High Power 980 nm Yb-doped Picosecond Fibre System Pumped by a Cladding Pumped 925 nm Nd-doped Fibre Laser

A. B. Grudinin, S.E. Goncharov, I. D. Zalevsky
Fianium -NewOptics Ltd, 20 Compass Point, Ensign Way, Southampton, UK
e-mail address: abg@fianium.com
O. G. Okhotnikov, L. Gomes, N. Xiang, T. Jouhti
ORC Tampere University of Technology, Tampere, Finland
E.M.Dianov, I.A.Bufetov, V.V.Dudin, A.V.Shubin
Fibre Optics Research Centre, Moscow, Russia
A.N.Guryanov, M.V.Yashkov, A.A.Umnikov
Institute of Chemistry, N. Novgorod, Russia

Abstract Picosecond pulses from a 980 nm passively mode-locked fibre laser are amplified up to energies of 50 nJ in a short length core-pumped fibre amplifier pumped by single mode cladding pumped 925 nm fibre lasers.

OCIS codes: (140.3510) Fibre lasers; (320.5340) Picosecond phenomena

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High peak power ytterbium-doped fiber lasers and amplifiers offer not only a broad tuning range over 180 nm (970 -1150 nm) [1] but also compactness and maintenance free operation which makes them very attractive for practical use. In this context fibre lasers operating at 980 nm is of particular interest since it gives direct access to 490 nm spectral region which is widely used in a number of applications such as fundamental study, imaging, micromachining, bio-medicine etc.
Here we report high power 980 nm picosecond fibre MOPA (master oscillator-power amplifier) where a low power passively mode-locked fibre laser is followed by a high power Yb-doped fibre amplifier.
In order to alleviate technical difficulties associated with three-level nature of the 980 nm transition of Yb-ions in silica glass and signal re-absorption [2] we have chosen a core-pumping approach where pump power provided by a high power cladding pumped Nd-doped fibre laser operating at 925 nm.
The schematic of the mode-locked fiber system is shown in Fig.1.

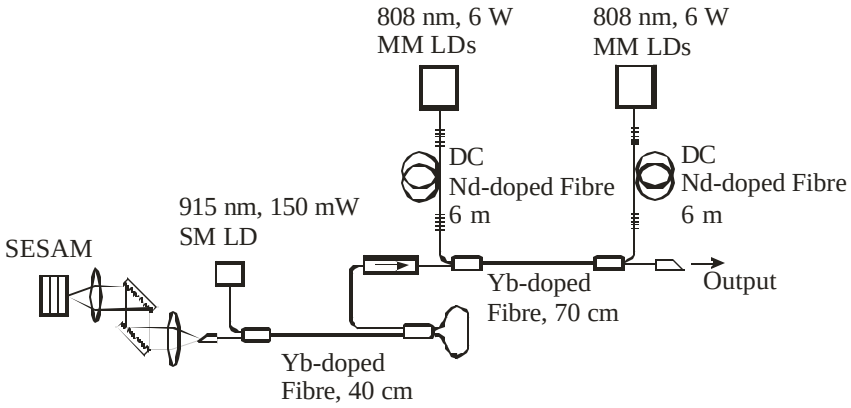

Fig.1 *Experimental lay-out*

The master source is a passively mode-locked fibre laser pumped by a 915 nm single-mode pigtailed laser-diode. The fiber laser was pumped through a 915 nm /980 nm fused-fiber WDM coupler. The length of the doped fibre was kept short enough to avoid signal re-absorption and lasing at longer wavelengths (~ 1030nm) In order to achieve an easy self-starting the total intracavity dispersion was made negative by

incorporation of a cavity dispersion compensator based on a bulk grating pair. A GaInNAs-based SESAM, operating in the 940-1050 nm wavelength-range is used as one of the cavity mirrors and this has resulted in stable and truly self-starting mode-locking regime of operation. The laser was producing pedestal-free 1.6 ps transform-limited pulses at a 30 MHz repetition rate with an average power of approximately 3 mW.

A 980 nm power amplifier was based on a conventional core-pumped Yb-doped fibre. Pump power was provided by a cladding pumped Nd-doped fibre lasers operating at 925 nm ($^4F_{3/2} - {}^4I_{9/2}$ transition). Unwanted lasing at a conventional four level transition ($^4F_{3/2} - {}^4I_{11/2}$) was suppressed by compensation of a 1060 nm gain by wavelength dependent loss.

The laser was end-pumped by a high brightness multi-emitter pump module capable of delivering up to 8 W in a 100 μm, 0.3 NA fibre. High reflection fibre Bragg grating was written on an auxiliary double-clad fibre so that the laser was pumped through the grating. With 4 W of absorbed power the laser was producing 1.2 W of single mode power at 925 nm (see Fig.2) with lasing threshold of 500 mW and slope efficiency of 37%.

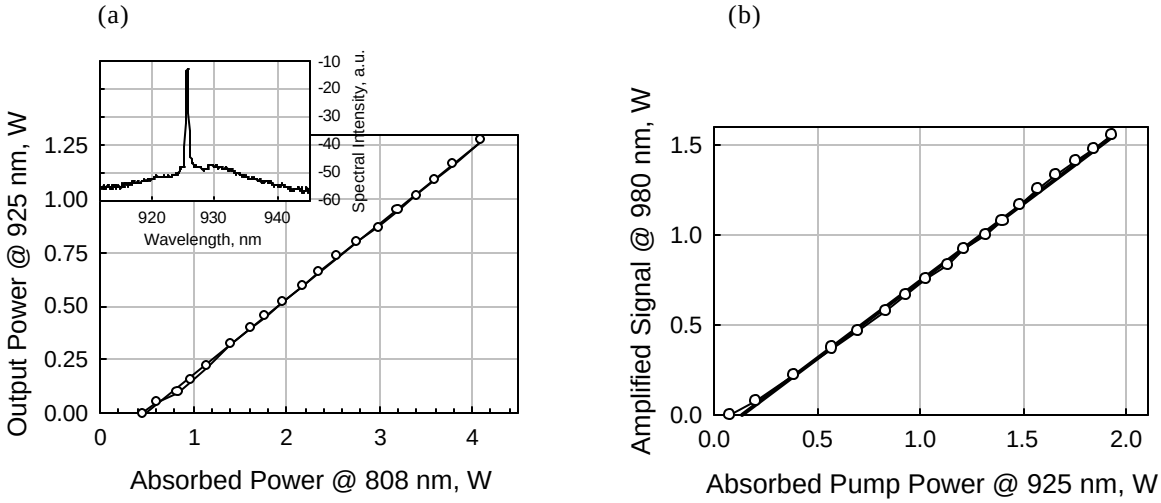

Fig.2 *Output power vs pump power for (a) cladding pumped 925 nm fibre laser (Inset: optical spectrum of the laser) and (b) core-pumped 980 nm fibre amplifier.*

The 980 nm fibre amplifier was bi-directionally pumped and with 2 mW of launched signal power was delivering 1.55 W of saturated output power exhibiting more than 80% slope efficiency (see Fig.2b). High power core-pumped amplifier exhibits not only excellent slope efficiency but also because of relatively short length does not distort temporal shape of amplified pulses although spectral broadening is clearly seen at the output (see Fig.3a,b)

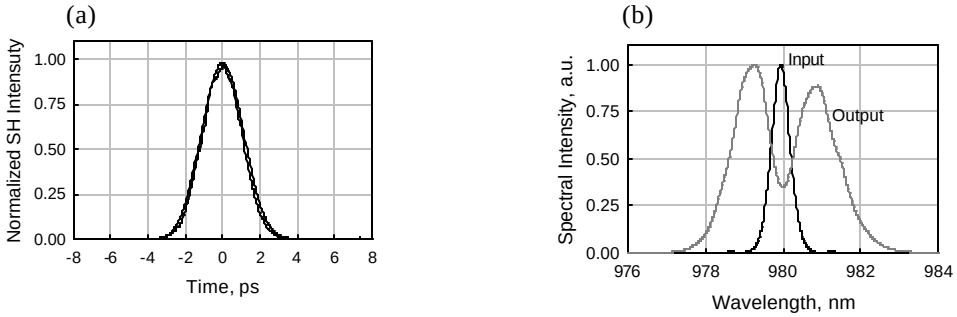

Fig.3 *Autocorrelation traces (a) and spectra (b) of input and output pulses.*

In summary, we have demonstrated a practical picosecond fibre system delivering high energy pulses in the 980 nm spectral range. The system is pumped by a power scalable Nd-doped cladding pumped fibre laser operating at 925 nm.

References

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2. K. H. Ylä-Jarkko, R. Selvas, D. B. S. Soh, J. K. Sahu, C. Codemard, J. Nilsson, S.-U. Alam, and A. B. Grudinin, "A 3.5 W 977 nm cladding pumped jacketed-air-clad ytterbium-doped fiber laser" , Proc. Advanced Solid-State Photonics, San Antonio, Texas, Feb. 3-5 2003, postdeadline paper PDP 2