A practical and compact subpicosecond optical fibre amplifier

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Many experiments on all optical signal processing for high speed communications systems require the generation of high energy subpicosecond pulses. The production of such pulses in optical fibres is limited by the high peak powers generated in the fibre core and the onset of large nonlinear effects such as SPM induced spectral broadening and Raman scattering of the pulse energy to longer wavelengths. The usual technique to overcome these limitations is to employ chirped pulse amplification (CPA) to initially stretch the pulses to reduce the peak power before amplifying and recompressing them. This technique has proved successful at generating pulses with microjoule energies [1] but only at low (kHz) repetition rates. At the high repetition rates used in communication experiments CPA cannot be used because it will create overlap and interference between the pulses and therefore a different approach is required. In this paper we demonstrate the use of a large area Er/Yb fibre to directly amplify subpicosecond pulses to energies greater than 1 nJ with peak powers in excess of 2000 Watts in an all fibre configuration.

The main component of the amplifier is an Er/Yb codoped fibre with a 200 µm diameter and 10 µm core radius backward pumped through a WDM by up to 800 mW of light at 1047 nm from a diode pumped source. The fibre is doped with 12000ppm of Ytterbium and 2000ppm of Erbium. The amplifier also includes polarization independent input and output isolators, and an excess pump light blocking filter. The large core area of this Er/Yb doped fibre reduces the effects of the fibre nonlinearity during the amplification process when compared with standard 5 µm core diameter fibres. In addition the fibre pigtailed of all the other components where cut short (<20 cm each) to minimize SPM and dispersive effects in these sections. The total length of fibre in the amplifier was limited to less than 2.5 metres.
The device was tested using 0.7 ps (fwhm) pulses from a passively modelocked fibre laser operating at a wavelength of 1543 nm and a repetition rate of 76 MHz with an average output power of 3 mW. The input and output spectra and autocorrelations are shown in figures 1 and 2 respectively as a function of output power. Pulse energies of 0.5 nJ with 630 Watts of peak power could be obtained without significant pulse shaping or spectral broadening giving a total average power of 35 mW. At higher peak powers self phase modulation begins to occur in the fibre pigtails at the device output and the dispersion in these fibres leads to soliton type compression although clean autocorrelation traces were still obtained at average powers of up to 80 mW, corresponding to a pulse energy of 1 nJ and a peak power of 2.5 KW, where the pulselength has decreased to 0.36 ps. Higher pulse energies of up to 1.5 nJ could be obtained but the increased peak power resulted in rapid broadening of the spectrum to >30 nm bandwidth.

The amplifier was also tested with 60 fs pulses obtained from a dispersion decreasing fibre. At the amplifier output the pulses had broadened to 200 fs, which indicates the practical lower limit to the pulsewidth at the amplifier input. In this case the maximum pulse energy was limited to 0.25 nJ with a peak power of 1100 Watts before break up of the pulses occurred.

In conclusion we have demonstrated a compact all fibre amplifier capable of generating subpicosecond pulses with energies in excess of 1 nJ which are suitable for use in terabit/s communications experiments and terahertz measurements.

[1]. D. Taverner, A. Galvanauskas, D. Harter and D.J. Richardson, CLEO '96 Technical Digest pg 496, paper CFDS.