100W, Fiberised, Linearly-Polarized, Picosecond Ytterbium Doped Fiber MOPA

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Abstract: We report a PM, fully-fiberised, picosecond fiber MOPA delivering 20 ps pulses at repetition rates up to 970 MHz and at average powers of up to 100 W.

OCIS codes: (060.2320) Fiber Optics Amplifiers and Oscillators; (320.5390) Picosecond phenomena

1. Introduction

High average power laser sources operating in the picosecond regime are useful for a wide range of applications including frequency-doubling and the pumping of OPOs. Gain switching (GS) of laser diodes provides a practical and low cost method to generate picosecond pulses at GHz repetition rates and milliwatt average power levels. Such devices represent excellent seeds for high power fiber MOPAs allowing power scaling to the 100 W regime. We recently reported average powers in excess of 300 W from a 1060 nm gain-switched FP laser seeded ytterbium doped fiber amplifier (YDFA) MOPA [1, 2]. Whilst this represents an impressive achievement it is to be appreciated that this system incorporated free space pump and signal coupling - greatly compromising the practicality of the system. Moreover, the output polarisation was ill-defined limiting the utility of the system for many frequency conversion applications.

Herein we present an all-fiber, diode-seeded, YDFA MOPA source generating linearly polarised, diffraction-limited, 20 ps pulses at average output powers of up to 100 W. This system represents a considerable improvement in practicality and performance relative to previous high power, fiber-based picosecond pulse sources [3].

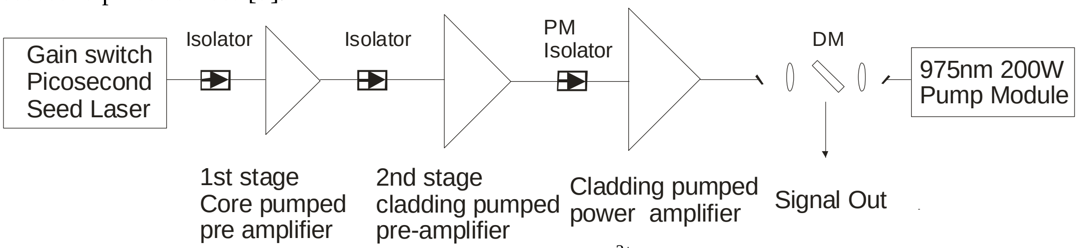

Fig. 1. Schematic diagram of the Yb^{3+}-doped fiber MOPA.

2. Experiment and results

Fig. 1 shows the experimental setup. A 1060 nm FP laser diode in a high-speed fiber-pigtailed package was gain-switched using a pulsed drive current with an associated DC bias. The FP diode was wavelength stabilized with a fibre Bragg grating centered at 1059.9 nm to ensure single longitudinal mode operation. A chirped fiber Bragg grating (CFBG) was used to compensate the inherent chirp of the GS pulses prior to amplification. The compression process resulted in ~20 ps pulses with a corresponding average power of 1.3 mW at a repetition rate of 970 MHz and ~40 ps pulses at an average power of 600 µW at a repetition rate of 495 MHz. The pulses were then amplified in a three-stage YDFA MOPA chain. The first stage was a 4.5 m long core pumped YDFA and the second stage was a 3.5 m long cladding pumped, single mode YDFAs. An in-line optical isolator was used to prevent ASE cross-coupling between the two stages.

The output of the second stage amplifier was coupled into the 4.5m long, polarisation maintaining (PM) power amplifier via a fast-axis blocking PM isolator. The power amplifier fiber has a core diameter of 25 µm, core NA of 0.055 and pump NA of 0.45. The amplifier was end-pumped (70% coupling efficiency) using a commercially available wavelength stabilized, 975 nm diode stack. Output powers as high as 100W were obtained at a slope efficiency of 72% as shown in Fig. 2. The beam quality (M^2) of the amplified signal output was measured to be 1.3 – close to the diffraction limit. The measured polarisation extinction ratio (PER) was better than 12 dB. The maximum pulse energy generated in these experiments was 0.2 µJ and the maximum peak power 5 kW (both at a repetition rate of 500 MHz).

The optical spectra of the amplified pulses are shown in Fig. 3 and Fig. 4 where it is seen that an Optical Signal to Noise Ratio (OSNR) in excess of 35dB was obtained for the 495MHz repetition rate signal pulses with a 5dB improvement due to the higher seed power at the higher pulse repetition rate. Such a high OSNR indicates that it should be possible to scale to even higher power/energy levels with increased launched pump power. Fig. 5 illustrates the spectral broadening observed due to SPM at a pulse repetition rate of 970 MHz and Figs. 6 and 7 show the temporal profiles of the input and output pulses when operating at 970 MHz and 495 MHz repetition rates respectively. The corresponding full width at half maximum was measured to be ~20 ps and ~40 ps respectively. (Note the increased pulse duration at 495 MHz repetition rate was caused by the CFBG which did not compensate the chirp introduced by the gain-switched laser diode as well as it did while operating at 970 MHz repetition rate). The figures show that no significant temporal distortion occurs during amplification.

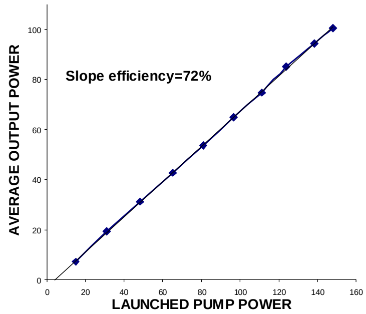

Fig. 2. Slope efficiency at 1060 nm

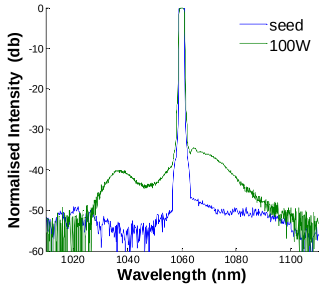

Fig. 3. Spectra at 970 MHz rep. rate

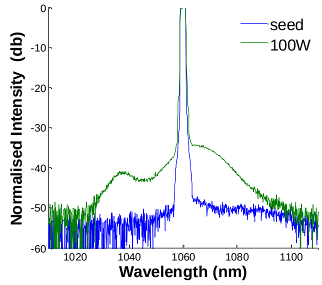

Fig 4. Spectra at 495 MHz rep. rate

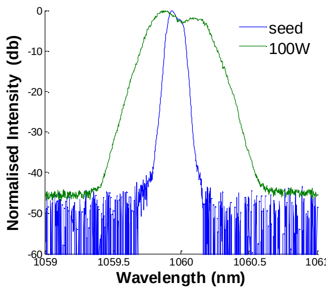

Fig. 5. Spectra at 970 MHz rep. rate, 2 nm span

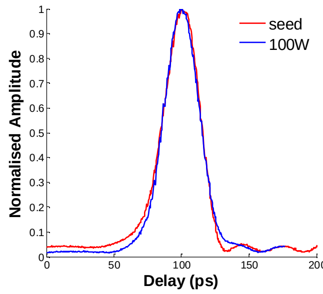

Fig. 6. Pulse shape at 970 MHz rep. rate

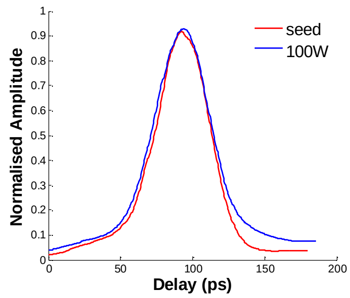

Fig. 7. Pulse shape at 495 MHz rep. rate

3. Conclusions

We have successfully demonstrated a 100 W, linearly polarized, close to diffraction-limited, 20 ps pulse source based on an all-fiber MOPA seeded by a GS-laser diode. Pulse energies of 0.2 µJ and peak powers of 5 kW were obtained. Our experiments show that further scaling should be possible in due course.

Such high average power, single polarisation, near diffraction limited picosecond sources represent an attractive technology for high power nonlinear frequency conversion applications.

4. Acknowledgement

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5. References

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