

trotec



Laser Technology
in education

| SETTING NEW STANDARDS

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1 / Laser Cutters in education at schools and universities

Laser systems are being used at more and more universities and colleges. In many specialist areas such as model making, industrial design or fashion design, this digital tool is already part of the standard workshop equipment. Here, students become acquainted with the most important tools of digital manufacturing, preparing them for professional life.

They use laser systems for prototype construction, test set-ups and research and art projects. A modern product design methodology is mastered with the "laser" as a tool: "Digital Fabrication" means that the process is completely digital from the idea to the finished workpiece. Prototypes can be adapted quickly and new ideas can be implemented faster with a laser machine, compared to other technologies such as milling or 3D printing.

The laser machine enables the engraving of texts and graphics and the cutting of various materials with only one device and one work step. This saves space and time. Pupils, students and teachers learn or teach at the pulse of time. The operation and use of laser machines are quite easy to learn.

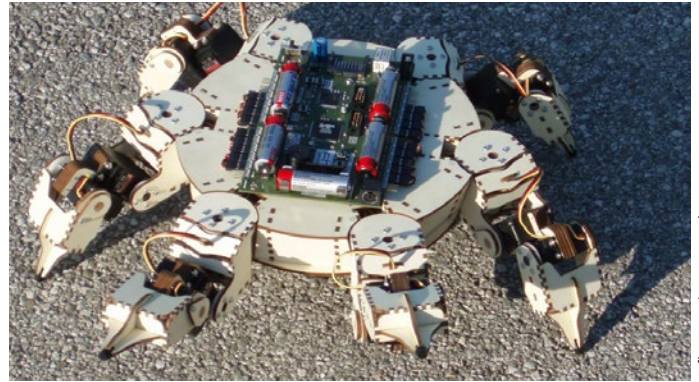


Examples of applications



© jku.at

Laser-cut test set-ups in research



© fh-ooe.at/campus-wels

Robots made of wood



Precision laser cuts in fashion design



Detailed architectural models



Laser-cut pen holder



© buildingblogs.com

Prototype construction



© papplab.at

Cardboard furniture design



Wall decoration: Elephant laser cut from TroCraft Eco

2 / What Materials Can A Laser Machine Process?

With laser machines, you can engrave, cut and mark the widest possible range of materials. The palette ranges from glass, plastic and wood, rubber, leather and metals to textiles, cardboard or MDF. Depending on the laser source of the machine, such as CO₂ or fiber laser sources, different materials can be processed. A Trotec Flexx machine contains both a CO₂ and a fiber laser source. You'll find an overview in the following table.

Material	Engraving			Cutting			Marking		
	CO ₂	Fiber	Flexx	CO ₂	Fiber	Flexx	CO ₂	Fiber	Flexx
Glass	●		●				●		●
Rubber (laser rubber)	●		●	●		●			
Stone	●		●						
Ceramics, porcelain	●		●						
Natural fiber (e.g. cotton, linen)	●		●	●		●	●		●
Felt (synthetic, wool)	●		●	●		●			
Microfiber	●		●	●		●			
Leather	●		●	●		●		● ¹	● ¹
Synthetic leather	●		●	●		●			
Wood	●		●	●		●			
Paper	●		●	●		●			
Cardboard	●		●	●		●			
Mirror	●		●	●		●			
Metal									
Aluminum		●	●				● ²		
Anodized aluminum	●	●	●						
Brass		●	●						
Copper		●	●						
Precious metal		●	●					●	●
Metal, painted	●		●						
Stainless steel	● ²	●	●					●	●
Steel		●	●						
Titanium		●	●						
Plastics									
Acrylic (PMMA)	●		●	●		●			
Acrylonitrile butadiene styrene copolymer (ABS)	●		●	●		●			
Engraving materials (laminates)	●		●	●		●			
Polyamide (PA)	●		●	●		●		● ¹	● ¹
Polybutylene terephthalate (PBT)	●		●	●		●			
Polycarbonate (PC)	●		●	●		●		● ¹	● ¹
Polyethylene (PE)	●		●	●		●			
Polyester (PES)	●		●	●		●			
Polyethylene terephthalate (PET)	●		●	●		●			
Polymide (PI)	●		●	●		●			
Polyoxymethylene (POM) e.g. Delrin®	●		●	●		●			
Polypropylene (PP)	●		●	●		●			
Polyphenylene sulfide (PPS)	●		●	●		●			
Polystyrene (PUR)	●		●	●		●			
Foam material (PVC-free)	●		●	●		●			
Polystyrol (PS)	●		●	●		●			

¹ Results can vary; subject to qualification due to the high material variability.

² The above metals can be processed with a CO₂ laser. This requires an additional processing step and the use of consumables, e.g. laser marking paste.

Frequently Asked Questions:

Can I cut metal with the laser machine? Cutting metal requires a very high laser power; flatbed lasers typically don't have this. Furthermore, pure oxygen under high pressure must be used for metal cutting. Systems that are optimized for this are again not suitable for plastic cutting due to the high risk of explosion. Nowadays, almost no CO₂ lasers are used for metal cutting. These have been completely replaced by fiber laser systems. On Trotec laser machines with a fiber laser source, you can engrave and cut thin metal foils made of aluminum, brass, copper or precious metals up to 0.5 mm.

What is the maximum thickness for cutting acrylic? The rule of thumb for a crystal-clear acrylic cut is: For every 10 watts of laser power, 1mm acrylic can be cut perfectly. So a laser with 120 watts of laser power can cut 12 mm perfectly. A thicker separation cut is also possible. Note the difference between a separation cut and a quality cut.

Which materials can I not engrave or cut with the laser machine? Even though the list of processable materials is almost endless, there are a few points to consider. There are materials that you should not engrave with the laser machine. During processing, substances are released in the form of gases or dust, which endanger the user and the functioning of the machine. This includes PVC, among other things. When heated, hydrocyanic acid is formed.





Some materials are not suitable for laser engraving or laser cutting due to the particular substances they contain. When processing these materials, dangerous gases or dusts may be produced. Care should also be taken when processing „flame-retardant“ materials as this property is often achieved by adding bromine.

Can a laser machine cut Dibond? Unfortunately, aluminum composite boards such as Dibond cannot be laser cut. In principle, materials made of aluminum or plastic can be processed with the laser engraving machine. However, the combination of aluminum-plastic-aluminum leads to an unusable and therefore uneconomical result in laser cutting. In the interior, laminate or acrylic sheets serve as a good alternative to Dibond. These are very easy to engrave and cut with the laser machine.



Caution with these materials:

- Inferior leather (Chrome VI)
- Carbon fibers (carbon)
- Polyvinyl chlorides (PVC incl. synthetic leather with PVC)
- Polyvinyl butyral (PVB)
- Polytetrafluoroethylenes (PTFE /Teflon®)
- Beryllias
- Materials containing halogens (e.g. fluorine, chlorine, bromine, iodine and astatine), epoxy or phenolic resins.

Why are these materials unsuitable for the laser cutting machine or engraving machine? If the mentioned materials are laser engraved or laser cut, dusts or gases may be produced that endanger or impair the laser user or the functionality of the laser machine. For this reason, we don't recommend processing these materials with a Trotec laser machine.

3 / Laser safety

The laser beam is focused light and very hot. So hot that you can cut all kinds of materials with it. Especially in education, safety and eliminating the risk of injury must be top priority.

When using high quality equipment and with proper operation, laser devices are very safe and easy-to-use tools.

Laser machines are divided into internationally applicable safety classes based on their performance and the associated risk of injury to eyes and skin: Class 1 offers the highest level of safety. Laser radiation can escape from class 4 machines. The use of protective equipment (e.g. protective goggles or protective glass) is necessary here.

Classification of the laser safety classes:

Class 1 laser systems:	The accessible laser radiation of this class is harmless – even with long-term exposure or the laser machine is in a radiation-tight housing.
Class 2 laser systems:	These include visible lasers (e.g. laser pointers with less than 1mW of power), which are only eye-safe when exposed to radiation of less than 0.25 seconds.
Class 3 laser systems:	In any case, the accessible laser radiation is dangerous to the eye. Pay particular attention to reflections (e.g. from reflective material surfaces). Trotec does not offer class 3 laser systems.
Class 4 laser systems:	Here, damage can be caused to eyes and skin or fires can be started within the danger area of the laser system. With this laser class, the user is obliged to strictly adhere to protective regulations!

We would like to refer you to the Laser Institute of America at this point. At www.lia.org you'll find detailed information on the basics of laser safety.



Please contact us for more information and advice on the topic of laser safety.

Which protective devices does a Trotec laser machine have?

The design of the Trotec laser machines offers optimal protection of the user. The fast and efficient extraction of dust and gas is guaranteed by the closed concept. The Trotec laser plotters belong to safety class 2. Laser pointers are built into all Trotec laser machines to show the user where the laser hits the material. According to the internationally applicable standard, laser pointers with less than one milliwatt power belong to laser class 2. Trotec laser machines are among the safest laser machines in the world. All Trotec laser machines are CE-compliant and thus meet the essential safety and health requirements of the EC Machinery Directive 2006/42/EC. But at Trotec, the protection of laser users goes beyond that:

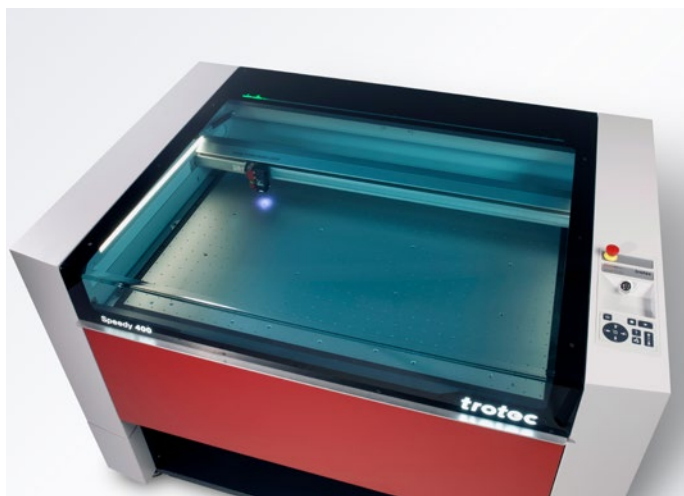


Interlock safety switch

Cladding elements, side covers/front lid and the protective cover serve as protection for the laser machine. These covers are fitted with interlock safety switches. If the protective cover or another interlock-secured cover is opened, a signal sounds and the laser machine immediately interrupts the laser process. Thus ensuring maximum safety for the user at all times. Nevertheless, laser machines should never be operated unattended.

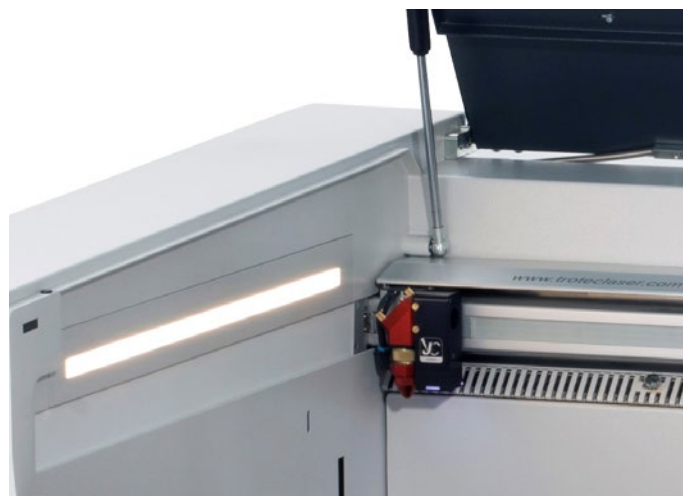
Temperature sensor with warning signal

Some materials (e.g. acrylic) tend to flame, especially during laser cutting. The specially-developed temperature sensor alerts the laser user when the temperature in the work area exceeds a critical value. The operator can react instantly to the acoustic warning signal and interrupt the laser process.



Protective cover

For all closed laser systems (e.g.: Speedy, R or Q series of Trotec), the acrylic cover provides extensive protection from the laser light. Depending on the laser source, different protective covers are used. For example, laser machines with a CO₂ laser source have a blue acrylic cover, while machines with a fiber laser source have a green cover. Due to the coloring of the acrylic glass, the laser light is completely absorbed, thus providing extensive protection for the laser user.



Safety switch for immediate interruption of the power supply

In a dangerous situation, the power supply can be interrupted by means of various safety switches and buttons. The laser process is immediately stopped.

- Main switch: Main power supply is disconnected
- Key switch: Motor, laser source and electronics are de-energized
- Emergency stop button: Electric circuit is interrupted, the laser beam and all movements are stopped



If Trotec flatbed lasers are equipped with a pass-through, the housing has an opening at the back through which the laser radiation can exit. These laser machines therefore belong to laser class 4. Laser machines in safety class 4 may only be operated with special protective equipment (e.g. protective glass, screens or laser protective goggles), so that maximum laser safety is guaranteed.

Filter and exhaust system

An exhaust system is the key to the safe and clean operation of your laser system, because it extracts the vapors and residues that arise during laser processing. An exhaust system not only helps you to keep the work area clean, it also protects the laser operator and improves the quality of the finished workpieces. An exhaust system should contain several filters to capture as much fine dust as possible. The Atmos exhaust systems offered by Trotec, for example, are equipped with various filters, including an activated carbon filter that absorbs odors. We will be happy to advise you on which exhaust system is the best choice for your workshop.



4 / Laser Operation

4.1. Getting started with laser operation

It doesn't take much for students to start working with the digital tool „laser“.

Which hardware do I need?

- a laser machine
- a computer
- an exhaust system

What software do I need to operate a laser cutter?

Ruby® is both a graphics and a laser program. With all the graphics tools that laser users need: Your students can create designs, graphics, photo and text elements with it. The Ruby® laser software allows the direct import of files such as pdf, svg, png, etc. Faulty files are automatically cleaned up when they are imported. These functionalities halve the time from the idea to the finished product. Without costs for additional software packages. The user guidance is intuitive, the workflow is quick and easy. This means that there's no need for a long training course. You can find the parameters in the Ruby® material list. You can download missing parameters from the cloud.

Many common programs such as Adobe Illustrator, CorelDRAW, Inkscape or AutoCAD 123 D, are compatible with a Trotec laser. Both raster and vector-based files are suitable for laser processing. However, vector graphics usually offer the best results for laser cutting.

4.2. Lots of students, one laser machine? No problem!

Ruby® connects all your laser machines in one network. Thanks to the new workflow, jobs can be prepared by one user and produced by another anywhere and at any time in the network. Use of the laser machine is no longer bottlenecked towards the end of the semester. Thanks to remote access, the project can be prepared independently of the laser cutter.



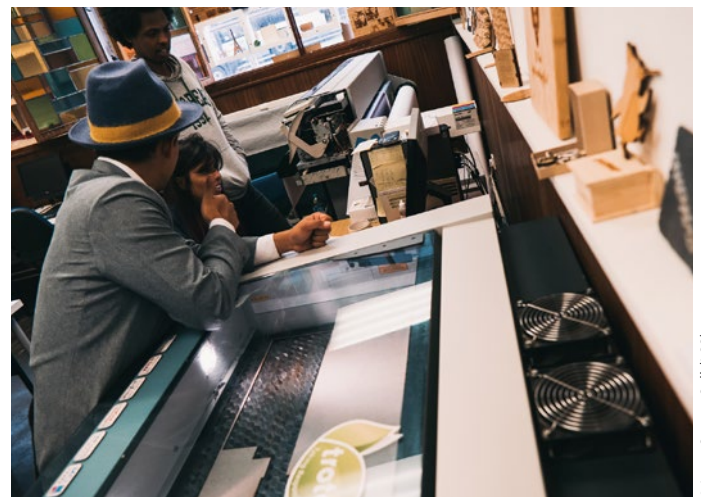
4.3. Manage Shared Spaces efficiently

Laboratories or workshops at schools or universities are used by many different people. Fabman (<https://fabman.io/>) is a system for the efficient and cost-effective management of shared spaces. It is a combination of web-based software and RFID bridges with which machines can be integrated into the system. It simplifies many daily administrative tasks and at the same time increases safety when using the machine.

- **Safety:** Fabman can ensure that only trained personnel operates certain machines. Furthermore, the integrated dead man function ensures that workstations are not left during operation.
- **Reservations:** Members can reserve machines for specific times. The Fabman bridge ensures that only the member who reserved the machine can actually start the machine.
- **Automatic billing:** Members pay automatically, e.g. depending on usage time
- **Statistics:** With Fabman, operators of shared spaces have access to a wealth of valuable data about their members and their user behavior.
- **Access control:** Fabman can not only regulate access to machines, but also secure entrance doors to buildings or individual rooms.



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4.4. For beginners: laser training for software and laser machine

During the set-up of your laser machine you will already be taught the first important steps - half a day of laser training is sufficient to be able to operate the machine yourself. Trotec also offers you further training units in the form of full-day courses.

Depending on the focus of the selected course, these include theoretical basics on the laser and its mode of operation, software training or materials science. In the majority of cases, however, practical work is trained on different machines or with different materials.

Tips and tricks for parameter determination:



<https://www.troteclaser.com/en/learn-support/helpcenter/laser-parameter>

Pass on your knowledge to colleagues and students. In addition to the training program, Trotec offers video tutorials on its own YouTube channel.



5 / Laser Projects

Free laser templates for universities and schools

In the know-how section of our website <https://www.troteclaser.com/en/learn-support/laser-projects>, we provide a variety of laser templates for download. At schools and universities in particular, knowledge differs between users.

Laser templates and the corresponding settings make it easy to get started with your first self-lasered workpieces. We have put together some highlights for students from our free laser templates. Once you have downloaded the file and the laser parameters, you can get started.



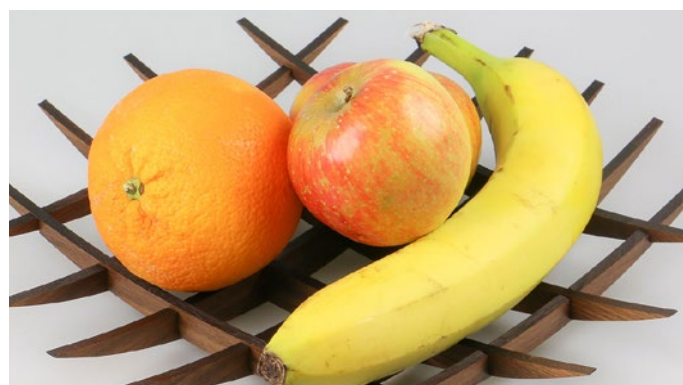
Miniature rocking chair made from TroCraft Eco



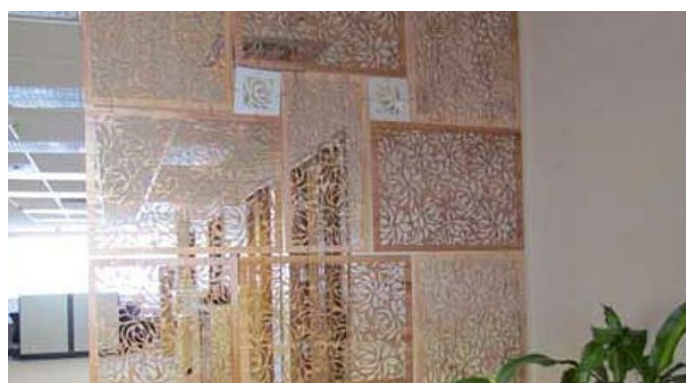
Model airplane



Paper packaging



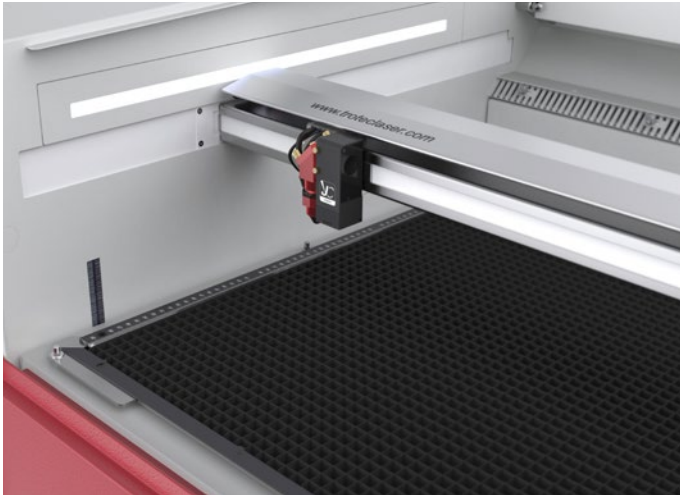
Fruit bowl made of solid wood



Partitions made from different materials



Windmill made from TroCraft Eco and acrylic



6 / Technical Service and Support

6.1. How do I service a laser machine?

Some laser systems are easier to maintain than others. Trotec laser machines are extremely durable due to their design and high-quality components. They have unique features such as InPack technology™ – a patented design feature that protects the sensitive components of your laser machine, e.g. the processing area, the laser head, the mirror and the lenses, from dirt and dust. This guarantees years of trouble-free operation even with intensive use. Trotec machines also offer better protection for applications that generate particularly high amounts of dust (e.g. rubber and wood engraving). The processing area is sealed so that no dust can settle on the electronics or motors. This increases the service life of your machine and reduces the cleaning time to a minimum.

6.2. What service & support can I expect from Trotec?

At Trotec, close customer relations are a lived reality rather than an abstract concept. Which laser system you choose for your university or school depends on a number of factors. At Trotec, we pride ourselves on providing the best maintenance and support in the industry to our customers – including numerous well-known universities, colleges and schools – throughout the entire life cycle of their laser machine. Especially at the end of the semester, when many students want to finalize their projects, the guarantee that your laser machine will not fail, or that it will quickly be ready for use again if it does fail, is worth its weight in gold. We provide a well-designed maintenance schedule that will help you get the most out of your laser machine.

Whether you opt for an annual inspection of your laser machine or a comprehensive TroCare package, you can rest assured that your laser machine is in the best hands. Of course, our experts are also available to help you, free of charge, by email or telephone.

7 / Laser technology terms

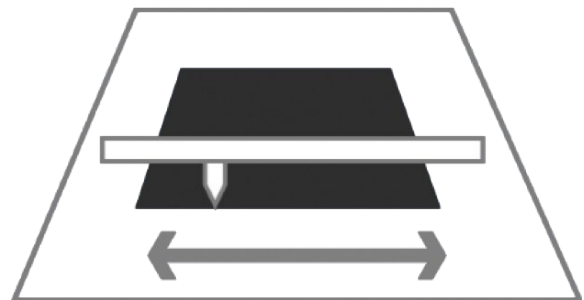
7.1. How does a laser machine work?

Raster and vector are two types of graphic files, each of which is best suited for a specific type of laser processing. The main difference between vector and raster graphics is that raster graphics are made up of pixels, while vector graphics are made up of paths or lines. Depending on your particular application and the results you want to achieve, it's important to understand this distinction.



Process: Raster engraving

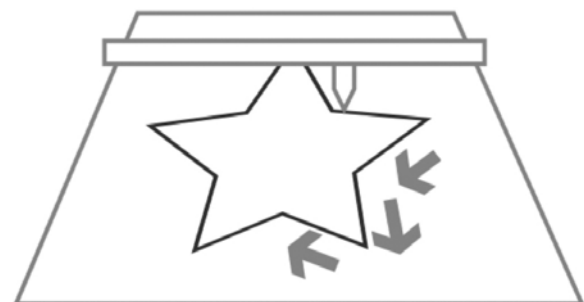
- Similar to a printer
- The work head moves on the X-axis from left to right and back
- Graphics are traced line by line
- Graphics are rasterized bitmaps
- Settings are DPI (dots per inch) and PPI (pulses per inch)
- Very fast X-axis, slow Y-axis movement



Raster engraving

Process: Vector cutting

- Work head moves along a certain path (vector)
- Cutting paths are vector lines, arcs or bezier curves
- Vectors are traced one after the other
- Control via speed, laser power and Hz (Frequency)
- "Slower" X-axis and Y-axis movement
- Depending on the set laser power, the material is either cut through or scratched out



Vector cutting

In order for the laser machine to "know" which lines of the graphics need to be cut and which need to be engraved, these must be set in the graphics as follows.

Cutting lines:

- Must always be vectors

Engraving area:

- Vectors and pixel graphics

In the laser software, cut lines are usually set in red, while engraving elements are set in black. However, you can use any color available in the material database for cutting or engraving.

7.2. Laser terms simply explained

The “Laser technology in education” eBook offers an introduction to the world of lasers. This glossary explains some technical terms in more detail.

CO₂ laser (gas laser)

Laser machines with a CO₂ laser source are gas lasers based on a carbon dioxide gas mixture. This is stimulated electrically. With a wavelength of 10.6 micrometers, CO₂ lasers are primarily suitable for processing non-metallic materials and most plastics. CO₂ lasers are relatively efficient and have a very good beam quality. They are therefore the most popular laser types. This type of laser is suitable for the following materials: Wood, acrylic, glass, paper, textiles, plastics, foils, leather, stone.

Fiber laser

Fiber lasers belong to the group of solid-state lasers. They generate the laser beam by means of a so-called seed laser and amplify it in specially constructed glass fibers to which energy is supplied via pump diodes. With a wavelength of 1.064 micrometers, they achieve an extremely small focus diameter, which means that their intensity is up to 100 times higher than that of CO₂ machines with the same average output. The fiber laser is ideal for marking metals by means of annealing, for metal engraving or for high-contrast markings on plastics. They are essentially maintenance-free and are characterized by a particularly long service life of at least 25,000 laser hours. One special type of fiber laser is the MOPA laser, in which the pulse durations can be set variably. This makes the MOPA laser one of the most flexible lasers on the market and it can be used for many applications. Fiber lasers are suitable for these materials: Metals, coated metals, plastics.

Nd:YAG, Nd:YVO (crystal laser)

Crystal lasers are also solid-state lasers. Nowadays these laser machines are diode-pumped for marking applications (previously via flash lamps). The most common laser types in this category are Nd:YAG (Neodymium-doped Yttrium-Aluminum-Garnet) and Nd:YVO (Neodymium-doped Yttrium-Ortho-Vanadate), named after the doping element neodymium and the host crystal. At 1.064 micrometers, crystal lasers have the same wavelength as fiber lasers and are therefore also suitable for marking metals and plastics. In contrast to fiber lasers, relatively expensive pump diodes are used in YAG or vanadate lasers. These have to be replaced after as little as approx. 8,000 to a maximum of 15,000 laser hours. The crystal itself also has a significantly shorter service life than the fiber laser. The crystal laser is suitable for these materials: Metals, coated metals, plastics and, in some cases, ceramics.

Laser engraving

In laser engraving, the material is heated very strongly by the incident laser beam. Depending on the exposure time, the color changes to create a contrast or the material evaporates or burns. The achieved laser engraving is permanent and very resistant to abrasion. Laser engraving is used to give products an individual design or a personal touch. A sports trophy engraved with the name of the winner, ballpoint pens engraved with the company logo or a component that is marked with serial number and batch number – these are typical applications for laser engraving. The big advantage: With a laser machine, you can engrave virtually any design on different materials.

Laser cutting

Laser cutting is a type of thermal separation process. The laser beam hits the surface of the material and heats it so strongly that it melts or completely vaporizes. Once the laser beam has completely penetrated the material at one point, the actual cutting process begins. The laser system follows the selected geometry and separates the material in the process. Depending on the application, the use of process gases can positively influence the results. The high accuracy, speed and versatility of the laser are the big advantages when using a laser cutting process.

Laser marking

„Laser marking“ stands for the marking or inscription of materials and substances with a laser beam. A distinction is made between different processes such as engraving, ablation, discoloration, annealing and foaming. Laser marking is permanent and resistant to abrasion, heat and acid. Depending on the setting of the laser parameters, markings can also be made on certain materials without damaging the surface.

Due to the high precision of laser marking, very filigree graphics, 1-point fonts and the smallest geometries can be realized very quickly and clearly legible. With consistent results.

Typical materials for laser marking are metals (stainless steel, aluminum, gold, silver, titanium, bronze, platinum or copper), plastics (ABS, polycarbonate, polyamide, PMMA or plastics with laser additives), foils or engraving materials (laminates).

Laser parameters such as power, speed and ppi – we have briefly explained the most important parameters for you:

Power and speed parameters

The power and speed laser parameters are the most important settings in the material database, which can be set as a percentage between 0 and 100%.

The “Power” laser parameter describes the output power of the laser. 100% is maximum power. For dark wood engravings or stamp engravings, you generally need high power, whereas low values are used e.g. for paper.

The “Speed” laser parameter describes the movement of the laser head. Fast speeds lead to short exposure times, slow speeds lead to long exposure times. For example, large-scale engravings of TroLase materials are engraved at high speeds between 80 and 100%. For photo engraving with a lot of details, e.g. on wood, the speed should not be more than 10%. This setting also affects the quality of the laser cut.

Note that cutting and engraving speeds are not comparable.

Basically, cutting is slower than engraving. A „high“ cutting speed is 10%.

Parameters „PPI“ and „Hz“

The PPI (= pulses per inch) parameter determines how many laser pulses per inch are used in engraving. This should be equal to or a multiple of the dpi selected in the print setting to achieve a good result. If you set this parameter to „Auto“, the laser software will automatically determine the optimal resolution of the laser pulses. In the cutting process, the „Frequency“ parameter is crucial and is specified in Hz (=Hertz). It indicates how many laser pulses leave the laser per second. With a CO2 laser, the value can be set in a range from 1,000 to 60,000 Hz. For example, if you want to achieve a smooth edge when cutting acrylic, you need higher temperatures and so this value is set to at least 5,000 to 20,000 Hz. When cutting wood, on the other hand, a low frequency of 1,000 Hz is required, for example, to achieve the brightest possible cut edge.

TROTECLASER.COM

trotec

Trotec Laser GmbH
T +43 7201 15-244
info@troteclaser.com

 /trotecusa
 /troteclaser
 /TrotecUSA
 /TrotecLaserInc
 /TrotecLaserEngraving