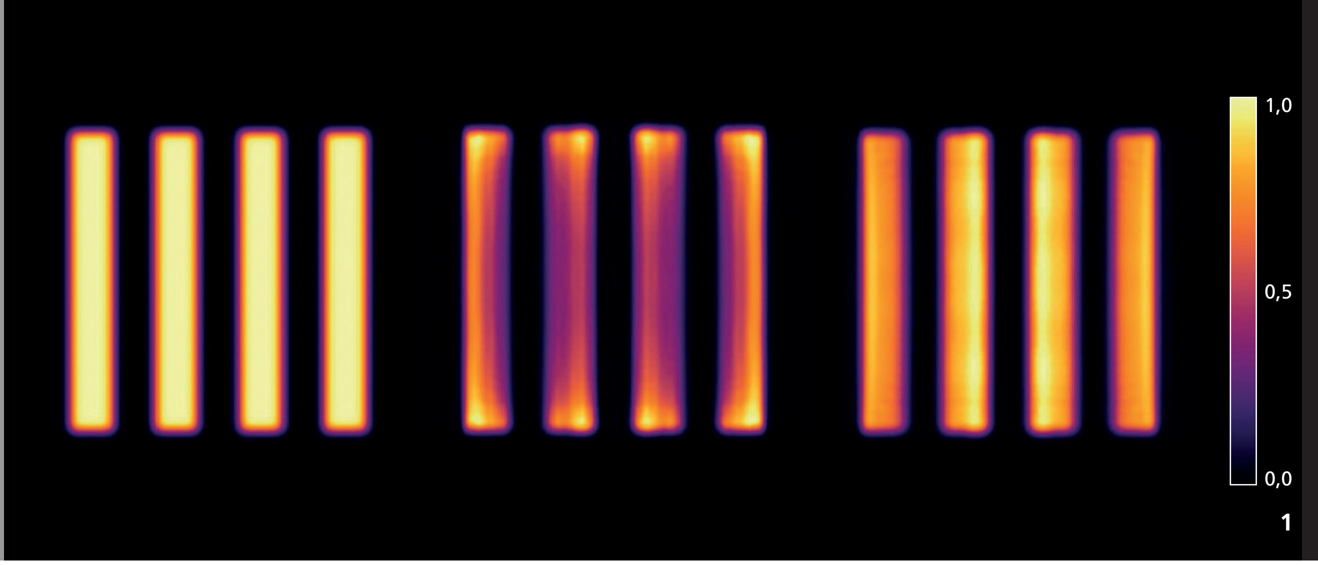

Subject to alterations in specifications and other technical information. 07/2021.

PROCESS-ADAPTED POWER-DENSITY DISTRIBUTIONS THROUGH DYNAMIC LASER-BEAM SHAPING AND AMPLIFICATION

Task

As an essential process parameter, the power density distribution (PDD) of the laser beam significantly influences the machining results of laser-based processes. In particular, process-adapted PDDs enable a distinct increase in machining speed and quality. However, changes in the process parameters or in the local geometry of the workpiece often require a dynamic adaptation of the PDD, e.g. in order to achieve constant machining results.

Method

In dynamic laser-beam shaping for laser materials processing, there is a trade-off between the required laser power and the required number of degrees of freedom. Dynamic beam-shaping elements such as Liquid Crystal on Silicon (LCoS) and Digital Micromirror Devices (DMD), each with a sufficiently high number of degrees of freedom (>> 100), have been limited to laser powers less than 200 W so far. To circumvent this trade-off, a laser beam can first be shaped at low laser powers and then amplified to the target power. However, nonlinear effects in optical amplifiers usually lead to a significant change of the PDD in the amplifier and in the target plane. By simulatively and/or metrologically accounting for these changes, Fraunhofer ILT – in cooperation with the Chair for Technology of Optical Systems (TOS) at RWTH Aachen University – has been able to iteratively adjust the PDD in the target plane until the target PPD is achieved. Moreover, influence of any number of other optical elements can also be taken into account and compensated for.

1 Examples of target PDD (left) and the PDD after passing through an ideal amplifier without (center) and with (right) compensation of nonlinear effects. All PDDs are normalized.

Results

The approach that scientists at ILT and TOS have developed accounts for nonlinear effects, thus enabling the industry to use modern, highly dynamic beam shaping elements for applications whose required laser power is far above the damage thresholds of these beam-shaping elements. The approach and the software tools it has developed can be applied to almost any amplifier geometry and optical system.

Applications

Now that highly dynamic laser-beam shaping is possible even at high laser powers (> 200 W), the institute has created the foundation for increasing productivity and/or quality of a variety of laser-based processes.

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