Recent advances in molecular-vibrational imaging with stimulated Raman scattering

誘導ラマン散乱顕微法による分子振動イメージングの進展

October 17 (Fri)
16:20-17:20

Room W319, 3F, Cooperation center, Wako campus, RIKEN
理研 和光キャンパス 研究交流棟 3F 会議室 W319

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Stimulated Raman scattering (SRS) microscopy is a label-free imaging technique that enables rapid, selective visualization of molecular and lattice vibrations. Its versatility supports diverse applications in biology and materials science. This presentation highlights advances in SRS microscopy driven by light source engineering. We introduce a dual-modality system integrating SRS with fluorescence microscopy, using a rapidly tunable laser generated by spectral filtering of Yb fiber laser pulses synchronized with a picosecond Ti:sapphire laser. This platform enables video-rate, frame-by-frame imaging of vibrational modes and fluorescence channels. With newly developed Raman probes, it supports super-multiplexed imaging, enzyme activity mapping, and super-resolution visualization of intracellular organelle dynamics. We have also applied SRS to materials science. The system probes strain in two-dimensional materials, while a fiber-based optical parametric oscillator extends coverage to 300–1400 cm^{-1}, visualizing strain in wide-bandgap semiconductors. Operating at telecommunication wavelengths, SRS allows 3D mapping of strain and temperature in silicon for advanced semiconductor evaluation. Finally, we present recent work using quantum optics to reduce the noise in SRS. Specifically, squeezed states of light suppress quantum noise. We also emphasize the fundamental link between Raman scattering and squeezing, interpreting both spontaneous and stimulated Raman scattering as simultaneous photon–phonon generation.

Pre-registration