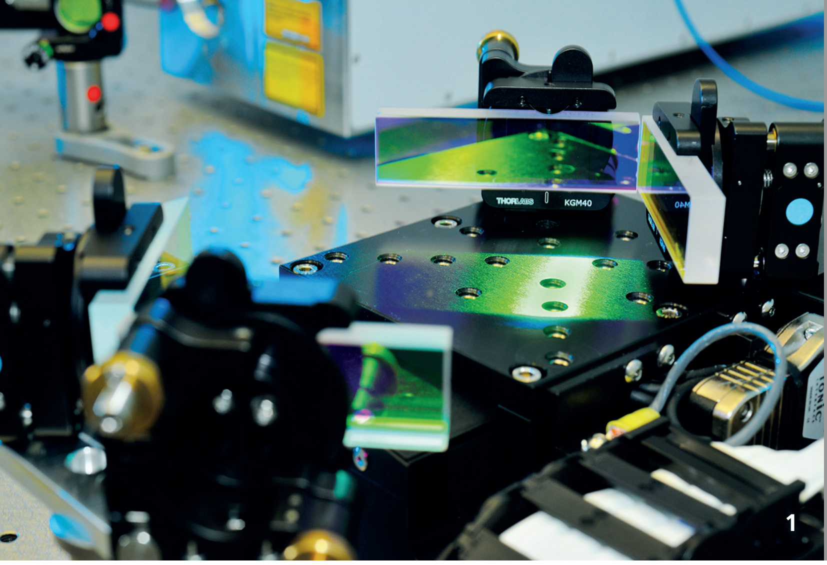

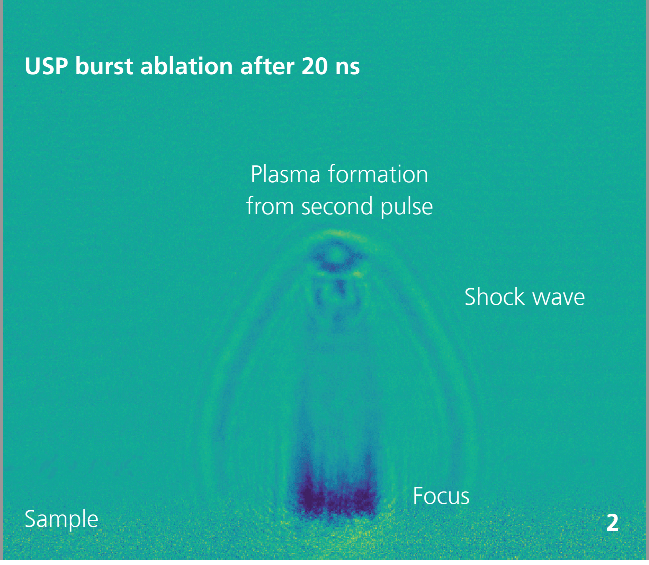

Subject to alterations in specifications and other technical information. 07/2021.

IN-SITU ANALYSIS OF LASER MACHINING PROCESSES USING PUMP-PROBE MICROSCOPY

Task

Although machining processes using ultrashort pulsed (USP) laser radiation provide high quality results, their productivity is still currently low compared to conventional processes. To increase productivity using high-power beam sources, research is using approaches based on high pulse-repetition rates for faster beam deflection, pulse bursts and multi-beams for parallel processing. Furthermore, scaled material processing can yield additional accumulation and shielding effects, as well as altered absorption. Understanding these effects is essential to control energy deposition in the workpiece. Pump-probe microscopy makes it possible to analyze and observe these excitation, shielding and accumulation effects during the process.

Method

A pump-probe system with high repetition rates and burst configuration has been developed to observe accumulation effects. The sample pulse is used for shadow photography of the modification generated by the pump pulse. The USP beam sources, which were specially developed by project partner TRUMPF GmbH & Co. KG, enable shadowgraphs to be made over a particularly long observation period. A microscanner from the project partner LightFab GmbH is used for rapid beam deflection.

1 Highly repetitive pump-probe system (processing station).

2 In-situ analysis of multispots.

Results

With the system implemented at Fraunhofer ILT, the institute was able to analyze shielding effects between burst pulses on material surfaces with a time resolution of 300 fs. In addition, it could investigate nonlinear absorption effects in the volume of transparent materials. The system is particularly suitable for analyzing pulse-to-pulse interactions for almost any spatially shaped beam distributions. Thus, a wide variety of tailored USP ablation processes can be depicted and analyzed in-situ.

Applications

The system offers high-resolution spatial and temporal process diagnostics for highly repetitive USP processes on surfaces of almost all materials and, moreover, in the volume of transparent materials. Applications range from large-scale de-coating processes for the glass industry, to scaling for the fabrication of microfluidics for medical technology, all the way to the creation of minute geometries for the semiconductor industry, or devices for quantum technology end-use applications.

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Contact

Martin Kratz M. Sc., Ext: -581
martin.kratz@llt.rwth-aachen.de

Dr. Arnold Gillner, Ext: -148
arnold.gillner@ilt.fraunhofer.de