1437 POST DEADLINE PAPER

Order of magnitude pulse compression in a CW synchronously-pumped optical parametric oscillator using periodically-poled lithium niobate

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Abstract

With 4 psec pump pulses from a diode-pumped cw mode-locked Nd:YLF laser, a synchronously-pumped parametric oscillator using periodically-poled $LiNbO_3$ generates 200-250fs signal pulses, with peak power exceeding that of the pump.

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Summary

We report strong pulse compression, by up to 20 times, from 4ps pump pulses to 200-250 fs signal pulses, in a CW synchronously-pumped optical parametric oscillator (SPOPO), based on periodically-poled lithium niobate (PPLN). The compressed pulses show excellent stability, and high conversion efficiency, with peak signal output powers exceeding the peak pump input powers.

The principle of pulse compression in a SPOPO has previously been demonstrated using BBO, with intense (~1MW) Q-switched mode-locked trains [1]. The requirements for compression are high gain (10^2 - 10^3 is quoted in [1]), and large group velocity walk-off between pump and resonated wave. With the singly-resonant OPO resonator biassed longer than the exact synchronism length, resonated signal pulses enter the nonlinear crystal delayed relative to the pump pulse and then 'walk-through' the pump pulse over the crystal length. The high gain allows the leading edge of the signal pulse to deplete the entire pump pulse, thus extracting essentially all of the pump energy into compressed pulses.

Extension of this technique to a CW-mode-locked regime is enabled by the use of PPLN, which provides high gain for much lower pump power. Also in practice we find that a parametric gain of ~10 suffices for strong pulse compression under CW mode-locked conditions. A PPLN crystal of 19mm length was used (fabricated at Crystal Technology), chosen to provide a group-delay comparable to the pump pulse duration for signal wavelengths in the range, 1.7-1.9μm, that we examined. A 4-mirror OPO resonator, either in a standing wave or ring configuration was used, with similar results for each. The output coupler, an uncoated $LiNbO_3$ or ZnSe flat, gave a Fresnel reflectivity of ~15%, thus enforcing high gain operating conditions. With the OPO

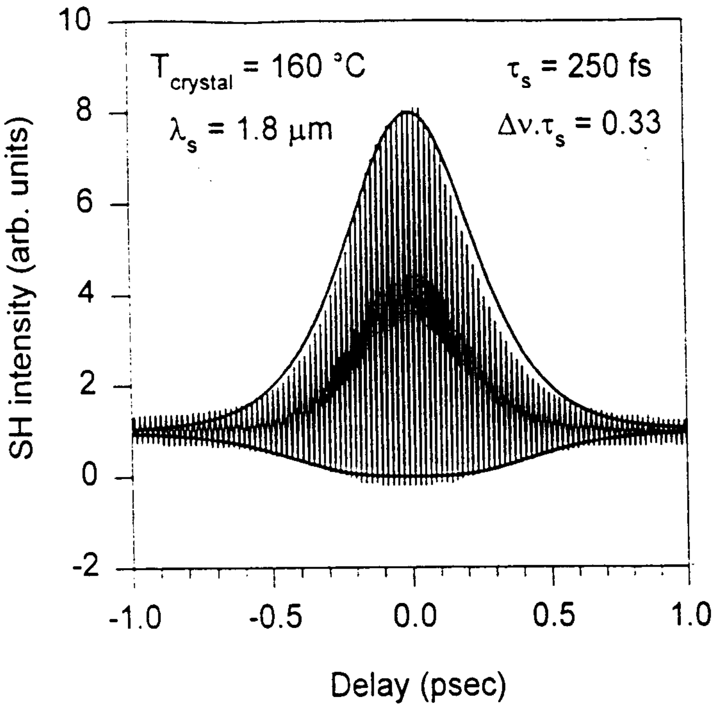

Fig.1. Interferometric SHG autocorrelation of 250fs signal pulse at 1.8µm

resonator set for exact synchronism with the 120 MHz pump pulse train (from a diode-pumped CW mode-locked 1047nm Nd:YLF laser, Microlase DPM-1000-120) average signal powers were at their maximum, ~300mW at 1.8µm for ~1W of incident pump. Simply increasing the resonator length by ~ 50µm gave compressed signal pulses of 200-250fs, with slightly reduced signal power, to ~220mW, hence peak signal powers of ~7kW, exceeding the 2kWof peak pump power. The non-resonant idler also shows significant, although less, compression, over the range 2.3µm to 2.7µm. The compressed pulses are very stable, and typical interferometric autocorrelation traces are very clean, (fig.1) indicating negligible chirp, and time-bandwidth procucts of ~0.33.

This compression technique confirms PPLN as a material well-suited to ultrashort pulse uses, offering a simple and effective route to widely tunable femtosecond pulse generation, avoiding the route based on OPOs driven by an Ar laser/femtosecond Ti:sapphire system.

References

1. J.D.V. Khaydarov, J.H. Andrews, K.D. Singer, J.O.S.A. B **12**, 2199-2208, 1995.