Heterodyne CARS Imaging with an Optical Parametric Oscillator

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1. Introduction

CARS microscopy is now an established method to acquire images of chemical distributions in a fast and reliable way. A prominent field of application is cell biology and medical applications. The bandwidth of vibrational oscillators is typically of the order of 6 cm^{-1} in condensed matter. Such a bandwidth can be excellently pumped with picosecond pulses. In a CARS experiment typically two synchronized laser-beams are necessary to stimulate the vibration phase grating. This resonant contribution to the CARS field is however accompanied by a non-resonant contribution of the polarizability of all molecules in the focal volume. In an optical parametric oscillator a single pump field generates two energy- and phase-matched new fields. The phase properties of these fields are related to the phase properties of the pump field.
We will show that the combined use of the fundamental laser frequency, the second harmonic thereof and the signal- and idler-field from the 2nd harmonic-pumped OPO results in a phase-preserving chain that can be implemented to give amplitude- and phase-images in CARS microscopy. On the basis of these signals background-free CARS images can be rendered directly.

2. Outlook

The turn-key potential of this all-solid state laser system and the broad tunability of the optical parametric oscillator together with the guaranteed synchronicity of all the pulse trains with a favorable temporal pulse overlap make this laser system a good candidate for a commercial CARS microscope. We will show applications in cell biology and pharmaceutical tablet formulations.

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