal alloy used in casting a Grammy award. Regardless of rarity or value, the fiber laser system can mark it.

DEEP METAL ENGRAVING

Deep metal engraving is a common application for the fiber laser system. In most instances, the required depth is to assure:

- The mark is permanent and will not wear in harsh environments
- And/or to meet a regulated specification (ATF).

When a Fiber Laser is a Great Alternative

- Metal identification plates/tags that historically have been done using an acid-etch process. Often times, these plates are then color filled.
- Machine tool, die and injection molding shops have used a manual stamping process or have had to run their expensive CNC equipment to mark on their parts, molds, bits and tools.
- OEM suppliers who find that set-up costs, manufacturing of tools and dies just aren't feasible or cost-effective for their smaller customers requiring minimal production runs.

Guidelines for Deep Metal Engraving

- Using a slow speed setting doesn't necessarily equate to depth. Longer laser dwell time typically results in more eruption of metal, leaving a raised mark instead of deep penetration.
- Use moderate speed (20-30%) and more passes to slowly chip away at the metal.
- Deep metal engraving requires maximum wattage. 30 or 50-watt is recommended.
- Frequency is generally set between the 1-5% range. A lower frequency range provides more bursts of laser power per pulse and is crucial to ablating the metal.

We've found that focusing "into" the metal by .010" to .030" (.254 to .762 mm) helps in the removal of metal. No technical data is available on whether refocusing after each pass is helpful or not. To better assist in removing metal cleanly, higher resolution (1200 dpi) with more overlap of laser pulses tends to provide a cleaner, more defined etch.

Deep engraving will require multiple passes. Multiple passes can easily be done by changing the number of copies in the print dialogue box. As with all materials including metals, the hardness or grade will ultimately determine what settings and how many passes are needed to achieve a certain depth. Use the guidelines above as starting points and experiment for best results.

PASSIVATION

Many times we've heard that companies interested in a fiber laser system will perform passivation on laser-marked metal parts. Exactly what is passivation? The following explanation should help in your overall understanding.

Some applications, in particular those involving medical devices, require a black mark that looks annealed, as opposed to an etched or engraved treatment that alters the microstructure of a material causing changes in properties such as strength and hardness. This laser process actually consists of growing a dense cohesive oxide coating on the surface and melting is specifically not required; hence, annealing is technically incorrect and misleading. IPG Photonics, the manufacturer of the fiber laser source, suggests the term "dark marking" is more appropriate.

What is Passivation?

According to ASTM A 380, passivation is "the removal of exogenous iron or iron compounds from the surface of a stainless steel by means of a chemical dissolution, most typically by a treatment with an acid solution that will remove the surface contamination but will not significantly affect the stainless steel itself."

In addition, it also describes passivation as "the chemical treatment of a stainless steel with a mild oxidant, such as a nitric acid solution, for the purpose of enhancing the spontaneous formation of the protective passive film."

In layman's terms, the passivation process removes "free iron" contamination left behind on the surface of the stainless steel as a result of machining and fabricating or laser marking processes.

These contaminants are potential corrosion sites which, if not removed, result in premature corrosion and ultimately result in deterioration of the component. In addition, the passivation process facilitates the formation of a very thin, transparent oxide film, which protects the stainless steel from "selective" oxidation (corrosion). So in essence, passivation is a cleaning process AND it creates a protective coating on the surface of the metal.

How is the Passivation Process Performed?

The process typically begins with a thorough cleaning cycle. It is intended to remove oils, greases, forming compounds, lubricants, coolants, cutting fluids, and other undesirable organic and metallic residue left behind as a result of fabrication and machining processes.

After removal of the organic and metallic residues, the parts are placed into the appropriate passivation solution. The most common passivation solution is a nitric acid bath; however, citric acid is considered to be a viable alternative as it is more environmentally-friendly and as such is being used in lieu of nitric acid. The method of passivation will vary depending on the metal type, passivation solution, and end-user requirements.

Passivation with a Fiber Laser System:

In order to assess passivation of metals marked with a fiber laser system, we purchased three common types of stainless steel, marked them using our suggested annealing settings for stainless steel, and then subjected them to passivation as follows: 15% citric acid bath at 150° F (65.5° C) with 40 kHz ultrasonic vibration for 20 minutes.

Note: Ranges of citric acid volume, temperature and ultrasonic bath time is variable depending on the material type. Each material was run at 1200 dpi and 600 dpi and tested with one, two, three and four passes. Multiple passes were performed to assess if additional marking created a more dense/durable annealed mark.

Results of the Passivation for each Material:

Material	Best Setting
304 Stainless Steel	1200 dpi, one pass produced the best mark resistant to passivation.
316 Stainless Steel	1200 dpi, one pass produced the best black mark resistant to passivation. 600 dpi rendered a gold color after passivation regardless of number of passes.
430 Stainless Steel	All marks were lightened during passivation to a gray color. The darkest mark is 1200 dpi, one pass.

In summary, the ability of a fiber laser system laser systems to produce marks that will remain after passivation will depend on the material type. Based on the limited tests we performed at Epilog, one pass, 1200 dpi marks will provide a better mark contrast after passivation.



GENERAL PLASTIC MARKING GUIDELINES

The term “plastics” is commonly used to describe various grades and types of polymers. To keep things simple, we’ll refer to all polymers as plastic. There are many plastics that are compatible with a fiber laser system’s 1062 nm wavelength of light. We refer to these as “engineered plastics” because many were designed to be laser-etched at some point during the manufacturing life cycle. These plastics are doped with an additive that results in a contrasting mark when the 1062nm wavelength of light is applied.

There are many other plastics that work just as well as the engineered ones. It’s amazing how many different plastics we receive for applications testing, most of the time their trade name and chemical composition aren’t disclosed or are unknown. The guidelines below will help in your quest to provide the best possible mark.

Most plastics that tend to work on a fiber laser system are those that are mold-injected and are physically hard. Industries where injection molded parts are common include automotive, aerospace, medical device and general manufacturing, to name a few.

Some of the more common compatible plastics include PET, ABS, polycarbonate and colored delrin. Some that are more difficult to mark using this wavelength of light include polyethylene, polypropylene and nylon.

Settings for Processing Plastics:

- Moderate to fast speed, typically in the 50-80% range.
- Moderate power, generally around the 30-60% range, depending on wattage.
- Medium to high frequency (50-100%) is helpful for processing plastics as it provides a steadier stream of laser power per pulse. Using a low frequency would result in inconsistent contrast and possibly cause foaming of the surface.
- Focus is generally left at zero. Adjusting the focus up or down in .010" (0.254 mm) increments can provide slightly better contrast but instead, consider adjusting the speed / power / frequency for same effect.

Most plastics are processed at 600 dpi for high contrast and detail. Cycle times are generally fast, so dropping the resolution would only affect print quality. Increasing resolution may prove helpful only on those plastics that are difficult to mark.

The majority of compatible plastics will provide a high-contrasting mark using the above settings. Darker plastics will turn white or varying shades of gray. Lighter plastics will turn dark gray to black. Fine tune the mark by increasing/decreasing power or frequency. Speed and focus can be left alone.

Incompatible plastics will either be transparent to the 1062 nm wavelength of light or will require the use of metal marking settings (low to medium speed, high power, and low frequency). The final mark for these plastics isn't as appealing, consistent or contrasting as their compatible counterparts.

Pigmentation of plastic can also dictate what settings are needed to produce a nice mark. The core polymer may be compatible, but due to chemicals used to add color, some colors may mark better than others. Having to adjust the printing parameters for different colors of the same compatible plastic is not uncommon.

VECTOR SCORING/ CUTTING GUIDELINES

Although not marketed as a cutting laser system, a fiber laser system is capable of cutting thinner metals. The thickness ranges from .005" up to .012" (.127 to .304 mm), depending on hardness. Some of the metals and materials tested include, but are not limited to, steel, aluminum, titanium, carbon fiber, ceramics, FR4/G10 circuit board material and solar wafers.

Guidelines for Vector Scoring/Cutting:

Use a strong exhaust to enhance the amount of suction the vacuum table pulls. Thin metals often won't lay flat and the amount of heat being applied to the metal can cause the metal to warp even more. Cover the remaining vector grid area with scrap material to further enhance the amount of vacuum pull.

The lower the frequency, the more strength in laser pulse. Use a lower frequency setting in the range of 1-20%.

For thicker materials, try using multiple passes at moderate speeds versus a single, slower speed setting. Too much laser dwell time can cause the material to warp and discolor.

Vector cutting applications on materials that have a metal base sandwiched within other types of polymers or organic materials do not tend to cut as well as raw metals. The end result is dependent on how the other materials react to a fiber laser system's wavelength of light but the typical result is a weak attempt at cutting the metal core while burning the surrounding polymer/material.

COMMON TYPES OF STAINLESS STEEL

Source: McMaster Carr www.mcmaster.com/#stainless-steel/=aj6he2

High-Strength Stainless Steel (Type 13-8 PH)	When heat treated, offers increased strength and good corrosion resistance, even under stress. Precipitation-hardenable. Maintains corrosion resistance up to 1100° F (593° C). Magnetic.
Wear-Resistant High-Strength Stainless Steel (Type 15-5 PH)	Commonly used in gears, cams, and aircraft parts. Combines high strength and wear resistance. Can be heat treated at low temperatures to increase mechanical properties. Maintains corrosion resistance up to 1100° F (593° C). Magnetic.
Corrosion-Resistant High-Strength Stainless Steel (Type 17-4 PH)	High strength with better corrosion resistance than Type 15-5 PH due to its slightly higher chromium content. Also known as Type 630. Can be strengthened by precipitation hardening at low temperatures. Maintains corrosion resistance up to 1100° F (593° C). Magnetic.
Corrosion-Resistant High-Strength Wear-Resistant Stainless Steel (Type 17-7 PH)	High strength. Good response to heat-treating. Moderate corrosion resistance.
Ultra-Corrosion-Resistant Stainless Steel (Alloy 20)	Equivalent to Carpenter 20. Commonly used in the chemical industry due to its resistance to aggressive environments. Nonmagnetic. Not heat treatable.

Super-Corrosion-Resistant Stainless Steel (Nitronic 60)	Nitrogen provides better corrosion resistance than Type 304 plus more strength in temperature extremes. Commonly used in chemical industry. Nonmagnetic. Cannot be heat treated. Temperature range not rated.
Super-Corrosion-Resistant Stainless Steel (A286)	Heat-treatable alloy with corrosion resistance similar to Type 316. Contains titanium for increased strength. Maintains corrosion resistance up to 1500° F (815° C).
Wear-Resistant Multipurpose Stainless Steel (Type 301)	Most strain-hardenable chromium-nickel stainless steel. Better wear resistance, fatigue strength than Type 304. Retains strength while stretching like 1095 steel. Good weldability, temperature resistance. May be slightly magnetic. Cannot be heat treated. Maximum corrosion resistance temperature 1550° F (843° C); minimum not rated.
Multipurpose Stainless Steel (Type 302)	Higher carbon content for slightly higher strength than Type 304 with same corrosion resistance. Not heat treatable.
Multipurpose Stainless Steel (Type 302/304)	Corrosion resistant. Meets Type 302 and Type 304 standards. Wire meets ASTM A580; spring wire meets ASTM A313 (choose extra-bright when a fine surface finish is important).
Easy-to-Machine Stainless Steel (Type 303)	Sulfur and phosphorus increase machinability. Low-carbon chromium-nickel (austenitic). Good corrosion, temperature resistance. May become slightly magnetic when worked. Not heat treatable. Maintains corrosion resistance up to 1500° F (815° C).

Multipurpose Stainless Steel (Type 304)	Most widely used stainless steel. Good weldability and formability. Maintains corrosion resistance up to 1500° F (815° C). May become slightly magnetic when worked. Not heat treatable.
Multipurpose Stainless Steel (Type 304/304L)	This dual certified 304/304L stainless steel is a reduced carbon version of Type 304 stainless steel.
High-Temperature Stainless Steel (Type 309)	Excellent temperature resistance. Similar composition to Type 304. Used in heat exchangers and furnace parts. Low carbon chromium-nickel (austenitic). Maintains corrosion resistance up to 1470° F (800° C). When worked, may become slightly magnetic. Not heat treatable.
Super-Corrosion-Resistant Stainless Steel (Type 316)	Higher molybdenum content provides better corrosion resistance than Type 304. Low carbon chromium-nickel (austenitic). Good weldability and temperature resistance. May become slightly magnetic. Not heat treatable. Maintains corrosion resistance up to 800° F (427° C).
Super-Corrosion-Resistant Stainless Steel (Type 316/316L)	This dual certified 316/316L stainless steel is a reduced carbon version of Type 316 stainless steel.
Easy-to-Weld Stainless Steel (Type 321)	Low carbon chromium-nickel (austenitic). Titanium provides superior weldability. Only strain harden (cold form - may become slightly magnetic). Cannot be heat treated. Maximum corrosion resistance temperature 1600° F (871° C); minimum not rated.



Wear-Resistant Stainless Steel (Type 410)	Chromium alloy (martensitic). Can be heat treated for extra hardness and improved wear resistance. Not recommended for highly corrosive environments. Not recommended for welding. Maintains corrosion resistance up to 1200° F (650° C).
Mold-Quality Wear-Resistant Stainless Steel (Type 420)	Excellent polishability and high hardness. Ideal for manufacturing plastic molds. Also used for knives, shafts, and surgical instruments. Heat treatable and magnetic. Maintains corrosion resistance up to 1150° F (621° C).

Corrosion- and Wear-Resistant Stainless Steel (Type 420V)	Use in place of tool steels, such as D2, when extra corrosion resistance is important. Better wear resistance than other stainless steels due to the addition of vanadium and carbon. Made of powdered metal for increased corrosion resistance. Maintains corrosion resistance up to 400° F (204° C). Magnetic.
Economy-Grade Stainless Steel (Type 430)	Chromium-based (ferritic) alloy. Good formability. Magnetic. Cannot be heat treated (strain-hardening has little effect). Room temperature alloy. Not recommended for temperature extremes or outdoor use. Chosen more for aesthetic purposes.
Tough Wear-Resistant Stainless Steel (Type 440A)	This high-carbon, high-chromium martensitic stainless steel offers greater hardness than Type 420 and greater toughness than Type 440C while still providing good corrosion resistance. Maintains corrosion resistance up to 795° F (424° C). Often used for cutlery, valve parts, and surgical instruments.
Ultra-Hard Wear-Resistant Stainless Steel (Type 440C)	Ideal for use in bearings, valve parts, and knife blades. This high-carbon stainless steel offers good wear resistance and is one of the hardest stainless steels when heat treated. Maintains corrosion resistance up to 800° F (427° C). Magnetic.
High-Strength Corrosion-Resistant Stainless Steel (Type 2205)	Duplex (austenitic-ferritic) stainless steel with high strength and good resistance to corrosion caused by stress. Maintains corrosion resistance up to 600° F (316° C). Commonly used for heat exchangers and oil and gas industry equipment. Magnetic. Not heat treatable.

COMMON TYPES OF ALUMINUM

Source: McMaster Carr www.mcmaster.com/#aluminum/=aj74i4

Precision-Cast Multipurpose Aluminum (Mic 6 Alloy)	Stress-relieved cast alloy. Outstanding machinability and stability. Not heat treatable.
Mold-Quality Aluminum (QC-10 Alloy)	Outstanding thermal conductivity along with high strength and surface hardness makes this heat-treatable alloy perfect for use in production injection molds and blow molds.
General Purpose Aluminum Foil (Alloy 1000 Series)	Primarily unalloyed. Has a minimum content of 99% aluminum. Suitable for use in the food industry, unless noted.
Basic Aluminum (Alloy 1100)	Commercially pure, 99% aluminum alloy. An excellent conductor of heat and electricity. Offers excellent corrosion resistance and is easily welded and brazed. Ideal for chemical equipment, heat exchanger fins, and sheet metal work. Not heat treatable.
Easy-to-Form Aluminum (Alloy 1145)	Similar to Alloy 1100. This alloy offers comparable ease of formability with an increased concentration of aluminum (99.45%).
Basic Aluminum (Alloy 1235)	Similar to Alloy 1100, this nearly pure aluminum alloy is ideal as EMI/RFI shielding in electronic applications,
Metric Easy-to-Machine Aluminum (Alloy 2007)	Excellent machinability. Ideal choice for components that require extensive machining, including tube fittings, hose parts, and screw machine parts.



Easy-to-Machine Aluminum (Alloy 2011)	Best machinability of all aluminum alloys. Most widely selected for screw machine parts, tube fittings, hose parts, and components that require extensive machining.
Weldable Easy-to-Machine Aluminum (Alloy 2017)	Machinability approaching that of Alloy 2011, along with weldability. Like all 2000 alloys, addition of copper reduces corrosion resistance.
High-Strength Aluminum (Alloy 2024)	Superior strength and good machinability. Most widely used aircraft alloy. Addition of copper improves strength, but decreases corrosion resistance.

Improved-Strength Basic Aluminum (Alloy 3003)	Good weldability, formability, and corrosion resistance. Similar to Alloy 1100 but with higher strength due to addition of manganese. Use in chemical and food processing equipment, tanks, heat exchangers, and sheet metal work. Not heat treatable.
Corrosion-Resistant Aluminum Foil (Alloy 3105)	Most corrosion resistant of the aluminum alloys. Excellent formability and welding characteristics.
High-Strength Super-Corrosion-Resistant Aluminum (Alloy 5083)	The strongest of the marine-grade alloys. Offers high strength in addition to excellent corrosion resistance and good weldability. Typically used in saltwater applications. Not heat treatable. Nonmagnetic.
Super-Corrosion-Resistant Aluminum (Alloy 5086)	Marine-grade aluminum alloy. Excellent corrosion resistance and good formability. Ideal for saltwater applications. Not heat treatable.
High-Strength Multipurpose Aluminum (Alloy 6013)	Heat treatable alloy. Corrosion resistance and thermal conductivity of Alloy 6061 with improved strength, hardness, and machinability.
Corrosion-Resistant Easy-to-Machine Aluminum (Alloy 6020)	Exceptionally machinable, heat treatable alloy is free cutting, offering excellent surface finish.
Metric Multipurpose Aluminum (Alloy 6060)	European equivalent to Alloy 6061. Good machinability, high strength and corrosion resistance. Use for light structural and architectural applications. Heat treatable.

Multipurpose Aluminum (Alloy 6061)	Most widely used aluminum alloy due to combination of strength, good corrosion resistance, and machinability.
Ultra-Corrosion-Resistant Architectural Aluminum (Alloy 6063)	Superb corrosion resistance. Perfect for outdoor applications.
Ultra-Corrosion-Resistant High-Strength Aluminum (Alloy 7050)	Offers better corrosion resistance than Alloy 7075 when under stress. Commonly used in aircraft applications. Heat treatable and nonmagnetic.
Ultra-Strength Aluminum (Alloy 7068)	Extremely high-strength due in part to a high zinc content. Significantly stronger and harder than Alloy 7075 with comparable corrosion resistance. Used for vehicle parts and other applications requiring extremely high strength. Heat treatable.
Corrosion-Resistant High-Strength Aluminum (Alloy 7075)	Exceptionally strong but still lightweight, this aircraft alloy has better corrosion resistance than Alloy 2024 due to the addition of zinc. Use for aircraft frames, keys, gears, and other high-stress parts.
Porous Mold-Quality Aluminum	Can be used to filter air, gases, and thin liquids. Perfect for creating molds used in vacuum forming and thermoforming. Porous to let air and moisture through, preventing bubbles and blemishes in material when forming. Not heat treatable.
Aluminum/Thermoplastic Composite	LDPE core with painted finish. Provides rigidity of sheet metal with lightness of aluminum.

TECHNICAL SPECIFICATIONS

Fiber/Dual Laser System Technical Specifications	
Maximum Engraving Area	Fusion Edge 12 Fiber: 24" x 12" (610 x 305 mm) Fusion Pro 24 Fiber/Dual: 24" x 24" (610 x 610 mm) Fusion Pro 36 Dual: 36" x 24" (914 x 610 mm) Fusion Pro 48 Dual: 48" x 36" (1219 x 914 mm) Fusion Galvo G100: F163: 4"x4" (101x101mm) F254: 6"x6" (152x152mm)
Max Material Thickness	Fusion Edge 12 Fiber: 7" (178 mm) Fusion Pro 24 Fiber/Dual: 9" (228 mm) Fusion Pro 36 Dual: 9" (228 mm) Fusion Pro 48 Dual: 12.25" (311 mm) Fusion Galvo G100: F163: 10" (254mm) F254: 6" (152mm)
Laser Source Wattages	Fusion Edge 12 Fiber: 30 watt Fiber Fusion Pro 24 Fiber/Dual: Fiber: 30 watt Dual: 60 watt CO ₂ /30 watt Fiber or 100 watt CO ₂ /50 watt Fiber Fusion Pro 36 Dual: 80 watt CO ₂ / 30 watt Fiber or 100 watt CO ₂ /50 watt Fiber Fusion Pro 48 Dual: 120 watt CO ₂ / 50 watt Fiber Fiber Laser source is air cooled, includes collimator. 1065 nm. Beam quality: M2 <1.1. Fusion Galvo G100: 30 watt Pulsed, 30 Watt MOPA, or 60 Watt MOPA Fiber laser
Intelligent Memory Buffer	Store multiple files up to 1 GB. Engrave any file size
Operating Modes	Optimized raster, vector and combined modes
Motion Control System	High-speed, continuous-loop, brushless DC servo motors on the x-axis using rotary encoding technology for precise positioning (Gavlo G100 N/A)

Fiber/Dual Laser System Technical Specifications	
X-axis Bearings	Ground and polished stainless steel, teflon-coated, self-lubricating bearings. (Fusion Edge 12) (Dual blocks on x-axis for greater rigidity on Fusion Pro 24, Fusion Pro 36, and Fusion Pro 48) (Gavlo G100 N/A)
Belts	Advanced B-style double-wide Kevlar precision drive belts. (Gavlo G100 N/A)
Resolution	User controlled from 75 to 1200 DPI
Speed and Power Control (engraving depth)	120 IPS (3.05 m/s) (Fusion Edge 12) or 165 IPS (4.2 m/s) (Fusion Pro 24, Fusion Pro 36, and Fusion Pro 48) with 5G acceleration. Computer-controlled in .001 increments up to 100%. Color mapping feature links Speed, Power, Frequency, and Raster/Vector mode (Gavlo G100 N/A)
Print Interface	USB, Wireless, 10Base-T Ethernet connections. Windows 7/8/10/11 compatible.
Size (W x D x H)	Fusion Edge 12 Fiber: 39.5" x 26.5" x 17.9" (1003 x 673 x 455mm) Fusion Pro 24 Fiber/Dual: 41.52" x 32.81" x 38.04" (1055 x 834 x 967mm) Fusion Pro 36 Dual: 53.52" x 32.81" x 40.54" (1359 x 833 x 1029 mm) Fusion Pro 48 Dual: 70.6" x 51.3" x 42.75" (1794 x 1304 x 1086 mm) Pedestal removed: 34"h (863 mm) Fusion Galvo G100: 28" x 23" x 31" (door closed) 28" x 23" x 37" (door open) 711 x 584 x 787 mm / 940 mm
Weight	Fusion Edge 12 Fiber: 138 lbs (63 kg) Fusion Pro 24 Fiber/Dual: 240 lbs (108 kg) Fusion Pro 36 Dual: 27 5lbs (124 kg) Fusion Pro 48 Dual: 650 lbs (295 kg) Fusion Galvo G100: 131 lbs (59.5kg)
Electrical	Auto-switching power supply 110-240volts, 50 or 60Hz, single phase
Ventilation Systems	Fusion Edge 12 Fiber, Fusion Pro 24 Fiber/Dual, Fusion Pro 36 Dual: One output port, 4" (102mm) in diameter. 350-400CFM (595-680m ³ /hr) Fusion Pro 48 Dual: Two upper output ports. One lower port. Total 735CFM. All ports 4" (102mm) diameter Fusion Galvo G100: One output port, 4" (102 mm) in diameter. 450 CFM (765m ³ /hr) External exhaust to outside or internal filtration unit required on all units.
Classification	Class 2 Laser Product - 1 mW CW MAXIMUM 600-700 nm.

DUAL SOURCE OPPORTUNITIES

Epilog also manufactures dual source systems with CO₂ and fiber lasers in the same cabinet (available in the Fusion Pro 32 and 48 models). The CO₂ laser source is compatible with a different set of materials than the fiber laser source, including:

	Engrave	Cut
Wood	X	X
Acrylic	X	X
Glass	X	
Coated metals	X	
Ceramics	X	
Delrin	X	X
Cloth	X	X
Leather	X	X
Marble	X	
Matboard	X	X
Melamine	X	X
Paper	X	X
Mylar	X	X
Pressboard	X	X
Rubber	X	X
Wood veneer	X	X
Fiberglass	X	X
Painted metals	X	
Tile	X	
Plastic	X	X
Cork	X	X
Corian	X	X
Anodized aluminum	X	
Twill	X	X



Dual-Source System Right for your Business?

Looking for Versatility:

A dual-source system is a good choice for businesses that will primarily be working with one type of material, such as metal etching, but would also like to have the ability to engrave acrylic or similar materials that the other laser source can handle.

Multiple Material Products:

It also works well for businesses that are etching products that have parts that each different source is compatible with, such as a wood and metal bottle opener where you want to engrave both materials in a single job.

Limited Budget:

Many companies also purchase a dual-source system when they want to increase their laser's versatility but have a limited budget.

Limited Space:

If you are looking for a laser that can fit into a small working space that can handle the most materials possible, a single dual-source system is a good choice for your business.

Two Laser Systems a Better Choice?

One drawback of dual-source systems is that whenever you are using one laser source, the other is unusable. For a small additional investment you can have both a CO₂ and fiber laser system so you are able to utilize either laser source technology at any time.

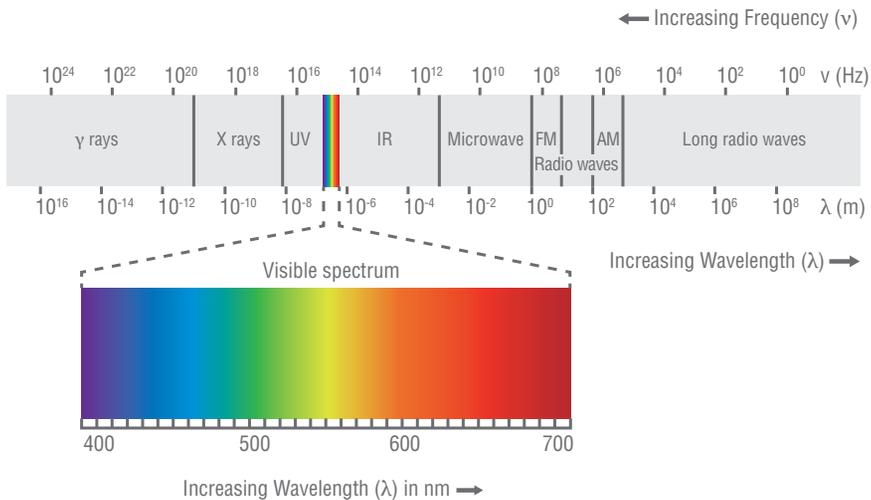
DEFINING TYPES OF LASERS

by John Doran - November 2010

What is Light?

Light is a form of electromagnetic radiation. It is usually characterized by its wavelength, which is typically measured in nanometers (that is, in billionths of a meter, or 1×10^{-9} meters. 25,400,000 nanometers equals 1" (25.4 mm).

Here is the "electromagnetic spectrum," which relates different forms of electromagnetic radiation to their wavelengths:



For purposes of understanding lasers, we generally think of light as electromagnetic radiation having wavelengths ranging from around 10 nm (the bottom of the ultraviolet, or UV, portion of the spectrum) up to about 1,000,000 nm (or 1 mm, the top of the infrared, or IR portion).

Note that light visible to the human eye comprises only a tiny portion of this range, from approximately 390 nm (deep violet) to 750 nm (dark red).

What is a Laser?

A laser is one of many highly-varied devices that amplify and then emit light by means of a quantum-mechanical principle called "stimulated emission of radiation."

Lasers generally emit light of a single wavelength, or a narrow band of wavelengths. Furthermore, their output is typically emitted in a narrow, intense beam - this is what makes them the energy source of choice for cutting and engraving. A lens is used to focus the beam onto a tiny spot for application to the work-piece. All other things (beam diameter, etc.) being equal, the size of this spot varies in direct proportion with the wavelength of the laser.

Here is a list of lasers commonly employed in materials processing equipment, together with their wavelengths and properties:

Semiconductor Diode:

Wavelength: 405 nm (violet, visible)
445 nm (blue, visible)
510 nm (green, visible)
635 nm – 670 nm (red, visible)
760 nm – 1625 nm (infrared, invisible)

Power: <1 mW to hundreds of watts

Diode lasers are the smallest, most efficient, least expensive lasers.

The red diodes are widely used for applications such as pointing and alignment. Most laser materials processing systems use them for a "red dot" pointer function.

The infrared diodes are used for fiber-optic communication and as an excitation source for solid-state lasers such as the Nd:YAG and the Yb fiber laser.

Arrays of infrared diodes may produce many hundreds of watts, but the optical beam quality is typically not good enough for direct materials processing. But as single-diode output power levels increase, we are likely to see the development of fiber-coupled diode lasers capable of being used directly for engraving and cutting.

Helium-Neon (HeNe)

Wavelength: 630 nm (red, visible)
Power: 0.1 mW to tens of mW

The HeNe laser is a gas laser, “excited” or energized by a DC electrical discharge. It was one of the first lasers to be invented, and was widely used in surveying and construction equipment, supermarket bar-code scanners, and as a red-dot pointer in older laser materials processing equipment.

In recent years the visible diode laser, with its smaller size and significantly lower cost, has rendered the HeNe laser obsolete for all but a few specialized applications.

Carbon Dioxide (CO₂)

Wavelength: 10,600 nm (far infrared, invisible)
Power: <10 W to tens of kilowatts

The CO₂ laser is also a gas laser, typically excited by DC or with a radio-frequency (RF) electrical discharge. Its wavelength, completely invisible to the human eye, is in the band that includes radiant heat.

At present, this is probably the least expensive engraving and cutting laser (dollars per watt). Optical quality is high, and the far-infrared wavelength interacts very well with most organic and non-metallic materials.

Bright metals behave like mirrors at the CO₂ laser wavelength, and so very high power (typically hundreds to thousands of watts) is required to cut or engrave them.

Neodymium-YAG (Nd:YAG)

Wavelength: 1064 nm (near infrared, invisible) (base wavelength)
532 nm (green, visible) (frequency doubled)
Power: <10 W to hundreds of watts

Nd:YAG is a solid-state laser, which emits from a rare-earth-impregnated mineral crystal excited by shorter-wavelength light produced either by an arc-lamp or by an array of semiconductor diode lasers.

Its wavelength is almost exactly one-tenth that of the CO₂ laser. Metals are much less reflective at 1064 nm, and so only a few watts are needed to allow surface engraving. Cutting typically requires many tens of watts.

Nd:YAG’s interaction with non-metals is rather poorer than with CO₂, so it is generally useful only on metals. Further, the optical quality of these crystalline lasers is often significantly worse than that of gas lasers; the shorter wavelength may not necessarily result in the expected smaller focused spot size.

Non-linear crystals may be used to frequency-double the output of the Nd:YAG laser into the green, where it interacts with certain materials (silicon, for example) more effectively. Both the infrared and frequency-doubled lasers may also be “Q-switched,” a technique that results in the output being a series of short, high-peak-power pulses rather than continuous-wave.

Ytterbium Fiber (Yb)

Wavelength: 1055 nm to 1070 nm (near infrared, invisible)
Power: <10W to thousands of watts

The Yb fiber laser, recently developed, is a solid-state laser like the Nd:YAG. Instead of a crystal, it employs a coil of rare-earth-impregnated optical fiber excited from one end by arrays of high-power laser diodes.

The Yb fiber laser wavelength is almost identical to that of Nd:YAG, but the output beam is of significantly better quality. Also as with Nd:YAG the output may be either continuous, or a series of high-peak-power pulses.

At present, the Yb fiber laser is significantly more expensive, watt for watt, than the CO₂ laser, and like Nd:YAG it is well-suited only for use on metals. However, as technology advances, costs will drop and the available power will increase to unprecedented levels - many tens of kilowatts!

Excimer

Wavelength: 157 nm to 350 nm (ultraviolet, invisible)
Power: <1W to 100W (average)
Pulse Energy: millijoules to >1J

Excimer, or “exiplex,” lasers are expensive, specialized pulsed lasers employed in certain industrial engraving, scribing, and cutting applications where its ultraviolet output wavelength is an advantage. It is also used for laser eye surgery, such as the LASIK procedure.

GLOSSARY OF LASER TERMINOLOGY

Ablation	A laser process where one layer of material is removed to expose a second, dissimilar material. For example, marking on anodized aluminum works this way.
Absorption	The process whereby electrons in an atom absorb energy, thus increasing their energy state to a higher and unstable state. The YAG crystal "absorbs" energy from the flash lamp or diode which raises the electrons in the crystal to a higher state, which then emits photons in the form of a laser beam.
Annealing	A laser process where the laser is used to heat steel or titanium to near the melting point, to induce a color change to black in the upper .001" to .003" of the material. Does not remove material, leaving a perfectly smooth surface when done properly.
Beam Expander	A telescopic lens system designed to increase the diameter of a laser beam which allows the focusing lens to produce a finer point.
CDRH	Center for Devices and Radiological Health. Government agency responsible for laser safety classifications.
Collimated	A method whereby a laser beam is tightly focused and photons do not diverge from the intended beam path. On the fiber laser, the collimator is located at the end of the fiber optic cable.
CO ₂	Carbon dioxide gas mixture used in gas lasers. Common term to describe non-solid state laser source. CO ₂ gas contains a proprietary mixture of CO ₂ gas, Argon, Helium and other components.
Color Change	A process where a laser induces a photo reaction in plastic to change the color of the plastic. Highly dependent on the type of plastic and laser used. Laser-specific pigments are available for many types of plastics to help this process. A very common example of this process is laser-marked ear tags for cattle and other livestock.
Continuous Wave Mode (CW)	A laser that is not pulsed. This provides a very even, if lower power, beam. Useful only in a few applications.

Deposition	Using a laser to melt a coating to the surface of a target material, leaving a raised contrasting mark. Application of Cermark LMM material is an example of this process.
Diode Pack	An array of diode lasers mounted together and focused into a solid-state laser crystal. Diode-pumped lasers have one or more diode packs which will eventually need to be replaced as the diodes degrade.
Diode Pumped	A laser which uses a diode laser as the pumping method. Diode Pumped Solid State (DPSS) lasers are a variation of the well known ruby, Nd:YAG, or other type of optically pumped crystal based laser where a high power IR laser diode or array of laser diodes provides the excitation instead of a flashlamp or other intense light source.
Engraving/ Etching	A laser process where the laser is used to remove material from a homogenous target, leaving a trench or hole. For example, laser marking on integrated circuits is usually a very shallow engraving.
Foaming	A laser process where the laser heats the surface of a plastic material to the boiling point, trapping air bubbles in the material as it cools. Creates a textured mark, usually with some color contrast. We see this with engraving on Lexan using a fiber laser system.
Fiber Laser	Technology using a long fiber optic cable doped with a rare earth element as the lasing medium. Noted for very compact nature of laser. Available as CW or pulsed.
F-Theta Lens	The "field flattening" lens which accounts for different distances from the galvos to various points on the surface of the target, maintaining an even focus.
Flashlamp	Extremely high power flashbulb used as pumping method in some YAG lasers. Flashlamp pumping is old technology and has been replaced in most marking applications with diode-pumping.
Galvanometer	A very high precision motor with a limited axis of rotation. Used to turn mirrors and guide laser beam. Referred to as "galvo."
Gas Laser	Laser employing gaseous lasing medium, CO ₂ lasers are an example.
Ground State	The natural stable energy level of an atom or molecule.
LASER	Acronym for "Light Amplification by Stimulated Emission of Radiation"

Laser Beam	A laser beam is a coherent beam of photons, all of the same wavelength and traveling along a tightly controlled axis.
Lasing Medium	Material holding atoms which become excited and decay into photons. This can be Gas, Solid-state, diode, or chemical.
Micrometers	1/1,000,000 meter. Symbolized as: μm . This is the typical measurement for wavelength in electromagnetic radiation. Electromagnetic radiation is also measured in nanometers, nm, which is .001 of a micrometer. Nd:YAG wavelength is 1.064 μm and 1064 nm.
Nd:YAG	Neodymium doped Yttrium Aluminum Garnet crystal used in "YAG" solid state lasers.
Nd:YVO4	Neodymium doped Ytterbium Vanadate crystal used in "Vanadate" solid state lasers. Same wavelengths as YAG, but with different pulse characteristics.
Optical Cavity	Term used to describe the area in which the working laser beam is created. Typically this includes the lasing medium, a pair of mirrors at either end of the cavity, and in some cases the Q-switch. This is the area where the cascading emission of photons happens and builds up energy. Many different designs of optical cavities are available which provide different performance characteristics.
Polishing	A laser effect where the laser beam heats the surface of a material and as it cools; it takes a different finish than the surrounding material. Creates marks which can look holographic. Most common on matte-finish metal parts.
Pumping Method	Means of applying energy to excite atoms in lasing medium (YAG crystal as an example) in preparation for decay and release of photons. Flash-lamp and diode pumped are the two most common
Q-Switch	A mechanical or more commonly an electro-optical switch meant to pulse a laser beam in a YAG or Vanadate laser. Pulsing generates much higher peak powers to increase the effective power of the laser. A Q-switched laser is a type of (or modification to) a pulsed laser which shortens its output pulse width, boosts peak output power, and improves the consistency of the output from pulse to pulse. However, there will likely be a reduction in total energy in the output when a laser is operated in Q-switch mode.

Radiation	Electromagnetic emissions; in lasers it is in the form of light, either ultraviolet, visible, or infrared. TV waves, Radio waves, and X-rays are all examples of electromagnetic radiation. Note that the term radiation does NOT imply radioactivity.
Scanhead	A subsystem of most laser markers which holds a pair of galvanometer motors and their associated mirrors, as well as the f-theta lens. This is the (usually) black box at the end of most laser marking systems.
Sealed Discharge Tube	A Gas laser where the gaseous medium is contained in a sealed optical chamber and doesn't need an external source of gas to recharge the lasing medium. This is the most common kind of marking CO ₂ laser.
Semiconductor Laser	A laser employing a semiconductor diode as the lasing medium. Also called a Diode laser. Laser pointers are semiconductor lasers.
Solid State Laser	Uses a solid crystalline material as the lasing medium and is usually optically pumped – can be pulsed or continuous wave (CW). Nd:YAG, for example.
Spot Size	The area of the laser beam when properly focused on the target material.
Stimulated Emission	The cascade process where excited atoms are stimulated by photons from other atoms to decay, releasing more photons, and carrying on building up an ever larger number of particles traveling in the same axis.
Yttrium	A chemical element in the periodic table that has the symbol Y and atomic number 39. A silvery metallic transition metal, yttrium is common in rare-earth minerals and two of its compounds are used to make the red color phosphors in cathode ray tube displays, such as those used for televisions.
Ytterbium	A chemical element in the periodic table that has the symbol Yb and atomic number 70. A soft silvery metallic element, ytterbium is a rare earth metal of the lanthanide series and is found in the minerals gadolinite, monazite, and xenotime. The element is sometimes associated with yttrium or other related elements and is used in certain steels. Natural ytterbium is a mix of seven stable isotopes.



GLOSSARY OF INDUSTRY TERMINOLOGY

Alloys	Base metal with metal or non-metal constituents melted together into a new molecular structure.
ASTM	American Standard of Testing and Materials. A non-profit organization that provides a forum for producers, users, ultimate consumers, and those having a general interest (representatives of government and academia) to meet on common ground and write standards for materials, products, systems, and services.
ASTM Standards	A series of documents, approved and published by ASTM, that include specifications or requirements, practices, guides, test methods, etc., covering various materials, products, systems or services. In the steel industry, the steel related ASTM standards are used by both the producers and users to ensure that a steel product or service meets all intended requirements. See ASTM - American Society for Testing & Materials.

Austenitic Stainless Steel	Non-magnetic stainless steel. This material cannot be hardened through heat treatment.
Case Hardening	Any process of hardening a ferrous alloy so that the case or surface is harder than the core or interior.
Carbon Steel	A steel that owes its specific properties chiefly to the presence of carbon, without substantial amounts of other alloying elements. It is also referred to as ordinary steel, straight carbon steel, or plain carbon steel.
Chamfer	A beveled surface to eliminate an otherwise sharp corner that is typically about a 45° angle. A relieved angular cutting edge at a tooth corner.
CNC	Computer Numeric Control: Controlled by a computer.
Cold Rolled	A metal finishing process that subjects strip or sheet steel to a cold-reduction mill. Steel that has been subjected to the cold rolling process is considerably thinner and stronger than hot-rolled sheet.
Cold Rolled Steel	Steel that was reduced to final thickness in the cold state by a rolling mill that creates a smooth surface with slight skin hardness.
EDM	Electrostatic Discharge Machine: Rapid series of electrical sparks to vaporize and remove metal.
End Mill	Type of milling cutter, a cutting tool used in industrial milling applications. It is distinguished from the drill bit, in its application, geometry, and manufacture. While a drill bit can only cut in the axial direction, a milling bit can generally cut in all directions, though some cannot cut axially. Endmills are used in milling applications such as profile milling, tracer milling, face milling and plunging.
Horizontal Machining Center	Uses a horizontal spindle. With a horizontal spindle, tools stick out the side of the tool holder and cut across the side of a part (work piece). Horizontal machining centers are far more expensive than equivalent capacity vertical machines, but have several advantages. Usually the tool holder of a horizontal machine is more rigid. Also, when machining the side of a part, metal chips fall out of the area being cut, leaving an uncluttered cutting area.
Ferrous Materials	Metals or alloys containing iron: e.g. stainless steel, carbon steel, pig iron.
Kerf	Space created after cutting through a material.

M Code	Used to signal an action from a miscellaneous group of commands. Change cutting tools, turn on or turn off the coolant, spindle, or work piece clamps, etc.
Machine Tool	Powered mechanical device, typically to fabricate metal components of machines by machining.
Martensitic Stainless Steel	Select group of 400 or 500 Series stainless steels that are magnetic and hardenable by heat treating.
Oxidation	A common form of chemical reaction which is the combining of oxygen with various elements and compounds. The corrosion of metals is a form of oxidation, rust on iron for example is iron oxide.
Rapid Prototyping	A number of rapidly evolving techniques for making prototypes and models quickly thus allowing designers to check their designs and make any necessary changes before investing in expensive tooling. A CAD model of the part is required and the model is usually built layer by layer.
Rockwell Hardness	A scale based on the material indentation hardness.
Salt Spray Test	An accelerated corrosion test in which the metal specimens usually coated steel are exposed to a fine mist of salt water solution either continuously or intermittently. Spray is usually 5% NaCl.
Stainless Steel	Various terrific alloys exhibiting high oxidation resistance through the alloying with chromium and nickel. Corrosion resistant steel of a wide variety, but always containing a high percentage of chromium. Stainless steels are highly resistant to corrosion attack by organic acids, weak mineral acids, atmospheric oxidation, etc.
Tolerance Limit	The permissible deviation from the desired value.
Tool Steel	Any high carbon or alloy steel capable of being suitable tempered for use in the manufacture of tools.
Vertical Machining Center	Uses a vertical spindle. With a vertical spindle, tools stick straight down from the tool holder, and often cut across the top of a part. One disadvantage of vertical machining is that when tools cut across the top of a part, the metal shavings, called "chips," often pile up around the tool and interfere with the cutting action. However, vertical machining centers are more common, primarily because they are less expensive than equivalent capacity horizontal machines.

GET MORE INFORMATION

Material Testing: If you have a material you would like us to test with the fiber laser, you can contact our Applications Lab at applications@epiloglaser.com or call +1 303-277-1188.

Setup a Demonstration: We have distributors located worldwide that can work with you to setup a demonstration. Call +1 303-277-1188 and we will direct you to the distributor for your area.

Request a Brochure and Sample Kit: Visit www.epiloglaser.com/request.htm and fill out the form to receive a full product line brochure and sample kit and a dvd demonstration that shows how the laser works.

If you have any other questions we can assist you with, please give us a call at +1 303-277-1188.





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