Video Rate Impulsive Stimulated Raman Imaging

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Light-based imaging techniques offer a non-invasive way to visualize molecules based on their structural and chemical properties. Among these, Raman scattering spectroscopy employs molecular vibrations to identify and differentiate chemical species in complex systems with high spatial resolution and chemical specificity. Raman scattering occurs when light interacts with a material, causing an energy shift in the incoming light. This phenomenon is inherently weak; therefore, the process is significantly amplified using the technique of coherent Raman scattering (CRS) in the frequency domain. However, for materials with low vibrational frequencies (<200 cm^{-1}), the spectral shift of the transmitted pulse is so small that it cannot be distinguished using standard spectral filters.

We propose an impulsive stimulated Raman technique that focuses on the time domain rather than the spectral domain. A short (<150fs) pump pulse is used to impulsively excite all the vibrational modes of molecules within the spectral bandwidth of the pulse[1]. Each vibration induces a distinct refractive index change, resulting in a transient variation in the refractive index. To probe this variation a delayed probe pulse is used and changes in its spectrum are analyzed as a function of the delay. By Fourier transforming the temporal signal of the transient refractive index we get the vibrational spectrum of the sample. Using an ultra-fast acousto-optics delay line, we perform hyperspectral imaging at the video rate of 7 Hz with a pixel dwell time of 25 us in a single acquisition[2]. We aim to explore the capability of this spectral imaging technique to detect low-frequency vibrational modes in CdSe and CdS nanoplatelets, which exhibit low frequency Raman spectra in the 10cm^{-1}-100cm^{-1} frequency range.

1. R. A. Bartels, D. Oron, and H. Rigneault, "Low frequency coherent Raman spectroscopy," Journal of Physics: Photonics **3**, 042004 (2021).
2. S. Metais, S. Suresh, P. Diniz, C. Vourdaki, I. Martin, S. Shivkumar, R. Bartels, N. Forget, and H. Rigneault, "Hyperspectral acquisition with ScanImage at the single pixel level: application to time domain coherent Raman imaging," Optics Express **32**, 38849-38863 (2024).