



## LASER-BEAM HELICAL DRILLING OF MICRO-HOLES WITH A HIGH ASPECT RATIO

### Task

Laser-beam helical drilling is a suitable technology for producing precision-shaped holes, but the achievable aspect ratio is limited to about 20:1 owing to beam propagation in the drilling channel. Several factors limit the aspect ratio of a precision drill hole with high roundness at the entrance and exit when drilled by ultrashort pulse (USP) laser radiation. In particular, the drilling technology or optics used are relevant as is the available maximum pulse energy of the USP laser radiation. The removal rate decreases sharply with increasing drilling depth due to the beam divergence and multiple reflections. Therefore, making high aspect ratio micro-holes in thick material poses a major challenge to manufacturing.

### Method

Using a helical drilling optics it developed, Fraunhofer ILT conducted studies on micro-holes with an ultrashort pulsed laser beam source and high pulse energy. The laser beam source has a wavelength of 532 nm, a pulse duration of 12 ps and a maximum single pulse energy of 650  $\mu\text{J}$ . The focus diameter is 25  $\mu\text{m}$ . The angle of incidence, position and rotational speed of the laser radiation are dynamically adjusted during the helical drilling process, whereby the degree of multiple reflections of the laser radiation and the temporal and spatial energy deposition in the drill hole can be adjusted selectively.

### Results

The large single-pulse energy results in high ablation rates. This way, a throughput time of less than 25 s was achieved for 3 mm thick steel. The aspect ratio is limited to about 50:1 by the diameter of the hole entry and exit of about 60  $\mu\text{m}$ . The roundness of entry and exit is  $> 0.92$ . The longitudinal section shows that holes can be drilled vertically to the material surface with an edge angle of almost  $90^\circ$  in the entry area. The roughness  $R_a$  at the borehole wall is less than 0.5  $\mu\text{m}$ .

### Applications

For example, high aspect ratio precision micro-holes in steel, glass, and ceramic can be used as spinning nozzles, injector nozzles, injectors, or vent holes. Increasingly, such precision holes will also be used in sensor and filter technology.

### Contact

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- 3 Drill hole entry with 60  $\mu\text{m}$  diameter.  
4 SEM image of longitudinal bore holes in 3 mm thick stainless steel.