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Editorial: Advances in digital holographic microscopy and applications

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Editorial on the Research Topic
Advances in digital holographic microscopy and applications

From Antonie van Leeuwenhoek's first glimpse of microorganisms to today's sophisticated optical imaging systems, microscopy has continuously evolved, revealing the hidden intricacies of the microscopic world. Among the latest advancements in this field, Digital Holographic Microscopy (DHM) stands out as a revolutionary technology, offering unparalleled capabilities and a broad spectrum of applications. DHM combines two well-established techniques, i.e., digital holography and optical microscopy, thus providing label-free and quantitative phase imaging. DHM can easily provide information on not only transparent samples with high endogenous contrast but can also quantitatively assess the thickness or refractive index. Due to these features, DHM has been widely applied for various applications ranging in industrial inspection, visualization of liquid/gas flow, biomedical imaging, etc. This research topic highlights advances in quantitative imaging technologies and non-destructive testing (NDT) for various industrial and medical applications such as semiconductor manufacturing and cell analysis. The papers in this collection explore cutting-edge techniques such as lensless multispectral digital holography and lensless digital holography for in-situ NDT, emphasizing their high-resolution, compact and real-time metrology capabilities. These technologies overcome the limitations of conventional optical setups and improve the accuracy and robustness of measurements in various environments.

Four invited papers have been accepted for publication in this Research Topic. The Guest Editors would like to thank the authors for their valuable contributions, the anonymous reviewers for their insightful feedback, and the editorial team for ensuring the success of this Research Topic. The Guest Editors hope that this Research Topic will serve as an important resource for students, researchers, engineers and industry professionals and will advance the field of quantitative imaging and non-destructive testing in industrial applications.

All the published articles are listed below:

Monitoring lipid accumulation in microalgal cultures is a promising approach for sustainable nutraceuticals and biodiesel production. This paper introduces a rapid, non-destructive method for quantifying lipid content in the microalga Phaeodactylum tricornutum using digital holographic microscopy (DHM). The approach leverages the

DHM's refocusing capability to analyze recorded hologram sequences, enabling the evaluation of lipid droplet volumes within living cells. Over one thousand lipid droplets are automatically analyzed from a hundred recorded holograms per sample. The method has been validated through correlative quantitative phase contrast and fluorescence imaging, and its versatility is demonstrated by applying it to larger calibrated spherical refractive particles (Yourassowsky et al.).

This article explores the use of lensless digital holography for *in-situ* non-destructive testing (NDT), providing high-resolution, wide-field and stable metrology suitable for real-time quality control. Traditional methods rely on bulky, complex systems that are unsuitable for *in-situ* measurements due to environmental constraints and temporal instability. Lensless digital holography, with real-time digital reconstruction and numerical focusing, provides accurate phase retrieval without complex setups, making it ideal for a variety of *in-situ* scenarios. The current capabilities of the technology are being demonstrated in applications ranging from vibration to thermo-mechanics, with metrology enhancement methods further extending its use in various industrial sectors (Ruiz-Cadalso and Furlong).

Automated cell counting method has the potential to enhance blood inspection, offering valuable pathological insights for disease diagnosis and treatment. In this article, the authors a novel approach for counting and analyzing rat blood cells (RBCs) flowing in a microfluidic device using digital holographic microscopy enabled by a Sobel operator. Authors employed Dice coefficients for automatic threshold selection, facilitating the efficient counting of RBCs that enables the rapid extraction of key parameters such as size, concentration, and dry mass in a label-free manner. Additionally, the proposed technique was shown to apply to various other types of cells, including COS7 and Siha cells (Xiong et al.).

This paper presents a lensless multispectral digital holographic sensor, Flash-WLI, designed for quality assurance in semiconductor manufacturing. By capturing digital holograms at different wavelengths, the sensor accurately evaluates the shape of reflective objects, providing a compact, robust alternative to traditional white light interferometry (WLI), which suffers from mechanical vibrations and bulky setups. Experimental results on a wafer sample confirm the sensor's high accuracy, with an axial resolution of ±2.5 nm (1σ). The consistency of these measurements with the Keyence VKX-3000 WLI model reinforces the reliability of Flash-WLI and positions it as a powerful tool for microstructure analysis in semiconductor manufacturing (Agour et al.).

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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