정전구동형 초소형 거울에 기반한 공초점현미경과 이를 이용한 3차원 영상 촬영

3D Imaging using confocal microscope based on the Digital Micromirror Device

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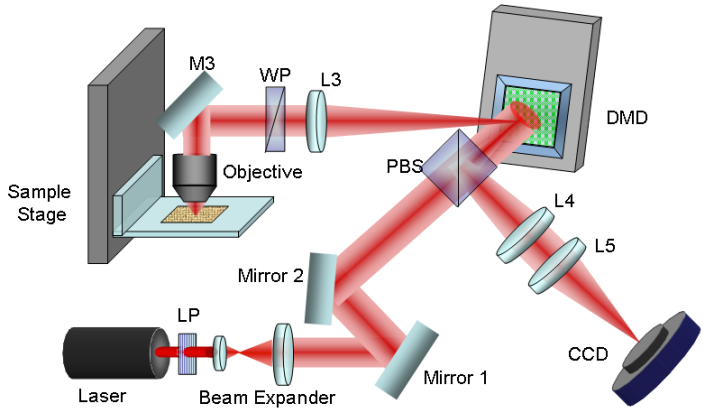
Confocal microscopy is widely used for 3D biological imaging due to its superior resolution and the depth sectioning ability.[1-2] But scan speed is slow because of scanning a single spot across the specimen. In order to improve the scan rate, many methods are developed and one of these is based on the Digital micromirror device (DMD)[3-4]. DMD offers large arrays of rapidly re-configurable micromirrors that can form arrays of reflection "pinholes" and the fast lateral scan is possible.

We develop a confocal microscope system for 3D imaging[5], which scan xy-plane by DMD mirrors and z-axis by linear stage moved by stepping motor. Fig. 1 shows the schematic diagram of this system. The light from the He-Ne laser passes the linear polarizer, the beam expander and the polarized beam splitter (PBS) and reach on the surface of DMD. Only the mirrors of "ON state", which act as the array of illumination and also detection pinholes", reflect light toward the sample. The reflected light passes the collimate lens, the quarter-wave retardation plate and objective lens and focus on the sample. The reflected light from the sample trace back through the optical components onto the DMD surface. Because this light passes the quarter-wave retardation plate two times, the returning light has the crossed-polarization to the illumination light and only this light is



He-Ne laser, 633nm
LP: linear polarizer
Beam Expander:
L1(5mm), L2(50mm)
PBS: Polarized Beam Splitter
DMD: (1024×768)
L3: Collimate lens (200mm)
WP: 1/4λ wave plate
Objective: 20×, 0.4NA
L4(200mm)
L5(100mm)
CCD: (1360×1024)

Fig. 1 Schematic diagram of the confocal microscope system with DMD engine

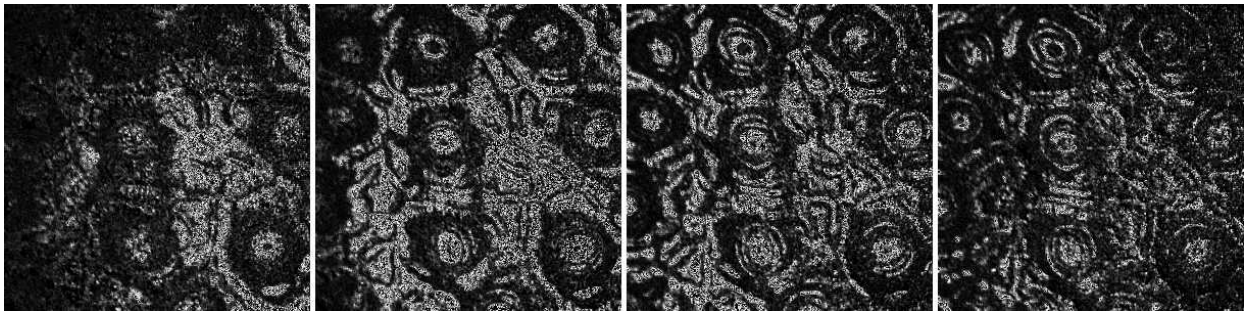


Fig. 2 Guard cells of the leaf of the Euonymus japonica, 4 sectional images every 5 ㎛.

reflected by the PBS[3]. This improve signal-to-noise ratio very much. The reflected light from PBS goes to CCD camera.

The lateral resolution of this system calculated by the full-width half max (FWHM) of Airy disk is 0.97 ㎛ at the objective plane and 21 ㎛ at the image plane (the surface of the DMD) with 20× objective lens. The system's lateral resolving power is characterized from imaging the USAF target and the line patterns with highest spatial frequency (228.0 lines/mm) is clearly resolved. The longitudinal resolution is evaluated by graphical measurement of the FWHM and is 7.2 ㎛. The scan rate is 0.3 frame/sec and it will be improved to 10-20 frame/sec after changing the DMD driver to high-speed type.

Guard cells of the leaf of a spindle tree are imaged by this confocal microscope. Fig. 2 is the 4 sections of the surface of the leaf with 5 ㎛ depth-interval and it shows that this system acts good as a 3D profilometry. Next we will try to image not only the surface of the sample but also the internal structure of the biological samples.

Acknowledgments

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