Special Issue on Optical In-Process Measurement Systems

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1. Introduction

Optical principles enable precise measurements, down to the quantum mechanical limits, and provide the fastest possible measurement speed: the speed of light. Driven by the ongoing advances in powerful light sources, accurate light modulation possibilities, and efficient light detectors, the capabilities of optical measurement systems are increasing. However, a current challenge is to make use of the benefits of optical principles for in-process measurements on real-world objects. Examples are flow processes on wind turbines, on airplanes, and in combustors; the thermal and mechanical processes on a workpiece during manufacturing; and the exploration of natural processes on Earth and in space. Studying non-idealized, non-scaled objects during their actual operation is an important task for the field of measurement science, since it allows us to gain new insights from the *actual* process behavior to be engineered. Furthermore, in-process measurements are required to create in-process controls.

In-process measurement conditions are often challenging and can result in limited optical access, an uncooperative measurement environment, a large measurement distance, a large measurement object, or a low signal-to-noise ratio. In order to break new ground for the transition “from the lab to the app” (from the laboratory to the application), optical in-process measurements have to be realized at the limits of measurability and beyond.

2. Progress of Optical In-Process Measurement Systems

This Special Issue covers a wide range of different optical measurement principles and in-process applications.

Regarding production engineering, an overview of recent advances in the optical measurement of the geometry of manufactured components is presented in [1]. In addition, for in situ measurements of the pitch of a diffraction grating, the diffraction pattern of a mode-locked femtosecond laser is studied in [2], while a real-time automated system to perform dual-aperture common-path interferometer phase-shifting is proposed in [3]. Furthermore, an improved Mirau-type coherence scanning interferometer with vibration compensation is described in [4], which widens the range of industrial applicability.

With a focus on 100% inspection during laser material processing, an inline measurement approach based on low coherence interferometry is presented in [5]. Considering hairpin welding, a camera-based spatter detection method to assess the quality of the in-process weld is further investigated in [6]. Finally, the in-process measurement capability of speckle photography to quantify not only the 2D but the complete 3D deformation of a loaded workpiece is proved and characterized in [7].

Regarding the engineering of fluid flows, spectroscopy is applied to study the diffusional behavior of new insulating gas mixtures as alternatives to the use of SF₆ in medium voltage switchgear in [8]. In addition, for the future development of an active explosion suppression system in coal mines, the optimal wavelength range for the optical sensing of the ignition of methane–air mixtures and coal dust is identified in [9].

Last but not least, two works concerning the in-process flow analysis for and on wind turbines are presented. To reliably assess the wind velocity and thus the suitability of a

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site for building a wind turbine, a novel transportable wind Lidar system with superior resolution is tested and successfully validated in [10]. Regarding the contactless investigation of premature flow transitions (from laminar to turbulent) on running wind turbines, a thermographic flow visualization with an automated, model-based detection is described in [11].

3. Outlook

This Special Issue highlights some of the recent achievements in advancing optical measurement systems for in-process applications in the fields of production engineering, process engineering and renewable energy systems. Since measurements are a key element for improving technical processes in terms of sustainability, efficiency and environment friendliness, optical in-process measurements are of increasing importance and will further shape our future world and society.

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