Several switch arrays were AR coated to obtain a reduction of the optical feedback and for improved coupling; a minimum fibre-to-fibre loss of 4dB at 100mA injection current was observed. Switches with 0dB fibre-to-fibre insertion loss are expected to be obtainable by using longer integrated amplifiers, providing a larger signal gain.

Conclusions: Monolithic 2 × 2 InGaAsP/InP laser amplifier gate switch arrays have been fabricated and evaluated. Measured switch characteristics include net chip gain, low fibre-to-fibre insertion loss, high extinction ratio of 40–50dB for both bar and cross states of operation, and high electrical isolation between the integrated laser amplifiers. It is of interest to scale this structure to larger switches because SCLA gate switch arrays have potential for switch sizes of the order of 16 × 16 or even 32 × 32 [8].

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M. Janson, L. Lundgren, A.-C. Mörner, M. Rask and B. Stoltz (*Opto and Microwave Electronics Division, Ericsson Components AB, S-164 81 Kista, Sweden*)

M. Gustavsson and L. Thylén (*Fiber Optics Research Center, Ericcson Telecom AB, S-126 25 Stockholm, Sweden*)

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PASSIVE, ALL-FIBRE SOURCE OF 30 fs PULSES

D. J. Richardson, A. B. Grudinin and D. N. Payne

Indexing terms: Pulse generation, Lasers, Optical fibres

The passive generation of solitonic pulses as short as 30fs from an all-fibre circuit is reported. The circuit comprises a passively mode-locked erbium-doped fibre laser, an erbium-doped fibre amplifier and a short section of dispersion-shifted fibre.

Advances in erbium-doped fibre fabrication, and more recently in the generation and amplification of ultrashort pulses [1–5], make the development of sub-100fs passive, pulse sources based on erbium-doped fibre a very attractive proposition.

Recently, a source of transform-limited 320fs pulses from a passively mode-locked fibre laser has been reported [4, 5]. One possible way to generate still shorter pulses is to exploit the pulse compression effects which occur during soliton amplification in a fibre amplifier [3]. We report the results of an experimental study of both the temporal and spectral characteristics of pulses generated within an integrated all-fibre unit containing a passive erbium-doped figure-eight fibre laser, an erbium-doped fibre amplifier and (optionally) a short section of undoped dispersion-shifted fibre. The unit is potentially diode pumpable and could therefore lead to a compact and robust source of ultrashort pulses in the 1550–1650nm wavelength region.

The experimental configuration is shown in Fig. 1. The nonlinear amplifying loop mirror (NALM) had a length of 35m and the gain was provided by a 3m section of 800 *ppm* erbium doped fibre ($NA = 0{\cdot}15$, $\lambda_{co} = 960$nm). The cavity round trip period was 5MHz. The performance of the figure-eight passively mode-locked laser had been described elsewhere [4]. With just 20mW of launched pump power at 980nm, a power easily obtainable from a laser diode, the laser produces bandwidth-limited soliton pulses with a duration of 450fs. The average output power in this instance was 120μW, with approximately 10 pulses circulating within the laser cavity. From the laser output coupler the pulses were delivered to an external cavity, pulse-compression amplifier which consisted of a length of erbium-doped fibre ($NA = 0{\cdot}15$, $\lambda_{co} = 1230$nm) with an Er^{3+}-doping level of 800 *ppm*. In our experiments both the amplifier and mode-locked laser were pumped from a common Ti : sapphire laser.

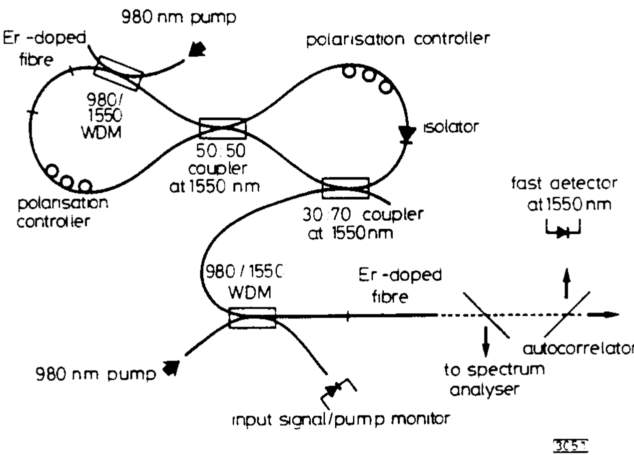

Fig. 1 *Experimental configuration*

It has been very recently shown that intracavity, the figure-eight laser supports fundamental order type solitons ($1 < N < 1{\cdot}4$ as measured in the isolator loop) [6]. Allowing for the 30% output coupling from the laser, and the discrete change in dispersion between the passive input and amplifier fibre we have a pulse with a soliton number of $N \simeq 0{\cdot}2$ at the amplifier input. Thus as the pulses propagate over the first few metres of the amplifier they increase their energy without experiencing significant nonlinear effects (the pulses broaden slightly due to the bandwidth-limited gain). When the pulse attains an energy close to that of the fundamental soliton the nonlinear effects such as the soliton self-frequency shift (SSFS) and soliton compression become significant and the bandwidth-limited amplification process becomes more complicated [2, 7]. As the pulse energy further increases, multi-soliton compression becomes dominant and results in an abrupt decrease in pulse width. The SSFS then attempts to split the pulse into its individual fundamental Raman soliton components. This effect results in the generation of a single or a few sub-100fs solitons, each with different central frequencies [1, 3, 9]. Note that the discussion above is somewhat simplified and that higher order effects such as resonant dispersion [8] and third order dispersion will each play a role in the amplification and compression process.

With the initial amplifier length of 5·5m and a pump power of 320mW, a total power gain of 29dB was obtained and pulse compression from 450fs down to 90fs was observed at the fibre output (Fig. 2), together with a wavelength shift (inset). The spectral spike at the input signal wavelength (Fig. 2) is due to incomplete energy transfer from the amplified pulse to the SSFS soliton. The time-bandwidth product for these pulses is 0·3, in reasonable agreement with that expected for a $\mathrm{sech}^2 x$ pulse shape. Thus, during soliton amplification and propagation we have transformed 450 fs fundamental solitons at 1·56 μm into 90 fs solitons at 1·59 μm. At higher amplifier gains, high-order soliton breakup into coloured solitons due to SSFS was observed, the individual pulse widths being of the order of 100 fs [9].

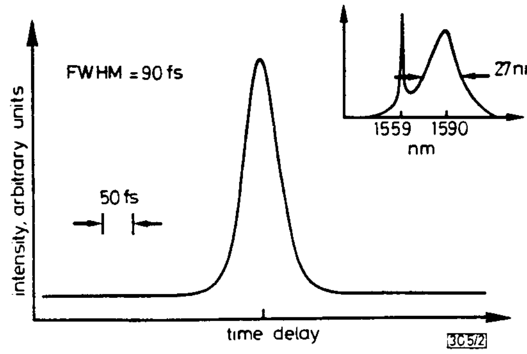

Fig. 2 *Background free autocorrelation trace and spectrum of 90 fs fundamental soliton pulses obtained at end of 5·5 m long EDFA section*

The amplifier length was gradually cut back to reduce the SSFS at the amplifier output and the amplifier pump adjusted slightly to obtain the shortest possible, single, high-order soliton pulse, as shown in Fig. 3. The half width of the pulse in this instance was approximately 50 fs, the amplifier length 3·2 m and the gain 30 dB. A short length (~30 cm) of undoped, dispersion-shifted fibre was then spliced to the amplifier output to obtain further pulsewidth reduction by high-order soliton compression. The dispersion of the fibre used was 3·5 ps/nm/km within the 1·55–1·61 μm wavelength range. In this case, at the pulse evolution 'focal point' within the dispersion-shifted fibre, the pulse duration is comparable to the Raman response time. We therefore expect SSFS to have a great influence on the pulse evolution, resulting in both temporal and spectral separation of the short central spike from the rest of the pulse and yielding compressed pulses at the output of the dispersion-shifted fibre. Using this technique

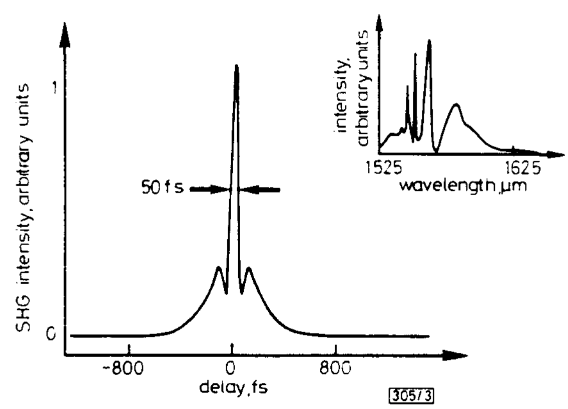

Fig. 3 *Background free autocorrelation trace and spectrum of 50 fs soliton pulses obtained at end of 3·2 m long EDFA section*

Total amplifier gain = 30 dB

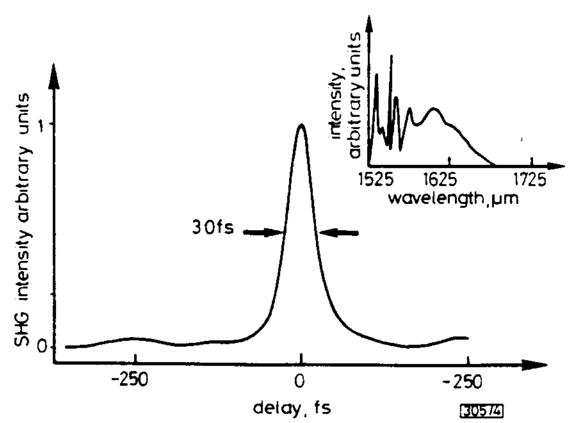

Fig. 4 *Background free autocorrelation trace and spectra of 30 fs soliton pulses obtained by compressing pulse shown in Fig. 3 within 22 cm long section of dispersion shifted fibre*

we have obtained reasonably clean pulses with durations as short as 30 fs at 1·59 μm (Fig. 4). At higher pump powers we once again observed coloured soliton generation.

In conclusion, we have demonstrated for the first time an integrated, all-fibre module capable of general solitonic pulses with durations as short as 30 fs within the 1·55 μm region. Repetition rate bursts as high as 1 GHz for ultrashort soliton pulses have been obtained.

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D. J. Richardson, A. B. Grudinin* and D. N. Payne (*Optoelectronics Research Centre, University of Southampton, Southampton SO9 5NH, United Kingdom*)

* On leave from Optical Fibre Department, General Physics Institute, USSR Academy of Sciences, 117942 Moscow

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COLLECTIVE-PROCESSING CORRELATOR SYSTEM FOR IMAGING RADIOMETER OF THINNED ARRAYS

K. Komiyama, Y. Kato and T. Iwasaki

Indexing terms: Radiometers, Remote sensing, Interferometry, Antenna arrays

A correlation processor is proposed for interferometric microwave radiometers of thinned arrays. In this system, each antenna signal is frequency-shifted by local signals of different frequency. These signals are gathered and processed collectively to generate correlation signals between all pairs of antennas. A conceptual design of the collective-processing correlator for a six-antenna thinned array is shown.

Introduction: Satellite microwave radiometers used for remote sensing presently have poor spatial resolution because of the limited aperture of the conventional receiving antenna.