Dither-locked mid-infrared femtosecond subharmonic OPO using $ZnGeP_2$

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Femtosecond subharmonic (also called as 'degenerate') OPO in which signal and idler waves are indistinguishable offers an elegant manner to generate broadband coherent light source, especially in the 2-20 μm mid-infrared (mid-IR) 'molecular fingerprint' region [1]. Mid-IR broadband femtosecond subharmonic OPO shows great potential for vibrational spectroscopy, coherent Ising machine, etc. To date, mid-IR broadband femtosecond subharmonic OPOs have been mainly demonstrated with orientation patterned GaAs/GaP (OP-GaAs/GaP) [2]. However, orientation patterned nonlinear devices tend to suffer from scattering loss and limited aperture (usually 1-2 mm).

Here, we demonstrate a dither-locked, mid-IR broadband femtosecond subharmonic OPO by using a birefringent crystal of $ZnGeP_2$ (ZGP). ZGP exhibits high nonlinearity (d_{36} = 75 pm/V), good transparency up to 12 μm, and allows birefringent phase matching with small spatial walk-off (12 mrad for this application), providing larger aperture.

Figure 1(a) shows the setup of our femtosecond subharmonic OPO using ZGP. The pump source is a watt-class femtosecond Cr:ZnS MOPA with a repetition rate of 140 MHz and a pulse duration of 130 fs [3]. The broadband anti-reflection coated ZGP crystal has a thickness of 1 mm and is cut at θ = 51° (φ = 0°) for type-I phase matching. The maximum output power of two reflected beams at 6.4% OC is 35.8 mW after a filter (Spectrogon, LP3000) under 620 mW pump. For our femtosecond subharmonic OPO using ZGP, it has several different states, e.g., ultra-broadband state, degenerate state, and double-resonant state. Using the dither-locking system, the subharmonic OPO can be locked at degenerate state and double-resonant state for >1 h. Fig. 1(b) shows the long-term stabilized spectra for degenerate state (upper) and double-resonant state (lower). The OPO cavity will be optimized with nitrogen purging to seek dither-locking of the ultra-broadband state (spectrum covering 3.6-6.5 μm), which suffers from serious absorption of CO_2 (near 4.3 μm) and H_2O (>5 μm).

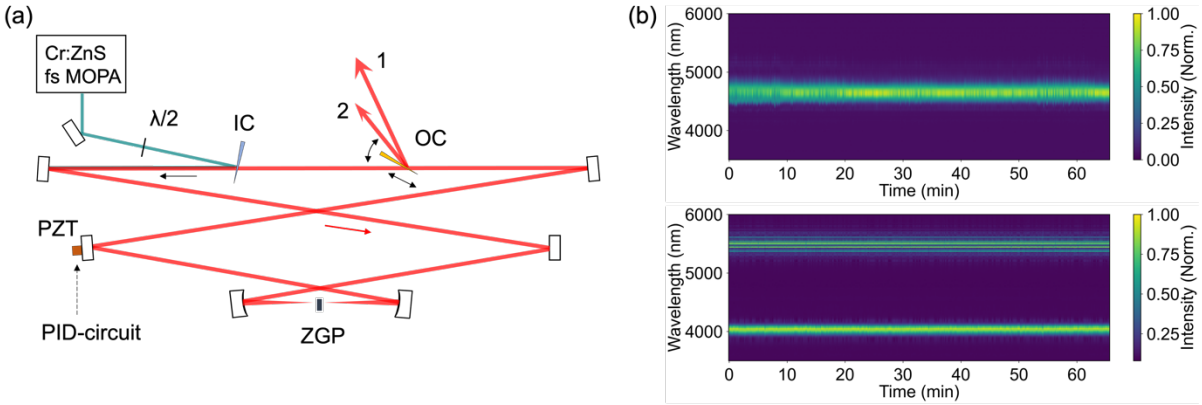

Fig. 1. (a) Schematic of the dither-locked femtosecond subharmonic ZGP OPO. (b) Long-term spectra stability of the degenerate state (upper) and double-resonant state (lower) measured every 10 s using FTIR spectrometer.

References

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[3] X. Bu, *et al., Opt. Express* **30**(6), 8517-8525 (2022).