Submitted to CLEO 95
1138

Two Gigahertz Soliton Fibre Laser Modelocked With Hybrid Saturable Absorber

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Abstract

A subpicosecond fibre soliton laser passively modelocked by the combined action of a multi-quantum well saturable absorber and nonlinear amplifying loop mirror is shown to operate with a stable repetition rate of over 2 GHz.

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Passively mode-locked fibre soliton lasers are attractive sources of short optical pulses for laboratory and telecommunications applications because of their properties of simplicity, tunability and subpicosecond pulse generation. Recently, a new design of fibre laser was proposed which combines the ease of self starting of saturable absorber modelocked lasers with the soliton shaping properties and intensity discrimination of a nonlinear amplifying loop mirror (NALM) [1]. In this paper we report the generation of subpicosecond soliton pulses from this laser at a stable repetition rate of over 2 GHz where the combined action of a multi-quantum well (MQW) saturable absorber and a NALM form a hybrid saturable absorber which is able to suppress the spectral sidebands observed in soliton lasers by up to 20 dB and give clean picosecond soliton pulses at the output.

The configuration of the laser is shown in Fig. 1. A NALM is formed between the output ports of a 60/40 coupler and includes ~30 metres of dispersion shifted fibre, a polarisation controller and a 2 metre long Er/Yb fibre amplifier. The amplifier is pumped by a Nd:YAG laser whose output is stabilised by feedback to an acousto-optic modulator which reduces pump power fluctuations to ~2%. The laser is started by adjusting the polarisation controllers to set the correct

phase bias in the NALM for soliton pulses to be generated. With the laser operating in the soliton regime stable harmonic modelocking was achieved at repetition rates of up to 2.1 GHz. Fig. 2a shows the RF spectrum of the laser output intensity at a repetition rate of 2.085 GHz which is the 369th harmonic of the fundamental cavity frequency. Several adjacent modes are also present in the spectrum. This is due to the residual fluctuations in the pump power which because of the quantisation of the soliton energy causes extra pulses to be created or pulses to disappear from the cavity. Further improvements in the pump stability would be required to reduce the number of modes present in the RF spectrum. Fig. 2b shows the corresponding optical spectrum with a width of 4.5 nm which indicates a pulsewidth of 560 fs. The repetition rate is stabilised by refractive index changes in the MQW acting as a passive phase modulator. Briefly stated, when a pulse is incident on the semiconductor the excitation of free carriers generates a negative change in refractive index [2]. Relaxation of the carriers drives the refractive index back towards the unsaturated value. When the next pulse arrives the time dependence of the refractive index provides phase modulation of the pulses which retimes the pulses and stabilises the repetition rate.

In conclusion we have demonstrated a stable repetition rate of over 2 GHz from a harmonic passively modelocked fibre soliton laser which is potentially very useful as a source of subpicosecond optical pulses.

References

1. S. Gray and A.B. Grudinin, submitted to Optics Letters.

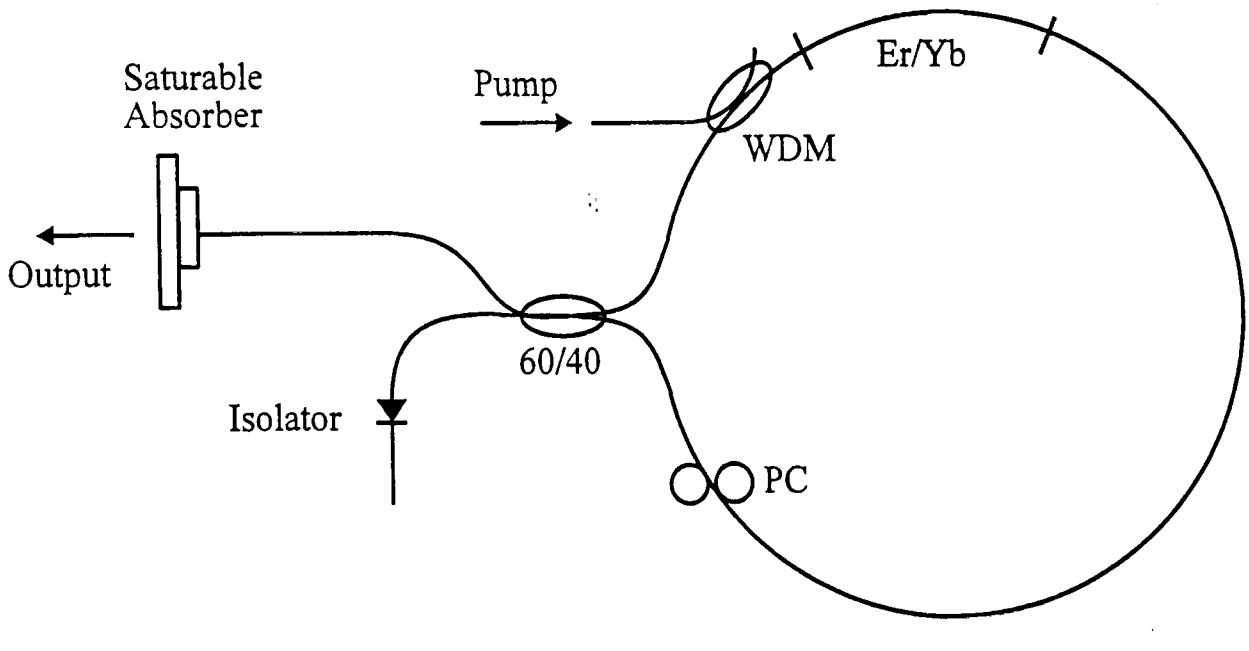
2. J.E. Ehrlich, D.T. Nielson, A.C. Walker and M. Hopkinson, Optics Communications, **102**,473 (1993).

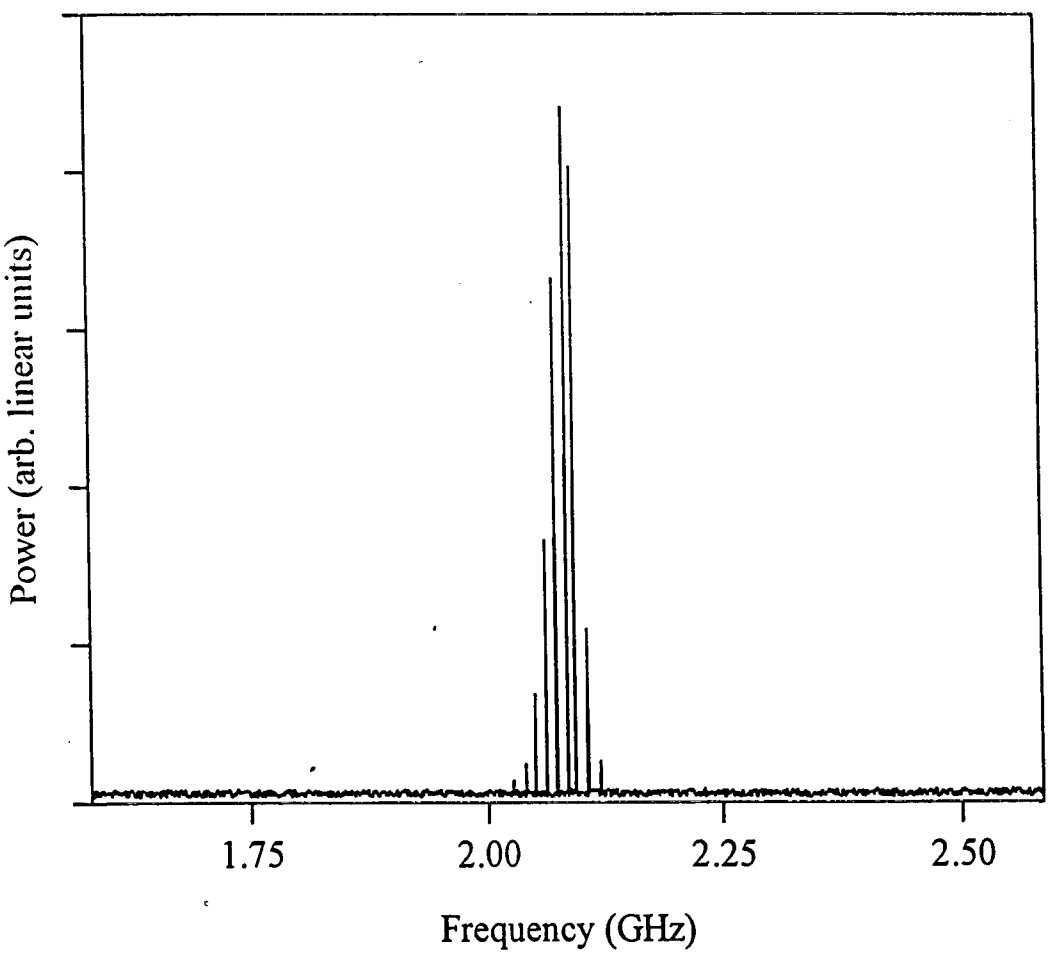
Figure Captions

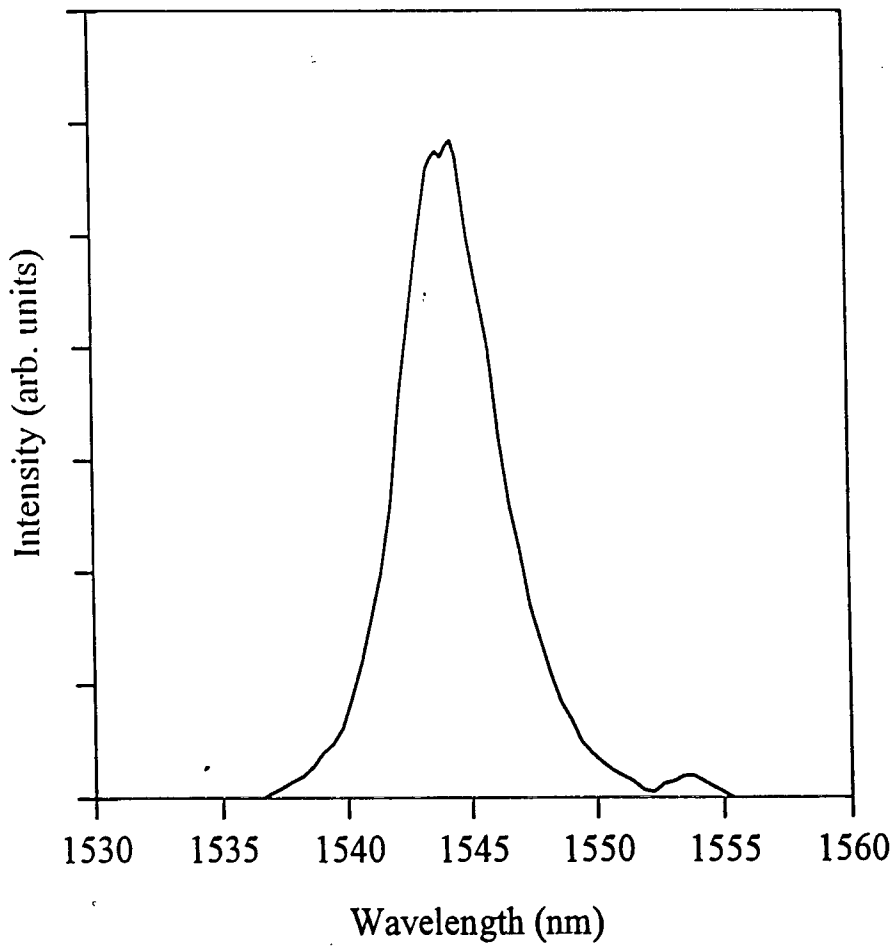
Fig. 1. Laser configuration.

Fig. 2a. RF spectrum of the laser output intensity at a repetition frequency of 2.085 GHz.

Fig. 2b. Optical spectrum of soliton pulses generated by the laser.


Saturable
Absorber
Pump
Er/Yb
WDM
Output
60/40
Isolator
PC


Power (arb. linear units)
1.75
2.00
2.25
2.50
Frequency (GHz)


Intensity (arb. units)
1530
1535
1540
1545
1550
1555
1560
Wavelength (nm)