Extended-cavity GHz-Repetition-Rate Femtosecond Optical Parametric Oscillator Pumped at 76 MHz

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Abstract: We report a dispersion compensated 1-GHz femtosecond optical parametric oscillator synchronously pumped by a 76-MHz Ti:sapphire laser using a cavity longer than the fundamental synchronous cavity length with improved output power and near-transform-limit pulses .

To date, most femtosecond synchronously-pumped optical parametric oscillators (SPOPOs) have been pumped by the Kerr-lens-mode-locked (KLM) Ti:sapphire laser at repetition-rates typically <100 MHz, generating output pulses at the same repetition-rate as the pump. For some applications, such as pump-probe spectroscopy or future optical telecommunication systems, ultrashort pulses at GHz repetition-rate are desirable. Three different approaches have been previously adopted to increase the repetition-rate of a femtosecond SPOPOs to the GHz range. The first deploys GHz-repetition-rate pump lasers, but suffers from the need for custom-designed, very-high-repetition-rate femtosecond pump laser with sufficiently high power [1]. The other two methods make direct use of the KLM Ti:sapphire laser at 70-100 MHz as the pump source [2-3], which are based on cavity length reduction leading to increased difficulty in attaining optimum mode matching with the pump, especially for the generation of highest harmonics towards GHz repetition-rate. Moreover, the physical limit prevents the inclusion of additional intracavity components such as prisms for dispersion compensation to improve pulse quality.

Recently, we demonstrated a 1 GHz femtosecond SPOPO pumped by a 76-MHz Ti:sapphire laser using a cavity longer than the fundamental synchronous length [4]. In this approach, femtosecond pulses at Qth harmonic of pump repetition rate can be produced by adding ($1/Q$) of pump laser cavity length to SPOPO cavity length. In this work, to extend the tunability into telecommunication wavelength range, improve the pulse quality and obtaining higher output powers, we deploy dispersion compensation using a pair of SF-11 prisms spaced 28 cm tip-to-tip internal to SPOPO cavity. As shown in Fig.1, SPOPO is based on PPLN crystal ($11\times0.5\times1$ mm^3) and is pump by a KLM Ti:sapphire laser at 76 MHz at 814 nm. By carefully increasing the SPOPO cavity length through adjustment of the P2-M3 arm, we successfully obtained and examined harmonics of pump laser repetition-rate.

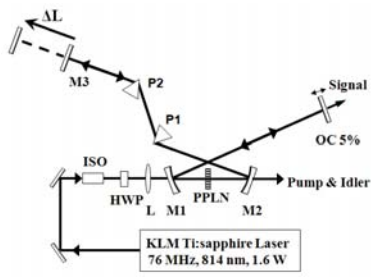

Fig. 1. Experimental setup of SPOPO and cavity length extension by $\Delta L=(1/Q).l_p$, where l_p is the pump laser cavity length. ISO: optical isolator, HWP: a half-wave plate, L: focusing lens, P1 and P2: prisms

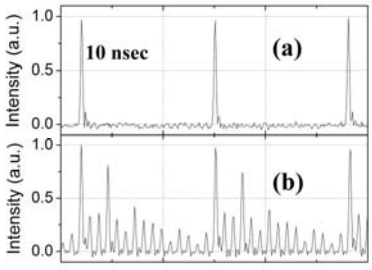

Fig. 2. (a) Input pulse train of KLM Ti:sapphire pump laser at 76 MHz, and (b) Output signal pulse train of the femtosecond SPOPO at the 15th harmonic repetition-rate (1140 MHz) pumped by this laser.

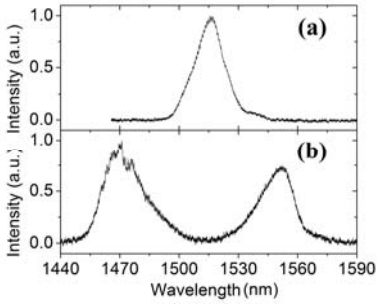

Fig. 3. Spectra of SPOPO output at the 14th harmonic repetition-rate (a) with and (b) without pair of SF-11 prisms.

The highest stable harmonic achieved was 14th, with threshold pump power of 1.14 W at a shifted wavelength range around telecommunication band. With an input power of 1.45 W after optical isolator and wave-plate, the average signal power through 5% output coupler was 70 mW at 1510 nm. The pulse trains corresponding to the pump laser and the SPOPO output signal pulses in the 15th harmonic are shown in Fig. 2. As depicted in Fig. 3, inserting pair of prisms (top) improved the output pulse spectrum and stability. Signal pulses with an average duration of 210 fs and FWHM bandwidth of 15 nm are produced implying near-transform-limited pulses.

References

[1] X. P. Zhang, J. Hebling, A. Bartels, D. Nau and J. Kuhl, W. W. Ruehle, and H. Giessen, Appl. Phys. Lett. **80**, 1873 (2002).

[2] D. T. Reid, C. McGowan, W. Sleat, M. Ebrahimzadeh, and W. Sibbett, Opt. Lett. **22**, 525 (1997).

[3] J. Jiang and T. Hasama, Appl. Phys. B **74**, 313 (2002).

[4] A. Esteban-Martin, O. Kokabee, K. Moutzouris and M. Ebrahim-Zadeh, Opt. Lett. **34**, Febreuary (2009).