K 6: Laser Applications I

Zeit: Mittwoch 11:00–13:00 Raum: HS 3

K 6.1 Mi 11:00 HS 3

Global modelling of the ns-laser shock peening — •Vasily Pozdnyakov[1], Soeren Keller[2], Benjamin Klusemann[1,2], Nikolai Kashaev[2], and Jens Oberrath[1] — [1]Institute of Product and Process Innovation, Leuphana University Lüneburg, Germany — [2]Helmholtz Centre Geesthacht, Institute of Materials Research, Materials Mechanics, Department of Joining and Assessment, Germany

Laser shock peening (LSP) is one of the industry applicable surface modification techniques to improve mechanical properties of the metals and alloys. It is a potential substitute of the conventional methods, e.g. shot peening. LSP deals with laser pulses with high intensity (> 1 GW/cm2) and short duration (ns-range). The promising method of the process prediction and optimization is a simulation, due to the great development of the computational techniques, low operational costs and good flexibility. It allows predicting the plasma and shock wave behavior, as well as residual stress (RS) distribution within the processing material.

In our research, a global model of Zhang et al. [1] is applied for macroscale LSP (mm-range). The plasma pressure temporal distributions are determined and used for the finite element simulation to predict the residual stress distribution within the material [2]. Predicted RS shows a good agreement with the experimental results.

[1] W. Zhang, Y.L. Yao, I.C. Noyan, J. Manuf. Sci. E. - T. ASME 126, 10 (2004)

[2] S. Keller, S. Chupakhin, P. Staron, E. Maawad, N. Kashaev, B. Klusemann, J. Mater. Process. Technol. 255, 294-307 (2018)

K 6.2 Mi 11:20 HS 3

Three-dimensional direct laser written achromatic axicons and multi-component microlenses with multiple materials — •Michael Schmid[1], Simon Thiele[2], Alois Herkommer[2], and Harald Giessen[1] — [1]4th Physics Institute, University of Stuttgart — [2]Institute of Applied Optics, University of Stuttgart

Femtosecond 3D printing is an important technology for manufacturing of nano- and microscopic optical devices and elements. In the past, most structures have been created using only one photoresist at a time limiting performance and possible applications. We successfully combine two different photoresists (IP-S and IP-Dip) to realize multi-component three-dimensional direct laser written optics. Combining IP-S and IP-Dip we can correct chromatic aberrations and realize an achromatic axicon. In a second step we create the first three-dimensional direct laser written Fraunhofer doublet. We also characterize their optical properties and show the reduction of chromatic aberrations, proving the possibility and benefit of three-dimensional direct laser written multi-material and multi-component structures for micro-optics.

K 6.3 Mi 11:40 HS 3

Millimeter-sized 3D printed high-quality complex optical elements — •Simon Ristok[1], Simon Thiele[2], Andrea Toulouse[2], Alois Herkommer[2], and Harald Giessen[1] — [1]University of Stuttgart, 4th Physisc Institute — [2]University of Stuttgart, Institute of Applied Optics

Complex three dimensional structures on the micrometer scale can be fabricated by focusing a femtosecond laser at 780 nm into a UV sensitive photoresist. The photoresist is polymerized via two-photon absorption at 390 nm in a small volume element around the laser focus, resulting in sub-micrometer resolution. By moving the focus through the photoresist arbitrary complex optical elements can be produced [1,2].

Particularly the high resolution renders this direct laser writing technique suitable for the fabrication of high quality optical elements on the micrometer scale. However, if larger structures are required, challenges like prolonged fabrication time, increasing absorption inside the photoresist, and increased surface roughness arise. In this work we focus on how to overcome these challenges in order to increase the size of our structures to over 2 mm without stitching, narrowing the size gap between conventionally manufactured and 3D printed optical elements.

[1] T. Gissibl et al., Two-photon direct laser writing of ultracompact multi-lens objectives, Nature Photonics 10, 554 (2016).

[2] T. Gissibl et al., Sub-micrometer accurate free-form optics by three-dimensional printing on single-mode fibres, Nature Communications 7, 11763 (2016).

K 6.4 Mi 12:00 HS 3

High Index Materials for Femtosecond 3D Printing of Complex Micro-Optics — •Ksenia Weber[1], Peter König[2], Simon Thiele[3], Alois Herkommer[3], Peter William de Oliveira[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Stuttgart — [2]INM-Leibniz Institut für Neue Materialien, Saarbrücken, Germany — [3]Institute for Applied Optics and Research Center SCoPE, University of Stuttgart, Stuttgart

Femtosecond 3D printing is a powerful, state-of-the-art technology that allows for the fabrication of high quality micro- and nano-optical devices with sub-micrometer resolution. Since it is an additive process, it enables the fabrication of complex shapes which are difficult or impossible to create with traditional manufacturing methods. However, photopolymer materials used in femtosecond 3D printing typically exhibit very similar optical properties, with refractive indices mostly limited to values around 1.5. This severely reduces the design freedom in micro-optics compared to macroscopic optics where a vast range of different optical materials is available. Here we present a variety of novel 3D printable materials with refractive indices up to 1.66 and varying Abbe numbers. We demonstrate that these materials are suitable for the fabrication of high performance complex micro-optical components like high NA diffractive optical elements or multi-material devices like achromatic doublet lenses.

K 6.5 Mi 12:20 HS 3

Self assembly laser-induced nanostructuring of dielectric surfaces A review — •P. Lorenz[1], M. Klöppel[2], J. Zajadazc[1], I. Zagoranskiy[1], M. Ehrhardt[1], K. Zimmer[1], B. Hopp[3], and H. Bing[4] — [1]Leibniz-Institut für Oberflächenmodifizierung, Germany — [2]Fraunhofer-Institut für Verkehrs- und Infrastruktursysteme IVI, Germany — [3]Department of Optics and Quantum Electronics, University of Szeged, Hungary — [4]Advanced Launching Co-innovation Center, Nanjing University of Science and Technology, China

Nanostructured surfaces exhibit an increased interest for industrial. The usages of laser processes which utilize self-organization processes allow a fast, flexible and large-scale structuring. The IPSM-LIFE (Laser Induced front Side Etching using in-situ prestructured metal layer) allows nanostructuring of dielectric surfaces and metal layer supported by a self-organizing melt-forming process of the metal layer. At the IPSM-LIFE, a metal layer on a surface was irradiated, the first laser treatment results in a melting of the metal layer and the surface tension tends to a nanostructuring of the metal surface. The second laser treatment, the laser treatment of the pre-structured metal layer result in an evaporation of the metal layer and partial of the dielectric surface and finally in a nanostructuring of the surface. The resultant metal layer and the dielectric surface structures are dependent on the metal layer as well as laser parameter. The method allows the production of randomly distributed and periodically arranged structures with a minimum lateral size of up to 10nm and an achievable pattern depth of up to 1μm with an achievable aspect ratio of 2.

K 6.6 Mi 12:40 HS 3

Verwendung einer neuartigen Ultrakurzpuls-Strahlquelle für die Iridotomie — •Michael Körber[1], Bernd Braun[1], Hagen Kohl[1,2], Daniel Kopf[2] und Manfred Kottcke[1] — [1]Technische Hochschule Nürnberg Georg Simon Ohm, Nürnberg, Deutschland — [2]Montfort Laser GmbH, Götzis, Österreich

Die Laser-Iridotomie hat sich als augenmedizinische Behandlung des Engwinkelglaukoms bewährt. Die derzeit verwendeten gütegeschalteten Nd:YAG Laserquellen erfordern zur Überschreitung einer kritischen Intensitätsschwelle jedoch relativ hohe Pulsenergien von einigen 10 mJ, die zur Photodisruption des bestrahlten Gewebes führen.

In dieser Präsentation wird über die Anwendung einer neuartigen 10 ps Ultrakurzpuls-Strahlquelle berichtet. Durch die Bestrahlung mit ultrakurzen Pulsen soll das Regime des kalten Materialabtrags erreicht werden. Dabei werden die für die direkte Sublimation erforderlichen Pulsspitzenintensitäten schon bei geringen Pulsenergiedichten erreicht, die thermische Schädigung des Gewebes also minimiert. Der Laser besteht aus einem ultrakompakten gütegeschalteten Nd:YAG-Laser, spektraler Verbreiterung in einer Faser und anschließender Dispersionskompensation zur Pulsverkürzung. Die Pulsenergie beträgt ca. 20 μJ bei einer Repetitionsrate von 8 kHz. Zur Charakterisierung der Bearbeitungsergebnisse am Schweineauge wird optische und Rasterelektronenmikroskopie eingesetzt. Zum Vergleich wurden Versuche mit einem 20 W gütegeschalteten ns-Faserlaser durchgeführt, um Unterschiede und Verbesserungen zu evaluieren.