Terahertz Raman microscopy

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Coherent Raman microscopy has become a commonplace tool for label-free chemically selective imaging in biological applications and, more recently, in histology. Yet, typical coherent Raman microscopes probe molecular vibrations in either the C-H stretch region (~3000cm^{-1}) or the fingerprint region (800-1700cm^{-1}) which are indeed sensitive to the chemical content but much less so to structure and organization.

The use of low frequency Raman spectroscopy, at frequencies of several terahertz (<200cm^{-1}) can provide invaluable information about collective vibrational modes, which are strongly dependent on local structure. Its use has, however, long been impeded by the difficulty to overcome the strong scattering of the Rayleigh peak. Here we present schemes for performing rapid coherent Raman microscopy in this new spectral window with based on both coherent anti-Stokes Raman scattering (CARS) [1] and on impulsive stimulated Raman scattering (ISRS) [2]. We show that useful biological information can be obtained with pixel dwell times below 1ms, and demonstrate this by observing the spatial distribution of collagen and hydroxyapatite in partially mineralized tendons (see Fig. 1).

The utility of these imaging schemes, as well as simple implementations [3], requiring only standard ultrafast laser sources, will be discussed.

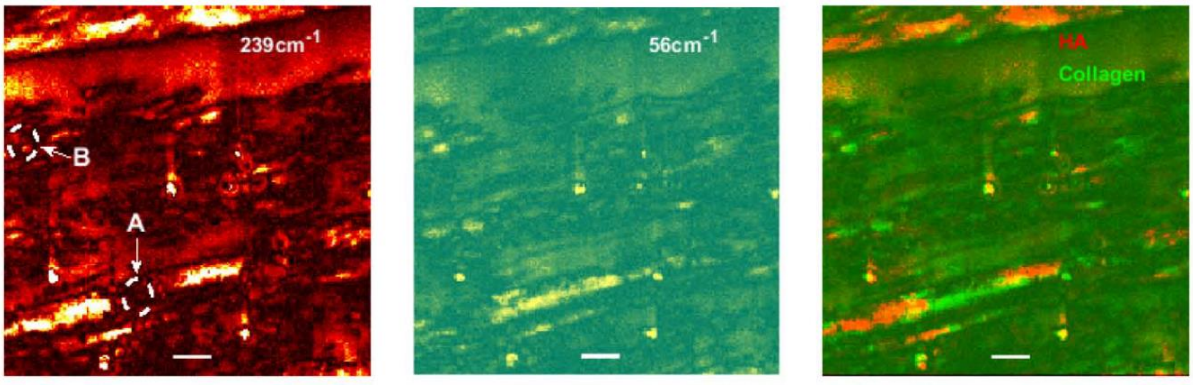

Fig. 1: THz-CARS imaging of hydroxyapatite (left, 239cm-1 line) and collagen (center, 56cm-1 line) in a partially mineralized turkey leg tendon. A merged image is shown on the right.

[1] L. Ren, et al., "Terahertz coherent anti-Stokes Raman microscopy", *Optica* 6, 52 (2019).

[2] D. Raanan et al., "Sub-second hyper-spectral low-frequency vibrational imaging via impulsive Raman excitation", *Optics Letters* 44, 5153 (2019).

[3] L. Ren et al., "A simplified approach to low-frequency coherent anti-Stokes Raman spectroscopy using a sharp spectral edge filter", *Optics Letters* 44, 3637 (2019).