

ENHANCED SENSITIVITY OF COHERENT RAMAN IMAGING BY A FREQUENCY MODULATED PORTABLE LIGHT SOURCE

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We present multicolor coherent Raman imaging (CRI) with enhanced sensitivity by a novel fiber optical parametric oscillator (FOPO). The FOPO combines a rapid and wide tunability for accessing Raman bands between 700 and 3500 cm^{-1} within only 5 ms with a frequency modulation (FM) at 20 MHz for enhancing CRI sensitivity by at least two orders of magnitude.

When measuring weak concentrations of Raman scatterers, the maximum achievable sensitivity is usually limited by the non-resonant background in coherent anti-Stokes Raman scattering (CARS) microscopy and by cross-phase modulation in stimulated Raman scattering (SRS) microscopy. To overcome these limitations, we implemented a frequency modulation at 20 MHz for fast switching between on- and off-resonance measurements by means of an unbalanced electro-optic delay in the feedback of the FOPO of reference [1]. The according two different round trip times in the FOPO together with chromatic dispersion and a fixed arrival time of the subsequent pump pulses effectively result in two distinct wavelength filters, one on- and the other off-resonance. This FM functionality can be seamlessly integrated into the all-fiber setup. We present concentration measurements of deuterated DMSO achieving two orders of magnitude higher sensitivity compared to CARS microscopy without FM. The resolvable concentration of down to 0.05 % is comparable to previously reported values of FM-CARS measurements using solid-state laser systems [2,3,4], however, now realized with a robust and portable fiber-based light source. We also present live FM-CARS of two resonances, acquired by inter-image wavelength switching within 5 ms between 2150 and 2850 cm^{-1} and reduced in background by means of the FM.

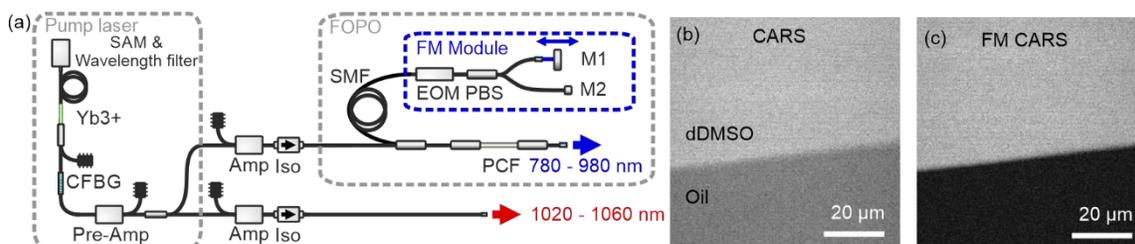


Fig. 1 (a) Schematic experimental setup of the fiber optical parametric oscillator (FOPO) with the module for frequency modulation (blue box). (b) Standard CARS image of an interface between deuterated DMSO and rapeseed oil measured at 2250 cm^{-1} . (c) FM-CARS image of the same sample with 4-fold enhanced contrast (pixel dwell time of 1 μs).

References

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