HIGH-POWER, PICOSECOND Er^{3+}/Yb^{3+} FIBRE LASER

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An actively mode-locked Er^{3+}/Yb^{3+} fibre laser is described giving transform-limited $sech^2x$ pulses of 200W peak power at a wavelength of 1.55μm. Average output powers in excess of 200mW are possible.

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The unique combination of an active medium, non-linearity and negative group-velocity dispersion make erbium-doped fibres extremely attractive as the basic component of fibre soliton lasers[1,2]. Recently, we have obtained greatly improved performance in a 1.06 μm pumped fibre amplifier based on Yb^{3+}-sensitised, Er^{3+}-doped silica fibre[3]. This development enables the use of readily-available high-power solid-state mini-YAG lasers as pump sources and thus considerably increases the output available from practical fibre lasers. We report here a high-power fibre laser source based on the new co-doped fibre which is capable of generating transform-limited picosecond pulses with peak powers as high as 200 W.

The experimental set-up is shown in Figure 1. The laser gain was provided by 5m of Er^{3+}/Yb^{3+} co-doped fibre (N.A. = 0.15, λ_{co} = 960 nm) containing 7500ppm of Yb^{3+} and 880ppm of Er^{3+}-ions. This was fusion spliced to a 20m length of telecommunications single-mode fibre (N.A. = 0.11, λ_{co} = 1250 nm). Although pumpable by a mini-YAG laser, for experimental purposes we employed a standard Nd^{3+}:YAG laser. To overcome problems of mirror damage at high pump powers, no mirror was used at the pump end of the fibre, feedback being provided by the 4% Fresnel reflection only. Laser output was taken from a dichroic beamsplitter and the fibre rear mirror was highly reflective at the laser wavelength.

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This configuration is far from optimum and results in relatively-low fibre laser efficiency. Intracavity amplitude modulation was provided by a bulk lithium niobate device similar to that described in ref. 4. A novelty was that the modulator was included in the feedback loop of a simple electrical circuit and was therefore self-resonant at a frequency of 82MHz, removing the need for an external signal generator.

A launched pump power of 300mW at 1.06μm yielded a fibre laser output power of 40mW, giving an overall 13% pump/signal transfer efficiency. More recently, by employing an improved fibre this has been increased to 35%, giving an output of 200mW for 550mW of pump.

A typical autocorrelation trace of the mode-locked laser output pulses is shown in Figure 2 and the corresponding spectrum in Figure 3. The autocorrelation trace shows that the pulse is accompanied by a low-level pedestal containing some 30% of the total energy. The pulse shape is an excellent fit to a $sech^2$ shape, giving a pulse duration of 1.7ps and a peak power of 200W. To our knowledge this represents the highest output power from an Er^{3+}-doped fibre laser to date. Decreasing the pump power by some 10% and adjusting the state of polarisation to match the Brewster-angled modulator permitted complete removal of the pedestal at the expense of a slight increase in pulse width to 4ps.

For the fibre core area of 70μm^2 and group velocity dispersion of 15ps/nmkm, a 1.7ps-duration fundamental soliton has a peak power of 15W. Thus the 200W fibre laser output pulses are high-order soliton pulses and the effect of high-order soliton pulse compression must play a significant role in the pulse formation process. The output spectrum also has a central peak which is a feature typical of high-order soliton pulse compression[5]. This was confirmed by investigating the laser performance in a shortened resonator consisting only of a length of co-doped fibre (1.2m) and no undoped fibre in order to reduce the non-linear effects. In this configuration the output pulses were of 20ps duration and the spectral bandwidth was correspondingly reduced to 0.15nm.

In conclusion, a mini-YAG-pumped Er^{3+}/Yb^{3+} co-coped fibre laser provides an attractive source of high-power transform-limited pulses for applications in advanced communications, particularly those involving soliton transmission.

References

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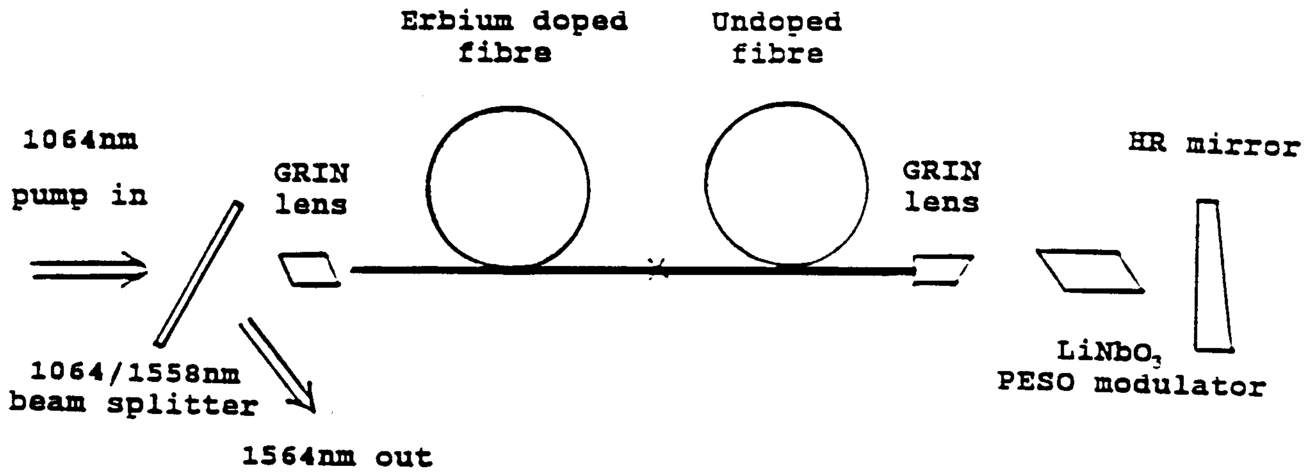

Figure 1 Fibre laser configuration

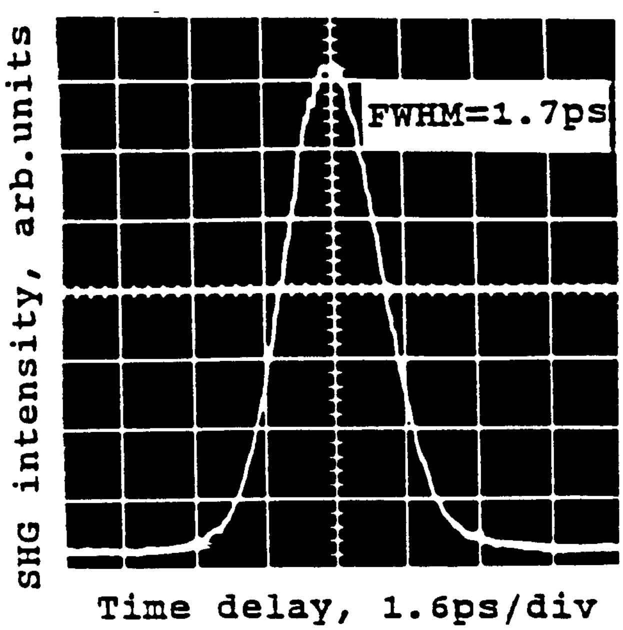

Figure 2 Autocorrelation trace of 200W mode-locked output pulse

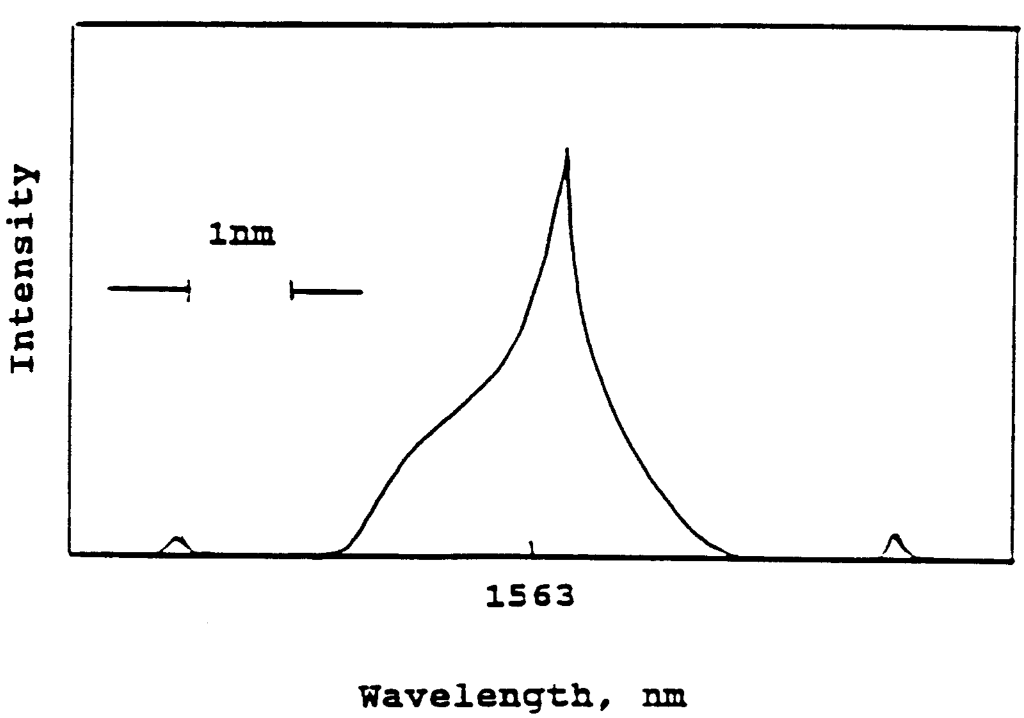

Figure 3 Output spectrum of mode-locked pulses