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MIR Supercontinuum Using Gain-Switched and Modelocked Pumping

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Low-noise MIR sources are desirable for applications including sensing, imaging and materials processing. These sources can be realized through supercontinuum generation, whereby pump pulses are spectrally broadened during propagation through nonlinear media. Both gain-switched diodes and modelocked lasers can act as pump sources, with the former offering excellent flexibility, whilst the latter typically displays superior noise properties.

In this contribution, we investigate noise properties of MIR supercontinua generated using these two competing pump architectures. We consider pump pulses from a 1930 nm commercial modelocked laser (AdValue AP-ML01) with pulse duration ~ 3.5 ps, and an in-house fabricated amplified gain-switched 1950 nm diode with pulse duration ~ 100 ps (Fig. 1 (a)). A 1 m length of pulse break-up fiber (SM1950) follows each source to initiate modulation instability and generate high peak power solitons, which are coupled to a 4 m length of 7.2 µm core diameter ZBLAN fiber. Pumping at > 1.9 µm, as opposed to the more mature 1.5 µm, offers potential for higher MIR conversion efficiency. The ZBLAN output is directed either to a spectrometer, or a photodiode to measure the relative intensity noise (RIN) at three wavelengths using bandpass filters: 1.9 µm, 2.3 µm, 3.25 µm with FWHM of 200 nm, 50 nm and 500 nm, respectively. We aim to demonstrate that despite their higher RIN, the gain-switched pump can achieve supercontinua with noise levels comparable to that achieved with modelocked pump lasers, since soliton dynamics largely dictate the noise properties. Furthermore, the inherent robustness and flexibility, including simple repetition rate control, make the gain-switched approach extremely attractive. The gain-switched system consists of two pre-amplification stages and one power amplification stage (similar to [1]). Fig. 1 (b) displays output power at 1 MHz and 10 MHz as a function of 791 nm pump power coupled to the power amplifier stage, and an example pulse train sample at 1 MHz (inset). The output spectrum and spectrally-resolved RIN from the gain-switched laser, SM1950, and ZBLAN are displayed in Fig. 1 (c) and (d) for an input pump power of 1.17 W at 1 MHz and 2.63 W at 10 MHz, respectively. Here we observe larger spectral broadening at 1 MHz, owing to higher peak power, with a -30 dB MIR edge of 3550 nm, compared to 2750 nm at 10 MHz. The RIN out of the gain switched laser is 5.5 % at 1 MHz and 6.7 % at 10 MHz (compared to 3.3 % at 31 MHz for the modelocked laser), and after the ZBLAN fiber is 3.4 %, 8.5 % and 12.7 % and 4.1 %, 24.3 % and 87.4 % at 1.9 µm, 2.3 µm and 3.25 µm and 1 MHz and 10 MHz, respectively. The RIN values increase with repetition rate and towards spectral edge, since this region is inherently noisier [2]. These encouraging preliminary results will be compared with the performance from modelocked pumping, and the implications for MIR applications will be discussed. This project has received funding from Horizon Europe 101058054 (TURBO) and 101057404 (ZDZW), EU H2020-ICT-37 101015825 (TRIAGE) and Villum Fonden 00037822 (Table-Top Synchrotrons).

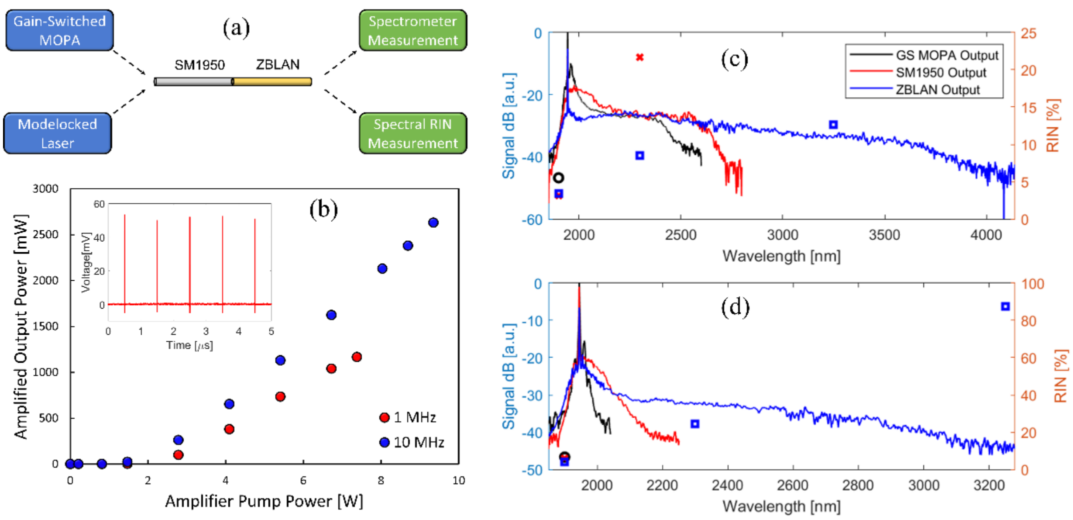

Fig. 1 Experimental schematic (a), gain-switched output power at 1 MHz and 10 MHz with 1 MHz pulse train example (inset) (b), output spectrum and RIN from gain-switched system, SM1950 and ZBLAN at 1 MHz (c) and 10 MHz (d).

References

[1] S. Liang, et al., "295-kW peak power picosecond pulses from a thulium-doped-fiber MOPA and the generation of watt-level > 2.5-octave supercontinuum extending up to 5 µm," Opt. Express **26**, 6490-6498 (2018).

[2] U. Møller, et al., "Power dependence of supercontinuum noise in uniform and tapered PCFs," Opt. Express **20**, 2851-2857 (2012).