단일모드광섬유와 헤테로다인검출을 통한 동초점 현미경 광학계

Confocal optical microscopy using single-mode fiber and heterodyne detection

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Confocal microscopy has long been considered as a useful 3-D imaging tool of obtaining tomographical information on biologic tissues underneath skin[1]. Quite a few confocal setups have been proposed and tested during the last decades, but most of them suffer low S/N ratio and poor depth discriminating ability for thick turbid media. To overcome the problems, new methods such as multi-photon microscope[2] and optical coherence tomograpy[3] have emerged especially for clinical applications. These methods offer high performances for many applications, but they have a drawback of requiring a short pulse laser with high power capacity. Nowadays, new attempts are being made to search for alternatives, and our work is also focused on enhancing S/N ratio without using a short pulse laser which is costly and bulky.

Figure 1 shows the schematic of our confocal microscope system. Confocal imaging is realized simply by using a single optical fiber instead of two pinholes usually adopted in conventional confocal setup. Reciprocating optical path is made through a 2x2 fiber coupler which connects the optical fiber to a laser diode laser source and at the same time to a photodetector. The optical fiber has a small effective core diameter of about 2 μm, thus high intensity point illumination becomes possible with no significant loss of light transmitted from the source. Sharp rejection of off-focus light scattered from the object is also achieved with self-alignment capability. A Mirau type objective is used to amplify the on-focus light by monochromatic interference with the reference light reflected from the reference mirror.

Figure 2 shows a representative axial response of our confocal setup. Focusing ability in turbid media is estimated by using a standard mixture of 500 nm diameter polymer microspheres having a scattering coefficient(μ_s) of $5mm^{-1}$. After immersing a chrome-coated glass plate inside scattering media under the 500μm, we measured axial response. Figure 3 shows measured axial responses of interference signal when the scattering coefficient of the media μ_s is 0 mm^{-1}, and $5mm^{-1}$, respectively. In this paper, we present a high performance confocal microscope for imaging turbid media like tissues. Adopting a Mirau interference objective for heterodyne detection allows us to achieve as high as 73dB S/N ratio, and still more, efforts of optical setup can be minimized by

using a single-mode fiber[4].

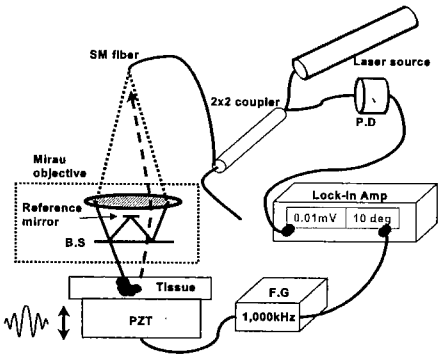

Figure. 1 Schematic diagram of Fiber confocal setup with Mirau interference objective

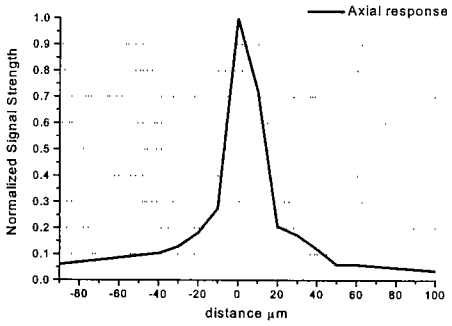

Figure 2 The axial response of fiber confocal setup

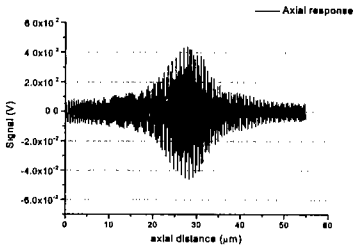

Figure 3. (a) Axial reponse of interference signal when μ_s =0mm^{-1}

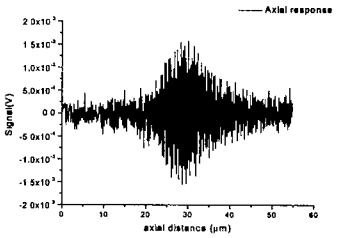

Figure 3(b) Axial reponse of interference signal when μ_s =5mm^{-1}

Reference

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