40 GHz modulational instability erbium-doped fibre ring laser incorporating a sampled fibre Bragg grating

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Abstract

A 40 GHz modulational instability erbium-doped fibre laser in an all-fibre ring configuration is demonstrated utilising a sampled fibre Bragg grating. Transform limited pulses as short as 4.4 ps have been achieved with low threshold.

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Summary

The increasing demand in transmission bandwidth calls for a full exploitation of optical fibre bandwidth potential by wavelength division multiplexing and optical time division multiplexing (OTDM). In OTDM systems, laser sources with high repetition rates are essential. Modulational instability (MI) can be used to generate continuous short-pulse trains at high repetition rates [1]. Recently, a low threshold MI laser employing a bulk Fabry-Perot filter and a bandpass filter has been reported [2]. Similar spectral characteristics can be offered by a sampled fibre Bragg grating [3]. This paper presents, for the first time, an all-fibre mode-locked fibre ring laser utilising a sampled fibre Bragg grating operating at a repetition rate of 40 GHz.

The schematic of the ring laser is illustrated in Figure 1. The erbium amplifier has a saturated output power of 12.5 dBm. The zero dispersion wavelength of the 2 km length of dispersion-shifted fibre (DSF) is 1528 nm. A polarising optical isolator ensures unidirectional operation in the laser cavity and a sampled fibre Bragg grating is used in conjunction with a 3 dB fibre coupler to achieve the cavity filtering.

The sampled grating is made through a periodic modulation in the refractive index profile with a digital sampling function to generate the sinc-shaped envelope (Figure 2). A duty cycle of 1:8 generates 7 channels within the 2.8 nm of envelope half-width, whilst the modulation period of 2.54 mm results in a channel spacing of 40 GHz [4]. The sampled grating exhibits combined features of both a Fabry-Perot filter and a bandpass filter. It has a free-spectral range of 40 GHz with a finesse of 10, which confines the lasing line separation. Its spectral envelope centred at 1532 nm acts as a bandpass filter for supermode noise suppression [5]. Pulse trains are generated by modulational instability in the DSF [2].

Figure 3(a) and (b) show the optical spectrum and autocorrelation trace of the laser output at 40 GHz repetition rate. The laser gives an average output power of 5.5 dBm when mode-locked. The full-width half-maximum (FWHM) pulse width is 4.4 ps (assuming $sech^2$ pulse profile) and the spectral halfwidth is 0.65 nm. This corresponds to a time-bandwidth product of 0.36 implying near transform limited output pulses.

In conclusion, we have successfully shown the generation of picosecond pulse trains at high repetition rates in an all-fibre ring configuration. The ring laser has a simple configuration utilising a sampled fibre Bragg grating. The modelocking mechanisms are the combined actions of lasing spectral line confinement and overall filtering in the sampled grating, modulational instability in the DSF and polarisation switching through the polarising isolator. Transform limited pulses with pulse widths as short as 4.4 ps has been achieved. This compact diode-pumped ring laser has a low threshold and is useful for future high bit-rate lightwave communication.

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References

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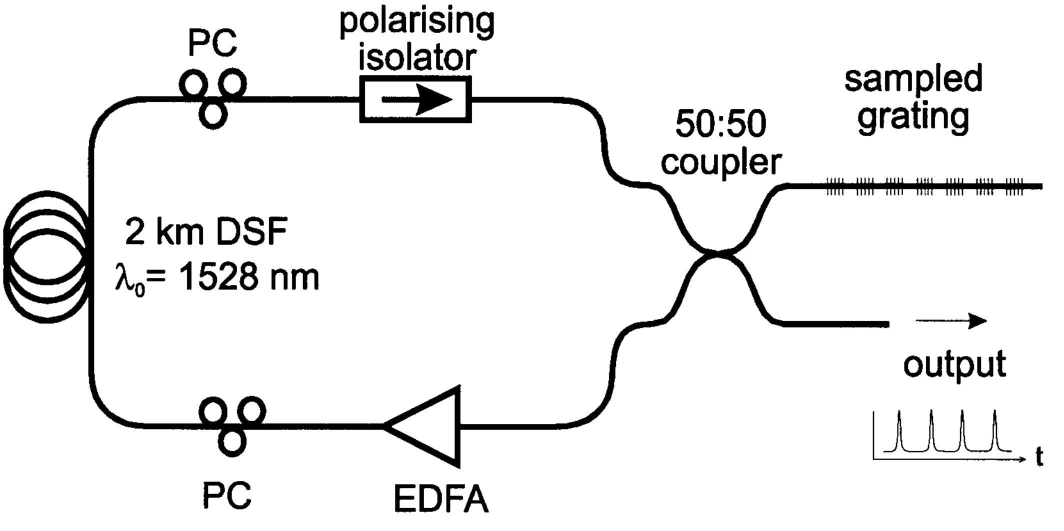
Figure Captions

Fig. 1 Schematic of the fibre ring laser.

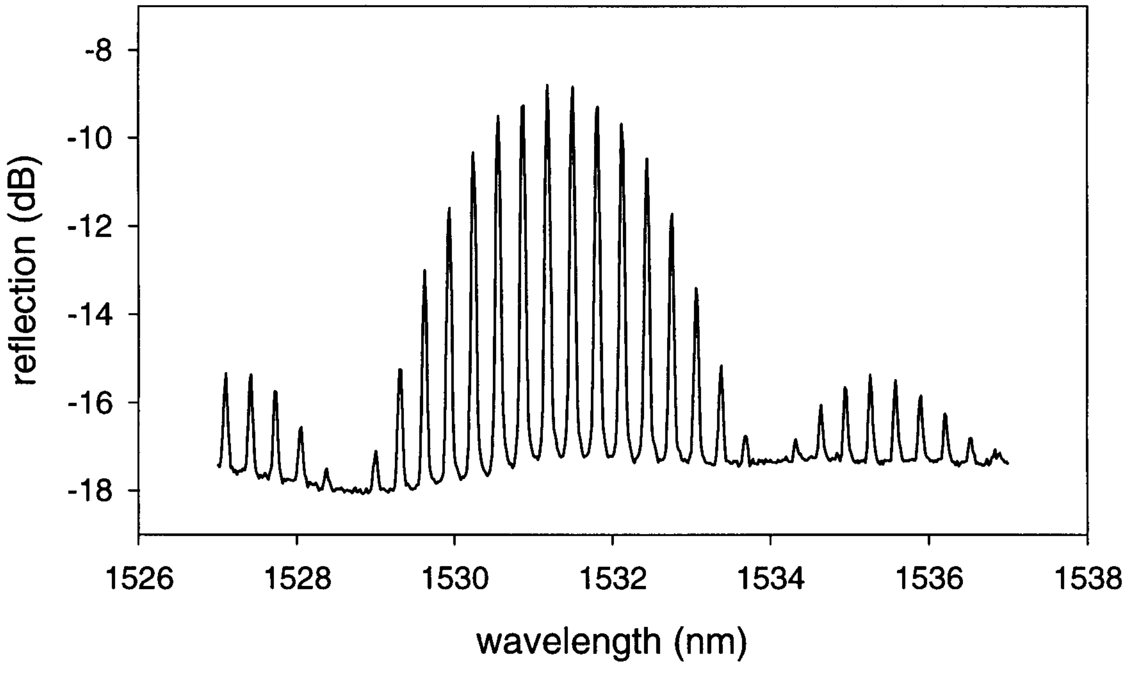
Fig. 2 Reflection characteristics of the sampled fibre Bragg grating.

Fig. 3 Laser output at 40 GHz. (a) Optical spectrum and (b) autocorrelation trace.



polarising
isolator
PC
sampled
grating
50:50
coupler
2 km DSF
λ0= 1528 nm
output
t
PC
EDFA

Figure 1



-8
-10
-12
-14
-16
-18
reflection (dB)
1526
1528
1530
1532
1534
1536
1538
wavelength (nm)

Figure 2

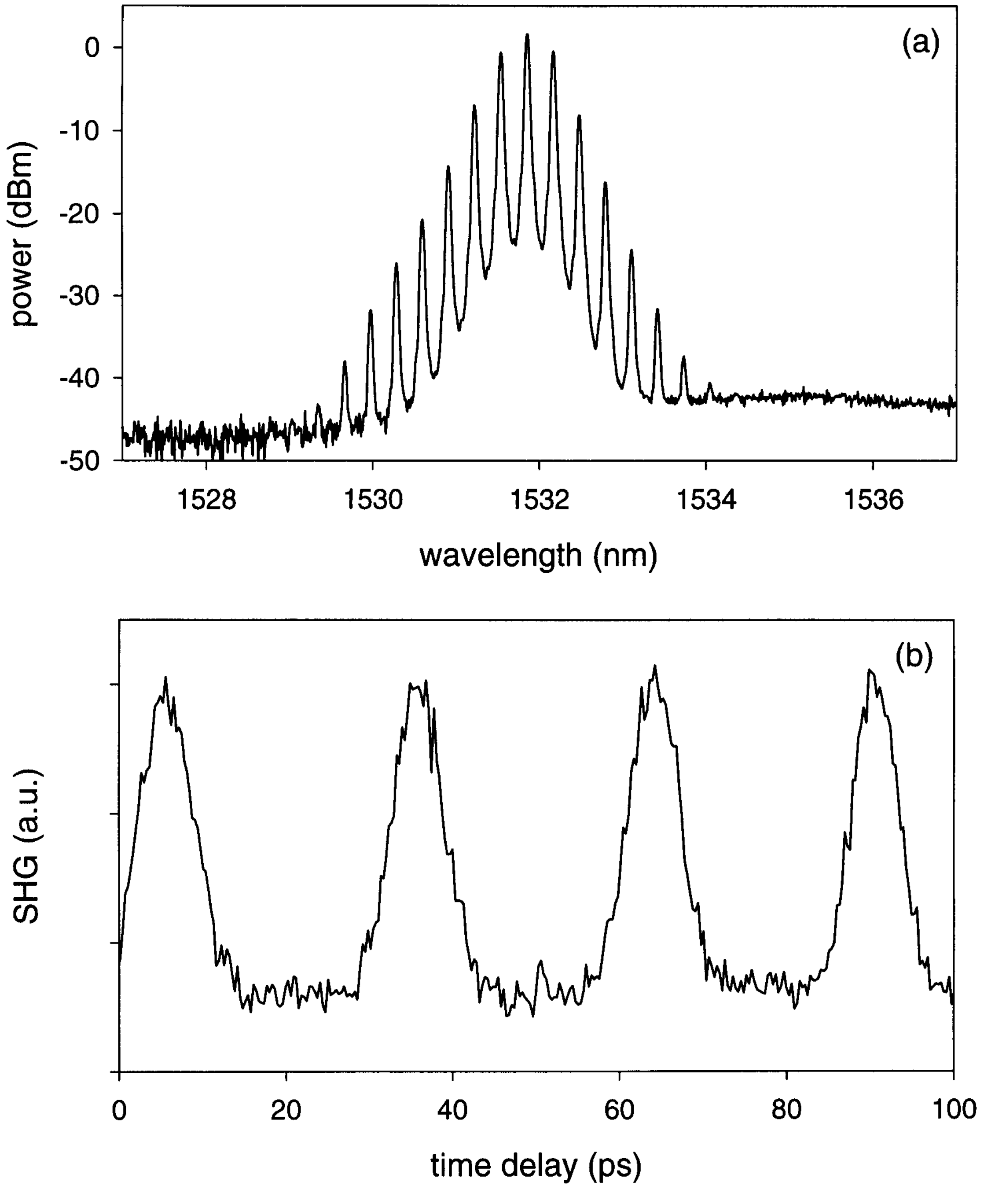

(a)
power (dBm)
0
-10
-20
-30
-40
-50
1528
1530
1532
1534
1536
wavelength (nm)
(b)
SHG (a.u.)
0
20
40
60
80
100
time delay (ps)

Figure 3