New Generation of Cladding-pumped Fibre Lasers and Amplifiers

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Abstract

High power fibre lasers and amplifiers are becoming a firm alternative to conventional solid state lasers for operation in the regions of 1 and 1.55 μm [1]. There are a wide variety of applications for these devices in fields such as telecommunications, medicine, material processing and defense. Both continuos wave (CW) and Q-switching operation are interesting for different applications [2]. High intensity, high power, high energy pulses; prevention of nonlinear effects and fibre facet damages are also among the challenges. In this talk, we will present results of our work on Yb and Er/Yb-doped high power cladding-pumped fibre lasers. For CW operation, a very simple configuration was set-up. The pump source consists of a broad-stripe diode with nominal output of 60 W at 915 nm. The output of pump source was launched to the fibre using a beam-shaping technique [3]. Reflection from the flat fibre ends is enough to initiate lasing. The output power is taken from both ends of the laser.

Among our results in CW regime, we can mention the demonstration of fibre lasers with up to 85% slope efficiency with respect to absorbed pumped power and maximum output power in excess of 20 W pumping from both ends. High energy pulsed sources are required for several applications. Using in-house fibre fabrication facilities, we demonstrated a Q-switched, cladding-pumped, ytterbium-doped, large mode area (LMA) fiber laser operating at 1090 nm [4]. This laser was capable of generating 2.3 mJ of output pulse energy at 500 Hz repetition rate and over 5 W of average output power at higher repetition rates in a high-brightness beam (M^2 = 3). Using a similar fibre, with a smaller core, we generated > 0.5 mJ pulses in a

diffraction-limited beam.

We investigated the performance of another Yb-doped fibre laser with a section of tapered fibre for beam quality improvement in CW and pulsed regime [5]. A high-power cladding-pumped fibre laser was demonstrated. A fiber taper inside the laser cavity with a multimode fiber is used to suppress higher-order modes while increasing the intensity by ~3.5 with small power penalty. This laser was also tested in Q-switched regime of operation. Figure 2 show the results for Q-switched regime.

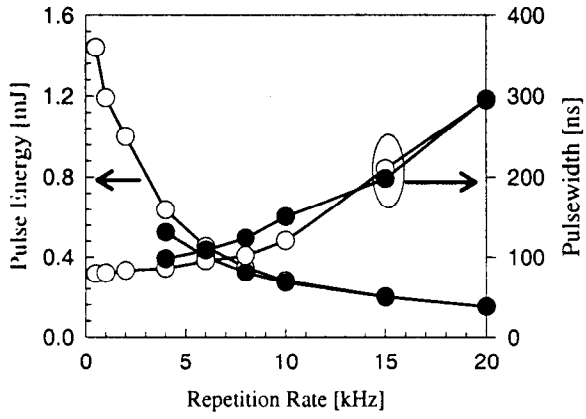

Fig.1 (a) CW Output power vs. launched pump power in cladding pumped fibre lasers (b) Pulse energy and average power as a function of repetition rate

The output beam was of good spatial quality, multimode in the case of conventional fibre, with an $M^2=7.5$ and quasi mono-mode in the tapered case, with an $M^2=1.8$. The high power, diffraction-limited output already available from cladding-pumped ytterbium-doped fibre lasers operating makes them attractive for non-linear frequency conversion via frequency doubling and via pumping of optical parametric oscillators (OPOs) and amplifiers (OPAs). In addition to high brightness, these sources must have a linearly polarised output beam and narrow linewidth. In a recent experiment, we demonstrated 9-W of linear polarisation, narrow linewidth (0.2 nm), and wavelength tunable (~40-nm) output in CW operation [6]. The tuning range from the laser is shown in Figure 2.

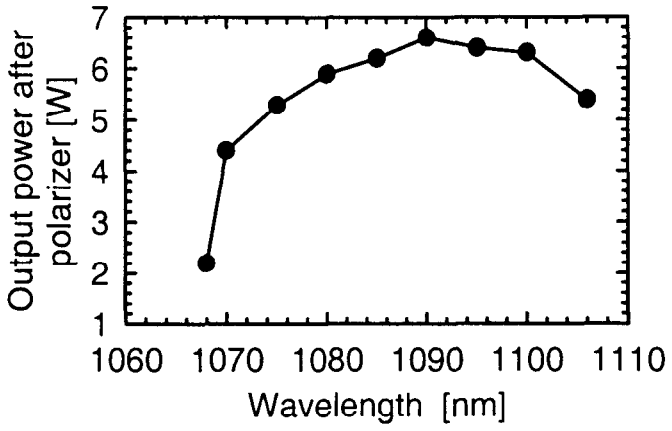

Fig. 2 Tuning range for single polarisation fibre laser

Finally, for applications in the region of 1550 nm, we demonstrated a laser source with a multimode, 6.2-W output power at 1550 nm.

In conclusion, we have explored the flexibility of fibre lasers and demonstrated their capabilities of delivering power in the region of several tens of watts. Cladding pumping technique has been implemented for high absorption and slope efficiency. Q-switched and CW operation has shown that our lasers are capable of delivering high energy pulses and high power, single polarization, wavelength tunable narrow linewidth beams.

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