Mid-Infrared Optical Parametric Generation in $CdSiP_2$

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Abstract: We report parametric generation of near- and mid-infrared picosecond pulses at 100 kHz in $CdSiP_2$ pumped at 1.064 μm, providing 154 mW of idler at 6.204 μm and 1.16 W of signal at 1.282 μm.

Cadmium silicon phosphide, $CdSiP_2$ (CSP) [1], is a recently discovered nonlinear material which offers unique properties for parametric down-conversion into the mid-IR. It offers a transparency above ~6.5 µm and a noncritical phase-matching (NCPM) capability with an effective nonlinear coefficient as high as $d_{eff}=d_{36}$=84.5 pm/V. It has a band-gap well below 1 µm, which permits pumping at 1.064 µm, and under type I (*e→oo*) parametric generation with NCPM can provide an idler wavelength beyond 6 µm, a spectral range of great interest for medical applications. Here, we report efficient generation of picosecond pulses in near- and mid-IR in CSP at 100 kHz using single-pass parametric generation (OPG) pumped by a mode-locked Nd:YVO_4 laser at 1.064 µm. We demonstrate an average signal power of 1.16 W at 1.282 µm and idler power of 154 mW at 6.204 µm for 6.1 W of pump power.

The pump source is an amplified mode-locked Nd:YVO_4 laser at 1.0642 µm. It can deliver up to 40 W of average power at 100 kHz with a pulse energy of 400 μJ. The pump beam is collimated to a ~500 μm diameter before the crystal. Pumping is single-pass. The CSP crystal was cut at θ=90° (φ=45°) for type I (*e→oo*) interaction with a length of 8 mm and an aperture of 6.75 X 6 mm (along the *c*-axis). Both crystal faces were AR-coated for the pump, signal and idler wavelengths

We observed OPG output at 1.1 W of pump, corresponding to a pulse energy of 11 µJ and pumping intensity of 0.62 GW/cm^2 (see Fig. 1). For 6.1 W of pump, we generated an average signal power of 1.16 W at 1.282 μm with pulse energy of 11.6 µJ, representing a power efficiency of ~19% and a photon conversion of ~23%. We also measured an average idler power of 154 mW with a pulse energy of 1.54 µJ at 6.204 μm, representing a power efficiency of ~2.5%, with a photon conversion efficiency as much as ~15% from the pump to idler. Beyond 6.1 W of pump, we observed the onset of lensing in the CSP crystal. By chopping the pump beam at different duty cycles (Fig. 1), we verified the origin of the saturation and lensing as thermal (see Fig. 1).

The measured autocorrelation of the signal is shown in Fig. 2, corresponding to a pulse duration of 6.36 ps, and a spectrum centered at 1.282 μm with a bandwidth of 8.5 nm, resulting in a time-bandwidth product of 9.3. The idler spectrum, shown in Fig. 3, is centered at 6.204 μm, and has a bandwidth of 122 nm. The dips in the spectrum correspond to absorption lines of water, as verified by the HITRAN molecular database. The signal and idler peak wavelengths of 1.282 μm and 6.204 μm are in close agreement with the calculated values of 1.286 μm and 6.180 μm for a pump wavelength of 1.0642 μm based on the Sellmeier equations for the material.

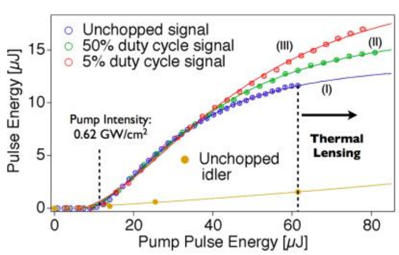

Fig. 1. Signal pulse energy versus pump pulse energy at the input to the CSP crystal.

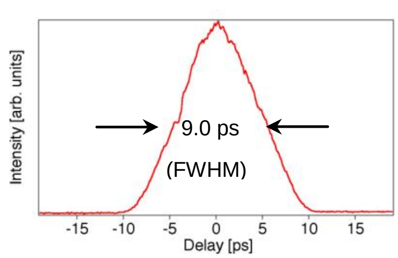

Fig. 2. Intensity autocorrelation of the the signal pulses at 1.282 μm.

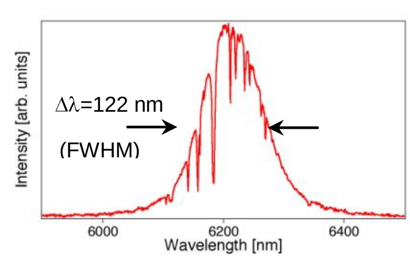

Fig. 3 Spectrum of idler centered at 6.204 μm

References

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