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Video-rate spectral imaging with fiber-laser-based stimulated Raman scattering microscope

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Stimulated Raman scattering (SRS) microscope has enabled label-free rapid Raman spectral imaging. Recent studies have reported video-rate imaging with a pixel clock of over 10 MHz [1, 2]. However, these systems require expensive and bulky devices such as a solid-state laser or an optical parametric amplifier. On the other hand, fiber lasers are used for low-cost and compact systems although they are noisy compared with solid-state lasers. In order to reduce the noise, collinear balanced detection (CBD) has been proposed [3], although it has been performed at low data acquisition rate. Here, we demonstrate video-rate spectral imaging with a home-made Er-doped fiber laser (Er-FL) using the CBD technique.

Figure 1 shows our experimental setup. The Er-FL provided 80 MHz picosecond pulses. Output of the Er-FL was amplified and frequency-doubled so as to generate a pump beam at 780 nm. For CBD, we introduced a delay-and-add line (DAL). An Yb-doped fiber laser at pulse repetition rate of 40 MHz and a tunable bandpass filter [4] were used to generate a wavelength tunable Stokes beam. Intensities of SRS signals were measured by detecting 40 MHz modulation of the pump beam. Figure 2(a) indicates a SRS image of polystyrene and PMMA beads (500 x 500 pixels, 30 frames/s and a 13 MHz pixel clock). The wavelength of Stokes pulses was tuned to observe an aromatic C-H stretching signal at Raman shift of approximately 3050 cm^{-1}. Figure 2(b) shows a visible light image at the same region. Strong SRS signals were found only inside of the polystyrene bead. We also acquired SRS images at Raman shifts between 3000 and 3200 cm^{-1} (not shown).

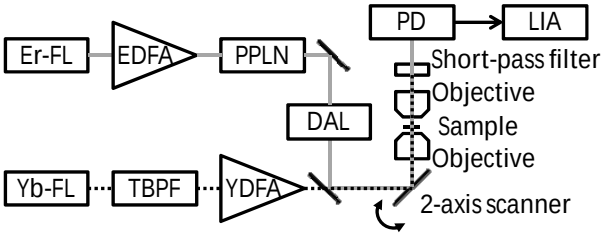
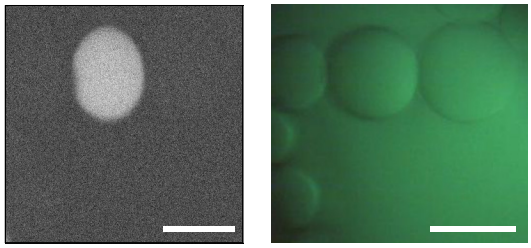


Figure 1. Experimental setup.
Er-FL: Er-doped fiber laser. EDFA: Er-doped fiber amplifier. PPLN: periodically poled lithium niobate. DAL: delay-and-add line. Yb-FL: Yb-doped fiber laser. TBPF: tunable bandpass filter.
YDFA: Yb-doped fiber amplifier. PD: photodiode. LIA: lock-in amplifier.

We have confirmed that the fiber-laser-based SRS microscope can improve sensitivity up to video rate by CBD. The optimization of the Er-FL will enable us to acquire SRS signals in the C-H stretching region (2800-3100 cm^{-1}).



(a) (b)

Figure 2 (a) SRS image. (b) Visible light image. The scale bars are 20μm.

References

[1] Y. Ozeki *et al.*, Nature Photon. **6**, 845 (2012).
[2] B. G. Saar *et al.*, Science **330**, 1368 (2010).
[3] K. Nose *et al.*, Opt. Express **20**, 13958 (2012).
[4] Y. Ozeki *et al.*, Opt. Lett. **37**, 431 (2012).

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