Continuous-Wave, Single-Frequency Optical Parametric Oscillator Pumped by a Frequency-Doubled Fiber Laser

G. K. Samanta[1], S. Chaitanya Kumar[1], Ritwick Das[1], and M. Ebrahim-Zadeh[1,2]

[1]*ICFO-Institut de Ciencies Fotoniques, Mediterranean Technology Park, 08860 Castelldefels, Barcelona, Spain*

[2]*Institucio Catalana de Recerca i Estudis Avancats (ICREA), Passeig Lluis Companys 23, Barcelona 08010, Spain*

Main author email address: goutam.samanta@icfo.es

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}~10pm/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 commercial, high-power, high-cost, frequency-doubled cw Nd:YVO_4 laser (Coherent, Verdi-10). Here, we demonstrate operation of such green-pumped cw SROs using a fiber-based laser pump source. To our knowledge, this is the first report of a cw SRO pumped by a fiber-laser-based pump source in the green.

The key to the successful realization of such a cw SRO has been 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]. A 30-W, cw single-frequency Yb fiber laser (IPG Photonics, YLR-30-1064-LP-SF) at 1.064 μm is frequency-doubled in a 30-mm MgO:sPPLT crystal (HC Photonics) 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 and is configured in a compact ring cavity [1,2] comprising two concave mirrors of radius of curvature 100mm, and two plane reflectors. All mirrors have R>99%@840-1000 nm and T>85%@1100-1500 nm, except for one of the plane mirrors (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.

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_{00} 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-to-peak power stability (<10.7%) than idler (<11.7%) over 40 minutes. The frequency stability of the signal at 971.14 nm was measured using a wavemeter (High finesse, WS/U-30). Under free-running conditions, the signal output exhibits a natural peak-to-peak frequency stability <75 MHz over 15 minutes with a short-term frequency stability <10 MHz over 10 seconds, confirming robust, high power, frequency-stable source and its potential for spectroscopic applications.

References

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