Live multicolor coherent Raman imaging with a portable light source

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We present multicolor coherent Raman imaging (CRI) with rapid wavelength tuning within only 5 ms between successive images. To promote the non-stationary application of CRI, e.g. for diagnostic bed-side imaging, we fitted the all-fiber light source setup into a portable, passively cooled housing with a compact footprint of 35x35x18 cm³.

In order to visualize rapidly evolving or moving samples in coherent Raman imaging (CRI) with high chemical specificity, successive images at multiple vibrational resonances have to be acquired at video-rate speed. Recent approaches to video-rate multicolor CRI, based on parallel laser amplifiers [1] or spectral focusing techniques [2], allowed wavelength switching on a timescale of (sub)milliseconds, but only across a bandwidth of 300 cm⁻¹ at maximum, significantly limiting the chemical specificity. In contrast, the here presented light source is tunable within 5 ms across the wide spectral range between 700 and 3530 cm⁻¹, spanning the fingerprint, silent and high-wavenumber regions. Therewith, the wavelength can be tuned in a frame-by-frame manner adequate for multicolor image acquisition with up to 100 frames/s. For a first demonstration, we have applied the light source for visualizing lipids and deuterated dimethyl sulfoxide (dDMSO) in mouse ear tissue with coherent anti-Stokes Raman scattering. Rapid switching of the excitation wavelengths to target 2130 cm⁻¹ and 2845 cm⁻¹ within only 5 ms allowed, to visualize how dDMSO has penetrated from the surface down to about 60 µm deep in the skin, without the need for a relative delay adjustment between pump and Stokes beam.

Fig. 1: (a) Time trace of the switching process between two wavelengths. (b) CARS image of a colloidal mixture of deuterated DMSO (2130 cm⁻¹, red) and olive oil (2845 cm⁻¹, blue). (c) CARS image of dDMSO and subcutaneous fat 60 µm deep in mouse ear tissue following the application of dDMSO to nude mouse ear tissue.

References: