Editorial

Koji Sugioka* and Stefan Kaierle*

Optics for material processing

DOI 10.1515/aot-2016-0009

Since the invention of the laser in 1960, material processing has been one of major applications of lasers, and the use of lasers in material processing is still a rapidly growing area of research and development. The main driving force behind this situation is that the lasers can offer distinct features in material processing of high quality, high efficiency, high flexibility, high resolution, versatility, low environmental load, and so on. Thus, laser material processing is currently used widely from fundamental research to industrial applications. Furthermore, recent advances in ultrafast lasers, which is a generic term for picosecond and femtosecond lasers, have opened a new door to laser material processing in terms of the capabilities in ultrahigh-precision micro- and nanofabrication of opaque and transparent materials, three-dimensional (3D) and volume processing.

Controlling the schemes of focusing, patterning, or scanning of laser beams as well as the laser beam parameters including laser power (or pulse energy), repetition rate, irradiation times, and polarization is of importance for enhancing the performance of laser material processing. To this end, many efforts for manipulating the laser beams using specific optics have been made by many groups. Thus, we have decided to publish this special issue, consisting of three review articles and five research articles, to review the current trends and novel schemes of optics for high-performance material processing. Outlines of each article are briefly described below.

The review paper titled 'Near-field optics for nano processing' by Mitsuhiro Terakawa et al. provides recent progress on precise nanofabrication beyond the diffraction limit of focused laser beams using near-field enhanced by small structures. Both the theoretical approach and experimental results are discussed, followed by demonstration of the nano patterning and the application to biological field. Near-field laser nano processing opens new avenues not only for material removal or nanohole processing, but also for versatile manufacturing, fabrication, and stimulation techniques.

The review paper titled 'Interfering laser processing' by Yoshiki Nakata introduces direct pattering of 2D and 3D microstructures by laser interference. The interference patterns can be created by splitting a coherent laser beam into multiple beams and then correlating them. Various laser beam correlations are characterized. The interference patterns controlled by the beam number, phase shift, and amplitude variation in each beam enable fabrication of diversity of lattice units in a single step. Versatility of interfering laser processing will offer many applications in many scientific and practical fields.

The review paper titled 'Holographic femtosecond laser manipulation for advanced material processing' by Satoshi Hasegawa et al. presents enhancement of performance of femtosecond laser processing in terms of high throughput and high energy-use efficiency by holographic femtosecond laser manipulation, in other words, parallel femtosecond laser processing. The holographic femtosecond laser manipulation can be performed typically using a computer-generated hologram displayed on a spatial light modulator. This beam manipulation technique offers great advantages for large-area machining and high-speed fabrication in material processing including cutting, drilling, micromachining, nanostructuring, 3D and volume processing, etc.

In the research article titled 'Theoretical and experimental analysis of scan angle depending pulse front tilt in optical systems for laser scanners' by Lasse Büsing et al., the authors describe how dispersion in optical systems for laser scanners may lead to scan angle-depending pulse properties and propose solutions to overcome this issue.

The research article titled 'Transient beam oscillation with a highly dynamic scanner for laser beam fusion cutting' by Cindy Goppold et al. lines out promising investigation results and procedural possibilities for improvements of the cutting performance in the case of fiber laser fusion cutting of thick stainless steel by means of the application of a highly dynamic scanner.

***Corresponding authors: Koji Sugioka,** RIKEN Center for Advanced Photonics, Wako, Saitama, Japan; and **Stefan Kaierle,** Laser Zentrum Hannover, Hollerithallee 8, 30419 Hannover, Germany,
e-mail: ksugioka@riken.jp (Koji Sugioka);
s.kaierle@lzh.de (Stefan Kaierle)

www.degruyter.com/aot

The research article titled 'Adaptive optical beam shaping for compensating projection induced focus deformation' by Oliver Pütsch et al. describes how an additional beam-shaping device, which is integrated between the laser source and the scanner, allows for an *in situ* compensation to ensure a field invariant circular focus spot within the interaction zone. This way, scanner-based laser processing can be improved significantly.

The research article titled 'Formation of in-volume nanogratings in glass induced by spatiotemporally focused femtosecond laser pulses' by Zhaohui Wang et al. describes evolutions of nanograting formation inside porous glass by irradiation of linearly polarized femtosecond laser beams. They employ both conventionally and spatiotemporally focused femtosecond laser pulses to compare the structures formed by each pulse and reveal that the spatiotemporally focused beam achieves higher axial resolution, which will benefit the applications to fabrication of nanooptics and nanofluidics.

The research article titled 'Direct generation of superhydrophobic microstructures in metals by UV laser sources in the nanosecond regime' by Jose L. Ocana et al. illustrates how the application of laser sources with emission in the UV and at ns time regime is used to structure surfaces. The surface structuration of metal surfaces (specifically Al) with regard to the modification of their wettability properties is described as an application basic for the generation of self-cleaning properties of extended functional surfaces.

It is clearly a challenge to comprehensively cover the advances in optics for material processing in a single special issue, and some other important techniques are definitely missing as many researchers are very actively working in this field. Nevertheless, we believe that this special issue offers useful information on recent trends of optics for material processing to readers of *Advanced Optical Technologies*. The last but not the least, we would like to thank all the contributors of the articles for their great efforts and kind cooperation in publishing this special issue.

Koji Sugioka and Stefan Kaierle,
Guest Editors

Koji Sugioka
RIKEN Center for Advanced Photonics, Wako
Saitama, Japan
ksugioka@riken.jp

Koji Sugioka received his BS, Ms Eng, and Dr. Eng degrees in Electronics from Waseda University (Japan) in 1984, 1986, 1993, respectively. He Joined RIKEN in 1986 and is currently a Unit Leader of RIKEN-SIOM Joint Research Unit at RIKEN Center for Advanced Photonics. He is also a guest professor at Tokyo University of Science since 2006 and Tokyo Denki University since 2004. His current research interests include ultrafast laser processing for microfluidic, optofluidic, microelectronic, and optoelectronic applications. He is currently a member of the board of directors of the Laser Institute of America (LIA) and Japanese Laser Processing Society (JLPS), and the SPIE, OSA, and IAPLE Fellow. He served as a chair, co-chair, and committee member of numerous international conferences related to lasers and laser applications. In particular, he is known as one of the founders of International Symposium on Laser Precision Microfabrication (LPM). He is also the editor-in-chief of Journal of the Laser Micro/Nanoengineering (JLMN).

Stefan Kaierle
Laser Zentrum Hannover, Hollerithallee 8
30419 Hannover, Germany
s.kaierle@lzh.de

Stefan Kaierle studied Electrical Engineering and went on to do his PhD in Mechanical Engineering at RWTH Aachen University. In 1998, he entered Fraunhofer ILT as a department head for system technology. He published more than 150 scientific papers in journals and conferences and holds more than 10 patents. He had been appointed to two guest professorships at Changchun University (in 2005) and at Beijing University of Technology (in 2007), China. In 2012, he moved to Laser Zentrum Hannover (LZH) and assumed responsibility for the department of Materials and Processes. Stefan Kaierle has been the President of the European Laser Institute (ELI) for 10 years (2003–2013) and is now a member of the Board of Directors of the Laser Institute of America (LIA). He has been chairman and board member of many international conferences. His academic achievements have been honored by the Laser Institute of America (Fellow), the European Laser Institute (Fellow), and the CIOMP (Honorary Professor).