3D Fluorescence Imaging of Plant Cells by using Off-axis Incoherent Digital Holographic Microscope

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We experimentally demonstrate the three-dimensional (3D) fluorescence imaging of plant cells by using a common-path off-axis incoherent digital holographic microscope. Since, fluorescence plays an important role in medicine and biology, for example for biomolecule labeling, gene expression, bio-sensing, etc. In recent years, several 3D fluorescence imaging techniques have been vigorously studied. Among these techniques, incoherent digital holography has been established as a promising technique. The existing incoherent digital holographic systems require recording of multiple holograms and careful calibration and therefore, it is needed to develop an innovative system with capabilities of single-shot and strong stability. In view of this, we developed a highly stable single-shot common-path off-axis incoherent digital holographic microscope. The 3D imaging capability of the proposed system is verified by performing the experiment on moss plant cells where fluorescence protein is transfected into nucleus. Fig. 1 shows the schematic of the off-axis incoherent digital holographic microscope [1]. In the system, a focusing lens with a diffraction grating is displayed onto a phase-mode spatial light modulator (SLM). The diffraction grating splits the incident incoherent light wavefronts from the plant cells into two light waves with the slight change in the propagation direction in order to achieve the off-axis interference. Therefore, the fluorescent light from the plant cells is modulated by SLM: an unmodulated transmitted fluorescence light and a tilted diffracted light with slightly different wavefront curvature are obtained. These two wavefronts, the unmodulated and the modulated wavefronts by SLM interfere at the image sensor plane and form a digital hologram. The object information can be retrieved from the recorded digital hologram by the appropriate reconstruction algorithm. In the presentation, the holograms and their reconstructed images are presented. The proposed system could be an efficient tool for the single-shot measurement of various parameters of biological cells and tissues.

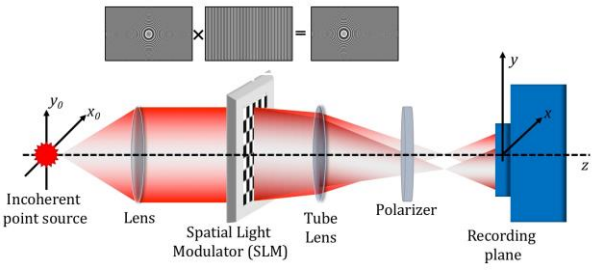

Fig. 1 Schematic of common-path off-axis incoherent digital holographic microscope.

Reference

[1] X. Quan, M. Kumar, O. Matoba, Y. Awatsuji, Y. Hayasaki, S. Hasegawa, and H. Wake, Opt. Lett., 42, pp. 5447-5480 (2018).