ICFO

PhD THESIS DEFENSE: Compact Phase Imaging Platform and its Application to Material Science and Manufacturing

SEBASTIAN HAGELE

July 23, 2024

14:30

ICFO Auditorium and Online (Teams)

As the world moves towards increasingly miniaturized and complex technologies and devices, the need for imaging and metrology tools for precise material characterization and fabrication process control is rising accordingly. For highly transparent and ultra-thin structures and samples (e.g., optical coatings, lithographic structures or biological cells), intensity-based imaging techniques fall short due to insufficient contrast, as well as failing to provide quantitative information.

To overcome these limitations, the field of phase imaging, based on superposition and interference of light, has emerged. In order to create image contrast, phase imaging does not leverage changes in intensity, but rather, as the name implies, changes in the phase of the electro-magnetic wave. With a long-standing history, and Nobel prizes awarded in 1953 to

Zernike's ï¿½phase contrast microscopeï¿½ and 1971 to Gabor's holographic methods, the field has evolved to ï¿½quantitative phase imagingï¿½ (QPI), using sophisticated met ods and setups to control and manipulate the state of light in order to recover the phase inf rmation quantitatively. Herein, the category of ï¿½common-pathï¿½ techniques promise adaptable, compact, robust, and cost-efficient imaging devices, enabling use in industrial pplications outside of a well-controlled lab
nvironment. In this thesis, we will describe the development and technological inno ations of a ï¿½common-pathï¿½ phase imaging platform based on the ï¿½lateral-sheari g interferometric microscopyï¿½ (LIM) technology. We will implement and adapt the platfor to various optical setups, e.g., for large-area lens-free imaging and for high-resolution icroscopic imaging. We will also demonstrate the performance and versatility of the platform y exploring a range of applications, with a focus given to material scienc
and manufacturing. Specifically, we will perform volumetric imaging of the tiniest femto econd laser-written refractive index (RI) changes inside glass. This is followed by the characterization of semi-transparent ultra-thin gold films using multispectral intensit and phase imaging, enabling us to determine the complex RIs of the films of varying thickn ss. Lastly, we will apply the platform to the imaging of curing grades and RI changes in ph topolymers, such as those used in resin-based 3D printing. Further applications of the pl tform could include surface metrology, imaging of 2D materials, as well as quantitative ph se imaging for bio- and cell-imaging applications, with the possibility of integrating the w ole platform into a compact add-on which could be added to any co
mercial microscope. In summary, this thesis will make evident the significant potential of p ase imaging in both research and industrial settings, enabled by the proposed compact pha e imaging platform. The work builds the foundation for future innovations and development with a potentially lasting impact on the

Tuesday July 23, 14:30 h. ICFO Auditorium and online via Teams
Thesis Director: Prof. Dr. Valerio Pruneri and Dr. Roland Alfonso Terborg
Hosted by: Prof. Dr. Valerio Pruneri