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Broadband Coherent Raman Scattering for Rapid Spectroscopic Imaging

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Over the past ten years, coherent Raman imaging (CRI) has evolved from a curiosity to a practical tool for investigating some classes of biological and material questions. An important key to this evolution has been the ability to rapidly obtain information from many spectral peaks. Most vibrational spectroscopic information is found in the fingerprint region where spontaneous Raman can be used to achieve >3:1 signal to noise ratio for weak fingerprint peaks in biological systems, but typically requires acquisition times of several seconds; too slow for imaging. Coherent Raman methods have previously been unable to acquire high quality fingerprint spectra. We have overcome this limitation by developing a highly efficient signal excitation paradigm and appropriately harnessing the nonresonant background (NRB) signal that accompanies the resonant signal of interest. With these and other innovations, we have developed a CRI approach based on broadband coherent anti-Stokes Raman scattering (BCARS) that provides an unprecedented combination of speed, sensitivity, and chemical selectivity [1]. Using this system we are able to obtain high quality Raman spectra in the fingerprint and CH stretch regions from biological specimens at 3.5 ms, enabling rapid, label-free chemical imaging of even delicate samples. I will briefly put our approach in context with the broader CRI field, describe key technical features of the present imaging system and provide application examples in materials and biology. I will also briefly discuss focus areas for future advances, and speculate on ultimate performance limits for coherent Raman imaging.

[1] Camp, J. J., Lee, Y. J., Heddleston, J. M., Hartshorn, C. M., et al. High-speed coherent Raman fingerprint imaging of biological tissues. Nat Photon 8, 627-634 (2014).