

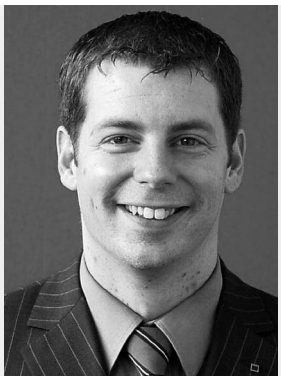

Dr. Dirk Sutter (left)
Dr. Jochen Kleinbauer (middle)
Dr. Sascha Weiler (right)

TRUMPF Laser GmbH + Co. KG,
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Ultrafast Laser for Efficient Industrial Micromachining

The industrial implementation of cold laser ablation, cutting, and drilling by use of ultrashort pulses has been a vision for more than 20 years. Early experiments with Ti:sapphire amplifiers as the paradigm of ultrafast technology during the last decades have demonstrated the huge potential of picosecond and femtosecond laser pulses for precision machining. Unfortunately these lasers cannot be directly diode-pumped, and with only a few scientific exceptions their average power is limited to a few watts at most, resulting in uneconomical processing speeds, in particular for micromachining applications. In addition, chirped-pulse amplification (CPA) as the standard, yet complex approach to achieving high pulse intensities still lacks suitability for operation in harsh industrial environments.

Within the past few years Dr. Dirk Sutter and his team colleagues have pioneered an alternative, directly diode-pumped technology by successfully scaling the average power of few-picosecond thin-disk regenerative amplifiers with no need to employ CPA. At TRUMPF Laser they conducted the original research project, performed with partial government-funding and in close collaboration with scientific and industrial partners, focussing not only on the laser itself but also on its applications. Based on their fundamental results, they transferred the concept through product development, resulting in TRUMPF's very first ultrafast product family, the TruMicro 5000 series.

An intrinsic property of thin-disk laser technology is its natural power scalability, owing to the outstanding cooling quality of the laser medium by heat removal from a thin volume over a large surface area. Thin-disk lasers differ from fibre lasers, which also exhibit excellent thermal properties, in terms of the achievable peak powers. This fact stems from the much larger laser beam diameter at the disk compared to thin fibre cores, decisively lowering the optical intensity, in combination with the much shorter material path inside the medium, reducing the nonlinear interaction length. This dominant advantage is the key to picosecond amplification without CPA. Thus, thin-disk lasers are predestined to ultrafast peak power technology. The specified parameters of the TruMicro 5050, with an average power of 50 W in the infrared, and the TruMicro 5250, with 25 W in the green, are currently unique and shall be scaled further in the future.

Specific applications range from precision drilling of metals, e.g. fuel injection nozzles that allow for a cleaner and more efficient combustion in automobiles, over machining of silicon and thin-film solar cells, to medical applications such as stent cutting. All these applications benefit from the actual world record average power, while exploiting that no post-processing is required to achieve unprecedented precision at highly productive speed. With great dedication Drs. Kleinbauer, Weiler, and Sutter pushed this innovation to what may well mean nothing less than the real commercial break through of ultrafast lasers in material processing.

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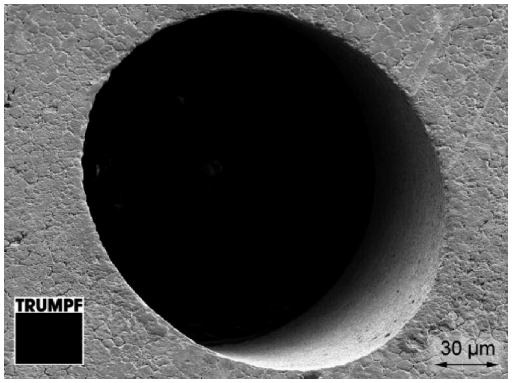
Area of Application
Industrial Micromachining

Technological Impact
- New ultrafast laser source
- Reduced process costs for users
- Improved quality assurance by eliminating need for post processing by cold laser-matter interaction



Left: Laser head of the TruMicro 5000 product series.
Right: Cylindrical hole drilled with the TruMicro 5050 in stainless steel under an angle with respect to the surface. The sharp edge shows no signature of heat deposition: neither burrs nor any change of the material structure is visible. No post-processing was used. The conicity of the hole can be precisely controlled with helical drilling optics.
(Photos: TRUMPF Laser GmbH + Co.KG, Schramberg)