SUBMITTED TO OFC'97

C-00095

1296

Passive spectral gain control of a 4-channel WDM link employing twincore erbium doped fibre amplifiers

Christian V. Poulsen, Oliver C. Graydon, Richard I. Laming,

Mikhail N. Zervas and Liang Dong

Optoelectronics Research Centre
University of Southampton
Southampton
SO17 1BJ
UK

tel +44 1703 593141
fax +44 1703 593142
E-mail cp@orc.soton.ac.uk

Abstract: A channel power equalising WDM link using twincore erbium doped fibre amplifiers showing inhomogeneous properties has been investigated. Non-divergent and self regulating propagation of a 4 wavelength channel systems is demonstrated employing twincore EDFAs.

Introduction: Wavelength Division Multiplexing (WDM) is proving to be the preferred choice for expanding the capacity of optical communication systems. Using this technique bit rates exceeding 1 Terrabits/s have been demonstrated [1]. However, due to the combination of the gain spectrum and the predominantly homogeneous properties of erbium ions in silica glass the different wavelength channels will diverge. A new technique to overcome this problem is presented employing twincore erbium doped fibre amplifiers (TC-EDFAs) that induce inhomogeneous broadening in the gain medium at room temperature [2,3]. A 4-channel WDM link using cascaded TC-EDFAs is presented. It is demonstrated experimentally that the TC-EDFA can passively compensate for the wavelength dependence of the erbium gain spectrum thus allowing non-divergent and self regulating propagation of individual channel powers.

Experiment: The experimental setup of the TC-EDFA is shown in Figure 1. The twincore fibre is fabricated with two identical Er-doped cores of $GeO_2/Al_2O_3/SiO_2$ composition with a peak absorption of 6 dB/m at 1530 nm. The cores have a radius of 1.5 μm, NA of 0.27 and a separation 4.5 μm. The TC-EDFA is pumped with 180 mW of pump light from a 980 nm laser diode.

Results: Four multiplexed channels spaced 1 nm apart from 1550 nm to 1553 nm were launched into the TC-EDFA. To simulate a WDM link employing a cascade of identical TC-EDFAs a single amplifier stage and a feed-back technique were used. The interstage loss is 13 dB corresponding to an amplifier spacing of 65 km assuming a fibre loss of 0.2 dB/m. For a

comparison the experiment was also carried out using equivalent conventional EDFAs operated under identical conditions.

In Figure 2a and Figure 2b the output powers are shown for the TC-EDFA and the conventional EDFA. The 14-stage link corresponds to a total distance of 910 km. To demonstrate the self regulating properties of the TC-EDFAs, an extra 5 dB loss was introduced at 1553 nm after the fifth stage. In the case of the conventional EDFA, the different wavelength channels slowly spread as number of stages is increased (Figure 2b), where as in the case of the TC-EDFA the channels are self regulating (Figure 2a). In figure 2c the powerspread is plotted showing that the TC-EDFA is self-healing with ~0.2 dB per stage clearly demonstrating the inhomogeneous properties of the TC-EDFA.

Stabilization of the powers of the individual channels is accomplished by hole generation which exactly compensates for the shape of the gain spectrum. To evaluate the hole depth, the gain spectrum around the saturating signal was measured. A second weak modulated probe signal was fed into the TC-EDFA and monitored at the output using a lock-in amplifier. The hole depth is found to be an increasing function with the strength of the saturating. Consequently, channels with weaker powers generate shallower holes and receive greater gains. It is this characteristic which gives the TC-EDFA self-healing properties. However, for very large input powers the TC-EDFA over-saturates and the hole depth reaches a maximum, in this case 4 dB, corresponding to an upper limit for the equalisation.

Conclusion: A new amplifier type has been investigated incorporating inhomogeneously broadened twincore erbium doped fibre amplifiers. The self regulation of individual channel powers in a 4-channel WDM link has been demonstrated and a hole depth of up to 4 dB has been measured in the gain spectrum. Further improvement of the twincore fibre design will make it possible to employ even more (16-32) channels in a non-divergent WDM link and achieve polarisation insensitivity.

Acknowledgements: This work was supported through an EPSRC ROPA award. R. I. Laming is a Royal Society University Research Fellow. The ORC is an EPSRC funded interdisciplinary research centre.

References:

[1] H. Onaka, H. Miyata, G. Ishikawa, K. Otsuka, H. Ooi, Y. Kai, S. Kinoshita, M. Seoin, H. Nishinoto and T. Chikama, "1.1 Tb/s WDM transmission over a 150 km 1.3 μm zero-dispersion single-mode fiber", Postdeadline paper PD19, OFC'96.

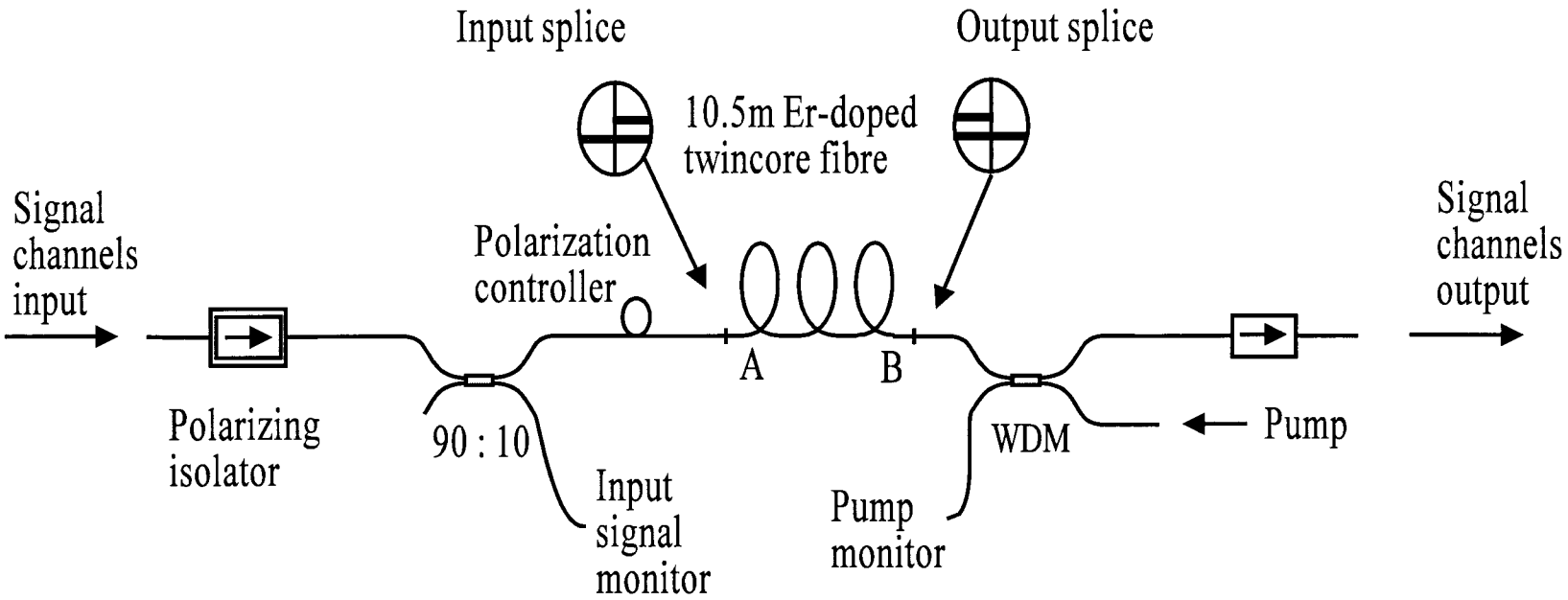
[2] R. I. Laming, J. D. Minelly, L. Dong and M. N. Zervas: "Twin-core erbium-doped fibre amplifier with passive spectral gain equalisation", Electronics Letters, 1993, Vol. 29, No. 6, pp. 509-510.

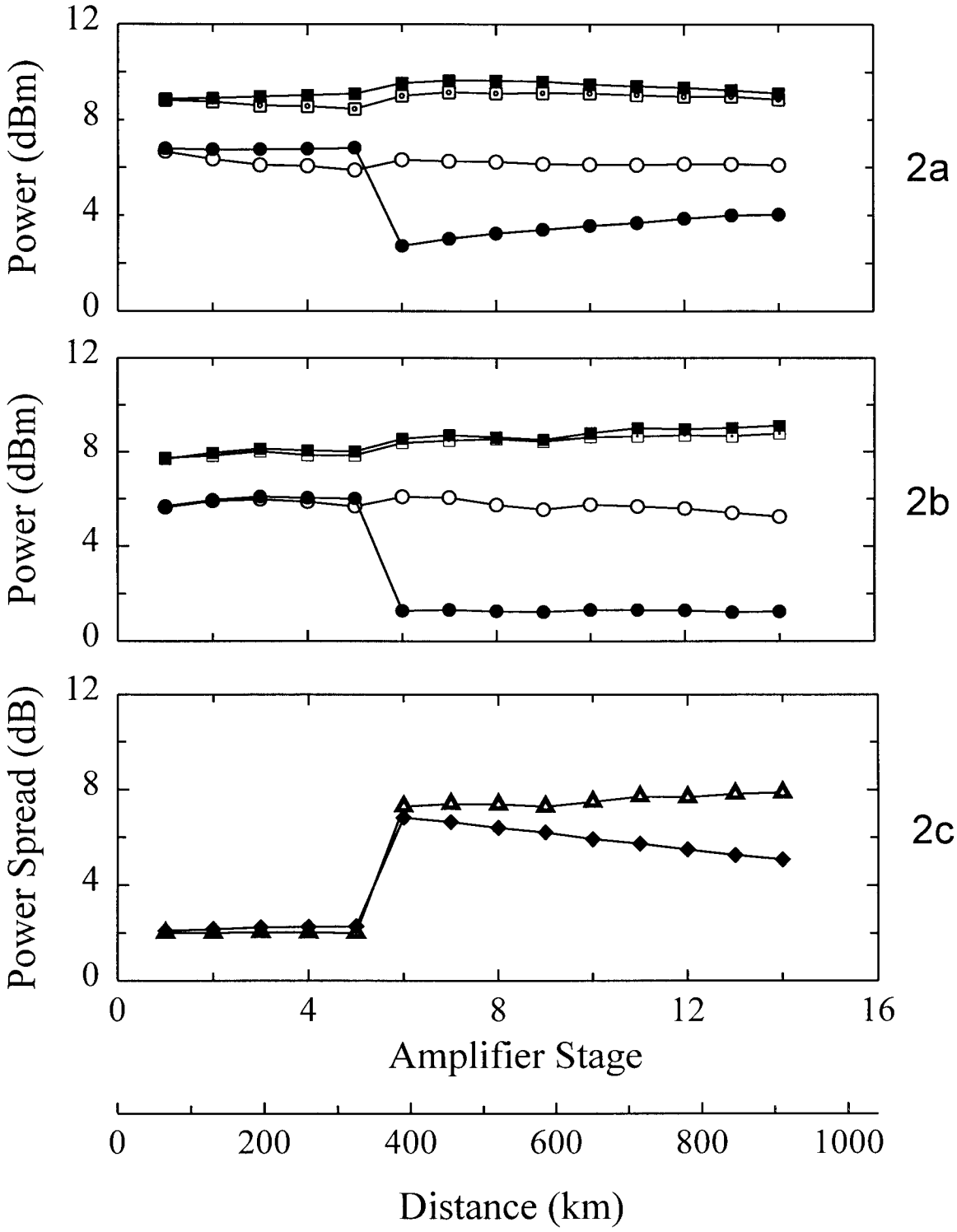
[3] M. N. Zervas and R. I. Laming.: "Twin-core fiber erbium-doped channel equaliser", Journal of Lightwave Technology, 1995, Vol. 13, No. 5, pp. 721-731.

Figure Captions:

Figure 1. Experimental setup of the twincore erbium doped fibre amplifier.

Figure 2. The output powers of a 14-stage WDM link with 4 wavelength channels employing TC-EDFAs (2a) and conventional EDFAs (2b). The powerspread in the two cases is shown in Figure 2c.


Input splice
Output splice
10.5m Er-doped
twincore fibre
Signal
channels
input
Polarization
controller
Signal
channels
output
A
B
Polarizing
isolator
90 : 10
Input
signal
monitor
WDM
Pump
Pump
monitor


Power (dBm)
12
8
4
0
2a
Power (dBm)
12
8
4
0
2b
Power Spread (dB)
12
8
4
0
2c
0
4
8
12
16
Amplifier Stage
0
200
400
600
800
1000
Distance (km)