Fiber-based light source with multi-color output and fast wavelength tuning

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Fiber lasers are of high interest for a variety of applications due to their robustness and small footprint. In combination with a synchronized output at different wavelengths, they provide a powerful tool, e.g. for the field of microscopy and spectroscopy. Therefore, we present a fiber-based light source with fast tunable multi-color output and low-noise characteristics.

The light source (schematic in Fig. 1(a)) consists of an oscillator and a subsequent fiber-based optical parametric oscillator (FOPO) [1], enabling synchronized output of pulses at two wavelengths with a repetition rate of 40 MHz. An electronically tunable filter allows to tune the oscillator wavelength between 1020 nm and 1060 nm within 5 ms per arbitrary wavelength step.

By exploiting the parametric four-wave mixing process in a photonic crystal fiber, frequency-shifted light is generated in the FOPO. Due to a steep phase matching curve of the FOPO the relatively narrow tuning of the oscillator wavelength leads to a broad tuning of the FOPO wavelength from 750 nm to 950 nm. In addition to the fast wavelength-switching mechanism of the oscillator, a frequency modulation (FM) [2] scheme was implemented in the FOPO to enable pulse-to-pulse wavelength-switching of the FOPO pulses, which was verified by the measurements shown in Fig. 1(b) and (c). The FM scheme allows for probing different signals almost simultaneously, and therefore, can be used for real-time background correction in microscopy purposes [2].

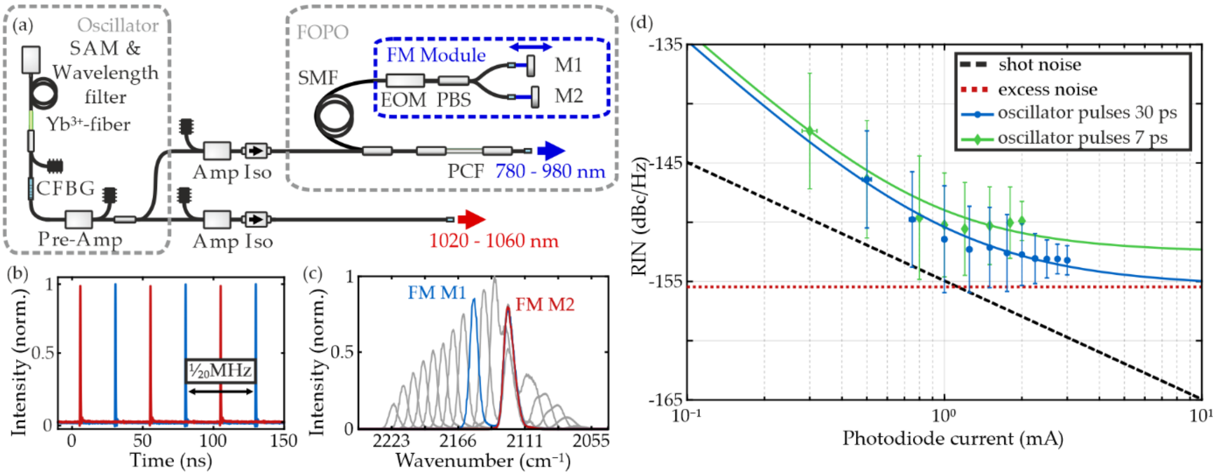

Fig. 1 (a) Schematic of the fiber-based light source with saturable absorber mirror (SAM), chirped fiber Bragg grating (CFBG), amplifiers (Amp), isolators (Iso), single-mode fiber (SMF), photonic crystal fiber (PCF), frequency modulation (FM) unit and mirrors (M). (b) Pulse-to-pulse wavelength-switching by the FM unit at half of the repetition rate of the oscillator. (c) Wavelength tunability within the four-wave mixing gain. (d) Relative intensity noise (RIN) for different pulse durations at variable photodiode currents.

As fiber lasers typically show high noise levels, that are not compatible with sensitive microscopy applications, the relative intensity noise (RIN) was measured. Different parameters like the pulse duration can effect the RIN [3], hence this aspect was investigated in more detail. By increasing the pulse duration from 7 ps to 30 ps due to spectral filtering, the RIN of the amplified oscillator pulses decreased by approx. 3 dB to -153.7 dBc/Hz [4], limited by excess noise around -155.5 dBc/Hz [5] as shown in Fig. 1(d).

In conclusion, the presented fiber-based light source is well suited, e.g. for microscopy or spectroscopy applications, due to its tunable multi-color output and low-noise operation.

References

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