



## PRECISE DEEP DRILL HOLES WITH ULTRAFAST LASERS

### Task

Deep drill holes with a high aspect ratio can be produced productively with long pulse lasers, but defects such as recast layers and cracks on the drill wall occur. Another drawback is that a certain fluctuation of the bore diameters cannot be avoided. Although ultrashort-pulsed (USP) laser radiation can be used to produce high-precision holes without defects, comparable drilling depths and aspect ratios have not yet been achieved, and productivity is also several orders of magnitude lower than with long pulse drilling.

### Method

By comprehensively investigating ablation behavior at high fluences and high average powers, research has laid the foundation for the development of deep drilling processes with USP laser radiation. In addition to these advances, Fraunhofer ILT has developed a new optical drilling system that makes it possible to drill significantly deeper and ablate at much higher rates. The institute has applied for a patent on this system.

### Results

Using the fundamental investigations, Fraunhofer ILT could identify a suitable range of process parameters and develop a design tool for the new optical drilling system. This tool is used to determine the required optical components and process parameters for a desired drill hole geometry. The tool can also be used to determine in advance which set of process parameters is most productive. With this so-called deep-drilling optical system, holes with a diameter of 200 to 1000  $\mu\text{m}$  can be drilled with an aspect ratio of up to 20 in materials such as metals or ceramics. In addition, this optical system can be used to create shapes at the hole entrance in the same process step before or after drilling.

### Applications

Precise, deep micro drill holes are needed in many high-technology applications, such as vent holes for tooling dies, cooling holes in gas turbines, or holes used as lubricant feeds for (forming) tools. In addition, many other drilling processes currently still using long pulse lasers can benefit from the increased precision and drill-hole quality provided by USP drilling.

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1 Machining of a turbine blade.

2 Longitudinal section of a sample drilled with USP laser radiation.