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## 4D MULTIBEAM OPTICAL SYSTEM FOR FLEXIBLE HIGH-POWER ULTRASHORT PULSE LASER MATERIAL PROCESSING

### Task

Thermal accumulation and plasma formation from high pulse energy limit the usable power of ultrashort pulsed laser beam sources in industrial applications and, thus, often prevent them from being used economically. Therefore, Fraunhofer ILT is investigating how a dot-matrix printer could serve as a model to solve these issues. Here, the laser power is divided into 8x8 beams, with each beam shaped by a few optical elements, thus enabling each individual beam to be switched on and off temporally.

### Method

The raw beam of an ultra-short pulsed high power laser beam source is split into a symmetric 8x8 beam matrix by a diffractive optical element. A prism stack composed of several prisms joined to form a component parallelizes the individual beams emerging at discrete angles, which are then coupled column-wise (1x8) into eight acousto-optical modulators. These switch each partial beam on or off individually by deflection. All switched-on beams are deflected and expanded by a combination of a second prism stack and a telescope, a combination that makes it possible to adjust the spot distance and the spot diameter on the workpiece. Individual lenses,

or stacks of eight lens strips identical in their optical characteristics bonded into a single component, form all the beams simultaneously, which reduces complexity and cost. The spot matrix is finally positioned and focused on the workpiece using a galvanometer scanner and a plane-field lens.

### Results

The novel approach based on prism and lens stacks makes it possible to fabricate compact and modular multi-beam optical systems. These scalable 4D systems overcome the limitations of common relay optical systems and fully compensate for spot matrix distortion caused by the scanner for the undeflected position. In addition to beam shaping in three dimensions, the individual temporal modulation of each partial beam enables users to structure components in any manner desired.

### Applications

The main field of application is in the manufacture of functional surface structures for industry, medicine and aviation, as well as for molding, embossing and printing tools.

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2 *Designed optical system.*