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Editorial

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Laser micro- and nano-material processing – Part 1

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This special issue of *Advanced Optical Technologies* (AOT) is dedicated to the field of laser-based micro- and nanostructuring methods. Due to the unique characteristics of pulsed laser systems, among them ultrafast sources with picosecond and femtosecond pulse durations, today we are experiencing an explosion of new technological developments that will open new perspectives for industrial applications in the near future. This becomes possible due to a continuous reduction of the cost of the laser sources as well as the outstanding improvement of the power stability, increased pulse repetition frequencies, as well as the simplicity of the new laser sources.

However, although these developments are necessary for boosting the availability of lasers in modern industrial manufacturing, they will not alone define the industrialization of laser-based applications. In this context, additional efforts are still necessary for understanding how specific surface functionalities on different materials can be created or even improved by developing specific textured surfaces as well as how to produce these topographies at high-throughput by the full utilization of the laser performance.

Our list of contributors for this issue reflects a leading-edge mix of experts in these areas, from all around the world. The special issue is published in two parts.

Part 1 of the special issue *Laser Micro- and Nano-Material Processing* contains three review articles and four more original research articles that are briefly summarized here:

Gräf discusses in a review article the fundamentals, properties and applications of laser-induced periodic surfaces structures (LIPSS). The article reveals the physical background of LIPSS on different kinds of materials and provides a description of relevant applications including structural colors in surfaces, wetting states or the modification of tribological properties. Short comments on future developments and perspectives related to forthcoming applications of LIPSS-based surfaces are also discussed.

The review article by Nivas et al. provides new ideas about the direct fabrication of complex surface patterns on silicon using femtosecond laser radiation in an optical setup that permits obtaining light beams with different spatial intensity distributions using q-plate beam converters. Within the novel developed surfaces, the authors present simpler azimuthal, radial and spiral shapes as well as very complex textures in which nanosized LIPSS and micro-scaled grooves are found following the local state of linear polarization manifested in the complex light beams.

Klein-Wiele et al. present a review article on diffractive beam management-based fabrication techniques of repetitive surface structures on various materials using ultrashort ultraviolet laser radiation. This is conducted by overlapping two or more coherent laser beams and thus creating interference patterns. The generation of the interfering beams is accomplished by diffractive optical elements like gratings, grating systems or computer generated holograms.

Alamri et al. report on the fabrication of repetitive structures using direct laser interference patterning (DLIP). In this case, they evaluate the processability of glass material by using an interference optical configuration using nanosecond-pulsed lasers with infrared radiation. The reported technology is based on irradiating a metallic absorber which is put in direct contact with the glass sample and locally inducing an etching process on the backside of the glass. Different topographic geometries are presented including like and dot-like structures obtained by the superposition of two and four laser beams, respectively.

Batal et al. employ two different fs-laser surface texturing strategies based on defocusing or sample tilt for

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the manufacturing of sub-micrometric LIPSS on polished cobalt-chromium-molybdenum alloy substrates with two different surface finishes. The LIPSS-functionalized surfaces are qualified regarding their wettability with water as the cornerstone for the proliferation tests with Saos-2 osteoblast cells. It is found that – compared to the non-irradiated surfaces – the LIPSS decrease the surface wettability featuring increased static water contact angles, while simultaneously enhancing the cell proliferation. Differences between the two processing strategies are identified.

Hu et al. describe a laser-based surface functionalization that allows improving spectroscopic analyses via surface enhanced Raman scattering (SERS), for example, for applications in food safety, eco-pollution, and bioscience. This is achieved via fs-laser processing of polytetrafluoroethylene surfaces to generate excellent superhydrophobicity. For trapping and localization of analyte droplets, tiny square-shaped areas of the surface remained unprocessed as "trapping areas". In combination with evaporation concentration of the analyte, for example, rhodamine 6G molecules with a concentration of 10^{-6} M it is demonstrated that the corresponding spectroscopic peak intensity detected in SERS can be enhanced by up to two orders of magnitude on the laser fabricated samples compared with that of the unprocessed reference.

Holder et al. address the technical problem that additively manufactured parts typically deviate from the targeted net shape and often exhibit a large surface roughness due to the intrinsic size of the powder grains. The authors combined advanced surface inspection via optical coherence tomography with a closed-loop controlled ablation by ultrashort laser pulses to post-process laser powder bed fusion manufactured aluminum parts. Through this joint approach, the surface roughness and the deviation of the workpiece from the targeted net shape geometry can both be reduced by more than 60%.

We would like to thank all authors for their contributions to this special issue, reporting on new insights in this fascinating topic that significantly increase the capabilities in manufacturing technology. We would like also to acknowledge AOT for coordinating and guiding this special issue as well as reviewers for their fruitful comments, which permitted improving the quality of the presented articles. We hope you will enjoy reading the articles in this special issue as much as we have enjoyed putting them together.

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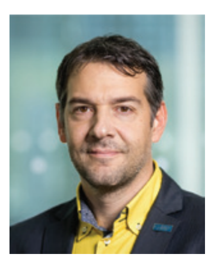
Jörn Bonse received a diploma degree in Physics from the University of Hannover, Germany, in 1996 and a Doctoral degree in Physics from the Technical University of Berlin, Germany, in 2001. He has occupied various research positions at institutions such as the Max-Born-Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI) in Berlin, the Spanish National Research Council (CSIC) in Madrid (Spain), and the Laser Zentrum Hannover (LZH) in Hannover, and was appointed as a Senior Laser Application Specialist at Newport's Spectra-Physics Lasers Division in Stahnsdorf, Germany. Currently, he is a Senior Scientist at the Federal Institute for Materials Research and Testing (BAM) in Berlin, Germany. His research interests include the fundamentals and applications of laser–matter interaction, especially with respect to ultrashort laser pulses, laser-induced periodic nanostructures, time-resolved optical techniques, laser processes in photovoltaics, and laser-related safety aspects. In 1999 he was a recipient of an award for applied research, presented by the federal German state of Thuringia, for the development of high-power fiber lasers. Dr. Bonse received a "2013 OSA Outstanding Reviewer Award" of the Optical Society of America (OSA) and served between 2014 and 2017 as an Associate Editor for the OSA journal *Optics Express*. He has authored more than 130 refereed journal publications and two patents related to his research activities.



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