Chirped-mirror dispersion-compensated femtosecond optical parametric oscillator

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We describe the operating characteristics of a femtosecond optical parametric oscillator employing chirped mirrors for intracavity group-velocity dispersion compensation. Pumped by 760 mW of power from a self-mode-locked Ti:sapphire laser, this device provides 100-fs near-transform-limited pulses continuously tunable from 1.18 to 1.32 μm with an average power of 100–180 mW. The limitations of the present setup and strategies for further pulse shortening are discussed.

Ti:sapphire laser-pumped optical parametric oscillators (OPO's) are attractive sources for tunable femtosecond light pulses in the visible[1,2] and near-infrared[2–7] spectral ranges. In principle, they can work without any group-velocity dispersion- (GVD-) compensating device.[3,6,7] Generation of transform-limited pulses shorter than 100 fs (and shorter than the pump pulse), however, necessitates compensation of the GVD that originates from both material dispersion and self-phase modulation in the nonlinear crystal.[2,4,5] Previously this GVD compensation was accomplished by insertion of prism pairs into the resonator.

In this Letter we report on the generation of transform-limited pulses as short as 73 fs from an OPO that uses chirped mirrors.[8] The application of chirped mirrors (CM's) for GVD compensation was recently demonstrated for femtosecond Ti:sapphire lasers.[9] The main advantages of CM's compared with prism pairs are the small insertion losses that lead to high frequency-conversion efficiency and output power of the OPO. The independence of the GVD from cavity alignment and the attainable reduction in the cavity length are attractive from practical points of view. Finally, CM's may become important for the generation of extremely short pulses (<20 fs) that require compensation of higher-order dispersion by use of a hybrid GVD-compensation system consisting of a prism pair and CM's.

The cavity configuration of our noncritically phase-matched KTP OPO[5–7,10] depicted in Fig. 1 has two-times-smaller material dispersion per round trip than a linear cavity. The OPO is pumped by 120–150-fs pulses from a Ti:sapphire laser (Coherent Mira 900). The focal length (10 cm) of folding mirrors M2 and M3 is two times longer than in the setups of Refs. 1, 2, and 4–7 to reduce the sensitivity to resonator misalignment. The transmission of the output coupler (M1) is 5%, and the back high reflector (M4) is mounted upon a piezoelectric translator (PZT) for fine adjustment of the cavity length. The pump beam is focused by an achromatic lens (L; $f = 10$ cm) into the 2-mm-thick KTP crystal. Tuning of the pump laser from 820 to 920 nm shifts the signal pulse wavelength from 1.18 to 1.32 μm. The spectral distribution of the OPO output pulses is characterized by an optical spectrum analyzer and the pulse width by autocorrelation measurements in a 1-mm-long β-barium borate crystal.

The CM's are designed to have a negative GVD of 85 fs^2 and a reflectivity of at least 99.5% over the spectral range from 1.1 to 1.4 μm. To study the influence of the CM's on the pulse duration and spectrum, we have varied the negative intracavity GVD in the cavity in steps by increasing the number of reflections from such mirrors. For comparison, data were taken first for a cavity with standard single-stack mirrors. Mirrors M2 and M4 were then replaced by CM's introducing a negative GVD. We obtained an increase in the negative GVD by inserting two additional CM's (M5 and M6) into the cavity. Using multiple reflections from these two mirrors, we can provide as much as eight times the GVD of one CM in the cavity.

The threshold of the OPO is typically 500 mW. At the pump power of 760 mW used in most experiments the average power-conversion efficiency of the OPO reveals significant saturation owing to the 50% depletion of the pump pulse. The spectral tuning range of the OPO from 1.18 to 1.32 μm is independent of the number of CM's and is limited by the sharp reflectiv-

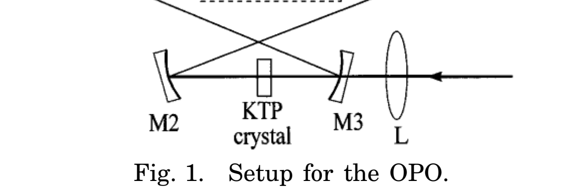

Fig. 1. Setup for the OPO.

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