INTEGRATION OF FIBRE COMPONENTS AND AMPLIFIERS

DAVID N. PAYNE

**OPTOELECTRONICS RESEARCH CENTRE, THE UNIVERSITY,
SOUTHAMPTON, S09 5NH, UNITED KINGDOM
TEL : (703) 593583 FAX : (703) 593142**

Abstract

The prospects for fully-integrated all-fibre circuits including active rare-earth-doped elements are reviewed with particular reference to the erbium-doped fibre amplifier. The requirement for new fibre components is identified.

INTEGRATION OF FIBRE COMPONENTS AND AMPLIFIERS

DAVID N. PAYNE

OPTOELECTRONICS RESEARCH CENTRE, THE UNIVERSITY, SOUTHAMPTON, S09 5NH, UNITED KINGDOM
TEL : (703) 593583 FAX : (703) 593142

Summary

The driving force of telecommunications development has led to the availability of a large number of all-fibre components, for example, four-port couplers, wavelength filters, grating reflectors and polarisers[1]. Fibre components have the advantage that they are readily spliced into fibre networks with little insertion loss and consequently increasingly-complex fibre circuits have been reported, particularly for sensors and signal-processing applications. The recent development of rare-earth-doped fibre amplifiers and lasers provides an active element and virtually completes the range of fibre components with characteristics which match existing bulk or micro-optic devices. The question remains therefore whether these fibre elements can be hooked up to form an integrated fibre circuit technology.

The move to all-fibre circuitry is exemplified by the rapid development of the erbium-doped fibre-amplifier (EDFA), shown schematically in Figure 1. The amplifier itself demonstrates two of the advantages of all-fibre components, namely (a) the low splice loss and reflections which enable high-gain and low-passband ripple to be achieved and (b) the lack of polarisation sensitivity. These advantages are not offered by planar guided-wave or bulk components. For example, no designer would consider the use of a bulk or planar beamsplitter at the input of the amplifier to introduce the pump light. Note that Figure 1 simultaneously shows all desirable fibre components and includes both a gain-flattening filter[2] and an amplified spontaneous emission (ASE) filter at the output. In practice, these two components would not be simultaneously used, the former having application in a line amplifier, where the latter is more suited to a pre-amplifier.

Reference to the Figure immediately identifies two fibre components which are not readily available, namely isolators and a bandpass ASE filter. Although all-fibre isolators have been reported[3], there seems little prospect at present of a practical version becoming available and therefore polarisation-insensitive, pigtailed bulk or micro-optic components must suffice. However, for the narrow-bandpass ASE filter prospects are more favourable and both fibre Fabry-Perot etalons[4] and grating resonators[5] (either etched or photorefractive) have been reported.

The availability of gain-switched diode-lasers and EDFAs have made possible the generation of high-power, short pulses with relative ease. This has allowed a number of non-linear fibre devices to be assembled, such as amplified non-linear optical loop

mirrors[6], soliton fibre lasers[7,8] and non-linear bitstream multiplexers and demultiplexers[9]. In addition, the fibre laser itself has emphasised the need to assemble low-loss, functional, all-fibre circuits, particularly for the extensive work currently underway on mode-locked soliton sources. This latter application, in particular, has identified the requirement for an all-fibre, high-frequency phase or amplitude modulator to replace the relatively-lossy integrated optic mode-locker currently used.

In conclusion, much recent progress has been made in integrating fibre components to form a comprehensive optical wiring technology. The development of fibre lasers and amplifiers has accelerated this progress by demonstrating both the advantages of all-fibre components, as well as the need for additional fibre devices. The balance between micro-optic (pigtailed) components and their all-fibre counterparts is currently uncertain and may well ultimately be decided upon cost.

References

1. See for example C.M. Miller, Passive Component Technologies Tutorial WD1, Proc. OFC 1989, p. 155, Houston, Texas.

2. M. Tachibana, R.I. Laming, P.R. Morkel & D.N. Payne:
"Erbium-doped fibre amplifier with flattened gain-spectrum",
to be published in Photonics Technology Letters.

3. G.W. Day, D.N. Payne, A.J. Barlow & J.J. Ramskov-Hansen:
"Faraday rotation in coiled, monomode optical fibres : isolators, filters and magnetic sensors",
Optics Letters, Vol. 7, No. 5, pp. 238-240, 1982.

4. C.M. Miller & F.J. Janniello:
"Passively temperature-compensated fibre Fabry-Perot filter and its application in wavelength division multiple access computer network",
Electron. Lett., Vol. 26, pp. 2122-2123, 1990.

5. C.M. Ragdale, D. Reid, D.J. Robbins, J. Buus & I. Bennion:
"Narrowband fiber grating filters",
IEEE J. Selected Areas in Communications, Vol. 8, No. 6, p. 1146, 1990.

6. D.J. Richardson, R.I. Laming & D.N. Payne:
"Very low threshold Sagnac switch incorporating an erbium-doped fibre amplifier",
Electron. Lett., Vol. 26, No. 21, pp. 1799-1781, 1990.

7. See for example L. Mollenauer, Solitons in the ultra long-distance transmission Tutorial WD1, Prof. OFC 1991, San Diego, California, p. 164.

8. D.J. Richardson, R.I. Laming, D.N. Payne, V. Matsas & M.W. Phillips:
"Self-starting, passively mode-locked erbium fibre ring laser based on the amplifying Sagnac switch",
Electron. Lett., Vol. 27, No. 6, pp. 542-544, 1991.

9. A. Takada, K. Aida & M. Jinno:
"Demultiplexing of a 40 Gb/s optical signal to 2.5Gb/s using a non-linear fiber loop mirror driven by amplified, gain-switched laser diode pulses",
Proc. OFC 1991, San Diego, California, Paper TuN3, p. 50.

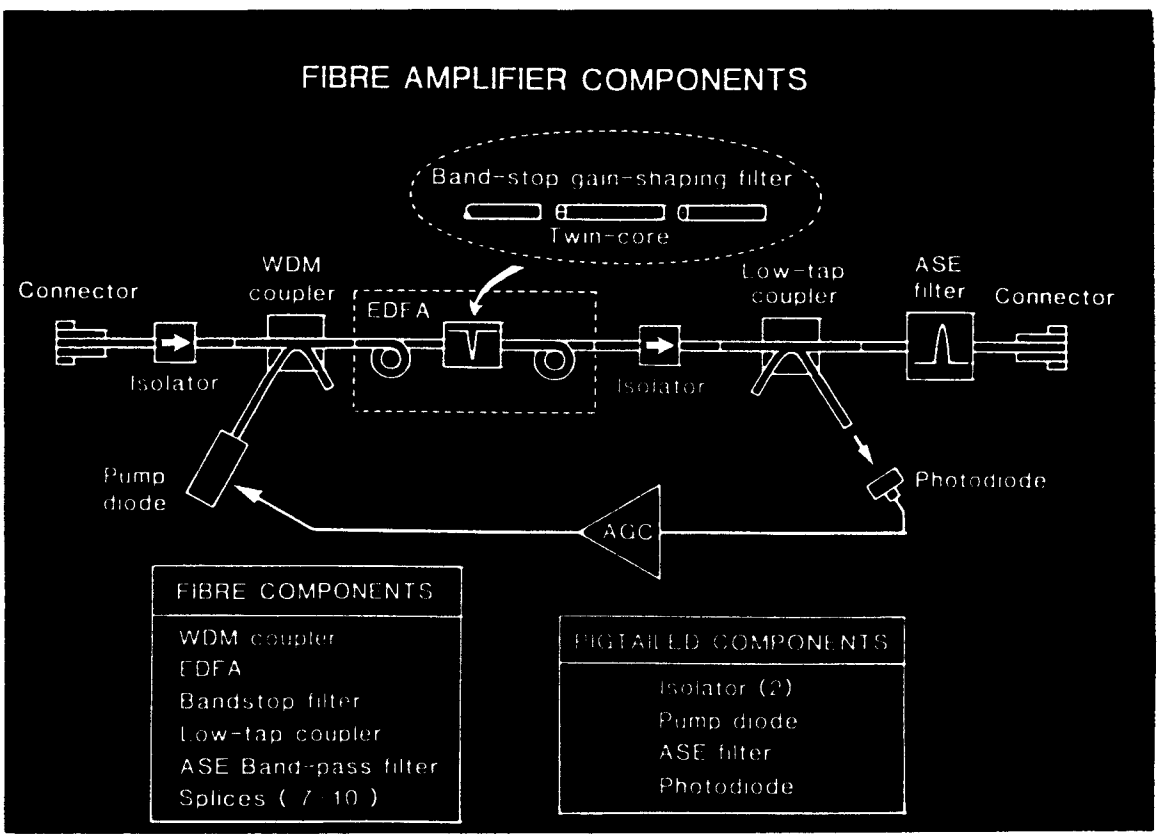

Figure 1 Component parts of a fibre amplifier