PLASMA BASED STRUCTURED ILLUMINATION MICROSCOPY

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1 Introduction

The resolution of a conventional fluorescent microscope is governed by the Abbe diffraction limit, restricting it to half the wavelength of the source used for illumination [1]. There are techniques that yield resolution beyond the limit among them confocal microscopy is the most well-known which uses pinholes to generate a focused point illumination and subsequently, a high resolution image of the fluorescent sample. Despite the improved resolution, the pinhole discards a portion of the emitted light due to which the signal level may become unusable, particularly for weakly fluorescent biological samples. Moreover, because the point source illuminates a small size of the sample, it has to be mechanically moved to scan the whole sample resulting in a slow imaging process.

Structured Illumination microscopy (SIM) is a fast and wide-field non-confocal microscopic technique in which the sample is illuminated by a non-uniform, modulated and spatially structured pattern revealing the high resolution information of a sample in the form of Moiré fringes [2, 3]. In order to yield a high resolution result, post-processing of a series of such images is done to extract the high frequency contents.

Illuminating a sample using ?? Talk here about the Nassenstein's paper that how he proposed the idea of using surface waves to form a standing wave illuminating pattern which in turn has a much smaller wavelength as compared to plane wave illumination signal in free space.

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2 Working Principle

The objective lens of a microscope can be considered as a low-pass filter due to diffraction. The impulse response of the filter, i.e., the image of a point source, is a blurred spot termed as the *point spread function*(PSF). When a sample that can be represented by $f(x,y)$ is illuminated by a signal $i(x,y)$, the output image, $m(x,y)$ of the microscope can be written in the spatial domain as:

$$m(x,y) = \big[f(x,y) \cdot i(x,y)\big] * h(x,y) \tag{1}$$

where h is the PSF, $\cdot$ is multiplication and $*$ denotes convolution operation.

The image can be expressed in the frequency domain by taking the Fourier transform:

$$\begin{aligned} M(k_x,k_y) &= \int_{\infty}^{\infty}\int_{\infty}^{\infty} m(x,y)e^{-j(k_x x+k_y y)}\,\mathrm{d}x\,\mathrm{d}y \\ &= \big[F(k_x,k_y) * I(k_x,k_y)\big] \cdot H(k_x,k_y) \end{aligned} \tag{2}$$

References

[1] M. Born and E. Wolf, *Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light*. Cambridge University Press, 1997.

[2] M. G. L. Gustafsson, "Surpassing the lateral resolution limit by a factor of two using structured illumination microscopy.," *Journal of Microscopy*, vol. 198, pp. 82–87, may 2000.

[3] R. Heintzmann and C. G. Cremer, "Laterally modulated excitation microscopy: improvement of resolution by using a diffraction grating," *Proc. SPIE 3568, Optical Biopsies and Microscopic Techniques III*, vol. 3568, pp. 185–196, 1999.