# 35 kW Peak Power Picosecond Pulsed Thulium-doped Fibre Amplifier System Seeded by a Gain-Switched Laser Diode at 2 µm

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High power fibre laser sources in the 2 µm wavelength region with picosecond-scale pulse durations have attractive applications such as materials processing, eye-safe radar and nonlinear frequency conversion to mid-infrared wavelengths. Current implementations are typically based on the amplification of picosecond pulses obtained from a mode-locked oscillator, and pulse energies of several hundred nano-Joule and peak powers of the order of 10 kW have been achieved [1, 2].

In this contribution we present, for the first time to our knowledge, the generation of picosecond pulses at 2 µm directly from a gain-switched laser diode and their amplification in a Thulium-doped fibre amplifier (TDFA) chain. The system is capable of operating at repetition rates in the range 2 MHz – 1 GHz without change of configuration, delivering up to 3.5 µJ pulse energy and 35 kW peak power.

The schematic setup of the system is illustrated in Fig. 1(a). A discrete-mode InGaAs/InP fibre-pigtailed laser diode (Eblana Photonics) operating at 2008 nm is gain-switched using a fast electrical pulse generator with a superimposed dc bias current. The first pre-amplifier consists of 4+12 m TDF (OFS TmDF200, 5/125 µm), the first part indirectly pumped by backward propagating amplified spontaneous emission (ASE) whilst the latter 12m is directly core-pumped by an Er/Yb fibre laser at 1565 nm. This configuration provides maximum gain at the signal wavelength [3]. A tunable and a fixed fibre Bragg grating (FBG) in series provide a tunable bandwidth, narrow-band ASE filter to remove excess ASE after the first pre-amplifier. The second pre-amplifier uses a short 2.2 m highly-doped core-pumped TDF (8/100 µm, drawn in-house) to minimize nonlinearities. In the final stage a 3.5 m long large-mode area TDF (Nufern, 25/250 µm) is free-space cladding-pumped by a 75 W fiber-coupled laser diode (Jenoptik).

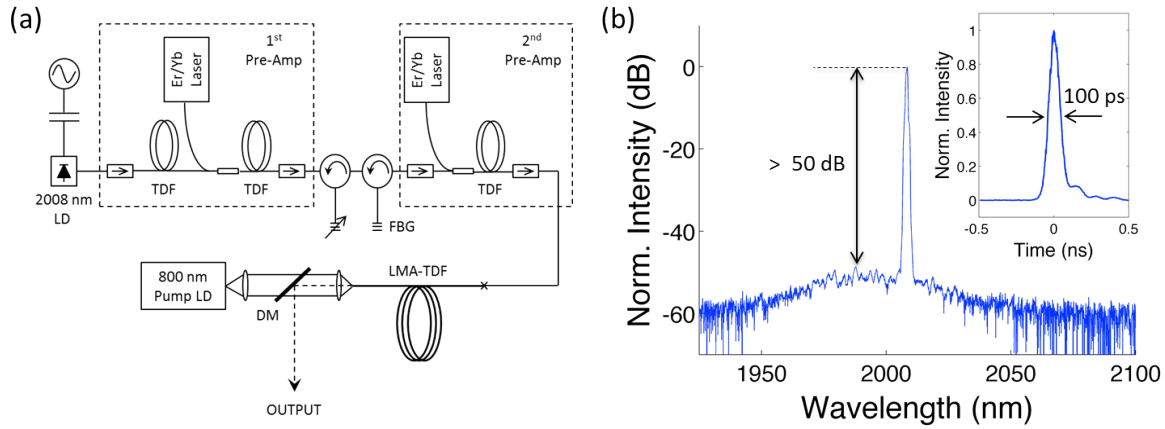


**Fig. 1** (a) Schematic setup. DM: dichroic mirror, other abbreviations explained in the text. (b) Spectrum at the output at high repetition rates. The inset shows a representative oscilloscope trace of the amplified pulses.

Typical temporal and spectral characteristics of the amplifier output are displayed in Fig. 1(b). 16 W average power (limited by available pump power) with more than 50 dB optical signal-to-noise ratio (OSNR) is achieved at high repetition rates, decreasing to 7.5 W average power and 25 dB OSNR for 2 MHz repetition rate, limited by the onset of modulation instability. Corresponding pulse energies are in the range 16 nJ – 3.5 µJ. The pulse duration varies between 90 – 120 ps, depending on repetition rate, giving rise to peak powers up to 35 kW.

In conclusion, we present the first master oscillator power amplifier system at 2 µm seeded by a gain-switched laser diode, achieving the highest reported pulse energies and peak powers for a picosecond pulsed system in this wavelength region.

## References

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