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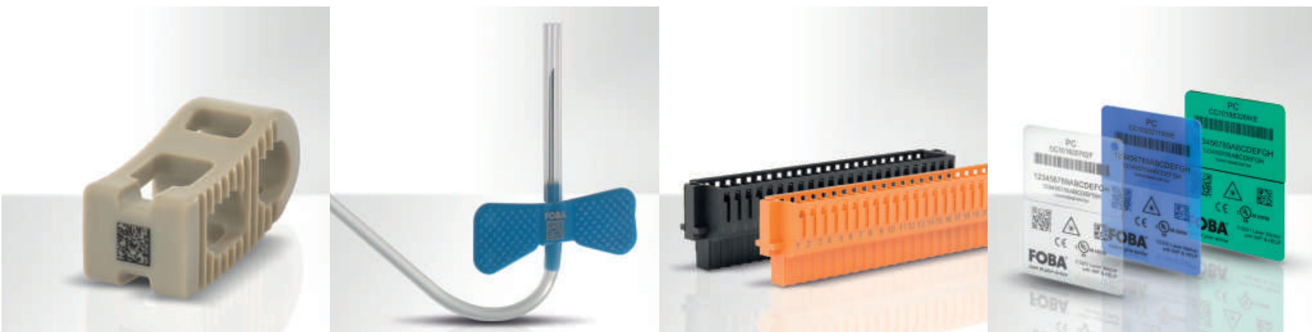
White Paper Laser Marking of Plastics and Resins

Applications in medical technology and automotive industry

Plastics are used in all industries. The versatility of the material, its relatively low cost and constant new developments make it a universal material. Plastics are proving to be enormously efficient, especially in medical technology and automotive engineering, and are establishing technological trends. The choice of the plastic to be used is based on its functional purpose and its intended use. The requirements for its marking are as varied as the nature of the plastics. The quality of the marking is not only determined by the type of the selected laser etching system and the utilized marking parameters, but also by the selection of special additives in the plastic mix.

Medical and automotive plastic applications



Plastics in the medical technology industry

Special demands for hygiene and biocompatibility

Patient safety, hygiene and biocompatibility, versatility and robustness or facilitation of patient care – these are just a few of the buzzwords that illustrate the many advantages of plastics for medical applications. In addition to the care and treatment of patients, the areas of application mainly include the use of plastics as a raw material for the manufacture of medical instruments and devices as well as implants.

Relatively low material costs allow for **disposable (single-use)** plastic products. This increases patient safety and hygiene, and simplifies and accelerates the work of hospital staff. Time-consuming cleaning procedures are no longer necessary. In case of **multiple use**, the utilized plastic must be resistant to partially aggressive cleaning agents and should not discolor during cleaning for aesthetic reasons.

In order to protect our health, plastics used on or in the human body mustn't release any harmful substances. Raw material suppliers are obliged to comply with the relevant regulations for the **protection of patient health.** As an example, bisphenol A (source material for polycarbonates and epoxy resins) and phthalates (slowly evaporating PVC softeners) have harmful hormonal effects and are prohibited.

Particularly tubes used in the body must fulfil certain characteristics: They must be gliding, flexible and bend-free. Appropriate plastics such as silicone can meet these criteria. In addition, in ideal situations, plastics can be compatible with human tissue. If they additionally have elastic and stable properties comparable to natural tissue, plastic implants can even be used as a long-term replacement of human tissue.

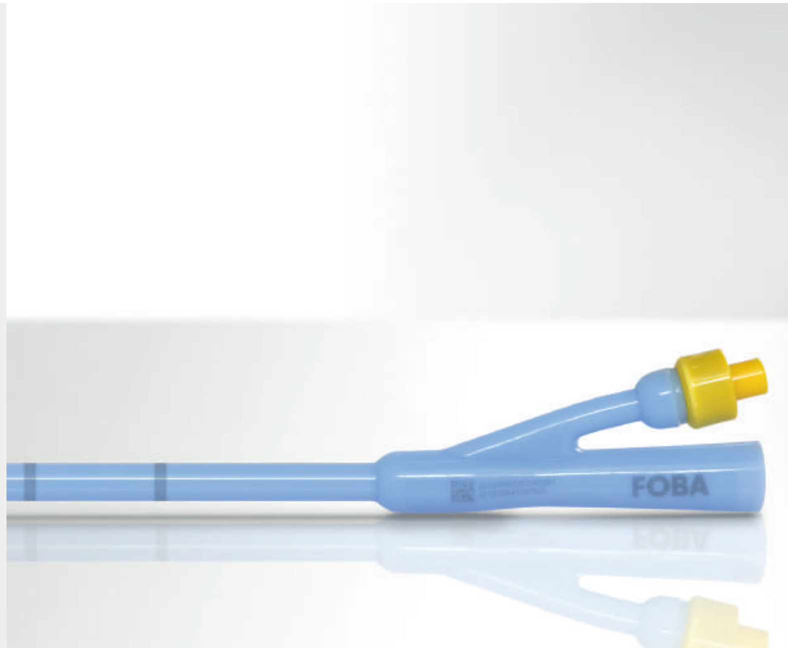
All these requirements also affect the labelling of plastic products: The marking process must not impact the surface so that the product can't release any harmful substances. This is where laser marking offers the advantage that the marking usually doesn't affect the biocompatibility of a product.

cf. www.mpo-mag.com/contents/view_online-exclusives/2017-10-09/5-ways-plastics-revolutionized-the-healthcare-industry/

Biocompatibility

Proof of the compatibility of materials that come into direct contact with the human body is based on EN ISO standard 10993. For plastics, it must be ensured that no soluble particles cause short-term or even long-term damage to health, including mutagenic damage. However, plastics that aren't biocompatible per se can also be made biocompatible by adding a coating layer.

→ *www.iso.org/standard/68936.html*



Plastics in the automobile industry

Materials for automotive design and future technologies

In automotive engineering, design, functionality and technical innovation are key. Possible applications for plastics are seemingly unlimited and are constantly evolving. Safety, driving pleasure and dynamics, weight reduction, heat resistance, display solutions or surface structure are driving innovation. While automotive interiors are already made almost exclusively of plastics, the material is also being used increasingly in the bodywork area.

Between 15 to 50 percent of a car is made of plastic. While the material is still being tested in the body construction area, the interior is almost entirely equipped with it. Haptics and appearance influence "ambience" and driving experience. Glossy surfaces – even without paint –, permanently dust-repellent panelling, different coloring or even noise-reducing elements are examples of **interior designs** that can be realized with plastics.

Energy-saving regulations lead to the development of low-consumption technologies. Plastics help to **reduce weight** and play a major role in the material mix in hybrid lightweight construction. They are also becoming increasingly important in **electromobility**. Plastics are well suited for a large number of electronic components, but also for batteries that can withstand extreme heat because the accumulators heat up during the charging process. The plastics used here must be able to shield or conduct electricity.

Next to heat, automotive plastics must also withstand substances such as oil, petrol, coolants or mechanical abrasion. In addition, there is a trend towards "owned" vs. "shared mobility", leading to further demands on the long-term resilience of the materials.

The laser marking of automotive components plays a special role in the field of lighting. Backlit displays, switches or buttons in a day-night design are designed with the help of laser marking systems using a paint removal process[1]. The high-contrast symbols must meet both optical, ergonomic and design related requirements.

[1] cf. also FOBA Application Case Study "Day-Night-Design: Accurate paint removal with Laser"

Direct part marking ensures traceability

*Direct part marking ensures seamless traceability in the **automotive sector**. Since a car consists of thousands of components, permanently legible marking with **data matrix codes, serial numbers or other alphanumeric characters** is indispensable not only for production-related reasons, for warehouse logistics and quality assurance, but also in the event of complaints or product recalls due to defective parts.*

*A proper UDI marking guarantees the traceability of individual **medical devices**, and is a decisive factor for patient safety, especially in the case of product defects and recalls. **Laser marking is the state-of-the-art procedure for the compliant, legally required UDI marking, as regulated by the FDA in the US and within the MDR in the EU.***

Plastics in industrial applications

Thermoplastics and Co. – powerful and versatile

When we talk about plastics in industrial applications, we usually refer to thermoplastics. Silicone elastomers or other plastic compounds, from standard products to high-performance thermoplastics, are used in countless applications.

The generic term "plastic" includes thermoplastics, polyurethanes, thermosets, elastomers, adhesives, coatings and sealants. For decades, the volume of plastics produced worldwide has been increasing[1]. In 2017, the volume was 348 million tons (64.4 million tons of which were produced in Europe). *cf. https://de.statista.com/statistik/daten/studie/167099/umfrage/weltproduktion-von-kunststoff-seit-1950/*

Thermoplastics are all-rounders in application and processing. Also referred to as plastomers, thermoplastics are characterized by the fact that they melt in a certain temperature range, can then be brought into a desired shape and remain in shape after cooling.

Thermoplastics belong to the group of **polymer** materials, together with **thermosets** and **elastomers**, both of which, unlike thermoplastics, cannot be melted or welded. The fourth type of plastic, the **Thermoplastic Elastomers (TPE)**, "combines the mechanical properties of vulcanized elastomers (rubber) at room temperature with the processability of thermoplastics." *cf. www.chemgapedia.de/vsengine/vlu/vsc/de/ch/9/mac/polymere_werkstoff/polymere_werkstoffe.vlu.html*

At about 80 percent, thermoplastics account for the largest share of polymers. They are processed through **injection molding or extrusion** or joined together by **welding**. All three processes have in common that the material is melted. In injection molding, molds are poured out, whereas in extrusion the plastic is pressed in order to produce films, tubes or bags.

Thermoplastics are among the most powerful plastics. They can be used in many ways without buckling due to their isolation and flexibility. In addition, they can be processed precisely and easily shaped even in the smallest formats. Some thermoplastics are referred to as high-performance plastics due to their special properties (see box below).

High performance plastics

Thermoplastics are divided into standard plastics, engineering plastics and high-performance plastic.[*] The advantages of high-performance plastics include their high temperature and chemical resistance, electrical and thermal insulation properties, special stiffness and heat resistance, mechanical damping against vibration and noise emission or biocompatibility.

The market share of high-performance plastics is less than one percent of the total plastics market. At over 6 Euros per kilogram, they are the most expensive ones compared to engineering plastics (2 to 6 Euros) and standard plastics (under 2 Euros).

*Although more and more applications are being realized with standard plastics, some requirements, particularly in medical technology or automotive engineering, can only be met with high-performance plastics. For example, **future mobility and transport** concepts and the entire field of **electrification** will depend on high-performance plastics. In **medical technology**, the high-performance plastic PEEK is used for spinal implants. PEEK is biocompatible, shows good mechanical properties and can be individually produced using 3D printing.*

[*] cf. article „Hochleistungen mit Kunststoff" (High performance with plastic) of Dr. Michael Gehde, K Magazin 3-2019, p. 10 ff. and https://de.wikipedia.org/wiki/Hochleistungskunststoffe (high performance plastics)

Silicone elastomers: strong performance, growing demand

Silicon rubber is another important plastic, and also belongs to the group of elastomers. Silicone rubber is very **heat-resistant** (-50°C to 250°C, special types even -110°C to 300°C) – even over a long period of time. Additionally, it is flexibly extensible and at the same time tear-resistant. Silicon rubbers are insensitive to chemicals, **transparent and neutral in smell**, **taste and haptics** as well as **water-repellent** and **low-pollutant.**

In addition, they are **easy to process**, i.e. by (micro) injection molding or in multi-component production, and they are are free of waste and temperature (i.e. post-processing by heating to remove possible residues is not required). Unlike **solid silicone (HCR)**, **liquid silicone (LSR)** can only be processed by injection molding, whereas HCR can also be extruded.[1]

Because silicone elastomers are toxicologically and physiologically harmless due to their inorganic Si-O compounds[2], they are **optimally suited for medical or baby products**. Silicone compounds in particular are suitable for use with food or drinking water contact or in the pharmaceutical sector, since LSR (in the standard version) is already bacterially resistant and can even be made bactericidal or sterile by means of certain additives, e.g. silver ions. Possible applications include bottle teats, duckbill valves (duckbill slit valve) or infusion/intubation tubes.

Due to their high heat resistance silicones are preferred in **automotive and aircraft construction**. Silicones are also highly resistant to ozone and UV radiation, gasoline or coolant.

Due to its mechanical shape retention, the material is used in sealing or damping. These properties make the material particularly interesting for **electronic applications.** Examples are spark plugs or ignition cables, seals, exhaust hangers, vibration dampers or radiator hoses.

For **new e-mobility concepts** such as autonomous driving or high-voltage technology, silicones are sometimes absolutely essential. Due to their heat resistance and permanently reliable sealing function they offer the high level of safety manufacturers require. Flame retardancy can also be guaranteed by suitable silicone additives.

[1] cf. K-Profi, edition 5/2019, p. 26 ff.: „Hitzebeständig, kalt vernetzbar, temperfrei" (Heat resistant, cold crosslinkable, temperature free)
[2] cf. FOBA Application Case Study "Laser marking of silicone elastomeres" www.fobalaser.com/applications/case-studies/laser-marking-of-silicone-elastomers/

Plastics in the medical and automotive industries

Applications and requirements

Medical Applications	Automotive Applications
Plastic applications, examples:	
→ Catheter, hoses, tubes, hose clamps → Medicine spoons/bottles, bottle tops → Bags/tubes for feeding, respiration, infusion → Wearables (smartwatches, hearing aids, insulin pumps etc.) → Ventilation masks, ventilation tubes → Surgical suction sets and suction cannulas → Infusion, transfusion or dialysis sets → Housings of medical electrical devices, including precision devices that must be highly sterile → Transport boxes → Joint and spinal column implants → Breast implants → Bone plates or screws → Suture material → Syringes, cannulas → Infusion sets → Anti-colic valves → Baby bottles and soother	→ Sealing rings → Electronic components → Control panels and instrument panel → Plastic coating layers → Seats and upholstery material → Pedals → Fuel lines and fuel tanks → Fittings → Shatterproof windscreens → Back foaming for sealing → Belts and belt connections → Flanges, joining elements → Turn signals and headlights → Trims, bumpers, spoiler bodies → Fuel tank caps → Buttons and switches → Mirror housings → Shock and silencer → Type plates
Required material properties, among others	
→ Biocompatibility → Transparency → Tear resistance → Mobility, Flexibility → Different colors for easy distinction → Reusability → Disposable use possible → Easy cleaning → Low weight → Resistance to cleaning agents → Breakage resistance, impact resistance	→ Abrasion resistance → Flame protection → Heat resistance → Electrical conductivity → Electrical insulation capability → Resistance to coolants, petrol, oil, etc. → Seal → Damping → Low weight → Breakage resistance, impact resistance → Possibility of coloring, optical-haptic quality → Free from vapours/low-pollutant

The mentioned applications and material properties as well as the mentioned common plastics are a selection without claim to completeness. The requirements for direct marking of plastic surfaces and the selection of marking lasers used are just as diverse as the fields of application for plastics

Plastics in the medical and automotive industries

Types of resins and their properties

Selection of most common plastics

Name	Acron.	Possible Applications	Material Properties
Polyethylen	PE-LD, -LLD, -HD, -UHMW, -X	Foils, injection molded parts, tubes, isolation, implants	most frequently used standard plastics
Ultra-high molecular weight Polyethylene	UHMWPE	Protective devices, lining technology, medical implants	low-wear, impact-resistant, stress and UV-resistant, good sliding properties
Polypropylene	PP	Packaging, dashboards, housings, coatings	hard and heat resistant standard plastic
Polyvinyl Chloride	PVC	Cable sheathing, floor coverings	durable, robust hard or soft plastic; *PVC plasticizers (phthalates) are harm-ful to health*
Polyurethane	PUR (PU)	Upholstery material, steering wheels, soft coatings, sound insulation, rattle protection	foam in different densities (hard or soft)
Polyethylene Tereph-thalate	PET	Bottles, foils, textile fibers	unbreakable recyclable plastic
Polystyrene	PS	Insulation, packing,	weatherproof, but UV-light-sensitive and flammable standard plastic
Polycarbonate	PC	Insulation, disposable medical products, car headlights, windows, eyeglasses	transparent, colorless, dimensionally stable thermoplastic
Polyetheretherketon	PEEK	Joint and dental implants, electronic components	high-temperature resistant, beige-colored polymer, also suitable for 3D printing, biocompatible
Silicone elastomers	LSR, HSR	Tubes, respiratory masks, sealing rings, pacifier	permanently heat-resistant, neutral, transparent, hydrophobic, flexible polymer plastics
Acrylonitrile-Butadie-ne-Styrene Copolymer	ABS	Housings, automotive parts, electronic components	robust, colorless to grey technical plastic
Polyoxymethylene	POM	Handles, ball bearings, locking parts, housings	high dimensional stability even at cold/heat, conductive
Polyamide (Nylon)	PA	Medical catheters (e.g. for suction, intubation or drainage)	transparent and flexible, tear-resis-tant

Plastic additives and fillers:
For highest functionality and contrast

Plastic compounds contain additives of various kinds. These include fillers such as carbon black, quartz, glass fiber, organic substances or pigments for coloring. Other additives function as chemical or organic stabilizers, or influence viscosity.[1]

Upper row: Laser optimized plastic plates from additive manufacturer Avient (formerly PolyOne): from left to right Olefinic (synthetic fiber made of a polyolefin such as polypropylene or polyethylene), nylon (polyamide), styrenic (polystyrene), PC (polycarbonate), TPU (thermoplastic polyurethane). Bottom row: Laser-optimized plastic samples from additive manufacturer Clariant: from left to right PSU in black and grey (polysulfone), PEEK and PP.

Laser additives increase the **contrast capabilities** of plastics and enhance the quality of laser marking. Some plastics are not suitable for laser marking without additives. Depending on their color, polyurethane, polypropylene, polyethylene, polystyrene and polyvinyl chloride, for example, require additives that enable laser marking.

Laser additives influence the absorption capacity of the plastic: The better certain wavelengths are absorbed, e.g. rays in the near IR range (1,064 nm, i.e. the wavelength of common fiber lasers), the higher the resulting contrast. In addition to the absorption, the **reflectivity** of an additive also influences the marking quality.[2]

Functionality: Additives that enhance or enable laser marking, convert visible UV and IR laser light energy into thermal energy. The color of the plastic changes where it was marked with the laser (color change) and the marking becomes visible with high contrast. Therefore, in addition to the material composition, the selection of a suitable laser system or its wavelength is also important for the marking.

Additives can also alter the **hygienic properties** of a polymer surface. Recently, additives have been developed that release **antimicrobial agents** – such as silver, copper or zinc – in a controlled manner using so-called carriers. These additives have proven to be effective and biocompatible.[3] Also **flame retardants** or laser **welding additives**, as well as all the other compound components, affect the marking properties of the material.

Another use case are **thermochromic additives.** They are utilized for the coating of plastics that can't be marked otherwise. These additives can prevent the paint from being roughened or perforated during laser marking. If the lacquer is not suitable for marking despite the additive, a "sacrificial layer" may be necessary to enable optimum marking results.

In the context of **environmental and health protection**, there are efforts underway to use additives in the widely used standard plastic PVC, which are not only effective, but also release fewer pollutants than conventional additives, e.g. in water. For this purpose, lead- or tin-based stabilizers are already being replaced by heavy metal-free or calcium-zinc-based stabilizers.[4]

The US **plastic compound manufacturer Avient (formerly PolyOne)** has specialized in the development of plastics with optimal marking properties by adding laser additives (OnCap™ Laser Marking Additive for polymers). Avient uses FOBA laser marking systems to test their developments and has provided a clear overview of plastics and their marking results in an information leaflet:
→ www.polyone.com/sites/default/files/2020-08/oncap-lm-additives-product-bulletin.pdf

[1] *Manufacturers like Gabriel-Chemie, PolyOne or Clariant offer various additives.*
[2] *cf. onlinelibrary.wiley.com/doi/pdf/10.1002/latj.200890043*
[3] *cf. www.devicemed.de/dosierte-wirkstoffabgabe-durch-anti-mikrobielle-kunststoffoberflaechen-a-834485/?cmp=nl-225&uid=224A55E2-8961-4C91-83A4-A794603B210D (dosed active ingredient release through antimicrobial plastic surfaces-)*
[4] *cf. content.yudu.com/web/1rl19/0A1rl2p/CWJun19/html/index.html?page=50&origin=reader (Compounding World, June 2019, page 51ff. "PVC additives take green line")*

More transparency in materials science
Medical Grade Plastics

While the MDR (Medical Device Regulation), which will be binding throughout the EU from May 2021, as well as the FDA guidelines for the USA, define the requirements for medical devices themselves, there were previously no official standards for the materials from which they are manufactured. The term "Medical Grade Plastics" was previously defined less as a concrete term than as a marketing term.[5]

In order to provide a reliable orientation for the selection of suitable plastics, a committee of material and product manufacturers, marketers and notified bodies developed the VDI Guideline 2017 Medical Grade Plastics. This Guide describes the basic requirements for medical plastics.

The specified properties are technical and include documentation and communication standards (such as information about recipe changes and transparency in the value chain).

The draft guideline submitted by the VDI in July 2019, can already be used by suppliers of polymer compounds and additives as a benchmark for possible product adaptations and serves to check the extent to which the above requirements are already met.

For laser marking, uniform material standards would offer the advantage that the suitable marking parameters could also be named more bindingly. The effort required for the user to find the parameters again could be reduced, especially since plastics with the same designation are often composed differently depending on the supplier.

For a fee, the guideline can be ordered from the VDI:
→ *www.vdi.de/richtlinien/details/vdi-2017-medical-grade-plastics-mgp*

[5] *cf. www.plastverarbeiter.de/84810/vdi-richtlinie-2017-medical-grade-plastics*

Liquid silicon elastomer Silopren LSR 2050 with laser marked parameter matrix. FOBA and Momentive Performance Materials have jointly worked out how to achieve high-contrast, long-lasting markings by precisely matching material, pigments and laser parameters.* →

Laser marking of plastics

Foaming, carbonization, color change, material removal

Depending on the wavelength of the selected laser system and the properties of the plastics, different marking effects are achieved. Suitable laser systems are CO_2, fiber and other solid state lasers.

The laser is particularly suitable for marking plastics, as its thermal energy acts locally and with pinpoint accuracy. The advantage of this precise irradiation is that the achieved color change is sharply limited and very **high in contrast**. The resulting **color tone** also improves the sharpness contrast of the marking.

In addition to its good legibility, laser marking is also recommended because of the **abrasion resistance** achieved: The material is not only "printed" on the outside, but its substance is changed. This is essentially done by **color change and material removal.**

Plastics **absorb** laser radiation more or less depending on their composition. The resulting **thermal changes in the material also create color effects:** Dark plastics usually produce a lighter color change, lighter plastics produce a darker color change or – as is sometimes the case with transparent materials – also a lighter marking.

Plastics generally absorb light best in the ultraviolet range (UV laser) and in the far infrared range (CO_2 laser). For this reason, **additives, fillers and pigments** are used to improve the absorption behavior and thus also allow other laser radiation – in the near IR range 1,064 nm (fiber laser) or visible green laser light (532 nm) – for marking.

Laser marking procedures on plastics

Carbonization

Dark coloration occurs during carbonization. Plastic compounds are broken up and the carbon from these compounds is released. The laser irradiation **discolors the plastic below the surface**, which remains unaffected externally. The resulting discolorations range from gray to blue-gray to black. Carbonization is mainly used for light-colored plastics, since a color effect from light to dark is achieved and thus usually a very good contrast.

Foaming/Frothing

The foaming causes **a sublime tactile marking on the surface.** This is caused by outgassing during laser marking: The small bubbles that settle on the surface of the material reflect diffusely and produce **light colored marks on darker materials.**

Layer removal

In the layer removal process, the laser **melts layers of the plastic surface** and removes these. Either the material itself or its coating, which was usually applied with the aim of achieving a specific marking effect, is removed. In this way, paint can be removed with high precision in the desired thickness from the underlying differently colored plastic layer, which becomes visible as a result.

← Speedometer ring by Fremach Morava s.r.o.

Day-Night-Design

With the so-called day-night design or paint removal, a part's **coating is removed from the transparent substrate material.** The resulting sharply defined symbols can be backlit in the dark. An example are car displays [2]. The highly precise removal of several layers of differently colored paint also produces desired marking effects with high contour sharpness without damaging the layer underneath.

Engraving

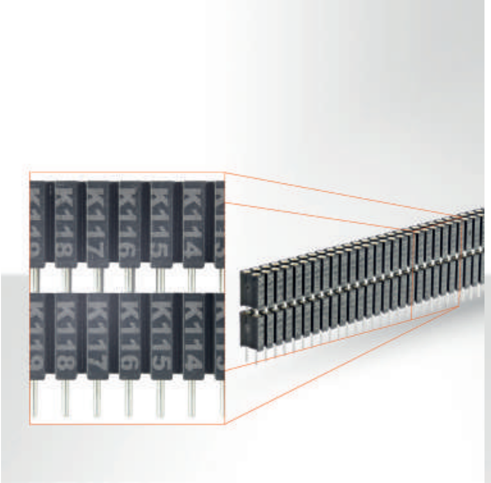
Laser engraving causes a deep marking by **melting** the engraved material and subsequent **vaporization**. Engraved marks are extremely robust and resistant against wear and tear. The marking remains legible even with possible downstream coating processes.

[1] *cf. Laser Journal LTJ, September 2008, No. 4, p. 40 ff., „Kunststoffe mit dem Laser beschriften" (lasermarking plastics) by Birgit Faißt*
[2] *cf. FOBAs Application Case Study „Day-Night Design: High-Precision Paint Removal with Laser"*

Line integration or single workstation?

Marking lasers designed for integration into production lines are compatible with various industrial communication protocols and easy to install.

If medical devices or automotive components such as surgical instruments or brake pads have to be marked manually, a stand-alone laser workstation in laser safety class 1 is used.





Car part by Gealan Formteile (gealan.com)

Marking procedures and marking effects on plastics

Laser marking systems differ in their **wavelengths** depending on the stimulating laser medium. Which marking laser is best suited for the respective application depends on the materials to be marked. Some lasers are more versatile than others as they are suitable for various materials.

When marking plastics, lasers with shorter wavelengths tend to achieve the best results. Nevertheless, **fiber lasers** are the most widely used systems in industrial parts marking. This is because they offer very good marking results for most applications when additives are mixed into the plastics. These results together with **relatively low purchase and operating costs and a long machine life** make them the perfect fit for a majority of users.

At least for various **light-colored plastics** short-wave **UV laser light** is advantageous as it neither heats nor damages the material during marking (keyword "cold marking") but applies high-contrast marks. Laser marking with UV laser is particularly suitable for silicone or white polyamide, i.e. for plastics that can be optimally marked with UV laser even without adding additives[1].

CO_2 lasers are suitable for marking materials with low stength (i.e. tires) and PVC and PET.

EFFECT →	COLOR CHANGE		MATERIAL REMOVAL (MELTING/VAPORIZATION)	
LASER ↓	Dark marking (carbonization)	Light marking (foaming)	Selective layer removal	Engraving (material removal)
CO_2 (9,300 – 10,600 nm)	limited	limited (i.e. PET bottles)	limited	yes (i.e. on black plastic parts or rubber)
Nd:YAG/Nd:YVO_4 (~ 1,064 nm)	yes	yes	yes	limited (on black plastics)
Yb fiber laser, pulsed (~ 1,064 nm, infrared near range)	yes	yes	yes	limited (on black plastics)
Green laser (532 nm)	yes	yes	limited	limited
UV laser (355 nm)	yes	yes	limited (for very thin layers)	limited (for very fine engravings)

[1] cf. FOBA Application Case Study „Laser Marking Silicon Elastomers"; see also Product datasheet FOBA V.0020-uv

Flexibility, quality, efficiency

The benefits of laser marking plastics

→ **Fast and flexible:** Laser marking is the fastest and most flexible way to apply **changing content**. This is important for the serial **consecutive marking** of automotive type plates or article numbers, but also for the product-specific UDI marking of medical devices.

→ **Non-contact and versatile:** Laser marking is **contactless**, pre-treatment of the to-be-marked surfaces is not necessary. **Materials of various qualities** can be marked with the laser, i.e. plastics with rough, curved or reflective structures or even with dirt.

→ **Permanent and reliably readable and traceable:** Laser marks are non-abrasive and permanent as the laser changes the material and not only its surface. As a result, applied contents ranging from characters and numbers to codes and symbols are **high-contrast and easy to read** – both by the human eye and by machines. Long life marks of high marking quality ensure full traceability throughout the entire life of the marked product or part.

→ **Easy integration:** State-of-the-art laser marking software **is compatible with most industrial communication protocols**, can be easily integrated into production environments and is able to transfer serial data into the marking process.

→ **Hygienic marking:** Plastics which must not emit any harmful substances in order to protect human health, can be marked **biocompatibly** with the laser. As the surface of these sensitive plastics is only minimally changed by a so-called cold laser marking, which is achieved with a UV laser, central **hygiene requirements** are met, since the adhesion of germs can be avoided by the damage-free marking with low heat input.

→ **Higher production efficiency, lower costs:** The use of a laser system for direct part marking not only improves the marking quality in the long term, but also increases **production efficiency** and reduces **costs**. Consumables and maintenance costs are low, and marking errors and thus rejects can be virtually eliminated with the help of a laser-integrated camera system for marking alignment and inspection.

Play it safe with laser marking vision control

*Marking systems with integrated vision pay off several times. → **Before marking,** they identify parts, check whether they are already marked and can reject faulty or incorrect products. They detect the component position and align the marking accordingly to ensure that the marking is applied where it is intended to be. → **After marking,** laser-integrated imaging helps with mark inspection, optical character verification (OCV) and code reading. This ensures maximum process reliability and minimal reject rates.*

With functions such as → FOBA's Mosaic laser marking can take place completety fixture-free. This not only minimizes set-up times and costs, but also the considerable effort required for documentation and validation, especially for medical applications.*

** Part detection and high-precision mark alignment for parts that have been placed randomly in the marking field*

Determining marking parameters precisely –
Power, speed, and frequency optimize the results

Thanks to targeted parameter settings, marking results can be influenced already during job setup. The aim is to produce the best possible legible marking in the shortest possible time. For optimum contrast, the laser beam must be so intense that it causes a clear color change but no burning of the material.

Plastics are among the materials whose marking is **relatively demanding**. The confusing composition of the different types always requires an **individual adjustment of the marking parameters.** Even minimal deviations can optimize or worsen the contrast.

The following parameters can be set in the marking software (basic parameters):
→ Laser power → Travel speed → Pulse rate → Number of repetitions

Additional (advanced) parameters, i.e.:
→ Pulse width → On/Off-delay

Parameter Expert and parameter database facilitate the determination of parameters

The FOBA MarkUS laser marking software includes optionally selectable laser parameters for specific materials. This allows users to fall back on preset empirical values. Depending on the selected service package, FOBA's application engineers provide a parameter database containing marking parameters adapted to different materials. These parameters are based on numerous sample markings carried out in FOBA's application laboratories.

Basic parameters			
Laser power (W)	**Travel speed (mm/s)**	**Pulse frequency (kHz)**	**Number of repetitions**
Common systems are offered with an output power of approx. 5–100 W, which is adjustable in percentage values.	The speed at which the laser beam moves over the object is measured in millimeters per second (mm/s).	In contrast to "continuous wave" lasers, many marking lasers are pulsed. The pulse rate is measured in kilohertz (kHz)..	To intensify the marking, the mark can be repeated at the same location once the parameters are set as such.

Further influencing variables, e.g.			
Type and size of to-be-marked characters	**"Marking on the fly"**	**Required marking time**	**Lens/focusing optics/ Fokussieroptik**
Single- or multi-font-based writing result in different marking intensities. For data matrix codes, other parameters may be needed than for the adjacent font. Small-sized characters will require different parameters than large ones..	With higher line speed in the production, the laser marking speed also has to increase. The size of the marking field determines the marking time available per part.	To increase the marking speed, adjustments can be made to the laser parameters. A variation in the font type like contour vs. filled characters or different kinds of filling also effects the required time..	The larger the aperture of the marking head, the finer the marked lines. The focal length of the lens determines the working distance and thus the size of the field. At the same time, it affects the laser spot size (focus diameter). The larger the focal length, the larger the spot diameter.

Universal talents for plastic laser marking:
Pulsed fiber lasers

The universal fiber lasers have proven to be suitable and powerful marking systems for virtually all materials. Special marking requirements can be optimally solved with specially configured laser systems.

Laser systems with a wavelength of 1.064 nm are most widely used in industrial parts marking. They can be used to achieve high-contrast color change effects as well as markings in layer removal or as engravings.

Fiber lasers are suitable for all kinds of plastics as well as many metals, ceramics or organic materials. On plastics with a high proportion of dark pigments, fiber laser markers cause a lighter coloration, whereas on lighter plastics a darker coloration is achieved. However, white markings on transparent variants are also possible.

Fiber lasers have a long service life and hardly any operating materials or consumables are required. Since marking head and fiber housing form a solid unit, the aim is to develop small marking units that easily integrate into production lines.

For marking jobs of small to large batch sizes, which are marked independently of a production environment, detached laser-class-1 marking workstations such as FOBA's M-Series are used.

Technical variations in the marking system offer optimal solutions for individual marking requirements, such as day/night design, UDI marking or high-speed marking-on-the-fly.

- → *Optimized for high-precision layer removal: FOBA Y.0201-DN with variable pulse length*
- → *High-speed markings for in-line marking-on-the-fly applications: FOBA Y.1000 (100 W)*
- → *Small-sized fiber laser for integration in production lines: FOBA Titus™ Y.0200-xs/Y.0300-xs (20/30 W)*
- → *Customizable, stand-alone laser class 1 marking stations: FOBA M-Series*

Y-Series fiber laser markers

FOBA®

Laser at your service

Laser marking of medical devices and automotive components

Traceability, product safety and high marking quality

Laser marking is ideal for direct part marking (DPM) and most suitable for variable data applications in mass production. The laser applies high-quality, permanently resistant, reliably traceable marks on products and components. Especially when used in combination with an integrated vision system, a laser marking solution can guarantee highest precision and process stability.

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Laser marking with FOBA's system, process and integrated vision solutions offers many advantages. **We would be happy to provide more information in a live presentation, in our application laboratories, at your premises or virtually. We'd also be happy to conduct sample markings on your material. Get in contact with us: info@fobalaser.com**

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