Superfluorescent Er/Yb Single-mode Fibre Source With 1 Watt Output Power

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Abstract

We describe a superfluorescent Er/Yb single-mode fibre source capable of generating 1 Watt of output power with variable bandwidths between 0.5 nm and 4 nm.

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Superfluorescent sources based on rare-earth doped single-mode fibres [1,2] are potentially useful in many applications where high brightness, low coherence and large bandwidth are required. These include sensors such as the fibre gyroscope and low coherence reflectometry systems. Additionally, the quiet continuous wave (cw) output characteristic obtained with a fibre based superfluorescent source contrasts strongly with the spiking on a microsecond timescale typical of fibre laser oscillators of similar power. One application of the source described here is to pump a fibre Raman amplifier for which a stable cw output is necessary.

In constructing a high power fibre superfluorescent source it is necessary to design the system so as to avoid inducing laser oscillation from the feedback due to Rayleigh back scattering [3]. This can be achieved by seeding a high power amplifier with a saturating signal from a low power amplified spontaneous emission (ASE) source [4]. By this method it is possible to extract almost as much power as can be obtained from a fibre laser under similar excitation.

The source is shown schematically in figure (1). It consists of an ASE seed source and two stages of amplification backward pumped by up tp 4.5W of light from a Nd:YLF laser operating at 1053 nm. The 125 μm diameter Er/Yb fibre is doped with 8000 ppm of Ytterbium, 600 ppm of Erbium, has a NA of 0.19 and an LP_{11} cutoff wavelength of 1350 nm. The three stages are separated by polarization independent isolators with >30 dB isolation thereby ensuring that the gain per stage is below the level required for lasing. Wavelength division multiplexers (WDM) link each section to allow the pump to bypass the isolators.

The length of each section was adjusted to achieve the maximum total output power. The length of the ASE source was limited to 5 metres to prevent lasing at 1535 nm. With the filter removed from the cavity and doped fibre lengths of 10.5 metres in the output amplifier, 5 metres in the preamplifier and 5 metres in the ASE source a maximum output power of 1.03 watts was generated. The spectra of the ASE seed and amplified output are shown in figures (2a) and (2b) respectively. The peak at 1544 nm in the output spectrum has a 3 dB bandwidth of 4 nm and by using an appropriate filter it should be possible to achieve a flat spectral profile over ~10 nm.

To generate narrow bandwidths suitable for a Raman pump a filter formed by a reflective Bragg grating centred at 1535 nm and bandwidth of 0.5 nm was placed after the ASE seed source. The maximum output power for this case was 980 mW but in the final amplifier stage the spectrum developed a pedestal extending up to 1570 nm as shown in figure (3a). The pedestal could be suppressed by shortening the output amplifier but at the expense of output power. Instead the light was passed through a 1535/1560 nm WDM which filtered out the long wavelength elements to give the spectrum shown in figure (3b).The output power after filtering was 900 mW.

In conclusion, we have developed a superfluorescent single-mode fibre source capable of delivering 1 Watt of optical power. By appropriate filtering the spectrum can be manipulated to suit the requirements of different applications.

References

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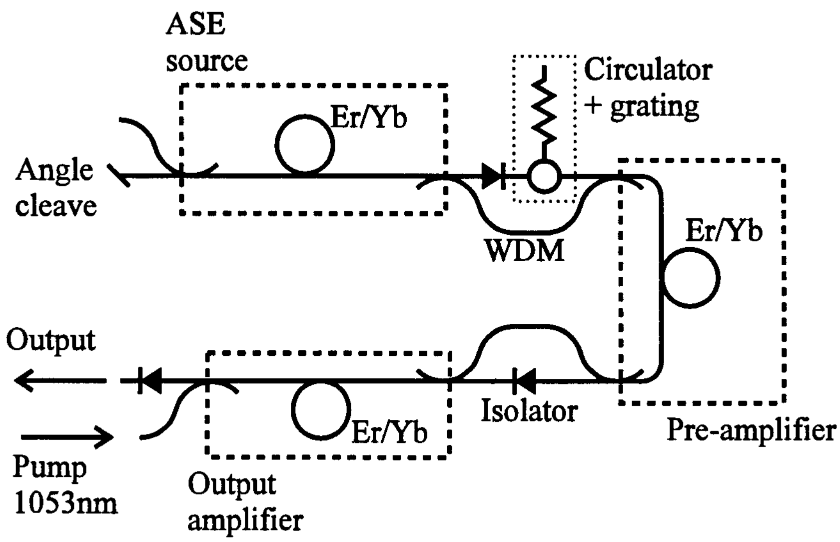
Figure Captions

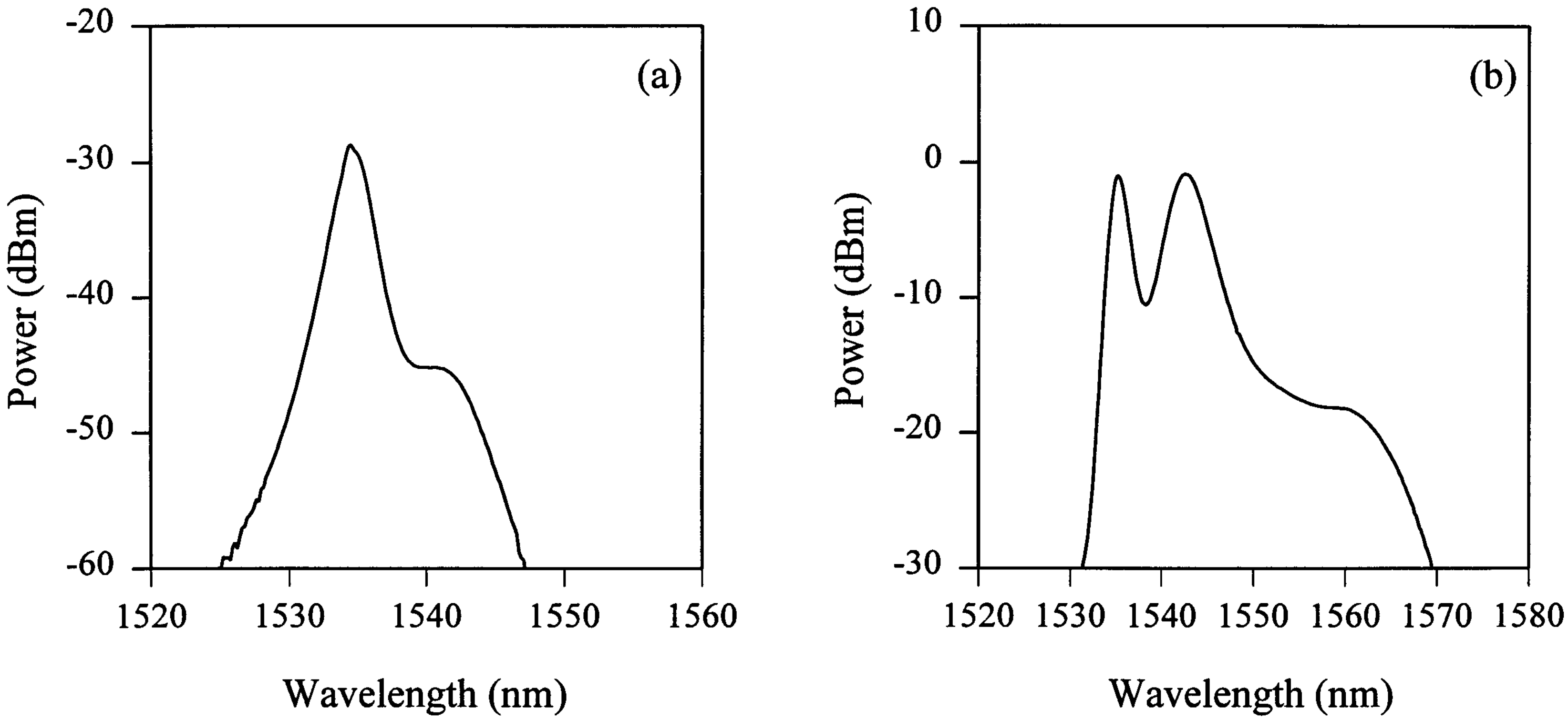
1. Configuration of the superfluorescent source.

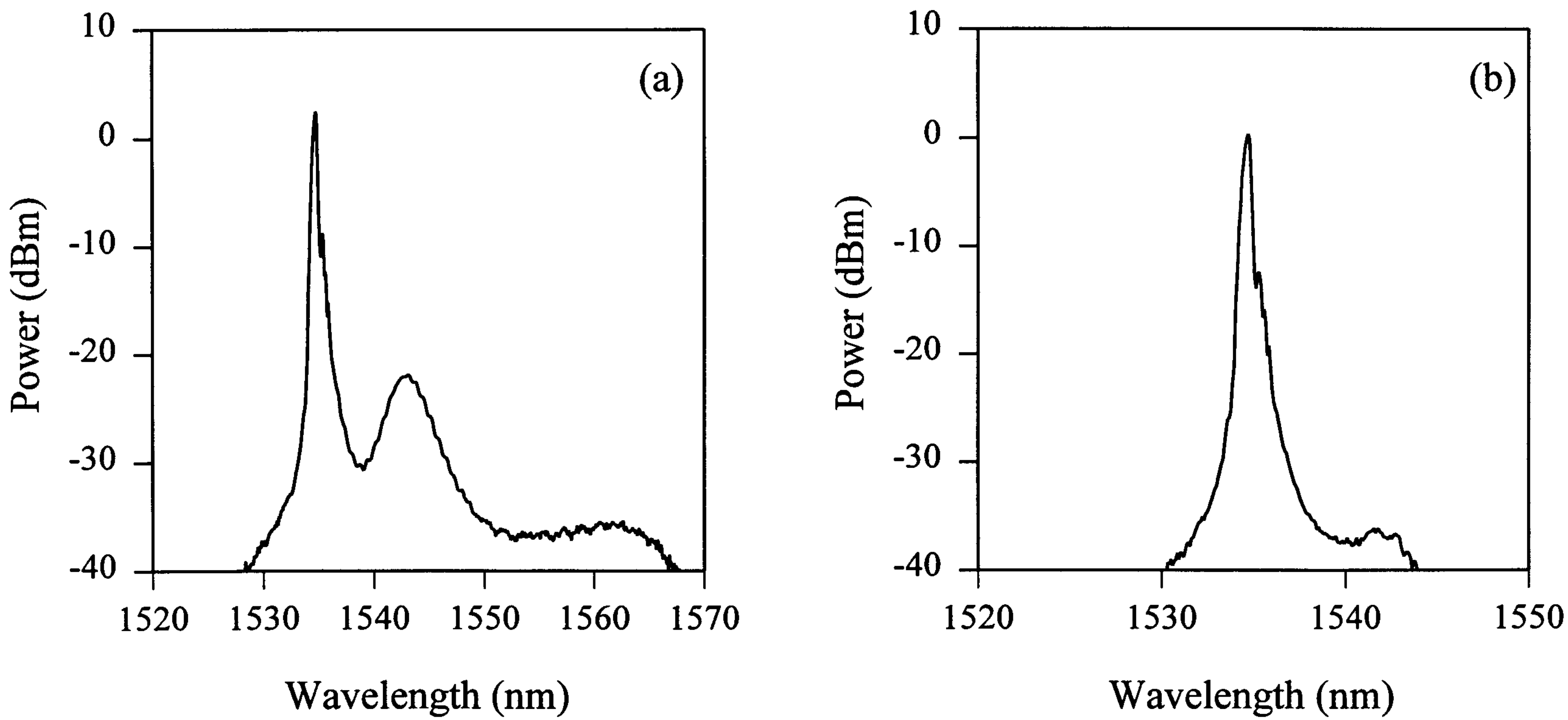
2. Optical spectra of (a) ASE seed source and (b) amplified output for an unfiltered system.

3. Optical spectra of (a) narrow bandwidth output generated using a reflection grating filter and (b) narrow bandwidth ouput after filtering through a WDM.



ASE
source
Er/Yb
Circulator
+ grating
Angle
cleave
Er/Yb
WDM
Output
Pump
1053nm
Er/Yb
Isolator
Output
amplifier
Pre-amplifier


(a)
Power (dBm)
-20
-30
-40
-50
-60
1520
1530
1540
1550
1560
Wavelength (nm)
(b)
Power (dBm)
10
0
-10
-20
-30
1520
1530
1540
1550
1560
1570
1580
Wavelength (nm)


(a)
(b)
Power (dBm)
Power (dBm)
10
0
-10
-20
-30
-40
10
0
-10
-20
-30
-40
1520
1530
1540
1550
1560
1570
1520
1530
1540
1550
Wavelength (nm)
Wavelength (nm)