Environmentally stable picosecond fibre laser with broad tuning range

N.J Traynor, Z.J Chen, J. Porta, J.D Minelly and A.B Grudinin

Optoelectronics Research Centre, University of Southampton, Southampton, SO17 1BJ United Kingdom

Tel: +44 1703 593141

Fax: +44 1703 593142

email: njt@orc.soton.ac.uk

Abstract

We demonstrate a robust, mode-locked, tunable Yb doped fibre laser. The use of dual mode-locked and Q-switched operation in a passively mode-locked configuration allows us to generate 5 ps pulses with a peak power of 750 W at a repetition rate of 100 MHz

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As laser technologies have matured there has been a drive towards configurations which offer simplicity and robustness, and which are readily compatible with existing and emerging devices and applications. In particular, periodically poled lithium niobate has recently emerged as a viable material with an effective nonlinear coefficient far greater than that of traditional nonlinear bulk materials. Consequently, there is a clear need for reliable, compact sources of high average or peak powers to pump harmonic generators and parametric oscillators; however, at present commercially available high power short pulse sources are bulky and expensive.

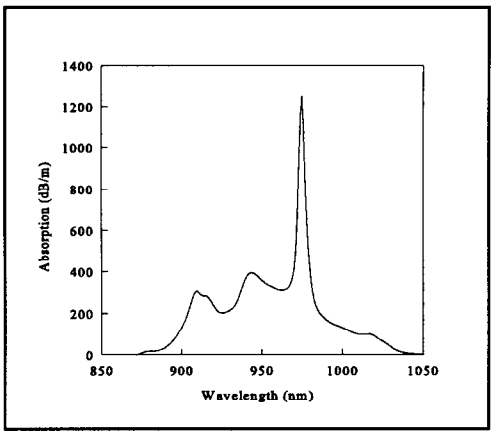

Figure 1: Absorption spectrum of Yb fibre used in the laser

In this paper we present an extremely compact and stable diode-pumpable Yb fibre laser capable of producing high peak power picosecond pulses over a broad tuning range, making this an attractive alternative to the currently available sources. The fibre used in our laser comprises a high absorption (see figure 1) alumino-phospho-silicate fibre. The host glass essentially eliminates the recently identified quenching effect[1] and enables high Yb^{3+} doping (15,000 ppm molar), allowing us to use very short cavities and achieve efficient, low threshold operation at repetition rates comparable to commercial systems.

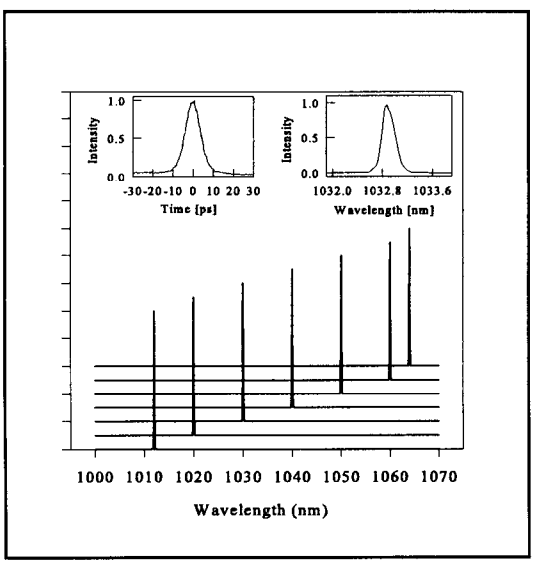

Figure 2: Tuning range of laser with (inset) typical autocorrelation and spectrum.

The laser was pumped with up to 300 mW of launched power. Frequency shifted feedback and spectral filtering was achieved by a double pass through an 80 MHz acousto-optic modulator via a 1200 lines/mm diffraction grating. The interplay between self phase modulation and intracavity filtering in this laser produces a strong mode-locking mechanism[2] . Despite the fact that the second pass of the feedback does not precisely satisfy the Bragg angle, operation of this laser is possible because of the finite

bandwidth of the Bragg condition. To our knowledge, this laser represents the first frequency shifted feedback (FSF) laser to take advantage of this fact.

Our laser produced a train of pulses at the fundamental cavity frequency of 100 MHz and was tunable over the entire Yb gain bandwidth from 1012 to 1064 nm (figure 2). This broad tuning range gives this laser a significant advantage over present commercial sources (Nd:YLF) as it alleviates the need for temperature tuning of PPLN based OPO's. Additionally, a threshold of 20 mW indicates the practicality of pumping this source with commercial 980 nm pig-tailed laser diodes. Mode-locked operation was self starting and polarisation insensitive, with excellent environmental stability (mode-locking was sustained indefinitely). The pulses were spectrally and temporally clean with pulsewidths of ~ 5.5 ps (figure 2, inset) over the entire tuning range. The time bandwidth product of the pulses was around 0.35 with peak powers of 150W (average power 90 mW). The strong mode-locking mechanism and high intracavity powers in this laser resulted in an very short buildup time for mode-locked operation (< 1μsec) and consequently we were able to demonstrate for the first time simultaneous mode-locked/Q-switched operation in a passively mode-locked fibre laser, as depicted in figure 3. This was achieved by gating the signal to the AOM on and off at a frequency of 400 kHz, and resulted in the peak pulse powers being increased to 750W.

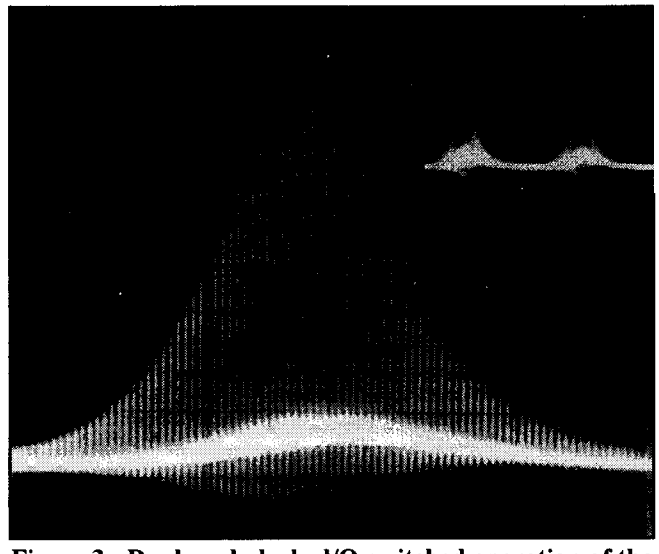

Figure 3 - Dual mode-locked/Q-switched operation of the laser (horizontal scale: 200 ns/div). Inset - two adjacent cycles of AOM switching

We have also achieved similar mode-locked operation in linear cavity lasers using double-clad Nd doped fibre and Er/Yb doped fibre. Our results in Er/Yb fibre in particular indicate the versatility of this laser design, where we have attained passive harmonic mode-locking up to 4 GHz (400^{th} harmonic) by addition of an InGaAs/InP MQW to the laser cavity, which acts as a passive phase modulator.

In conclusion we have developed a robust, diode-pumpable range of fibre lasers producing tunable picosecond pulses, and have achieved peak powers comparable to the current state-of-the-art commercially available mode-locked Nd:YLF source. In addition, our picosecond lasers are tunable over a wide spectral range making them attractive pump sources for OPO's and harmonic generators.

References

[1] R. Paschotta et al., Optics Comm. **136**, 375 (1997).

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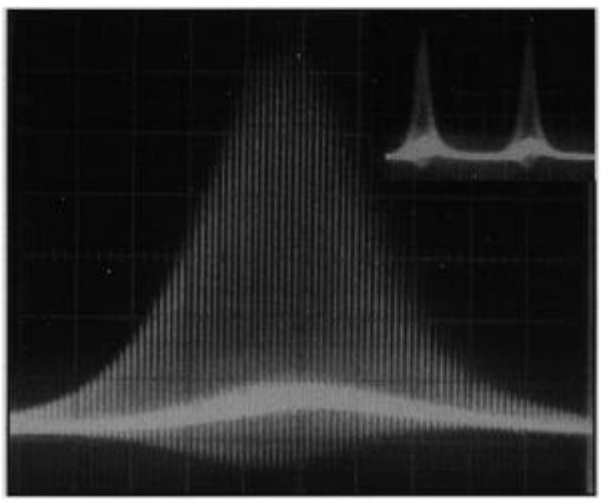

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