A stable narrow linewidth Q-switched Er-doped fibre laser

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Abstract

Q-switched pulses of stable linewidths less than 60MHz were generated for repetition rates up to 1kHz, using low doped erbium fibre as a saturable absorber combined with CW prelase technique.

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Compact sources with high peak powers and short pulsewidths are required for applications such as distributed sensing and laser range finding. Previously reported Q-switched erbium-doped fibre lasers consisting of Fabry-Perot or ring cavities are suitable for many applications in the operation wavelength around 1550 nm, but for distributed strain sensing based on spontaneous Brillouin scattering [1], a stable ultra-narrow linewidth pulsed source with sufficient peak powers is required to resolve the spectral information of the Brillouin signals.

Ultra-narrow linewidth Q-switched operation may be achieved using the prelase technique. In this technique, the laser is allowed to oscillate at low powers on a single longitudinal mode prior to opening the Q-switch, and the Q-switched pulse builds up from this initial lasing [2]. Although CW ring lasers readily operate on a single-mode, there is a tendency for mode-hopping due to the relatively large cavity length and associated close proximity of adjacent modes in the frequency domain. To overcome this tendency, we have combined the prelase technique and the use of a saturable absorber to stabilise the operating mode [3]. The laser (Figure 1), operates with a travelling wave in the pumped erbium gain section and a standing wave in the unpumped erbium section which acts as a saturable absorber.

The erbium gain section comprises of a 1.9m length of erbium-doped fibre (NA = 0.18, Er^{3+} concentration of 800ppm, second mode cutoff of 890nm and unsaturated absorption of 45dB/m). The saturable absorber uses a 2m of low erbium-doped fibre (NA = 0.125, second mode cutoff of 910nm and unsaturated absorption of 5dB/m). The circulator ensures unidirectional operation; feedback to the ring cavity was completed by a 99.9% reflectivity fibre Bragg grating reflector (λ_g = 1530nm, $\Delta\lambda$ = 0.05nm). The nonspliced ends of fibres were angle polished at 17° to minimise 4% Fresnel end reflections into the cavity.

The performance of the CW prelase signal was initially investigated. A scanning Fabry-Perot interferometer (SFP) confirmed stable single-frequency performance of the laser. The spectral linewidth of the laser was accurately determined using a delayed self-heterodyne interferometer (Figure 2). The RF linewidth was measured to be approximately 10kHz FWHM, which corresponds to a lasing linewidth of 5kHz assuming Lorentzian profile.

Q-switching operation was achieved by the use of an electro-optic modulator (EOM). Efficient operation of the EOM relies on linearly polarised light, and two dichroic sheet polarisers were inserted into the cavity. Typical pulses from the output of the laser with peak powers of 400mW were obtained with the EOM operating at a repetition rate up to 1kHz. The variation of peak power and pulsewidth of the Q-switched pulses as functions of the modulation frequency of the EOM are shown in Figure 3. The spectral behaviour of the Q-switched operation using the prelase technique was observed by detecting the peaks on the SFP, and the linewidth formed was measured to be less than 60MHz, representing more than an order of magnitude improvement over previously reported narrow linewidth Q-switched operation.

References:

[1] DE SOUZA, K., WAIT, P. C. and NEWSON, T. P.: *Electron. Lett.*, 1997, **33,** (7), pp. 615-616

[2] HANNA, D. C., LUTHER-DAVIES, B., RUTT, H. N. and SMITH, R. C.: *Opto-Electron.*, 1971, **3**, pp. 163-169

[3] HOROWITZ, M., DAISY, R., FISCHER, B. and ZYSKIND, J.: *Electron. Lett.*, **30**, (8), pp. 63-64

Figure Captions:

Figure 1 - Schematic diagram of single-frequency Q-switched laser configuration

Figure 2 - Output from self-heterodyne interferometer with a 28km delay line

Figure 3 - Variation of peak power and pulsewidth of Q-switched pulses with repetition rate

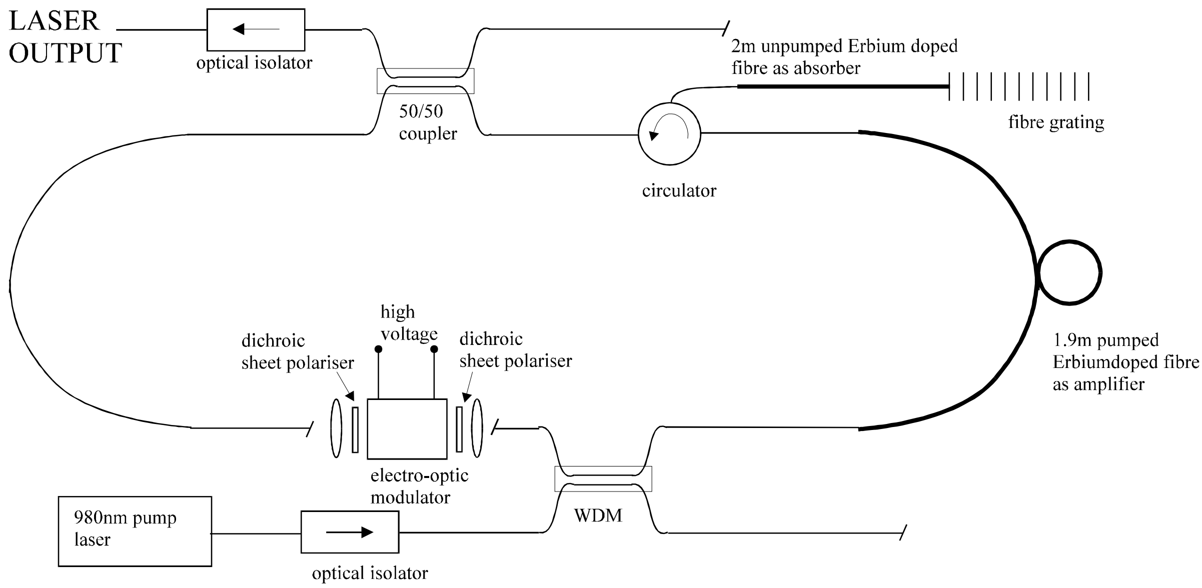

FIGURE 1

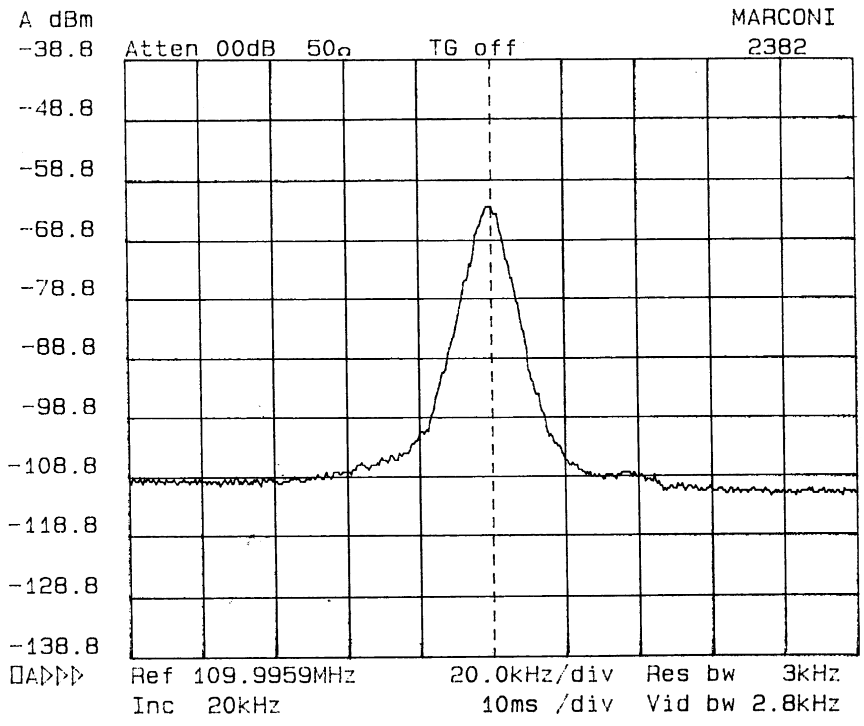

FIGURE 2

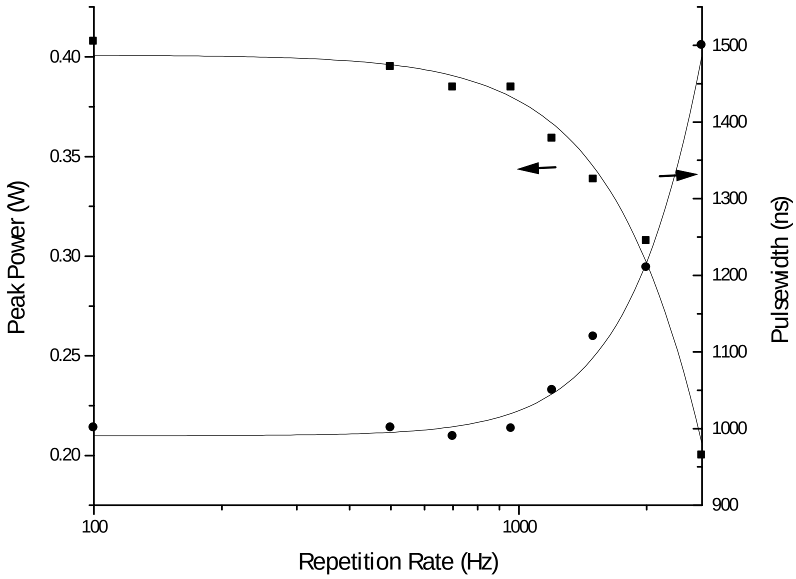
0.40
0.35
0.30
0.25
0.20
Peak Power (W)
1500
1400
1300
1200
1100
1000
900
Pulsewidth (ns)
100
1000
Repetition Rate (Hz)

FIGURE 3