1.2 mJ, 37 ns single-moded pulses at 10 kHz repetition rate from a Q-switched ytterbium fiber laser

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We have demonstrated a diode pumped 1.2 mJ, 37 ns Q-switched laser with good mode quality, operating at ~1075nm with a repetition rate of 10 kHz, utilizing a ytterbium doped LMA fiber.

Q-switch lasers operating in the mJ regime have a wide of sensing and materials processing applications. The market is currently dominated by crystalline or glass solid state laser systems. Several mJ Q-switched fiber lasers have been reported over the past few years however to date such systems have produced relatively long pulses (>100 ns), and/or are have been multi transverse mode rendering them unsuitable for many of these applications [1,2]. This is particularly true in the materials processing area where shorter pulse duration (typically 50ns or less) and good mode quality are fundamental requirements. In this paper we report a mJ Q-switched fiber laser operating at a 10 kHz repetition rate with single spatial mode output and sub 40 ns pulse duration.

Our cavity was a simple Fabry Perot design. The gain medium was a 4m long Yb-doped (8000 ppm) silica LMA fiber with a 40 μm core and 400 μm cladding diameter, with a flat index profile and NA~0.06. The fundamental mode area was calculated as A_{eff}~370 μm^2. The LMA was capable of supporting up to ~ 25 modes, but with gain favoured in the fundamental mode. The gain differential between fundamental and higher order modes was sufficient to allow us to obtain single transverse mode output from fiber during laser operation.

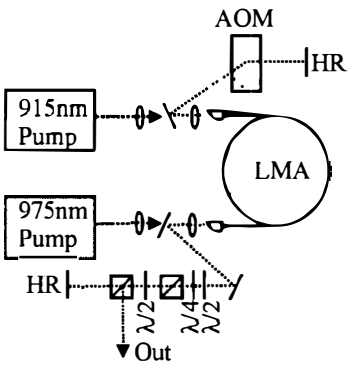

Fig. 1. Schematic of Q-switched laser

The fiber was pumped from both ends with 975nm (25W) and 915nm (32W) diode arrays. Q-switching was obtained using an AOM driven at a repetition rate of 10 kHz and a gate time of 2 μs. Feedback from the AOM end of the cavity was estimated to be ~35% allowing for the double pass through the AOM and loss due to relaunching into the fiber. The strength of feedback at the output end was controlled by means of an arrangement of waveplates and polarisers. The free-space parts of the cavity had a total length of ~1m.

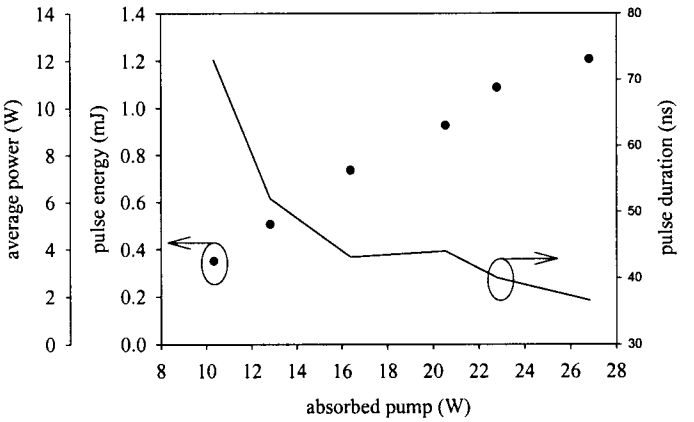

Fig. 2. Average power, pulse energy and pulse duration vs. launched pump power

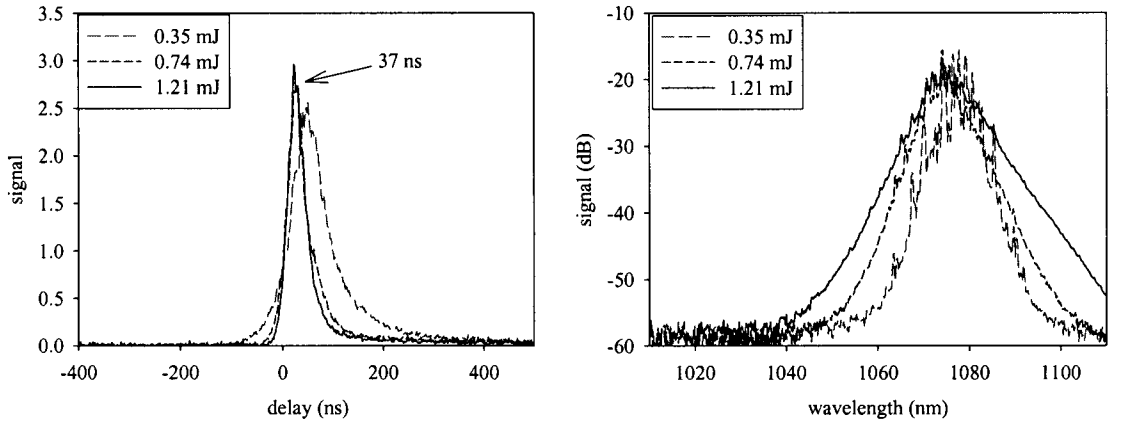

Fig. 3. Pulse shape and spectrum at various pulse energies

The laser performance was characterised as a function of output coupling at a repetition rate of 10kHz and the best system performance was obtained using ~10% feedback at the output end. At a pump power of 27W, the laser produced 1.2 mJ pulses of 37 ns duration (12 W average power). The pulse spectrum was centred at ~1075nm with a bandwidth of 9 nm. Approximately 15% of the pulse energy was in the long (~600 ns exponential decay) tail, with ~1 mJ energy in the main part of the pulse. The output was single-moded (M^2=1.1).

In conclusion we report a mJ Q-switched fiber laser operating at a 10 kHz repetition rate with single spatial mode output and sub 40 ns pulse duration. We believe this to be the first time that such a combination of output parameters has been reported for a simple Q-switched fiber laser system and consider it to represent a practical source for a wide variety of industrial applications.

[1] C.C.Renaud et al. *IEEE Journal of Quantum Electronics* 2001 Vol.37(2) pp.199-206
[2] C.C.Renaud et al. *CLEO 2001* Baltimore 6-11 May 2001 CTuQ5