Auto-balanced Detector for Fiber Laser Based Stimulated Raman Scattering (SRS) Microscopy

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High speed in-vivo imaging without staining is very important for biological research and biological practices. SRS is a multi-photon process that can image three dimensional chemical distributions by probing the vibrational levels of chemical bonds without any labeling. Compared with its predecessor confocal Raman microscopy, SRS has much greater sensitivity and higher imaging speed. With a solid state picosecond OPO laser system, a high frequency (10MHz) modulation and a phase sensitive detection, SRS reached shot-noise limit and the imaging speed can be as high as video rate.

However, the solid state laser system is expensive, heavy and susceptible to environment changes. The potential medical application of SRS has driven us to use the smaller, cheaper and more robust fiber laser as the light source for SRS. But the high frequency noise in fiber lasers voided the high frequency modulation scheme of SRS. Previous works have addressed cancellation of such noises in fiber laser SRS, but the imaging speed (3ms/pixel) is far from usable for high speed imaging. To make fiber laser SRS really useable, we used optical synchronized fiber laser and optimized the pulse parameters. Furthermore, we developed a high dynamic range auto-balanced detector with more than 40dB noise suppression capability. In our current laser system, 20dB excess noise is cancelled and shot-noise level at -157dBc/Hz is achieved. To compensate the variation of transmission of lasers over the complicated biological and medical samples, a PID loop is used to achieve the auto-balancing function. For 10% of light transmission variation, the bandwidth for auto-balancing is 500 kHz. Therefore, in our imaging condition (4ms/pixel), a pixel-to-pixel balancing is achieved. With the above system, we show high quality three dimensional bio-imaging in mouse tissue.