TRUMPF

White paper

High-quality engraving of stainless steel (316L) for the watch industry

Laser engraving instead of chemical etching

Content

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The challenge

Laser-based processes have been used in the watch industry for decades, but the quality requirements for watch parts are very high. Lasers therefore still have a hard time with many processes such as cutting, structuring and engraving.
In the past, chemical etching was used for engraving common stainless steel alloys in the watch industry (e. g. 316L/DIN EN 1.4404), which was, at least until now, a tried and tested process. However, from an ecological, environmental and economic perspective, there are many disadvantages to chemical etching. Therefore, laser-based engraving processes are increasingly requested as an alternative. Until now, it has often been difficult with short-pulse marking lasers and ultrashort pulsed lasers to meet quality requirements such as the absence of burrs (for short-pulse lasers) while simultaneously achieving comparable brightness, color and gloss as with etching. However, this is a prerequisite for replacing the established etching processes with laser-based processes in the long term.

Our solution

The latest generation of lasers in TRUMPF's TruMicro Series 2000 is able to adapt the parameters precisely to customer requirements. Thanks to the flexible, reliable and fast parameterization, the highest possible degree of quality can be achieved in laser engraving along with the highest throughput. Quality problems are therefore a thing of the past. The ultrashort pulses with minimum pulse durations of 400 fs limit the thermally induced heat input on filigree watch parts. This guarantees burr-free engraving. Since ultrashort laser pulses are usually much more efficient in terms of material removal than classic short-pulse systems, the process time at typical engraving depths of 50 to 100 µm is also significantly shorter. Therefore, ultrashort pulsed lasers are significantly more productive than short-pulse lasers in comparable power classes. With so-called burst settings, ultra-short pulsed lasers can engrave even the most difficult materials leaving a homogeneous, burr-free surface. After engraving, the surface is typically polished in a final process step that is combined with the finishing. As a result, it is virtually impossible to distinguish it visually from a chemically etched surface. Thanks to the TruMicro Series 2000's quickly adjustable pulse duration of between 400 fs and 20 ps, a wide variety of surface finishes are possible, from polished dark to light surfaces or even colored and matt surfaces, which are bright and glossy regardless of the viewing angle.

Devices and optics

- TruLaser/TruMark Station or machines from specialised integrators for the watch industry
- TruMicro 2030 (FU10)
- Galvanometer scanner for beam deflection, ideally Scanlab Excelliscan
- Typically f = 100 mm
  (→ ~30 µm spot, depending on application)

Materials

Due to the flexible parameter ranges of the TruMicro 2000, all metals (see below) can be processed to a high quality. Today, the focus is on developing processes for the stainless steel alloys commonly used in the watch industry (e. g. 316L/1.4404), which are difficult to engrave to a high quality with conventional lasers.

Figure 1: High-quality engraving in titanium (left), 316L (middle) and copper (right). Due to the enormous range of parameters, a wide variety of surface qualities and structures can be achieved by laser engraving with the TruMicro Series 2000.

Interesting facts

Laser features of the TruMicro Series 2000	Advantages of high-quality metal engravings
Flexible energy levels and repetition frequencies	Maximum removal rate possible
Pulse on demand (POD)	Constant energy input and reduced process time possible due to constant spatial pulse intervals
Burst modes	Homogeneous material removal possible on almost all metals
Pulse duration quickly adjustable (400 fs to 20 ps, < 800 ms switching time without changing the beam properties)	Targeted influencing of the surface finish with regard to gloss, matting
QCW mode	Micropolishing processes possible depending on material

- Application support

TRUMPF offers special cycle time studies and quality optimization. To achieve the desired optics, the use of a reference sample that illustrates the desired quality is recommended.

- Risks

The initial condition of the surface and inhomogeneities between different batches or steel alloys can affect the laser engraving. It is therefore common to make small parameter adjustments according to the respective materials and engraving geometries to ensure the highest possible quality.

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