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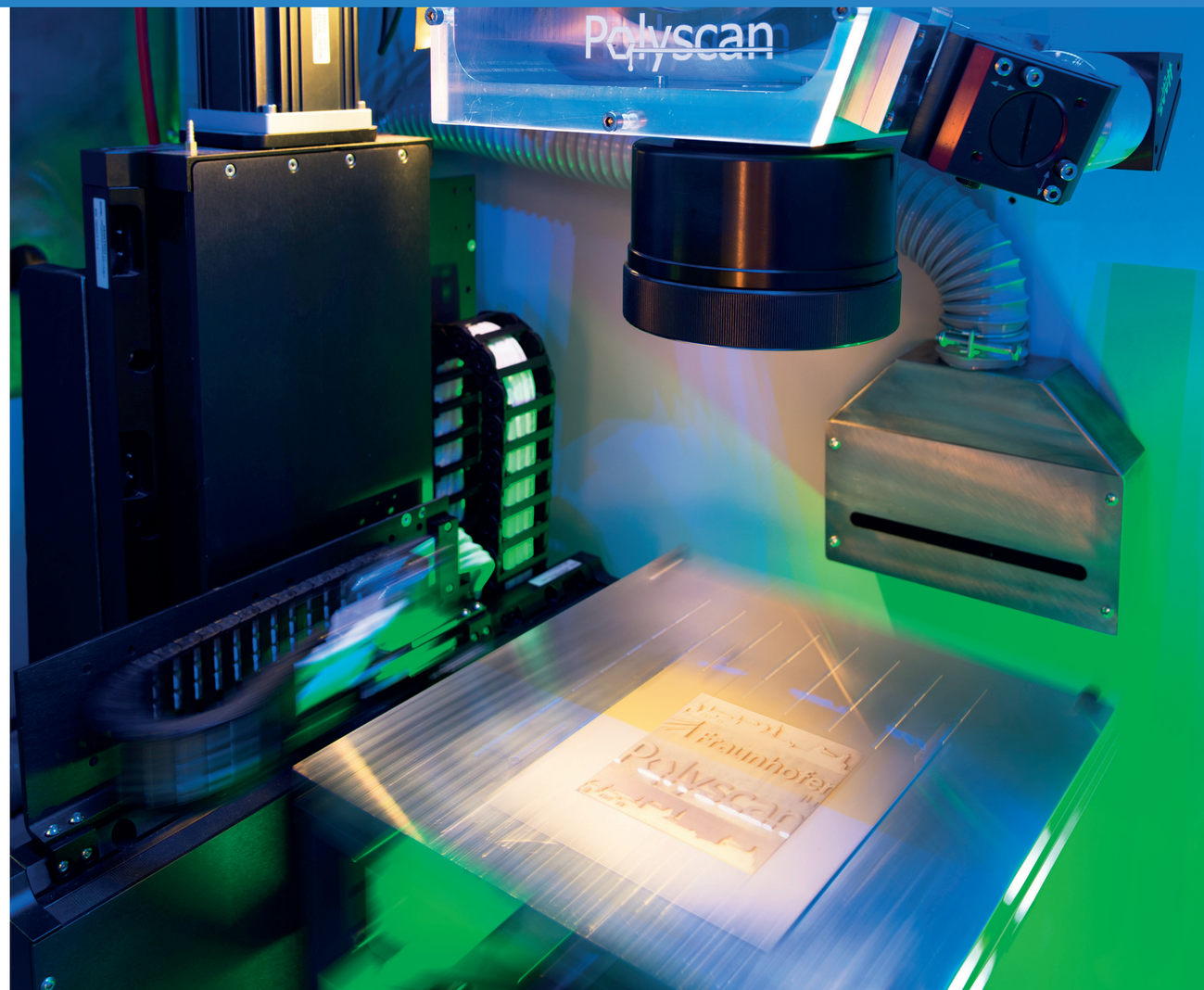
FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

POLYGON SCANNERS FOR LASER MATERIAL PROCESSING



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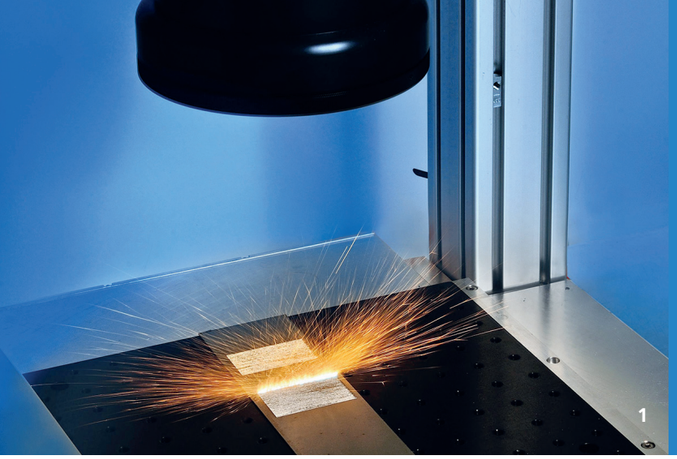
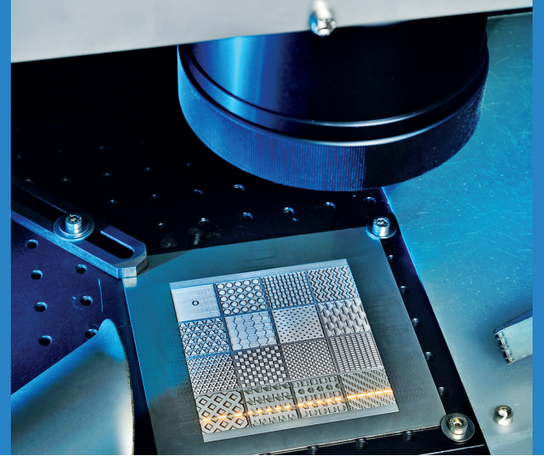
Fraunhofer Institute for Laser Technology ILT

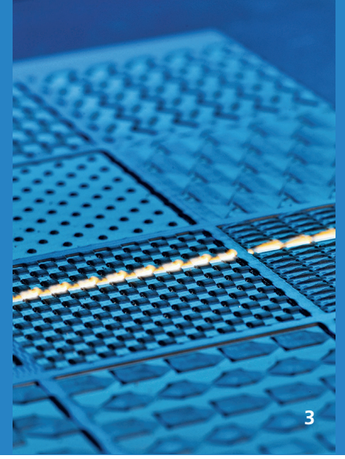
The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing technology and industrial laser processes. This includes laser cutting, ablation, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing. Furthermore, Fraunhofer ILT develops photonic components and beam sources for quantum technology.

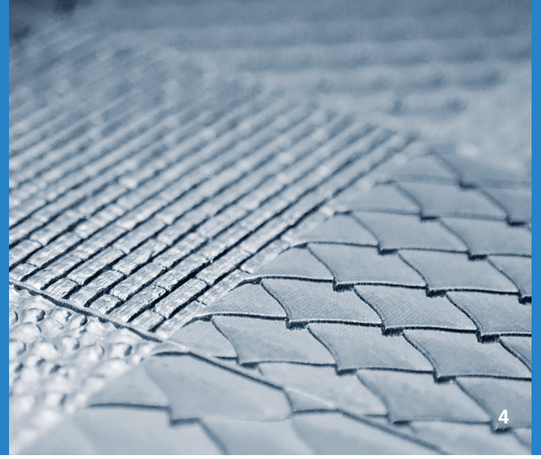
Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing lines. The institute focuses on research and development for industrial and societal challenges in the areas of health, safety, communication, production, mobility, energy and environment. Fraunhofer ILT is integrated into the Fraunhofer-Gesellschaft.

Subject to alterations in specifications and other technical information. 04/2019.









POLYGON SCANNERS FOR LASER MATERIAL PROCESSING

The Fraunhofer Institute for Laser Technology ILT develops application-specific, polygon-based laser scanner systems for surface treatment applications. Efficient laser ablation requires high average powers and high pulse repetition rates or high pulse energies. With polygon scanners, the available power of corresponding ultra-short pulse lasers can be utilized optimally, while the processed material does not over-heat. This enables an upscaling of the process to higher surface and volume ablation rates.

System Technology

In high-precision laser material processing, ultrashort pulse laser sources are used in order to minimize heat affected zones. So that the material does not overheat, however, system technology is required which distributes the required high-average power over the surface quickly. There are two possible approaches: increasing either the process parallelism, on the one hand, or its speed, on the other. Increasing the scanning speed requires low pulse energies and high repetition rates. At high repetition rates, the maximum speed of galvanometer scanners is not sufficient for the necessary pulse spacing, so that lasers have to be operated with reduced power.

The polygon mirror of a polygon scanner rotates at high and constant speed, thus increasing maximum scanning speed. This allows a low pulse overlap for optimum processing results and the utilization of full laser power. To achieve two-dimensional processing, the scanning line is shifted by moving the workpiece or by utilizing an additional galvanometer mirror. The pulse and position-accurate modulation of the laser beam is synchronized to the position of the polygon and the second axis.

Typical System Parameters

Wavelength	1030 nm to 1070 nm, 532 nm, 355 nm
Aperture	20 mm
Focal length	163 mm / 340 mm
Scan speed	360 m/s / 750 mm/s
Scan length	100 mm / 210 mm
Gating time resolution	12.5 ns / 1 µs
Gating jitter	25 ns / 5 µs

Depending on the control system and the scanning head configuration used, different spatial resolutions can be achieved. For example, at a scanning speed of 100 m/s and focal length of 163 mm, a resolution of up to ±3 µm is feasible with a hybrid scanner.

Applications

Polygon scanners can be used in the large-scale structuring or laser treatment of different materials with high-power ultrashort pulse lasers as well as cw lasers. Fraunhofer ILT develops polygon scanning systems for different applications based on both USP and cw lasers.

Hybrid Scanner for Large-Scale cw Applications

One of the developed systems utilizes a 2 kW fiber laser to create undercut grooves for large area plastic-to-metal joints in a continuous process. An additional galvanometer mirror is used to temporarily compensate for the constant feed of the workpiece and to set the desired number of passes at the exact line spacing. The industry standard control system features laser beam modulation with a time resolution of less than 1 µs; this way, process start and end can be set with high precision.

Polygon Scanner for USP Parallel Processing

Fraunhofer ILT designed a second system that uses USP processes for the dicing of semiconductor wafers. In addition to the fast deflection via the polygon scanner, the laser beam is split into three parallel lines with adjustable spacing. This allows the use of higher average power while avoiding disturbing heat influences. At higher scanning speeds, the timing accuracy of the industrial control is not sufficient, which is why the institute uses FPGA-based controllers (Field Programmable Gate Arrays) with time resolutions between 10 and 100 ns.

Polygon Scanner for Deep USP Engraving

For 2.5 dimensional structuring or deep engraving with high-power USP lasers, a third kind of polygon scanning system was developed. Here, the two-dimensional processing is achieved by shifting the workpiece with a high-precision linear axis. Thanks to the USP laser, this system can engrave deep textures at high ablation volume rates. Typically, the system uses pulse frequencies between 2 and 20 MHz and average output powers higher than 100 W for processing at scanning speeds above 100 m/s. In this process regime, material ablation rates greater than 10 mm^3/min for bitmap-based structuring at layer depths of 100 nm are no longer an issue.

Further Applications

Polygon scanning systems can alternatively be used for e.g. surface cleaning or for high-rate drilling. The existing system for high-speed processing with cw lasers could, for example, be used for the quasi-simultaneous soldering of solar cells. Depending on your application, we choose the best fitting scanning head and control or individually develop the perfect one for you.

Contact

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Cover: USP laser system for 2,5-dimensional structuring.

1 cw laser structuring for plastic-metal connections.

2 USP structuring of steel at 300 m/s.

3 Plasma of USP laser structuring of steel.

4 Steel sample structured by USP laser.

5 Principle demonstrator of a hybrid polygon scanner.