

Photonic-crystal fibers and fiber lasers as light sources in CARS microspectroscopy

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Chemically sensitive, vibrational microscopic imaging based on coherent anti-Stokes Raman scattering (CARS) has developed significantly in the recent years. As the potential of CARS imaging has unwound, so have efforts to reduce the complexity and cost of a light source capable of delivering synchronized “pump” and “Stokes” pulses at different wavelengths. We demonstrate how several aspects of the light source for CARS can be realized using photonic-crystal fibers (PCF)s instead of conventional optics, which leads to a reduction in cost and complexity.

Spectral resolution in CARS microspectroscopy can be improved by decreasing the spectral width of the pump pulse. Figure 1 shows how the spectrum of a broadband pulse can be compressed by sending it through a PCF.

For purposes of suppressing the nonresonant background in CARS, heterodyne detection can be employed. Here, a reference pulse is needed at the CARS signal wavelength. Figure 2 shows how a tunable reference pulse can be efficiently generated by mixing the pump and Stokes pulses in a short PCF.

PCFs can be put to use for frequency-shifting a laser pump pulse, so that the frequency-shifted pulse can be used as Stokes pulse. By sending a pulse through a PCF, it can be made to continuously redshift, with the total redshift being controlled by the PCF input power.

In addition, we have demonstrated CARS microspectroscopy with a virtually all-fiber light source, based on a home-built fiber laser.

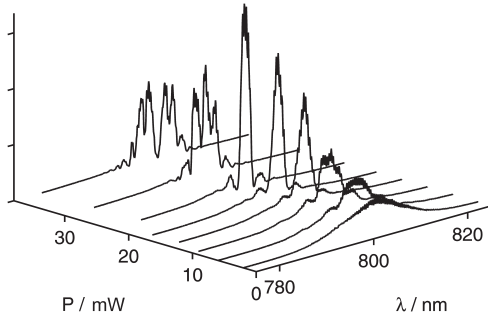


Figure 1: Spectra of spectrally compressed pulses for different initial powers P . A 20-fold spectral narrowing and a 6-fold spectral brightness increase are possible.

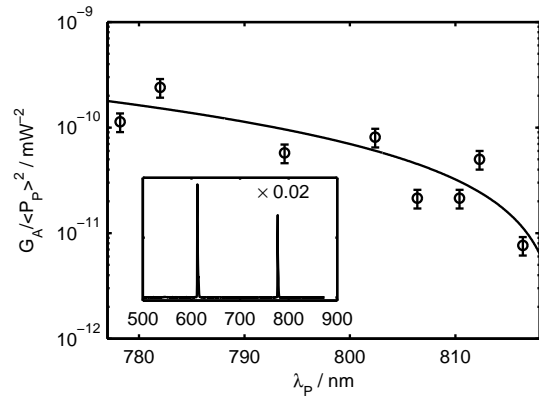


Figure 2: Single-pass gain G_A normalized to pump average power versus pump wavelength, λ_P . Inset: Example spectra of reference pulse (613 nm) and pump (778 nm). Stokes at 1064 nm not shown. Reference pulse power is typically 1 μ W.

- [1] E.R. Andresen *et. al.*: “Tunable light source for CARS microspectroscopy based on the soliton self-frequency shift”, *Opt. Lett.*, **31**, 9, 1328-1330 (2006).
- [2] E.R. Andresen *et. al.*: “Picosecond anti-Stokes generation in a photonic-crystal fiber for interferometric CARS microscopy”, *Opt. Exp.*, **14**, 16, 7246-7251 (2006).