Kristin Wallmeier[1]
Thomas Würthwein[1], Tim Hellwig[2], Maximilian Brinkmann[2], Nick Lemberger[1], Carsten Fallnich[1,3]
[1]Institute of Applied Physics, University of Münster, Corrensstraße 2, 48149 Münster, Germany
[2]Refined Laser Systems GmbH, Mendelstraße 11, 48149 Münster, Germany
[3]Cells in Motion Interfaculty Centre, University of Münster, Münster, Germany

k.wallmeier@uni-muenster.de

Single low-noise fiber-based light source for FM SRS

Stimulated Raman scattering (SRS) microscopy is a powerful tool for in vivo diagnostic imaging due to the chemically-selective and label-free nature of the Raman process. The SRS process can suffer from parasitic effects such as cross-phase modulation, two-photon absorption and thermal lensing with according distortion of the SRS signal and a corresponding reduction of the image contrast [1]. Several schemes were implemented to suppress these parasitic signals, e. g. frequency modulation (FM). We substantially simplified FM SRS microscopy by using only one single fiber-based light source that is fast and widely tunable in wavelength [2], allowing for FM SRS imaging with real-time background subtraction and improved image contrast. The principle of FM SRS uses pump pulses alternating in wavelength in combination with Stokes pulses fixed in wavelength. In our setup the resonant signal as well as parasitic contributions were probed alternatingly by pulse-to-pulse wavelength-switching and lock-in detection allowed for direct subtraction, resulting in live imaging with background corrected signals at four frames per second. The SRS signals were acquired with a home-built detector that showed – compared to a commercially available one – an 8-times improved contrast performance. As fiber lasers typically show high noise levels, that are not compatible with sensitive microscopy applications, also the relative intensity noise (RIN) was characterized. Different parameters like the pulse duration can effect the RIN [3], hence this aspect was investigated in more detail. By increasing the pulse duration from 7 ps to 30 ps due to spectral filtering, the RIN of the amplified oscillator pulses decreased by approx. 3 dB to -153.7 dBc/Hz [4], limited by excess noise around -155.5 dBc/Hz as shown in Fig. 1(c).

References

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Figures

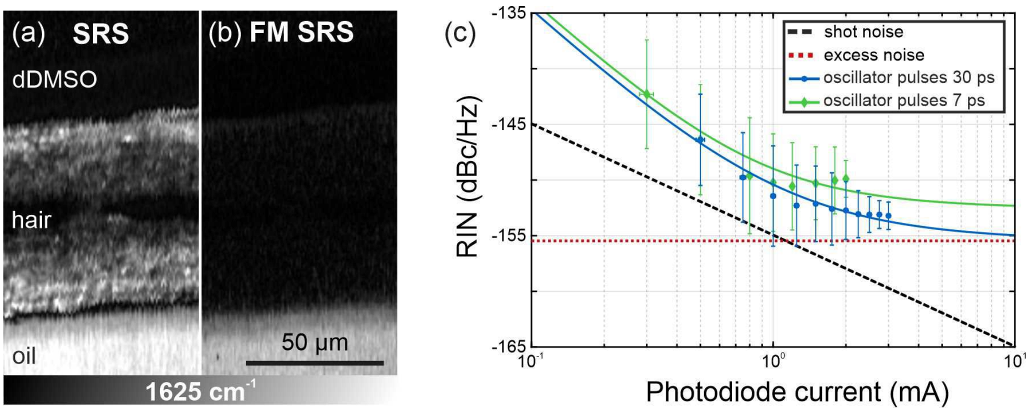

Figure 1: (a) SRS and (b) FM SRS image with parasitic background suppression by a factor of 8. (c) Relative intensity noise (RIN) for different pulse durations at variable photodiode currents.