# 0.5mJ pulses from a single transverse-mode Q-switched erbium fibre laser

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**Abstract**

We report pulse energies (>0.5mJ) and peak powers (>7kW) from a robustly single transverse-mode Q-switched erbium-doped fibre laser. The results represent record pulse energy extraction from a doped fibre laser system.

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Q-switched fibre lasers offer a simple and robust means for the generation of high energy, nanosecond pulses at eye safe wavelengths around 1550nm suitable for a number of industrial, sensing and nonlinear optics applications. Unfortunately, Q-switched fibre lasers based on conventional erbium doped fibre designs are limited to <10 μJ pulse energies by rapid energy loss in the form of amplified spontaneous emission during the gain recovery stage due to the high gain-efficiency of the fibres. Recently we showed that considerably higher pulse energies (180 μJ) can be achieved simply by increasing the mode field diameter (MFD) of the fibre and thereby compromising the gain efficiency of the system[1]. The increased MFD also improves the nonlinear and power handling characteristics of the fibre.

In this paper we describe our latest results based on this concept. We have achieved record output pulse energies of 0.52 mJ. The key to this result is the development of a novel fibre design capable of providing robust single transverse-mode laser operation with a vastly increased fibre MFD of ~35 μm. The erbium doped fibre was pumped with up to 2.5W of 980nm radiation from a Ti:Sapphire laser. The pump energy was launched into the fibre through a 980/1550nm dichroic mirror. The laser was of a conventional Fabry-Perot geometry formed by the 4% Fresnel reflection at the cleaved fibre launch and a lens coupled high reflectivity (HR) mirror at the other fibre end. Q-switching is achieved with an acousto-optic modulator positioned in front of the HR mirror and aligned to lase on the first order diffracted spot. The output laser radiation was separated from the incoming pump radiation by the dichroic beam-splitter.

The laser Q-switched stably at repetition rates between 0.1-5 KHz at a wavelength of 1560nm and produced average output powers in excess of 0.5W (Figure 1) corresponding to an estimated quantum slope efficiency of ~70% with respect to launched pump. The laser spatial output mode was confirmed experimentally to be robustly single mode. The highest pulse energies of 0.52 mJ were achieved at repetition rates below 200Hz with a corresponding pulse duration of 70ns (see Figure 2). The peak power of these pulses was 7kW, once again a record for a Q-switch fibre laser.

We believe these results to represent a significant advance in the development of high power/energy fibre laser systems which are now truly beginning to compete in these terms with more conventional bulk laser technologies.

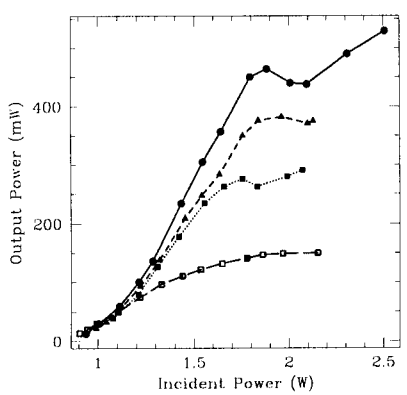


**Figure 1 Laser average output power characteristic: cw (circles), 4 kHz (triangles), 1 kHz (filled squares), 400 Hz (hollow squares). Fibre length =8m.**

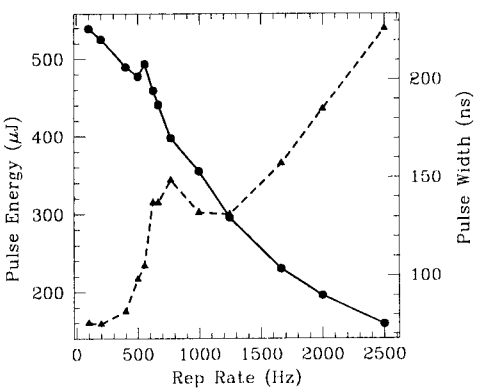


**Figure 2 Pulse energy (circles) and duration (triangles) versus repetition frequency. Fibre length=12m.**

[1] D.J. Richardson, P. Britton and D. Taverner, "Diode-pumped, high-energy, single transverse mode Q-switch fibre laser", *Electronics Letters* **33**(23) pp.1955-1956, (1997)