

A Picosecond Optical Parametric Oscillator Synchronously Pumped by an Amplified Gain-Switched Laser Diode

Florian Kienle,^{1,*} Kang K. Chen,¹ Shaif-ul Alam,¹ Corin B. E. Gawith,² Jacob I. Mackenzie,¹ David C. Hanna,¹ David J. Richardson,¹ and David P. Shepherd¹

¹Optoelectronics Research Centre, University of Southampton, Highfield, Southampton, SO17 1BJ, United Kingdom

²Covesion Ltd, Romsey, SO51 9AQ, United Kingdom

*flk@orc.soton.ac.uk

Abstract: We demonstrate a picosecond optical parametric oscillator synchronously pumped by a fiber-amplified gain-switched laser diode. Up to 7.3W at 1.54 μ m and 3.1W at 3.4 μ m is obtained at pulse repetition rates between 114.8 and 918.4MHz.

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1. Introduction

Synchronously pumped optical parametric oscillators (SPOPOs) are of great interest as sources of broadly tunable picosecond and femtosecond pulses. Such systems are normally pumped by mode-locked bulk solid-state laser systems with typical fixed pulse repetition rates of \sim 100MHz. However, the emergence of new sources of ultrashort pulses has led to various demonstrations of SPOPOs with repetition rates up to 39GHz [1], and combined signal and idler average powers up to \sim 27W [2]. The pump sources have also become more compact, allowing SPOPOs based on amplified mode-locked diode sources [3], fiber lasers [4], and passively mode-locked miniature bulk lasers [1]. In this work we demonstrate an SPOPO pumped by a simple gain-switched laser diode amplified by an Yb-doped fiber. 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 [5].

2. Experimental Configuration and Results

The pump laser used in these experiments has been described previously [5]. It consists of a gain-switched laser diode and a chain of diode-pumped Yb-doped fiber amplifiers with just one free-space coupling component, making it a highly stable and practical pump source. It delivers linearly polarized, 1.06 μ m, 21ps pulses with average powers up to 100W. The repetition rate can be varied between 100MHz and 1GHz through the use of an electro-optic modulator pulse-picker and the output beam has a stable M^2 of 1.02 due to the use of a tapered splice into the final power amplifier. The SPOPO used a periodically poled 5% MgO-doped congruent LiNbO₃ (MgO:PPLN) 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 from 26.5 μ m to 31.5 μ m. It was held in an oven at 150°C to eliminate any residual photorefractive and to provide effective heat sinking. Singly resonant standing wave and ring resonators were constructed in a standard bow-tie configuration with an overall cavity length matched to the lowest pump repetition rate of 114.8MHz.

A significant power roll-over effect was seen for the standing wave cavity operated at 918.4MHz, which appeared to be, at least in part, thermal in origin as the performance recovered when a 50% duty cycle chopper was placed in the pumping beam. This effect was significantly reduced when using a ring resonator. Fig. 1 shows the output power characteristics for the ring resonator for 1, 4, and 8 pulses circulating in the cavity for pump average powers up to 24W, limited by thermal effects in the isolator used between the pump source and the SPOPO. It can be seen immediately that the roll-over effect is absent at the lower repetition rates and while still apparent at 918.4MHz it occurs at significantly higher pump powers. The origin of the roll-over effects are not yet understood but we note that if just a few percent of the pump power is converted to heat then the strong dn/dT for the MgO:PPLN extraordinary refractive index combined with the heat removal from only one face of the slab-like nonlinear crystal would lead to a strong aberrated thermal lens.

For 114.8MHz operation we obtain 7.3W of signal at 1.54 μ m and 3.1W of idler at 3.4 μ m, with a pump depletion that saturates at \sim 70%. Tunability between 1.4 μ m and 1.68 μ m (signal) and 2.87 μ m and 4.36 μ m (idler) was also demonstrated by using poled gratings of different periods, with the results shown in Fig. 1(d).

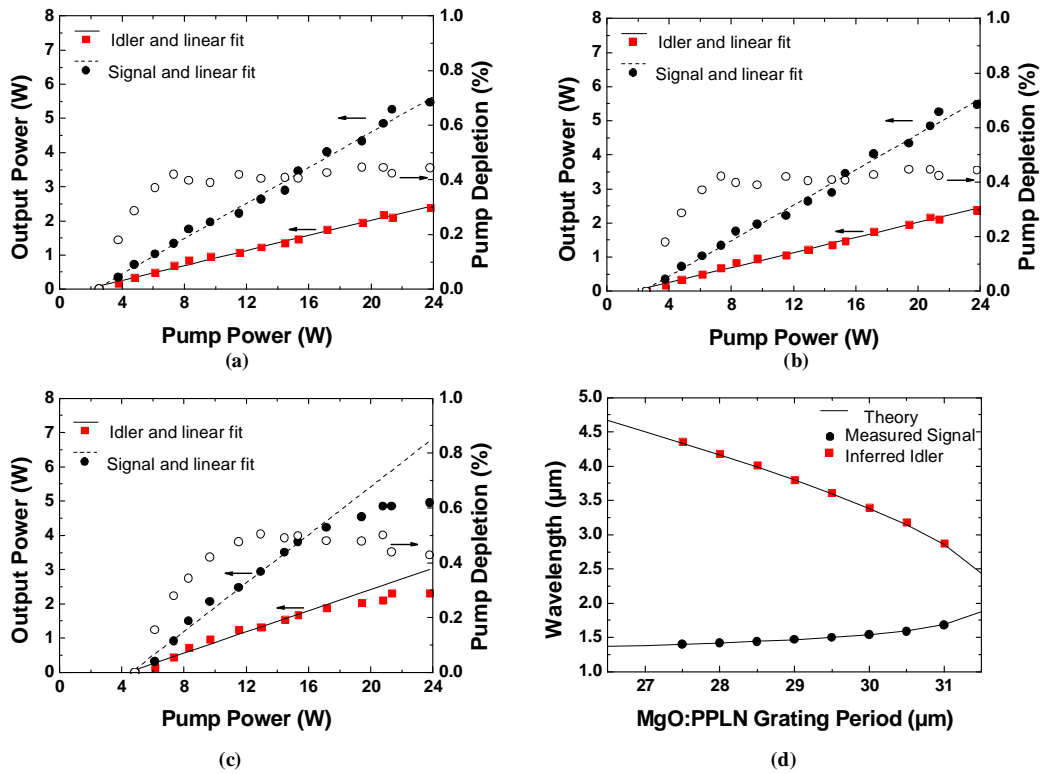


Fig. 1 Output power characterization of the ring cavity using a 65%R output coupler at (a) 114.8MHz, (b) 459.2MHz, and (c) 918.4MHz. The linear fits are to the first 10 data points in (c). The tuning performance is shown in (d), where different grating periods are accessed (temperature held at 150°C).

M^2 measurements indicated near diffraction-limited performance for the signal while the idler was slightly degraded to 3.2 by 1.6 in and out of the plane of the resonator. Signal and idler pulse durations were measured to be ~17ps.

3. Summary

We have demonstrated a high power, variable repetition rate, synchronously pumped optical parametric oscillator pumped by a fiber-amplified gain-switched laser diode. Further power scaling, along with any possible limitations, will be investigated using the compact pump source, which also has the potential for further increases in repetition rate and the production of shorter pulses [5].

4. References

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