Isotropic Differential Phase Contrast Microscopy with Wavelength-Coded Vortex Asymmetric Illumination Patterns

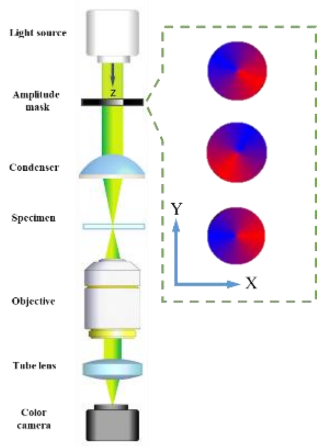
Yu-Hsiang Lin[1], Yu-Hsuan Chuang[1], J. Andrew Yeh[1], Yuan Luo[2,3,4]

1.Department of Power Mechanical Engineering, National Tsing Hua University, Hsinchu, 30013, Taiwan, R.O.C.
2.Institute of Medical Device and Imaging, National Taiwan University, Taipei 10051, Taiwan, R.O.C.
3.Molecular Imaging Center, National Taiwan University, Taipei, 10672, Taiwan, R. O. C.
4. YongLin Institute of Health, National Taiwan University, Taipei, 10087, Taiwan, R. O. C.

E-mail: ggg77882@gmail.com

KEY WORDS: isotropic differential phase contrast, pupil engineering, phase recovery, multiple wavelengths

Figure 1



Introduction

Differential phase contrast(DPC) microscopy [1] based on asymmetric illumination has been used to retrieve high-resolution quantitative image of a weak phase specimen (i.e. cells). However, due to the missing frequencies of DPC transfer function, some artifacts will be produced with 2-axis measurements when using half-circle pupil. Here, we proposed a new approach to achieve circularly symmetric transfer function by using radially asymmetric pupils with only 3-axis [2] in engineered illumination under partially coherent condition. Additionally, to shorten image acquisition time, our radially asymmetric pupils is combined with multiple wavelength.

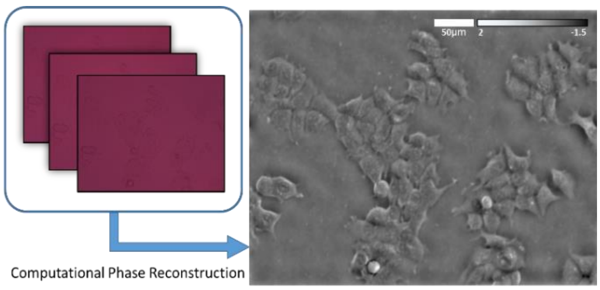
Experimental setup

The phase can be separated from intensity by utilizing weak object transfer function and quantitative phase measurement can be achieved by pair-wise images [1,2]. S is the light source function and P is the pupil function in the objective lens.

$$\widetilde{H}_{phase} = j\left[\iint S(\mathrm{u}')P(\mathrm{u}'+\mathrm{u})P^*(\mathrm{u}')d^2u' - \iint S(\mathrm{u}')P(u')P^*(u'-u)d^2u'\right]$$

Figure 1 is a schematic diagram of the proposed iDPC system setup with the TFT shield located on the Fourier plane of the condenser lens. TFT shield is controlled by Arduino to display wavelength-coded pupils as shown on the right side.

Figure 2



Experimental results

Figure 2 shows quantitative phase images of breast cancer cells generated by computationally reconstruct DPC images. The color bar in gray scales represents quantitative phase recovery of the cells.

References

[1] S. B. Mehta; C. J. R. Sheppard, "Quantitative phase-gradient imaging at high resolution with asymmetric illumination-based differential phase contrast," *Opt. Lett,* **34**, 1924-1926 (2009).

[2]Y.-H. Chuang; Y.-J. Tsai, Y.-Z. Lin and Y. Luo, “Isotropic Quantitative Differential Phase Contrast Microscopy with Radially Asymmetric Illumination,” Optics & Photonics Taiwan, the International Conference (OPTIC 2018).