Supplementary information

Multi-window SRS imaging using a rapid widely tunable fiber laser

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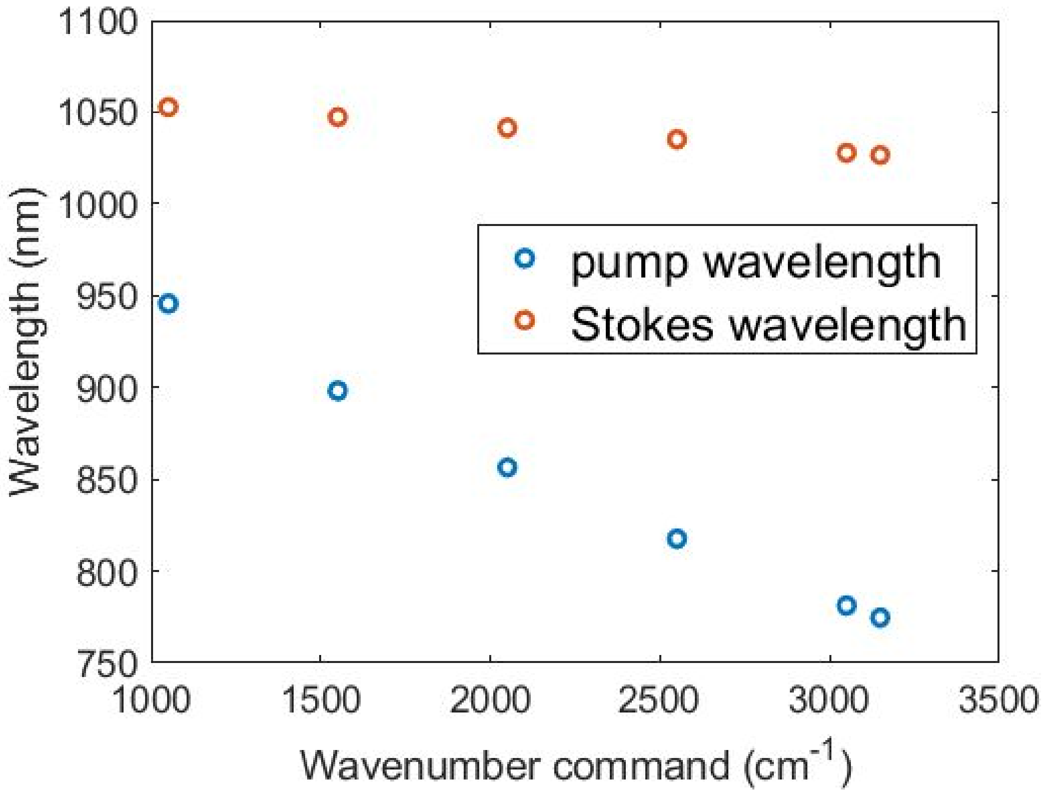
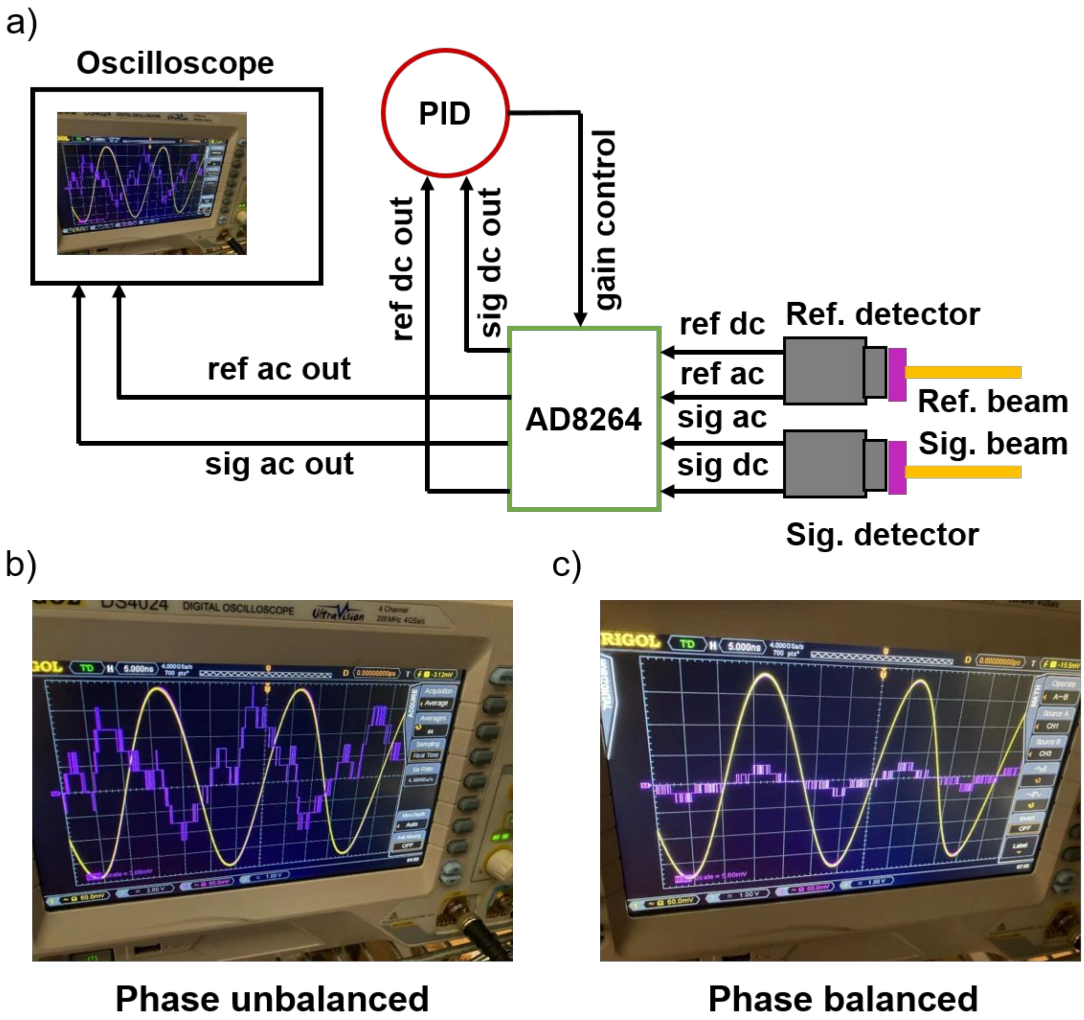
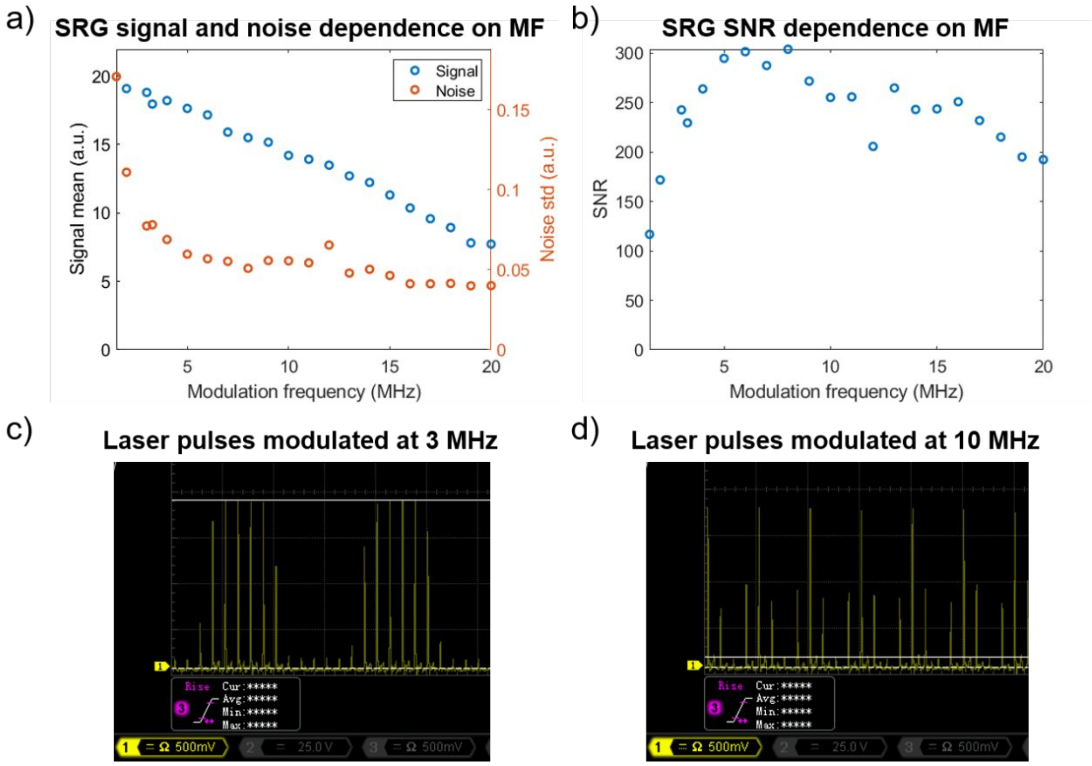


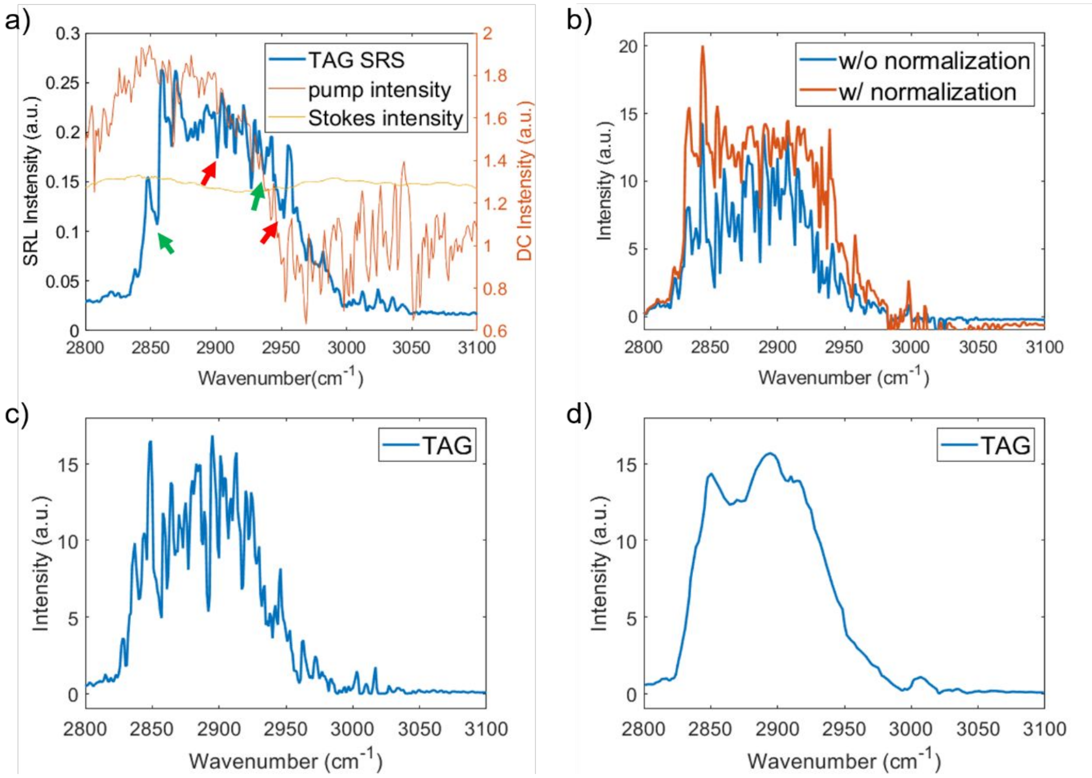
Supplementary Figure S1: Pump and Stokes wavelengths corresponding to different wavenumber command. The wavelength is measured by a visible-to-near infrared spectrometer (FLAME-S, Ocean Insight).



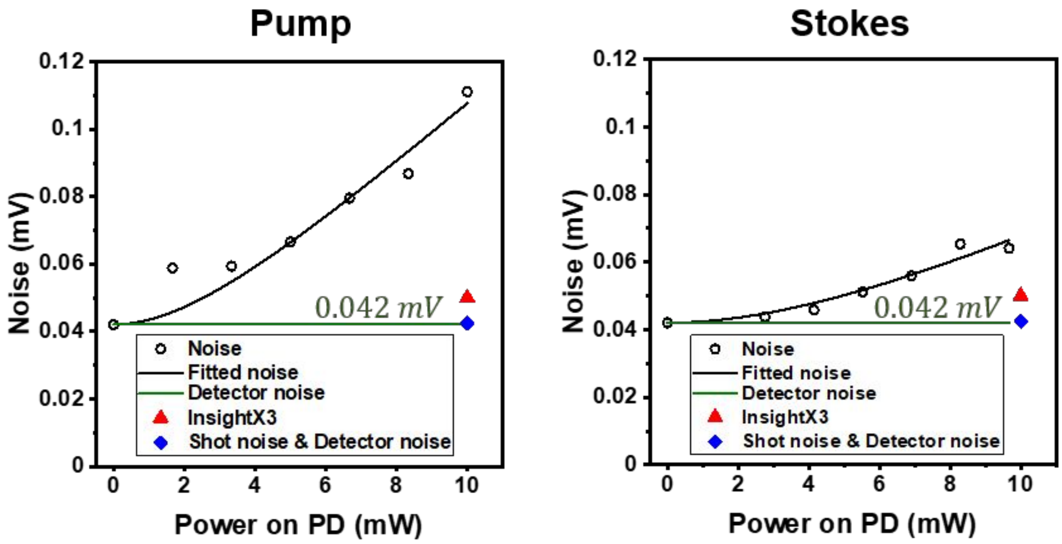
Supplementary Figure S2: Procedure for balancing the phase of the AC signal. (a) Schematic for visualizing the phase difference between the two arms. (b) AC signals from the two arms with phase unbalanced. (c) AC signals from the two arms with phase balanced. In the oscilloscope, the yellow curve is the electrical signal from the signal arm. The pink curve is the electrical signal from the reference arm (covered under the yellow curve). The purple polyline is the difference between the yellow and pink curves.



Supplementary Figure S3: Influence of modulation frequency on SRG detection. The modulation deterioration showed in (c) and (d) caused the SRG signal drop in (a). (b) The best SRG SNR is achieved at 6 MHz. MF: modulation frequency.



Supplementary Figure S4: Sharp dips in SRS spectra caused by FOPO instability. (a) Comparison between TAG SRS spectrum and laser intensity. Some sharp dips in the SRS spectrum show correlation with the pump intensity (red arrows). Some other dips are not correlated with the pump intensity (green arrows). (b) Raw TAG SRS spectrum and TAG SRS spectrum normalized by pump intensity. The normalization did not solve the artifacts issue due to multiple factors collectively causing the problem. (c) Raw TAG SRS spectrum. (d) Spectrum in (c) after deleting bad data points and smoothing with average mean with window of 5. TAG: triacylglycerol



Supplementary Figure S5: Noise dependence on laser power after auto-balanced detection. The measured noise is fitted using equation: $noise \propto \sqrt{elec.\,noise^2 + laser\ noise^2} = \sqrt{elec.\,noise^2 + a * power^{b}}$. For shot-noise limited condition, b=1. For electrical noise dominant condition, b=0. The fitted b for pump is 1.89 and for Stokes is 1.91, suggesting that the residual noise is not shot-noise or electrical noise dominant. The laser noise measured from a solid-state laser (InsightX3, Spectra-Physics) using the identical setup serves as a reference for the state-of-the-art noise level. The theoretical shot noise level is calculated from the photocurrent: $\Delta V = \Delta I * R * G$

$$< \Delta I >^{2} = 2 * e * I * \Delta f$$

ΔV:Shot noise in voltage, ΔI: Shot noise in current, R:photodiode load resistor, G: Signal gain, e: elementary charge, I:photocurrent, Δf: measurement bandwidth