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Editorial

Optics for laser material processing

Laser material processing has become a mature technology, as one may learn from the VIEWS article ‘Laser materials processing market reaches record high’ by Arnold Mayer. We have chosen this market review as an introduction as it shows the importance of the topic: lasers for industrial applications are no longer tools for technology pioneers or other enthusiasts; the technology is now accepted and competes with a number of traditional systems. Laser technology arrived in markets such as welding, cutting, and marking and, therefore, has to fulfill several conditions:

- Reliability: laser systems and, in particular, key components such as beam shaping and deflecting optics have to maintain their function 24/7 in production environments for months and years.
- Precision: machines and processes must work without repetitive alignment procedures and have to deliver exactly the same result over the lifetime of the components. This is particularly important for the optics components, which are typically subject to thermal loads, vibration, debris, and further distortions.
- Economy: laser material processing competes with classical, mainly mechanical and machining. Thus, it has to demonstrate a clear economic advantage to guarantee a sustainable business development.

On the other hand, laser material processing may offer particular advantages over traditional material processing technologies. One of the most advanced laser technologies making its way from the research labs to manufacturing grounds, just recently, is the application of ultrashort or ultrafast laser pulses. This radiation allows extreme precision without irradiation in adjacent material (which made this technology very attractive for medical applications such as eye surgery). Even more than in other cases, the shape of the laser pulse plays a crucial role in the laser matter interaction of ultrafast lasers. The tutorial from Koji Sugioka and Ya Cheng presents the state of the art of the optics in such systems, emphasizing the spatial, temporal, and spatiotemporal manipulation of the laser pulse.

A further aspect of laser microprocessing is discussed in the article by Christian Nölke et al. They develop a laser cladding system with a resolution down to 5 μm using a hollow laser beam. The development of the optomechanical setup to enable the creation of a hollow laser beam with a diameter that small is particularly challenging.

The article on the design of f-θ lenses from Leo Beckmann approaches the laser material processing with pulsed laser radiation from another point of view: while most of the design of optical elements in such devices follows classical optical design rules, the high peak power of the laser pulses create additional requirements, that he discusses using an example of the design of an f-θ lens.

Still, the workhorses in laser material processing are continuous wave lasers with up to several kilowatt laser powers. Mirrors are often the most critical optical components in these devices: they may define the efficiency, the polarization, and often, also, the focus. The paper from Marwan Abdou Ahmed et al. presents a new concept for mirrors based on subwavelength grating waveguides. These elements make it possible not only to select a polarization in the resonator but also to filter a particular laser wavelength with narrow spectral bandwidth.

The most promising developments in laser material processing are certainly driven by the development of diode-laser systems. These lasers are not only rather energy-efficient devices but also permit the application of large-scale industrial manufacturing processes known from the semiconductor and electronics industry. Again, optical elements are the key components to deliver energy from the semiconductor source to the amplifying medium or to the manufacturing process directly. The requirements and the design of such components is the topic of the article on ‘Optical Components and Optical Systems for VCSEL Diode-Laser Systems’ by Stephan Gronenborn et al. These optics allow for tailoring the laser profile, and in the future, they will be part of a wafer-level component integration.

Laser brazing might be already part of the established laser material processing technologies. Nevertheless, the requirements of the continuous and efficient industrial process lead to a continuous progress in the system’s technology. Oliver Pütsch et al. describe in their article the development of a sophisticated laser brazing head with a coaxial wire feeding and an enhanced functionality.

I hope this issue is of much relevance for all our readers, and I would like to express my gratitude to the guest editors of this issue: Peter Loosen (TOS-RWTH Aachen/Fraunhofer-Institut fuer Lasertechnik, Aachen, Germany), Martin C. Richardson (CREOL|The College of Optics and Photonics, UCF, Orlando, FL, USA), and Kazuyoshi Itoh (Osaka University, Osaka, Japan).

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In 2005, the General Membership Meeting elected him to the Executive Board and CEO for the DGaO-Annual Meeting 2006. Three years later, in 2008 and in 2010, he was elected as President of the DGaO.

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