

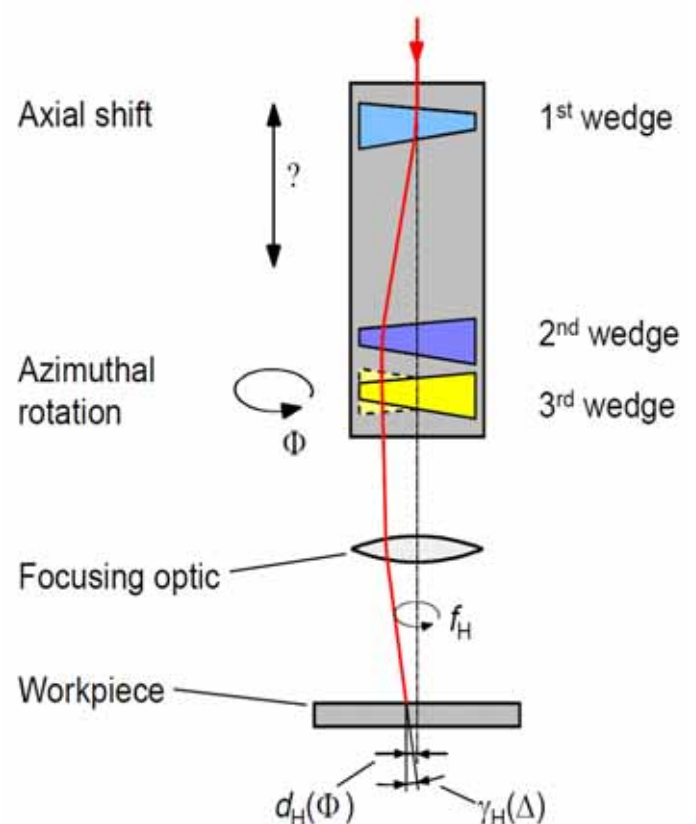
Helical Drilling Optic

The D+G Helical Drilling Optic allows the fabrication of microholes with highest precision. Increasingly small holes with extraordinarily restrictive tolerances, which are expected particularly in the field of fuel injection technology, can be obtained. The desired diameters of the holes typically reach down to $50\ \mu\text{m}$ at a material thickness up to 1 mm, resulting in aspect ratios of up to 20. Special hole geometries with defined tapering such as a negative conicity are frequently demanded for specific flow formation. The drilling process itself has high reproducibility, as well as high reliability and the drilling system is easy to handle.

Key features:

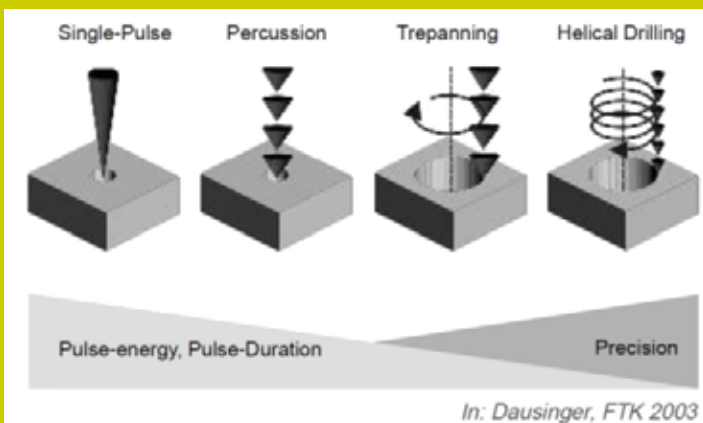
- high precision and stability in 24/7 production
- short installation time
- no influence on laser parameters (beam quality, pulse duration, polarization)

key component for the production of high precision holes:



Optical concept

Three specially designed wedges for systematic deflection of the laser beam are the main elements of the D+G Helical Drilling Optic. During the drilling process, all three wedges rotate around the optical axis of the incident laser beam. A variation of the distance between wedges 1 and 2, which are mounted in opposite orientation with respect to one another, generates a lateral offset of the beam on the focussing lens. This offset leads to a defined inclination angle at the workpiece's surface, providing large flexibility in selecting a taper angle. A rotation of wedge 3 relative to wedge 2 permits the setting of an angle of incidence of the laser beam on the focussing optic. This in turn causes a path diameter on the workpiece. The optical concept of the D+G Helical Drilling Optic is characterized by high accuracy and simple adjustment, compared to competing approaches. On the top of this, it offers the potential to increase process efficiency remarkably by drilling with an inclination angle, thereby exploiting the whole beam cross section for widening the hole.



Technical principle

A helical drilling process carried out by the D+G Helical Drilling Optic meets the desired requirements both from a quality and a geometry aspect. This optic uses a rotating system of optical wedges to lead the focus of the laser on the exact course predetermined by the drilling strategy.

Conventional trepanning cuts the desired hole out of the workpiece in a single roundtrip. Contrary to this, with the helical drilling process, the laser beam ablates the hole geometry, proceeding on a helical path into the depth of the workpiece.



Thus, trepanning is refined by splitting up the drilling procedure into many single steps. This technology produces highest precision morphologies. The D+G Helical Drilling Optic permits a path diameter from 0 to 400 μm as well as an adjustment of the beam inclination angle between 0 and 5° relative to surface normal of the workpiece. Due to this, laser drilling with well defined geometries can be achieved.

Control unit

The control unit of the D+G Helical Drilling Optic is based on the principle of allocating intelligent, autonomous drive units. The modularly designed system is rather easy to extend. Process parameters such as path diameter, path speed and inclination angle, as well as additional peripheric parameters, can be independently adjusted during the process. In fully automated operation, process sequences holding helical drilling and peripheric parameters as a function of time, can be recorded and recalled.

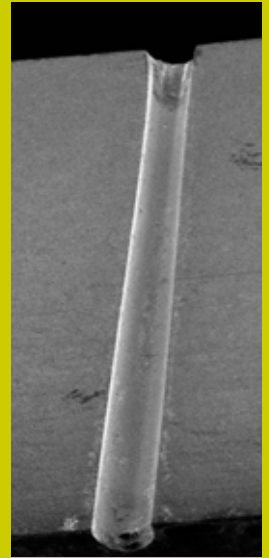
The interface to an external, superior control system is configurable and can either be implemented by conventional control signals or by industrial bus. A peripheric interface is available to control additional system technology, such as a beam attenuator. Periphery parameters can be included in process sequences and regulated through digital output. The control unit of the D+G Helical Drilling Optic can be supplied as an independent, enclosed unit in industry usable housing, as well as an integrated solution for customized systems.



Applications

Hole geometries with advanced complexity can be achieved in addition to cylindrical or conical holes with sharp edged entrances and exits. As independently controllable drive units enable the adjustment of the drilling diameter (on the fly) and the beam inclination angle, numerous process strategies are possible.

Holes of various diameters and undercuts can be produced in the workpiece without interrupting the manufacturing process. The amount of time required for shifting the drilling parameters is so short that parameter variations can even be performed within non-stop drilling. Hole geometries with bevelled edges, fillets of the aperture or Laval-like outlines can be reached by means of specific drilling strategies. The combination of process strategy (path diameter and inclination angle) and pulse energy (possibly pulse length) opens up completely new possibilities for efficient processes, whilst maintaining highest quality. For example, a hole can be prefabricated very quickly with high pulse energy. Afterwards, the resulting recast can be ablated with less pulse energy or pulse duration.



Accessories and Services

Wedge-Set: Different configurations (i.e. design wave length) are delivered pre-adjusted. They can be changed by our customers within a few minutes. **Focussing optic:** We offer a range of certified focussing optics for various wave lengths and focal lengths. Adjustable mounts are available. **Gas-flow nozzles and solutions for processing assurance** are available on request. **Processing development:** Based on our experience in laser drilling, we assist the processing development. Within our laboratory we can demonstrate and fabricate different processes.

Technical Specifications

Optomechanical Unit

Size	500 x 440 x 280 mm
Weight	40 kg
Beam height above table	138,5 mm
Wavelength	any (selectable between 0,18 μm - 2 μm)
Orientation for mounting	any
Maximum rotation frequency	3000 min-1
Max. time to change rotation frequency	3 s (1000 min-1/s)
Beam inclination angle 0 to 5° for f = 100 mm	continuously adjustable
Max. time to change inclination angle	1,5 s
Drilling diameter 0 to 400 μm for f = 100 mm	continuously adjustable
above 400 μm	on request
Max. time to change drilling diameter	1 s
Achievable drilling tolerance	$\pm 1 \mu\text{m}$ (reproducibility of path diameter)

Control Unit

Electrical power requirements	3-phase AC / 400 V / 50-60 Hz / 3,5 kVA / 25 A (max. pre-fusing)
Control unit housing	Industrial grade cabinet with integrated console (width / height / depth in mm: 600 / 760 / 350) Integration in existing machining stations and customized housing on request
Interface with opto-mechanical unit	System interconnection of customized length (max. 10 m)
User interface	Console with touch screen (LCD monochrome) Visible area 123 x 68 mm Dimension for mounting 210 x 158 mm
Interface to peripheric equipment	Digital output 24 V (max. 20 mA) Analog output 0 V to +10 V (max. 2 mA)
Interface to external control	Digital input 24 V (8 mA) Digital output 24 V (max. 20 mA) Profibus-DP optional



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