Thulium Doped Fibre Laser based on Theta Cavity Lasing Direction Rectification

Svyatoslav Kharitonov[1], **Camille-Sophie Brès**[1]
1. *Photonic Systems Laboratory, Ecole Polytechnique Fédérale de Lausanne (EPFL) STI IEL, CH-1015 Lausanne, Switzerland*

The development of thulium-doped fibre lasers (TDFL) is motivated by numerous potential applications in spectroscopy, remote sensing, medicine, material processing, and telecommunications. The all-fibre core-pumped ring cavity TDFLs exploiting fiberized grating-based filter [1] or Fabry-Pérot etalon [2] as a wavelength selective element were reported. An optical isolator should be inserted into the fibre ring cavity to ensure unidirectional lasing. Isolator-free unidirectional ring fibre cavity (sometimes referred to "theta" [3] or "yin-yang" [4] resonators) represents an attractive and cost-effective alternative solution. In theta cavities, non-reciprocal losses are introduced by providing an S-shape feedback within the main ring. An erbium doped fibre laser (EDFL) with theta cavity, providing close to 20 dB extinction ratio (ER) between output signals, propagating in favoured and suppressed directions, was demonstrated [5]. We report for the first time the demonstration of a unidirectional 2 μm TDFL, exploiting properties of the theta cavity.

The theta cavity laser consists of a fibre ring, and two additional couplers ($DC_{1,3}$) used to introduce non-reciprocal losses (Fig. 1). A counter-clockwise (CCW) lasing direction is favoured, and a clockwise (CW) one in suppressed. The fibre ring includes the gain unit (GU), tunable grating based band-pass filter, and 50% output directional coupler (DC_2). The GU consists of 11.5 m of thulium doped fibre (OFS TmDF200) bi-directionally core pumped with a 1600 nm pump obtained from an amplified tunable laser source (TLS).

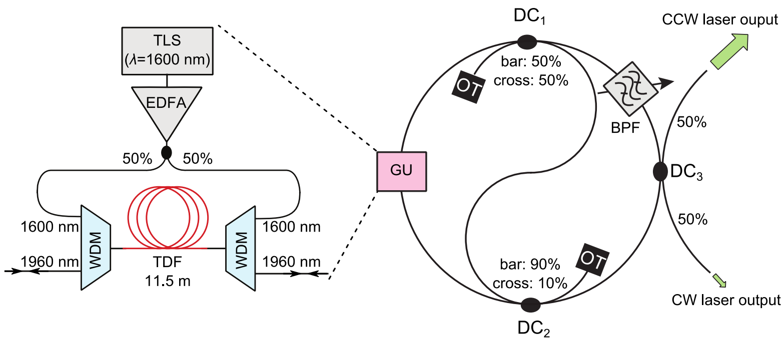

Fig. 1. Theta cavity TDFL layout. Details of the gain unit (GU) are shown on the left. TLS: tunable laser source; EDFA: Erbium doped fibre amplifier; WDM: wavelength division multiplexer; TDF: Thulium doped fibre; OT: optical terminator; BPF: tunable band pass filter; DC: directional coupler; CW and CCW: clockwise and counter-clockwise lasing directions.

The results of laser characterization are shown in Fig. 2. Stable lasing in the range 1880–2055 nm is obtained with the isolator-free cavity. For the 2 W pump, output lasing power in excess of 440 mW is measured, with a remarkable 2 dB output flatness. The averaged ER of 20 dB is achieved. The ER values are in a good agreement with those, reported for theta cavity EDFL [5]. The optical signal-to-noise ratio (OSNR) is better than 57 dB/1nm confirming the negligible ASE once the system reaches steady-state. The slope efficiency is 25%.

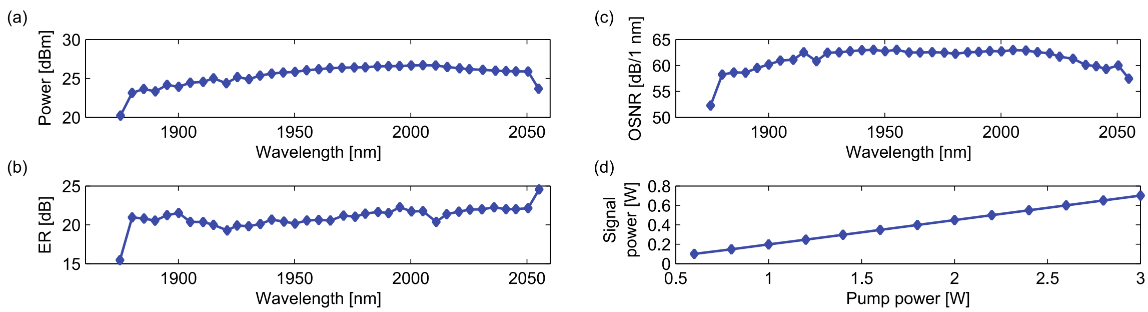

Fig.2. Characterization of theta cavity: (a) output power, (b) extinction ratio (ER) between lasing (CCW) and suppressed (CW) directions, (c) optical signal-to-noise ratio (OSNR); (a)–(c) are presented as a function of lasing wavelength for 2 W pump; (d) output power at 2000 nm as a function of pump power.

References

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