Fiber-Based-SHG-Pumped, High-Power, Single-Frequency Continuous-Wave Optical Parametric Oscillator

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Summary

We describe a cw, singly-resonant parametric oscillator pumped at 532 nm by a frequency-doubled fiber laser. Single-frequency idler (signal) powers >2 W (>800 mW) are generated across 855-1408 nm, with 10.7% peak-peak power fluctuation and frequency stability <10 MHz.

Introduction

Continuous-wave (cw) singly-resonant optical parametric oscillators (SROs) represent versatile sources of widely tunable, high-power, single-frequency radiation in spectral regions inaccessible to lasers. Pumped at 1.064 µm, PPLN cw SROs can cover the 1-5 µm spectral range, but access to wavelengths <1 µm is precluded by photorefractive damage in PPLN. Due to its large photorefractive damage threshold at and relatively high nonlinearity (d_{eff}~10 pm/V), MgO:sPPLT is an attractive alternative for frequency conversion below 1 µm. Recently, we demonstrated that by exploiting this material and pumping at 532 nm, we can achieve practical operation down to 850 nm [1], and as short as 425 nm in the blue [2]. Operation of these cw SROs was made possible only by deploying a relatively complex, commercial, high-power, frequency-doubled cw Nd:YVO_4 laser (Coherent, Verdi-10) at high cost. Here, we demonstrate operation of such green-pumped cw SROs using a fiber-based laser pump source. To our knowledge, this the first report of a cw SRO pumped by a fiber-laser-based pump source at 532 nm in the green. The key to the successful realization of such a cw SRO is efficient generation of high-power cw radiation in the green using simple single-pass second harmonic generation (SHG) of an infrared fiber laser in a suitable nonlinear crystal to provide the pump radiation [3].

Experiment

A schematic of the experimental setup is shown in Fig. 1. A 30-W, cw Yb fiber laser (IPG Photonics, YLR-30-1064-LP-SF) at 1.064 µm is frequency-doubled in a 30-mm MgO:sPPLT crystal with a single grating (Λ=7.97 µm) to provide up to 9.64 W of single-frequency green power at 532 nm [3]. The SRO is based on an identical MgO:sPPLT crystal [1,2] and is configured in a compact ring cavity comprising two concave mirrors, M_1 and M_2 (r=100 mm), and two plane reflectors, M_3 and M_4. All mirrors have R>99%@840-1000 nm and T>85%@1100-1500 nm, except for M_4 (output coupler, T=0.71%-1.1% @840-1000 nm), thus ensuring SRO operation. A 500-µm fused silica etalon (FSR=206GHz, finesse~0.6) is used for frequency control. Total optical length of the cavity is 711 mm (FSR~422 MHz).

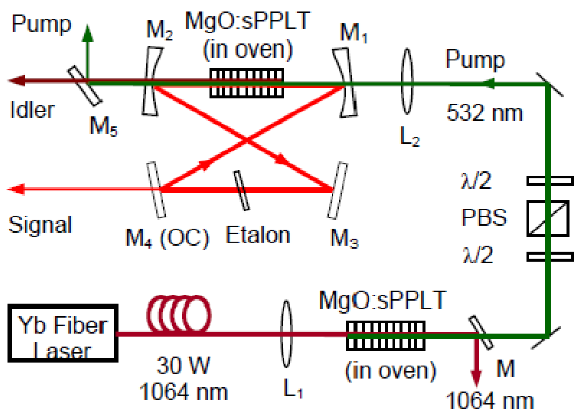

Fig. 1. Configuration of the cw SRO based on MgO:sPPLT, pumped in the green at 532nm with a frequency doubled Yb fiber laser.

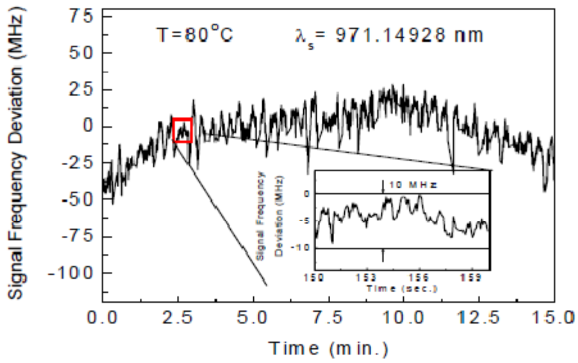

Fig. 2. Frequency stability of signal at wavelength of 971nm for crystal temperature of 80°C over 15 mins and (inset) short term frequency stability over 10 sec.

The SRO is tuned across 855-1408 nm by varying the crystal temperature from 59°C to 236°C [1]. With optimum output coupling (1.04%), we obtain a signal power of 800 mW in TEM_{oo} spatial profile (M^2<1.52) with simultaneous idler power of up to 2 W (M^2<1.26) across the tuning range, for a pump power of 7.3 W. The out-coupled signal shows higher peak-peak power stability (<10.7%) than idler (<11.7%) over 40min. The frequency stability of the signal at 971.14 nm, measured using a wavemeter (High finesse, WS/U-30), is shown in Fig. 2. Under free-running conditions, the signal output exhibits a natural peak-peak frequency fluctuation <75 MHz over 15 minutes with a short-term frequency stability <10 MHz over 10 seconds (inset of Fig. 2), confirming robust, high-power, frequency-stable operation of the device and its potential for spectroscopic applications.

Conclusion

In conclusion, we have demonstrated the first cw SRO pumped in the green by a frequency-doubled cw fiber laser. Using identical crystals of MgO:sPPLT for single-pass SHG into the green and as the SRO gain medium, and by exploiting output coupling of the resonant wave, we have extracted continuously tunable radiation across 855-1408 nm. The SRO provides an idler power of up to 2 W in a TEM_{oo} spatial mode (M^2<1.26). Non-optimum output coupling (T=1.04%), provides a signal power up to 800 mW in a TEM_{oo} profile (M^2 <1.52). The generated signal and idler power shows a peak-to-peak stability of <10.7% and <11.7% over 40 minutes. The resonant signal exhibits a passive frequency stability of <75 MHz over 15 minutes and <10 MHz over 10 s.

References

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