Narrowband and tunable optical parametric oscillator near and at degeneracy using a transversely chirped Bragg grating

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Summary

We demonstrate locking and tuning of a nanosecond optical parametric oscillators near and at degeneracy with oscillating wavelengths from 1000 to 1066 nm using transversely chirped Bragg gratings. The signal had bandwidths of <0.6 nm and energies of ~0.4 mJ.

Introduction

With optical parametric oscillators (OPOs) pumped by nanosecond lasers and using quasi-phase-matched crystals, efficient generation of wavelengths beyond the range existing lasers can be achieved. However, in the free running regime, the generated signal and idler waves have a broad spectral bandwidth, which is especially true near or at degeneracy.

By introducing a component for spectral selection into the OPO cavity, the signal bandwidth can be restricted. We have previously demonstrated that volume Bragg gratings written in thermo-photo-refractive glass are well suited for restricting and locking the OPO signal wavelength [1]. By simply replacing one of the OPO cavity mirrors for the grating, which acts both as a mirror and a filter, the OPO cavity is still very simple and compact. These gratings are also very durable, which is required due to the high fluencies in the OPO cavity, enabling a stable device.

Here we demonstrate a method for obtaining a tunable OPO signal, in addition to the spectral narrowing [2]. This is done by use of a grating with a transversely varying grating period, i.e. with a transverse chirp. Then, by simple translation of the grating, the OPO signal can be tuned in a very convenient way.

Experiments

The experimental setup is depicted in Fig. 1. The OPO was pumped at 532 nm by a Q-switched frequency-doubled, flashlamppumped Nd:YAG laser, that delivered 5 ns pulses with energies up to 2 mJ. The input coupler was flat and coated for high transmission at the pump wavelength and high reflectivity of the signal and idler. The nonlinear crystal was a periodically poled KTP with a period of 9.01 µm. The temperature of the PPKTP could be controlled to slightly tune the OPO gain to match the different gratings.

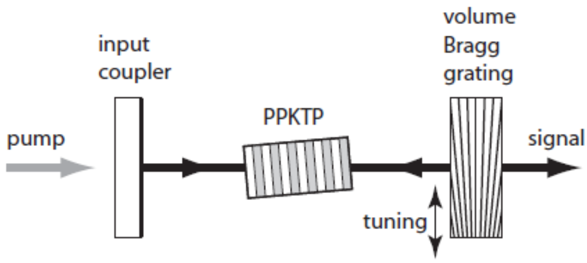

Fig. 1. OPO Setup

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The locking and tuning of the oscillating OPO signal were done by transversely chirped volume Bragg gratings (Optigrate), that provided tuning by translation. The grating was also used as the output coupler. Three different gratings were used, grating 1 with ~50% reflectivity for 997-1016 nm, grating 2 with ~35% reflectivity for 1010 - 1023 nm and grating 3 with ~60% reflectivity for 1055 -1066 nm.

When operating the OPO, the oscillating wavelength was set by the grating. By translating the grating, the OPO signal wavelength could be tuned, as shown in Fig. 2. The bandwidth of the generated signal was in all cases below 0.6 nm. At the maximum pump energy of 2 mJ, a total output energy of ~0.7 mJ was generated, corresponding to ~35% conversion efficiency.

Besides the strong signal and idler, additional subpeaks in the generated spectrum could also be seen, at regular intervals with a spacing equal to that between the signal and idler. We attribute these subpeaks to four wave mixing, generated by cascaded $\chi(2)$:$\chi(2)$ interactions, with the frequency-doubled signal or idler as the intermediate field and further amplified by the strong parametric gain.

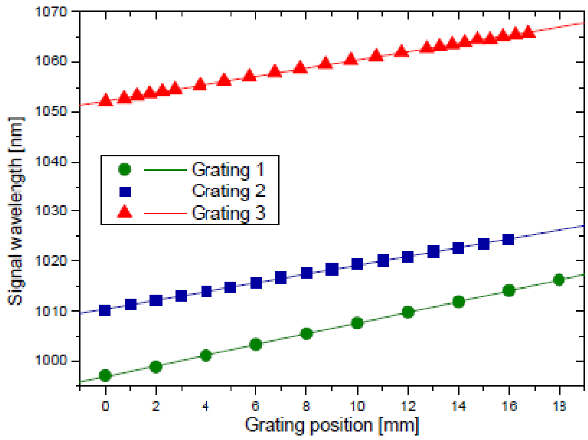

Fig 2. OPO oscillating wavelength tuning with grating position for different gratings, experimental points and linear fit.

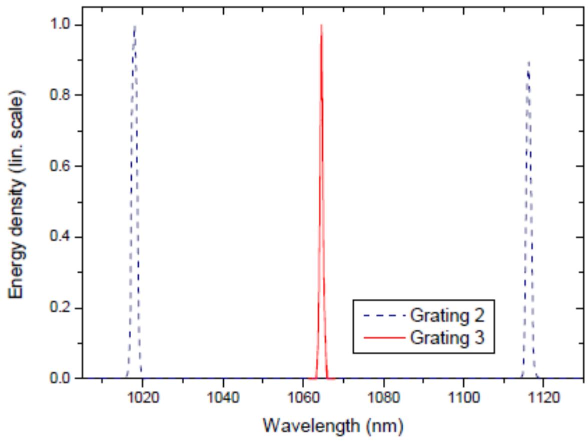

Fig. 3. Examples of OPO spectra, showing signal and idler for grating 2, and grating 3 tuned to degeneracy, where the signal and idler coincide.

Conculsions

We demonstrate a convenient method to generate tunable and narrowband radiation in an OPO near degeneracy by use of a transversly chirped Bragg grating. The studied OPOs operated at oscillating wavelengths from 997 to 1066 nm. Still, the technology is entirely based on components that can be tailored to generate radiation anywhere in their transparency range, so generation of light in other wavelength regions is also possible. One such region of interest is generation of wavelengths > 2 µm, that can subsequently be used to pump mid-IR OPOs, using nonlinear crystals that absorb radiation below 2 µm.

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References

[1] B. Jacobsson, M. Tiihonen, V. Pasiskevicius and F. Laurell, *Opt. Lett.* **30**, 2281 (2005).
[2] B. Jacobsson, V. Pasiskevicius, F. Laurell, E. Rotari, V. Smirnov and L. Glebov, Opt. Lett. **34**, 449 (2009).