

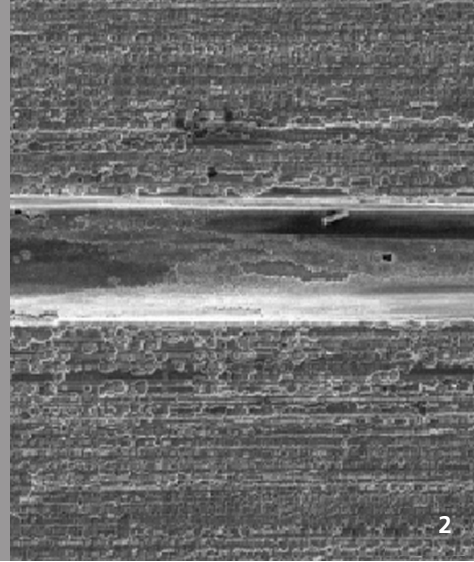
PRECISION HELICAL DRILLING WITH A HIGH ASPECT RATIO

Task

The industry faces a major challenge in manufacturing precision drill holes which have a diameter of approx. 100 μm and a high aspect ratio. While laser-beam helical drilling is a suitable technology for this question, the removal rate rapidly decreases with increasing drilling depth, and it may even cause plasma to build up in the drill hole. Moreover, in large drilling depths the hole geometry is not solely determined by the laser intensity distribution, but rather by a combination of many parameters, such as gas pressure, focal position, etc. To produce precision micro holes in thick material, therefore, the laser and process parameters have to be carefully matched to each other.

Method

Deep holes were drilled in 2 mm and 3 mm thick stainless steel with optics Fraunhofer ILT developed for helical drilling and a frequency-doubled ps laser with maximum single pulse energy of 150 μJ . By varying optical parameters such as incidence and offset of the laser beam and laser parameters such as focus position and pulse energy, the institute can precisely adjust the diameter and taper of the drill hole. The processing speed can be significantly increased by dynamically varying



the parameters and optimizing the drilling strategy. To examine the drill geometry and quality, the institute recorded the drill inlets and outlets and their cross sections by scanning electron microscopy.

Result

With the adjusted drilling precision, holes can be produced with a diameter of about 140 μm in 3 mm thick stainless steel. When the helical track and optimization were adapted to the drilling strategies, aspect ratios of more than 20:1 were achieved. Only minor melting deposits and heat-affected zones were detected at the inlet and outlet or on the wall of the hole. The roughness on the wall is $R_a < 2 \mu\text{m}$.

Applications

Precision holes with a high aspect ratio are currently used for spinnerets, injection nozzles and injectors. Increasingly, these kinds of holes are also being used in sensor technology.

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1 Hole cross sections in 3 mm thick stainless steel.

2 Hole wall of a deep drilling.