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Diode-pumped passively Q-switched tunable Er-Yb double-clad fibre laser

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Abstract: Reliable passive Q-switching of a cladding-pumped Er-Yb fibre laser at 1532-1563nm has been demonstrated using cobalt-doped ZnS crystal as saturable absorber. High peak powers >10kW were obtained for ~2.75W of absorbed pump power at 915nm.

Q-switching of Er and Er,Yb fibre lasers is an attractive way to generate high peak power pulses in the eye-safe wavelength domain near 1.5μm, and hence is of interest for a range of scientific and technological applications (e.g. LIDAR). In this paper we report a passively Q-switched tunable Er,Yb double-clad fibre laser with up to 60μJ pulse energy and peak power >10kW. To the best of our knowledge this is the highest peak power reported so far for a passively Q-switched Er fibre laser.

The fibre laser configuration used in our experiments (shown in figure 1) consists of ~2m length of Er,Yb-doped double-clad fibre (EYDF), with feedback for laser oscillation provided by an external cavity and the 3.6% Fresnel reflection from the opposite fibre end facet. The latter also served as the output coupler. The EYDF had a pure silica inner-cladding of diameter ~125μm and a Er,Yb doped phospho-silicate core of diameter ~11μm and 0.21NA. The fibre was coated with a low refractive index (n=1.375) polymer outer-cladding resulting in a high numerical aperture (~0.49) for the inner-cladding pump guide. To suppress lasing on higher order modes and reduce amplified spontaneous emission, a short length of standard telecom fibre was fusion-spliced onto the fibre end adjacent to the external cavity. The end facet of this fibre was angle-cleaved at 15° to avoid parasitic lasing between the end facets. The external cavity comprised a collimating lens (L_2) of focal length 4.5mm and a diffraction grating (600 lines/mm) aligned in the littrow configuration to provide the means for wavelength tuning. Two additional lenses, L_3 and L_4, with respective focal lengths 8.6mm and 15mm, were placed in the external cavity to produce a small beam waist at the location of the saturable absorber.

Passive Q-switching was demonstrated with Co^{2+} doped ZnS, LMA, and MALO crystals as the saturable absorber. The best performance was obtained using Co^{2+}:ZnS. This saturable absorber is characterized by a low initial transmission which suppresses CW lasing and a very low saturation fluence (0.15 J/cm^2 at 1.53 μm). With ~2.75W of absorbed pump power (delivered by a beam-shaped diode-bar at 915nm), we obtained Q-switched pulses of energy up to 60μJ and duration 3.5ns (FWHM), corresponding to a peak power of more than 10 kW, at a repetition rate of 5kHz. In addition, the laser could be tuned over 31 nm from 1532 to 1563 nm, and 95 % of the output power was polarised parallel to the grating lines. A particularly striking feature of the fibre laser performance is the very short pulse duration, which is shorter than the cavity round-trip time (~25ns). A tentative explanation for this behaviour will be presented. In addition, the prospects for further increase in pulse energy, average power and extension of the wavelength tuning range by using a modified fibre design with larger core and inner-cladding diameters to allow pumping by higher power diode-stack pump sources will be discussed.

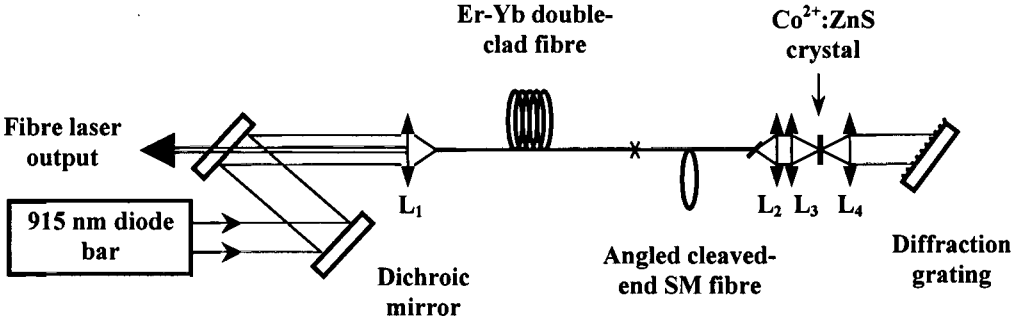

Fig. 1. Experimental set-up of the passively Q-switched Er-doped fibre laser. SM : single mode.