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2kW Peak Power Q-switched Erbium Doped Fibre Laser

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Abstract

A Q-switched Erbium doped fibre laser utilitising a novel low N.A. single mode fibre has been demonstrated. Pulse energies of in excess of 50μJ were obtained.

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Introduction: Q-switched fibre lasers have been reported since 1986 [1], and the advances achieved have been due to developments in acousto-optic modulator and pump laser technology [2,3], or new low loss types of modulator [4]. In this paper we report advances in Q-switched laser performance by focussing on a novel fibre type. Two methods can be applied to increase the energy stored in the fibre per unit length, either increase the Erbium concentration or increase the core area. The Erbium concentration can only be increased upto a threshold value after which clustering of the Erbium ions decreases the fibre efficency by a process of co-operative up-conversion.

The technique of increasing the core area to increase the energy stored per unit length is limited by the requirement that the fibre remains single mode at the signal wavelength. Single mode operation is maintained by decreasing the N.A. of the fibre, this is achieved by reducing the refractive index difference Δn, between the fibre core and cladding. Although decreasing the refractive index variation leads to the fibre becoming more sensitive to bend loss, this is not a problem with Q-switched lasers as typically less than 1 metre of fibre is used.

By increasing the energy stored per unit area, the length of the fibre can be kept shorter than conventional Erbium doped fibre and therefore the cavity photon lifetime which determines the pulse width can be minimised. The low N.A. of the fibre and the increased mode field area also has the advantage of reducing the amplified spontaneous emission (ASE) along the fibre, which would otherwise cause a reduction in the gain. [5]

This novel fibre in conjunction with Q-switching elements enables short high power pulses to be obtained, suitable for applications of eyesafe laser range finding, OTDR, remote sensing and free space communciations.

Experiment: The experimental arrangement is shown in figure 1.

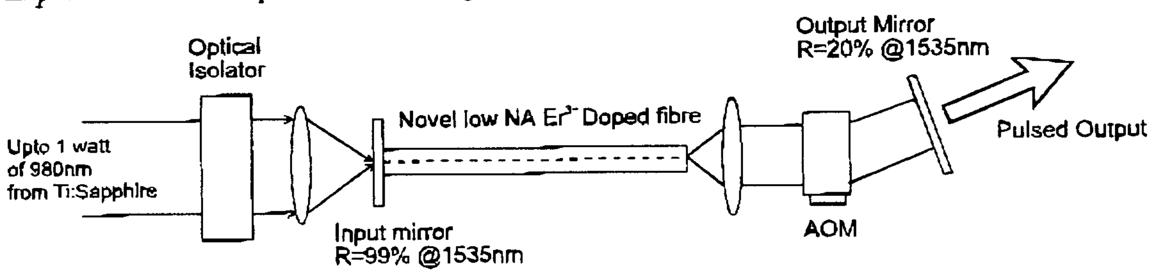

Figure 1 - Experimental Arrangement for Q-switched Fibre Laser

500mW of 980nm light from an Argon ion pumped Ti-Sapphire was launched into the Erbium fibre using a lens with a low N.A. (Newport FL-10B) through a dichroic mirror (99% reflecting at 1535nm and 94% transmitting at 980nm). The Erbium fibre was single mode at 1535nm and has a Erbium dopant concentration of 4000ppm, N.A. of 0.08 and a core radius of 7.5μm. The fibre end was angle polished to an angle of 16° to prevent the fibre lasing from the 3.5% Fresnel reflection. The length of the Erbium fibre was optimised for the available launched power. The light was then focussed with an FL-10B through an acousto-optic modulator onto an output mirror with a 20% reflectivity at 1550nm. The laser cavity was formed from the first order diffracted beam from the AOM, as the diffraction efficency of the AOM was not sufficent to prevent lasing when operating with feedback from the zero order. Using this configuration pulses in excess of 2kW peak power with a 25ns pulse width were obtained at a repetition rate of 500Hz (figure 2).

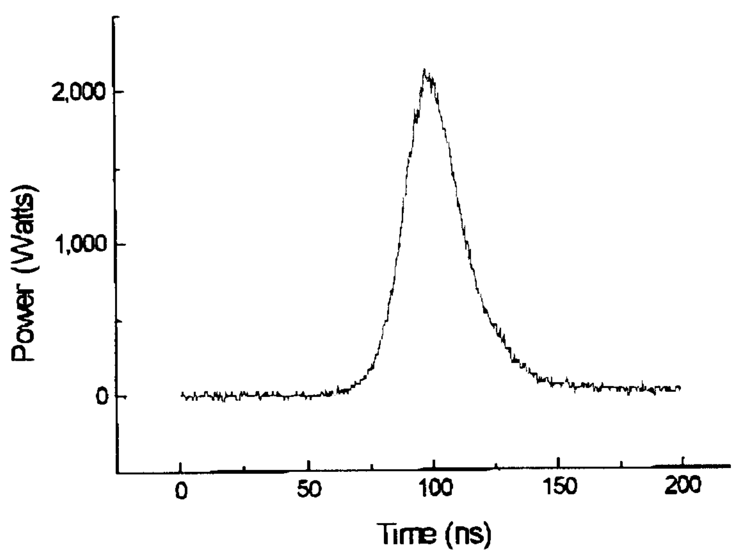

Figure 2 - Typical 2kW, 25ns pulse

Conclusion: We report a large increase in pulse energy from a Q-switched Erbium doped fibre laser using a specially fabricated low N.A. fibre. The continuing optimisation of the large mode area fibre with respect to dopant concentration and core radius should result in pulse energies in excess of 100μJ from portable MOPA pumped systems.

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