A high power, variable repetition rate, picosecond, optical parametric oscillator pumped by an amplified gain-switched diode

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Abstract: We demonstrate a picosecond optical parametric oscillator synchronously pumped by a gain-switched laser diode, which is amplified in an Yb-doped fibre amplifier chain. Up to 7.3W at 1.54µm and 3.1W at 3.40µm is obtained at pulse repetition rates between 114.8 and 918.4MHz.

Synchronously pumped optical parametric oscillators (SPOPOs) are of general interest as broadly tunable sources of ultrashort pulses. The emergence of new, compact sources of ultrashort pump pulses has led to various demonstrations of SPOPOs with repetition rates up to 82GHz [1] and combined signal and idler average output power of ~27W [2]. Possible applications include areas as diverse as telecommunications [1], ablation and deposition of polymer materials [3], non-invasive microscopy [4] and, in particular, CARS microscopy [5]. Here we demonstrate an SPOPO pumped by a gain-switched laser diode and an Yb-doped fibre amplifier system. This pump system benefits from a highly compact and simple design with a minimum of free-space components, a user-controlled repetition rate up to the GHz regime and the potential for scaling to high average powers [6].

The pump laser consists of a gain-switched laser diode and a chain of laser-diode-pumped Yb-doped fibre amplifiers [6]. It delivers Δt = 21ps, M^2 = 1.02, λ_c = 1.06µm, linearly polarized pulses with average powers up to 100W. The repetition rate can be user-controlled between 100MHz and 1GHz. The SPOPO used a periodically poled, 5% MgO-doped, congruent $LiNbO_3$ crystal for the nonlinear gain medium. The crystal, provided by Covesion Ltd., was 40mm long, 10mm wide and 0.5mm thick with eleven 0.5mm wide poled gratings with periods ranging from 26.5µm to 31.5µm. It was held in an oven at 150°C to eliminate any residual photorefraction. A standard bow-tie ring cavity configuration was constructed with an overall length matched to the lowest pump repetition rate of 114.8MHz that also allowed high repetition rate operation with multiple pulses circulating in the cavity.

Fig. 1(a) shows the output power characteristics at the lowest repetition rate of 114.8MHz. We obtained 7.3W of signal at 1.54µm and 3.1W of idler at 3.4µm for 24W of pump power, with the pump depletion saturating at ~70%. A significant roll-over effect was seen at higher repetition rates. The origins of the roll-over effect are not yet understood, but it is assumed to be of thermal nature and we note that if just a few percent of the pump power is converted to heat, then the high dn_e/dT value combined with the heat removal from only one face of the slab-like nonlinear crystal would lead to a strongly aberrated thermal lens. Tunability between 1.40µm and 1.68µm (signal) and 2.87µm and 4.36µm (idler), as shown in Fig. 1(b), was also demonstrated by accessing the different poled crystal gratings. Beam quality measurements indicated near diffraction-limited performance for the signal (M^2 = 1.2 × 1.1), while the idler was degraded to M^2 = 3.2 × 1.6. Signal and idler pulse durations were measured to be ~17ps.

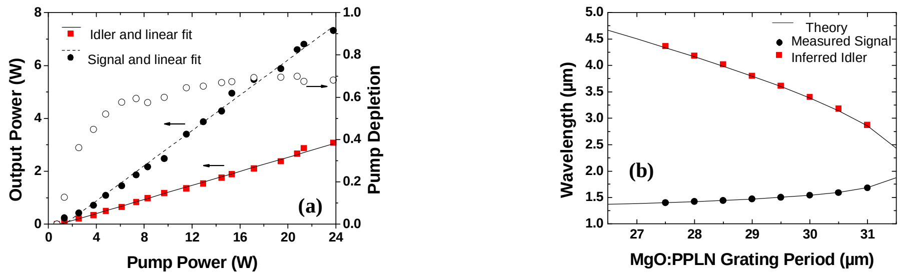

Fig. 1 Output power characterization of the SPOPO using an R = 65% output coupler at 114.8MHz repetition rate. The tuning performance is shown in (b), where different grating periods are accessed (temperature constant at T = 150°C).

We have demonstrated a high power, user-controllable repetition rate SPOPO pumped by a fibre-amplified gain-switched laser diode. Further power scaling will be investigated using this compact pump source, which also has the potential for further increases in repetition rate and the production of shorter pulses.

References

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