Low-Noise tunable source for Stimulated Raman Scattering Imaging

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Abstract

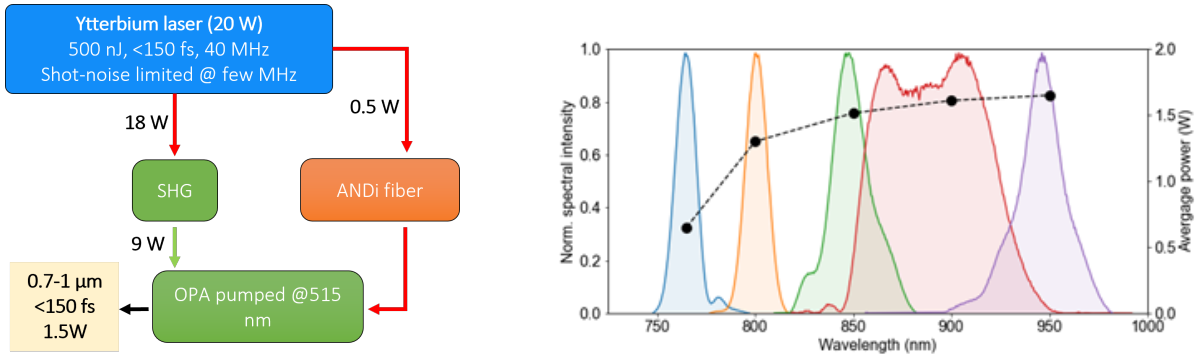
We present a low-noise tunable Optical Parametric Amplifier (OPA) at 40 MHz, pumped by a Kerr-lens mode-locked Ytterbium laser. The Relative Intensity Noise (RIN) at >1 MHz frequencies is shot-noise-limited (-160 dB/Hz). The developed OPA (1.5 W, 780 nm-1000 nm) is an alternative to Optical Parametric Oscillator (OPO).

Introduction

Application as Stimulated Raman Scattering (SRS) [1] are employed for biomedical and pharmacological analysis by non-linear optical microscopy. It is crucial to develop a system allowing the imaging of samples (ex. histology), either on a microscope slide or by endoscopy without staining or labeling processes. For SRS measurment, a low-noise source is required to achieve a decent signal-to-noise ratio [2]. Up to now, OPO are sources for SRS imaging. However, the cavity-pump frequencies synchronization and the low average power of these devices are a strong limitation. In this talk, we present a low-noise OPA with a high repetition rate (40 MHz) and high average power (>1 W), which is made possible by the recent emergence of high power femtosecond shot-noise limited lasers and All Normal Dispersion nonlinear (ANDi) fiber (opimized for Ytterbium wavelenght) supercontinuum.

Architecture

We generate a supercontinuum in an ANDi fiber [3], with parabolic dispersion around 1030 nm, pumped by a 40-MHz Kerr-lens mode-locked Ytterbium shot-noise laser (Flint, Light Conversion, sub-150 fs, 20 W, 1030 nm) which seeds a tunable OPA pumped by the second harmonic of the same pump laser (Figure 1a). With a high gain (> 200) the OPA delivers up to 1.5 W output average power (37 nJ/pulse) between 780 nm and 1000 nm, with 75 fs FTL pulse duration at 850 nm. The spectra and the average power are shown in Figure 1b.



(a) (b)

Figure 1: (a) OPA diagram, (b) Spectrum of the OPA output from 750 nm to 1 µm (colored curves) and average optical power (black dotted curve).

Results and conclusion

The RIN is defined as the ratio of the power spectral density over the total electric power at the output of a fast photo-detector. The RIN measurements of the pump, fiber and OPA output are shown in Figure 2. As the pump, the RIN of the OPA (and the fiber) reaches the shot-noise floor at -160 dB/Hz near ~ 3 MHz.

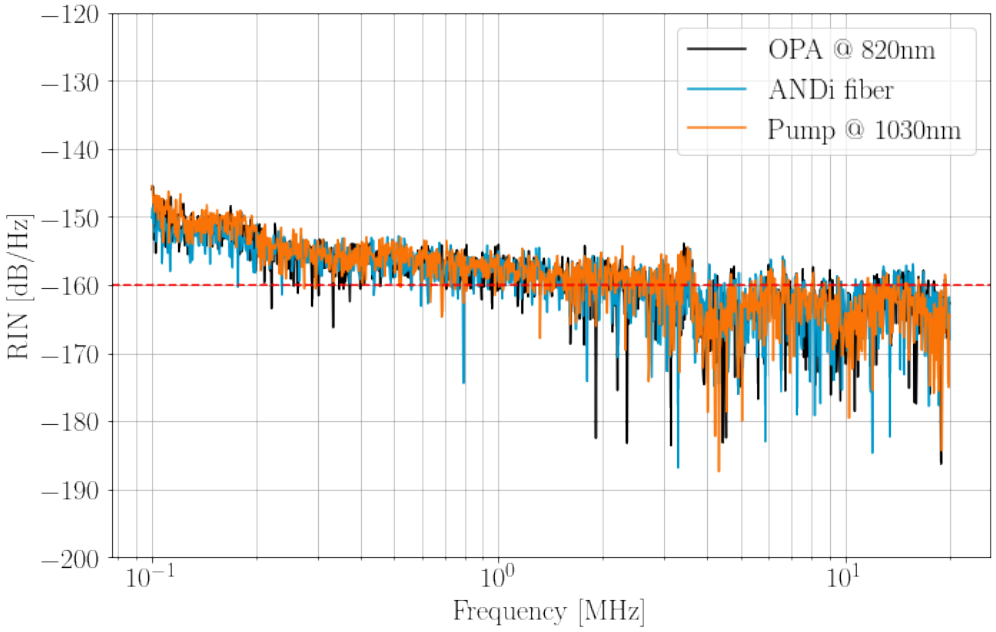


Figure 2: Relative intensity noise (RIN) over [100k-20M] Hz, for the pump at 1030nm (green), 8 cm of ANDi fiber (blue) and the OPA at 820 nm for an average current of 1.6 mA (shot noise in red dotted line).

In conclusion, we developed a low-noise, high repetition rate and high power source based on a single stage tunable OPA. The developed OPA is based on a simpler architecture than OPO, the latter requiring synchronized cavity and pump frequencies. The source is tunable between 780 nm and 1 μm (signal) and between 1.1 μm and 1.4 μm (Idler). This shows that neither the supercontinuum generation nor the amplification stage degrades the RIN of the pump laser.

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References

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