PHASE-SHIFTING METHOD APPLIED TO DIGITAL HOLOGRAPHIC MICROSCOPY USING A PROGAMMABLE LIQUID LENS

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KEY WORDS: phase-shifting, digital holographic microscopy, phase retrieval, wave propagation.

Phase shifting interferometry (PSI) is a technique to obtain quantitative phase measurements from intensity recordings [1]. One of the remarkable features of this optical method is the possibility of retrieving quantitative phase images (QPI) from holographic in-line geometries with no presence of the zero order and the conjugate image [2,3]. PSI is based upon the introduction of a controlled phase difference between two interfering waves. This methodology involves i) the search of an optimal setup to provide an accurate and controlled phase-shift and ii) an algorithm to retrieve the phase measurements from the recorded interferograms. The operational features of PSI make it a versatile tool that has been widely used in metrology, optical testing, biological research, among many others fields.

In this contribution, we introduce a PSI method based on an electronically tunable liquid lens (ETL) [4,5]. Particularly, the ETL has been used as a PSI device in digital holographic microscopy (DHM) [6]. The ETL is inserted in the trajectory of the reference wave of the DHM interferometer. The hallmark of ETL technology is the possibility of tuning its optical power by changing the applied voltage. As a result of the change in the optical power, the shape-thickness of the liquid lens is modified and, consequently, that modification is translated into a controlled phase shift, performed with great stability and accuracy. This proposed method has been successfully used to reconstruct quantitative phase maps of great quality and accuracy of a Fresnel lens, of a section of the thorax of a *Drosophila melanogaster* fly, and of human red blood cells (Fig. 1). From our experimental results shown in Ref. [6], one concludes that the main advantages of ETLs are that (i) they provides a phase shifting without any mechanical movement and (ii) the needed phase shifts for the implementation of any phase recovering via PSI are accurate enough.

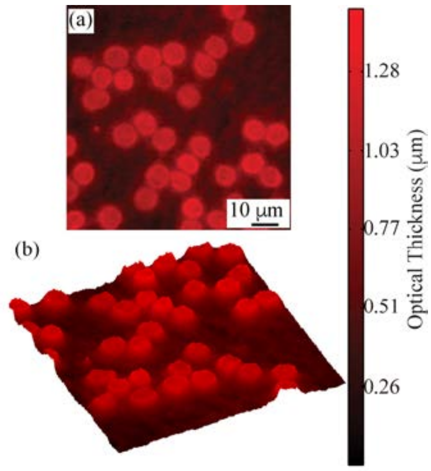

Fig. 1. QPI of human RBCs via PSI-DHM by using ETL as a phase-shifting device. Panel (a) is the recovered image in terms of optical thickness and panel (b) is its 3D view.

References

[1] K. Creath, *Prog. Opt.* **26**, 349 (1988).
[2] I. Yamaguchi *et al.*, *Opt. Lett.* **22**, 1268 (1997).
[3] I. Yamaguchi *et al.*, *Appl. Opt.* **40**, 6177 (2001).
[4] C. Quilliet *et al.*, *Curr. Opin. Colloid Interface Sci.* **6**, 34 (2001).
[5] B. Berge *et al.*, *Eur. Phys. J.* E **3**, 159 (2000).
[6] C. Trujillo *et al.*, *Opt. Letters* **41**, 1416 (2016)