Fourier transformed picosecond OPO based on PPSLT without spectral filtering element

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Summary

We demonstrate tunable synchronously pumped OPO system delivering picosecond Fourier-transformed limited pulses in near infrared spectral region. The developed OPO source offers a good compromise with Fourier transformed pulses around 10-15 ps duration and tunable in the whole telecommunication window from 1300 nm to 1600nm.

Introduction

Synchronously pumped optical parametric oscillators (OPO) are widely used sources of tunable ultrashort pulses, which can be applied for the measurements of optical nonlinearities of variety of materials. In this paper we demonstrate a tunable OPO based on a periodically poled stoichiometric lithium tantalate (PPSLT) crystal delivering picosecond Fourier-transformed pulses in near infrared spectral region. To the best of our knowledge, this is the first demonstration of a near infrared picosecond OPO that uses PPSLT. It has been developed for the characterization of nonlinear photonic crystals. The short pulses give high peak power required to easily generate the nonlinearities under studies, and also give access to time resolution in pump probe configuration.

Results and Discussion

The OPO is pumped by a mode-locked Ti:Sapphire laser with a pulse duration of 10 ps, a central wavelength set at 725 nm. It delivers an average output power of 1.7 W with a repetition rate of 80 MHz. A stable, bow tie, singly resonant cavity has been designed to minimize the round-trip loss. An output coupler with 80% reflectivity in the range 1530-1650 nm (and antireflective at the idler wavelength) is used. The PPSLT crystal is 20-mm long and has been selected for its high photorefractive damage resistance [1]. In order to achieve a signal radiation around 1550 nm, the crystal period has been set to 18μm and the temperature of the crystal is kept around 125 ^{0}C.

The cavity round trip has been set first to optimize the output power. With the maximal pump power of 1.7 W we obtained up to 450 mW of signal and 450 mW of idler radiation. The threshold of oscillation was found to be 750 mW. In that regime the spectrum for both signal and idler is considerably broadened with a full bandwidth of 10-15 nm at 1550nm in comparison with the spectral width of a Fourier transformed pulse of 10 ps.

It is well established that the cavity length detuning between a synchronously pumped OPO and the pump laser strongly influences the OPO output characteristics [2,3]. Fig. 1 presents the dependence of the output power with the cavity length detuning. Although the same behaviour for both signal and idler radiations is observed, the dependence looks like asymmetric with respect to the zero detuning. It is worth noting that both spectral and temporal behaviour were dramatically changed by varying the cavity length and that several regimes of generation have been observed with two main regions I and II (Fig.1).

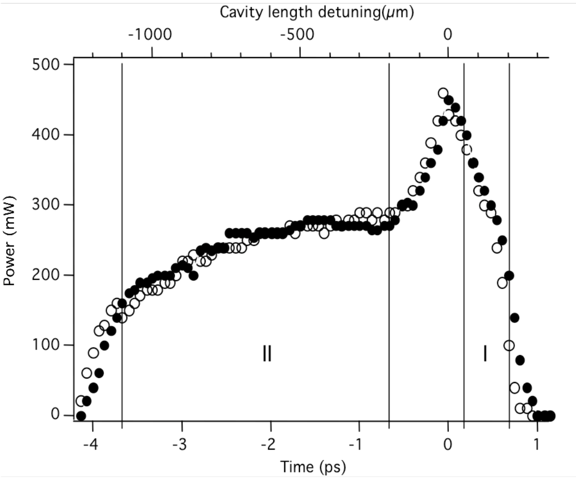

Fig. 1. OPO output power measurement of signal (filled circles) and idler (open circles) with the cavity length detuning.

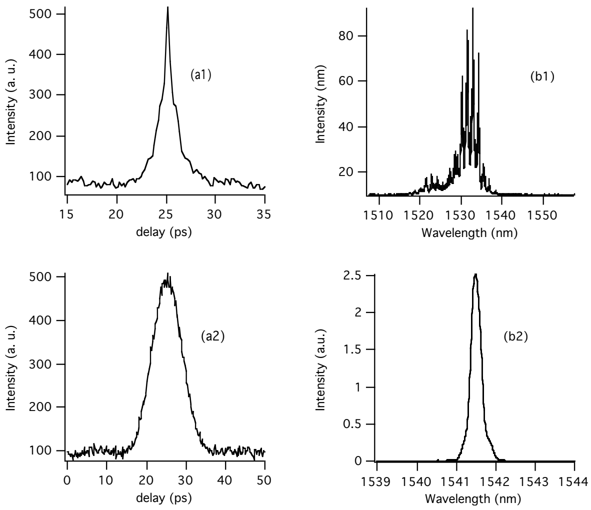

Fig. 2. Autocorrelations and spectra of signal pulses for the regions I (a1, b1) and II (a2, b2).

In Fig. 2, the autocorrelation traces and spectral profiles of the signal pulses are shown for these two regions. The differences in the pulses behaviour come from the strong group velocity mismatch between pump and signal pulses. The group velocity for the pump is lower than that of the signal. In the case of region I, corresponding to a positive cavity length detuning, the round trip time of the signal pulse is longer than the time separation between two pump pulses. Short pulses with duration between 1 and 2 ps (Fig.2, a1, b1) are generated through a compression effect [3]. At the crystal input, only the leading part of the signal pulse interacts with the trailing part of the pump pulse, thus leading to its amplification and depletion of the corresponding part of the pump pulse. Because the group velocity mismatch is of the order of the pump pulse duration, at the crystal output, the short signal pulse is now amplified by the unsaturated leading part of the pump pulse. This process allows a compression of the signal pulse to be 5-10 times in comparison with the pump pulse duration.

In the situation of a negative cavity length detuning (Region II, Fig.1), the signal pulse duration is of the same order of that of the pump pulse. For a given cavity length detuning, a spectral filtering effect occurs towards the wavelength that minimised the group velocity mismatch between the pump pulse and enables a Fourier transform pulse (Fig.2, a2, b2).

Large tuning of the OPO is obtained using temperature control of the PPSLT crystal. Wavelength tuning within the region of 1530-1640 nm (limited only by a output coupler transmission range) and idler wavelength in the region of 1300-1375 nm has been achieved. A minimum tuning step of 0.5 nm was obtained by the change of the crystal temperature by 0.1 ^{0}C.

References

[1] Kitamura K., Furukawa Y., Takekawa S., Hatanaka T., Ito H., Gopalan V., Ferroelectrics **257**, 235, 2001.

[2] Ebrahimzadeh M., French S., Miller A. J. Opt. Soc. Am. B. **12**, 2180, 1995.

[3] Tartara L. Opt. Lett. 32, 1105, 2007.