Compression of Pulses from Soliton Fibre Lasers in a Dispersion-Decreasing Fibre

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We report high-quality adiabatic compression of 2-4 psec pulses from a passive all-fibre soliton ring laser operating at 1550 nm down to 250 fsec in a 1.6 km dispersion decreasing fibre (DDF). Compression of 600 fsec solitons from a Figure-8 fibre laser down to 100 fs in a 100m DDF was also obtained.

1. Introduction

Dispersion decreasing fibres (DDF) are promising tools for the compression of soliton pulses. It has been shown theoretically [1-3] that picosecond fundamental solitons can be adiabatically compressed during propagation along a fibre with slowly decreasing chromatic dispersion, the effect is similar to that of soliton compression during adiabatic soliton amplification. In the DDF technique the pulse remains a fundamental soliton as it propagates and conserves the input pulse energy. Its duration therefore decreases in proportion to the absolute value of dispersion. The behavior of femtosecond solitons in DDF is more complicated due to the Raman Self-Frequency Shift (RSFS) and third-order dispersion effects [4].

In this paper we report for the first time a demonstration of the adiabatic compression of both picosecond and subpicosecond solitons in DDFs. A passive mode-locked erbium fibre ring laser [5] and a Figure-8 [6] laser were used as sources of picosecond and subpicosecond soliton pulses respectively. 2-4 ps solitons from the ring laser were compresed upto 230 fs in a 1.6 km DDF (DDF1) having dispersion of 10 ps/nm/km and 0.5 ps/nm/km at 1550 nm at the input and output, respectively. Compression of 600 fs solitons from a Figure-8 laser down to 100 fs was achieved in a 100 m DDF (DDF2) which had dispersion tapered from 10 ps/nm/km to 1.4 ps/nm/km over its length. 600 fs solitons were also adiabatically compressed down to 200 fs using the 1.6 km DDF1.

2. Picosecond soliton compression

The fibre ring laser whose operation is based on nonlinear polarisation evolution [6] consists of an erbium-doped fibre, a 180m section of lo-Bi fibre a polarization sensitive isolator and two polarization controllers (see Fig.1).In order to ensure sufficient laser output power the 70% output coupler was placed directly after the laser amplifier. By appropriate setting of the polarisation controllers and pump power, transform-limited soliton pulses with durations in the range 2-5 ps could be obtained at 1557 nm. A tunable attenuator was spliced between the laser output and the input to DDF1 enabling the pulse energy at the DDF to be matched to that of a fundamental soliton at the DDF1 input. Fig.3a and b shows typical autocorrelation functions and spectra at the DDF1 input and output respectively. 3.5 ps soliton pulses were compressed down to a duration of 230 fs, corresponding to a compression factor of 17. The compressed pulses are seen to have no pedestal and to remain bandwidth-limited. The compression process is accompanied by a spectral shift of ~ 10 nm due to RSFS. Note, that the spectral features observed in Fig. 3d at the original signal wavelength are associated with the generation of a low level dispersive wave along with the solitons within the passive laser cavity. The additional anti-

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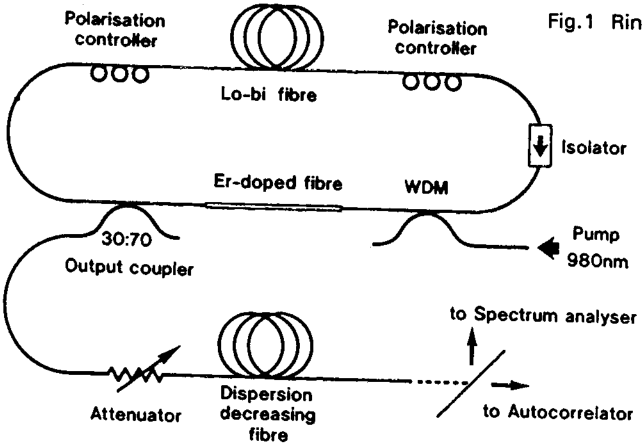

Fig.1 Ring laser configuration.

stokes component at ≈ 1520 nm is associated with soliton propagation in the vicinity of the zero-dispersion point and the effect of third-order dispersion [4]. The output soliton duration did not depend significantly on the input soliton pulse width in the tuning range 2 to 4 ps as expected due to the pulse width stabilisation of femtosecond soliton compression in DDFs [4].

3. Subpicosecond soliton compression

The Figure-8 laser [6] was constructed of fibre with dispersion D = 3.5 ps/nm/km. The 90% output coupler was placed immediately after the gain section. The isolator loop was

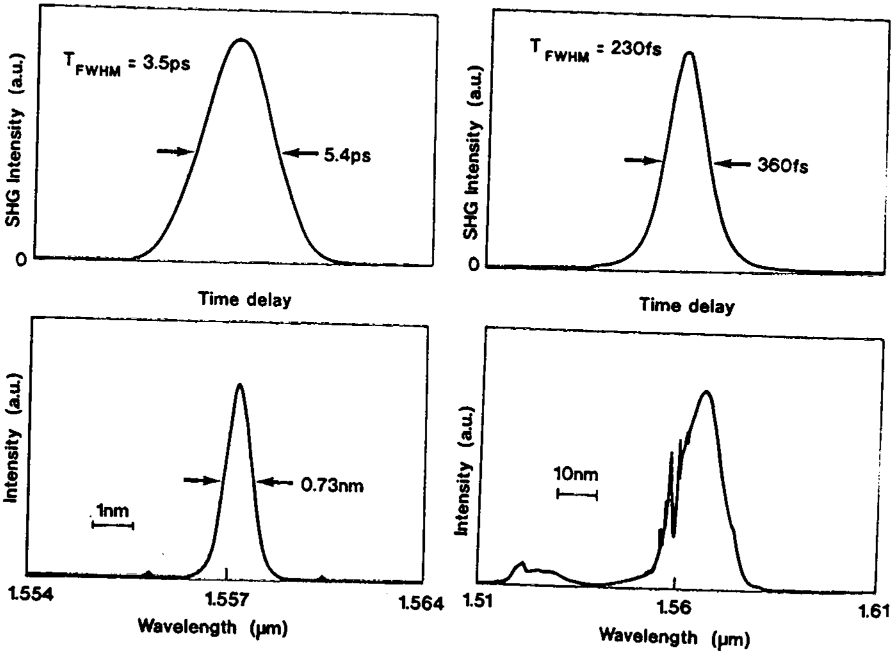

Fig.2 (a) 3.5ps pulses at DDF input.

(b) 230 fs pulses at 1.6 km DDF output.

5m long and the total cavity length 40m (see Fig.2). The laser generated 600 fs transform-limited pulses at 1558 nm (Fig.4a). The output passed through an optical isolator and attenuator into the DDF. Adiabatic soliton compression down to 100 fs and corresponding to a compression factor of 6 was obtained due to propagation in the 100 m DDF2 (Fig.4b). The additional spectral line at 1.536 μm in Fig.4b is simply an additional cw component from the laser. The compression of the 600 fs pulses in the 1.6 km DDF1 resulted in compression to 200 fs and a corresponding spectral shift of 25 nm. However, the basic features of the soliton compression remain the same as in the picosecond pulse case discussed earlier.

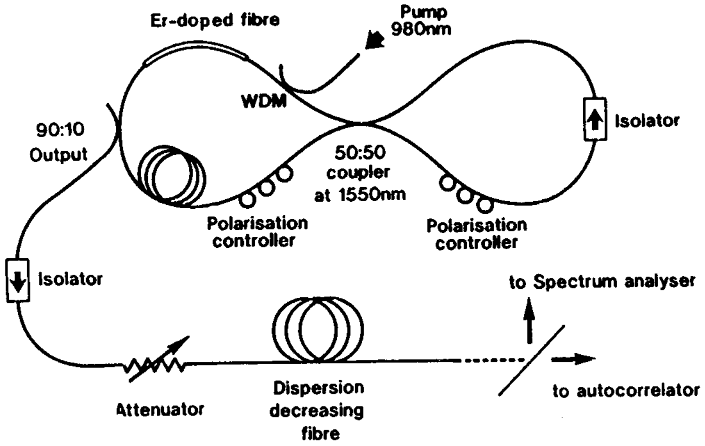

Fig.3 Figure-8 laser configuration.

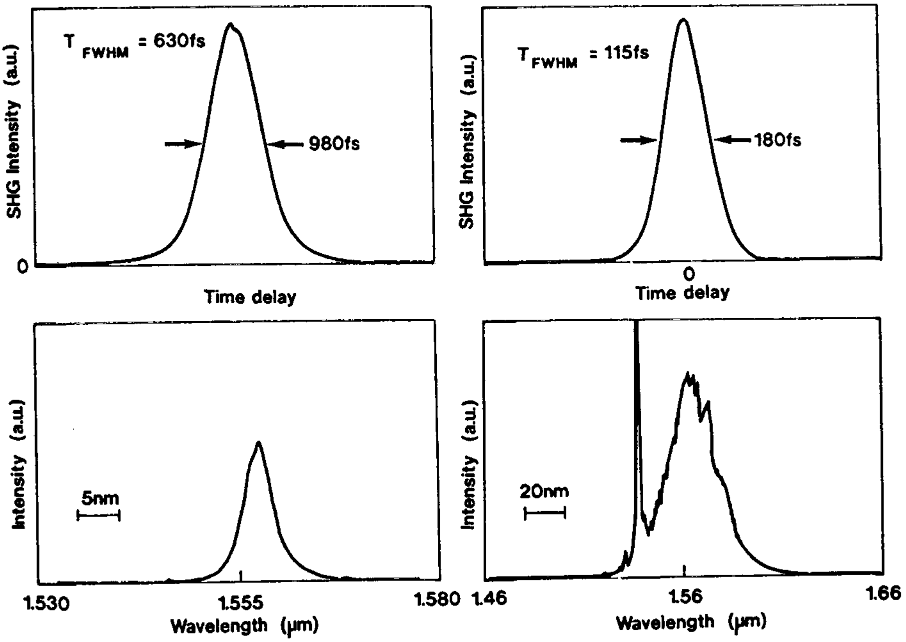

Fig.4 (a) 630 fs pulses at DDF input. (b) 115 fs pulses at DDF output.

4. Conclusion

We have demonstrated high-quality adiabatic soliton compression for both picosecond and subpicosecond solitons in a DDF. Compression factors of upto 17 have been obtained. In our opinion DDFs have great potential as simple passive pulse compressors for use in conjunction with various mode-locked fibre soliton lasers.

References.

1. K.Tajima, Opt.Lett. 12, 54 (1986).
2. H.H.Kuehl, J.Opt.Soc.Am. B 5, 709 (1988).
3. V.A.Bogatyrev et al. IEEE J Lightwave Technol. 9, 561 (1991).
4. S.V.Chernikov and P.V.Mamyshev, J.Opt.Soc.Am. B 8, 1633 (1991); E.M.Dianov et al.,in *Topical Meeting on Nonlinear Guided Wave Phenomena: Physics and Applications,*vol.2 of 1989 OSA Techn. Digest Series, p.157.
5. V.J. Matsas et al. Accepted for publication, Electron. Lett. 1992.
6. D.J. Richardson et al. Electron. Lett. 27, 542 1991.