Fibre-laser-pumped femtosecond PPLN optical parametric oscillator

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FRANCE

Abstract

The performance of a fibre-laser-pumped femtosecond PPLN optical parametric oscillator is described. The parametric oscillator exhibits a low threshold of 21mW, a high signal slope efficiency of 35% and generates broadly tunable 330fs pulses.

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High-power fibre laser systems are an emerging technology for compact, robust and stable generation of ultrashort pulses. Their power levels have now converged with the power levels needed for efficient frequency conversion in quasi-phase-matched nonlinear materials such as periodically poled $LiNbO_3$ (PPLN). The combination of these two technologies is seen as an attractive method for producing broadly tunable ultrashort pulses.

Here we present results of a synchronously pumped optical parametric oscillator (SPOPO) in PPLN, pumped by an Yb-doped, fibre laser source in a master oscillator power amplifier scheme. The operating characteristics of this system will be described, including its tuning behaviour, and the role of group velocity dispersion.

The experimental set-up is shown in Fig. 1. Each pulse from a modelocked, Yb-doped fibre oscillator [1] is amplified in a master-oscillator power-amplifier (MOPA) system, developing a stable parabolic pulseshape. These pulses are then recompressed using a diffraction grating compressor. The high power MOPA fibre source generates 215fs (FWHM) pulses at a repetition rate of 54MHz, delivering a maximum average power of 200mW to the OPO. An operating pump wavelength of 1.056μm was chosen for these experiments. The OPO investigated in this work is configured as a standing-wave resonator (see Fig. 1), similar to that previously described in detail in Ref 1. A 5mm-long, antireflection coated PPLN crystal was used with grating periods ranging from 29.8 to 30.5μm. The crystal is held in an oven at a fixed temperature of 100°C. Different wavelength regions are obtained by lateral translation of the crystal to access different grating periods.

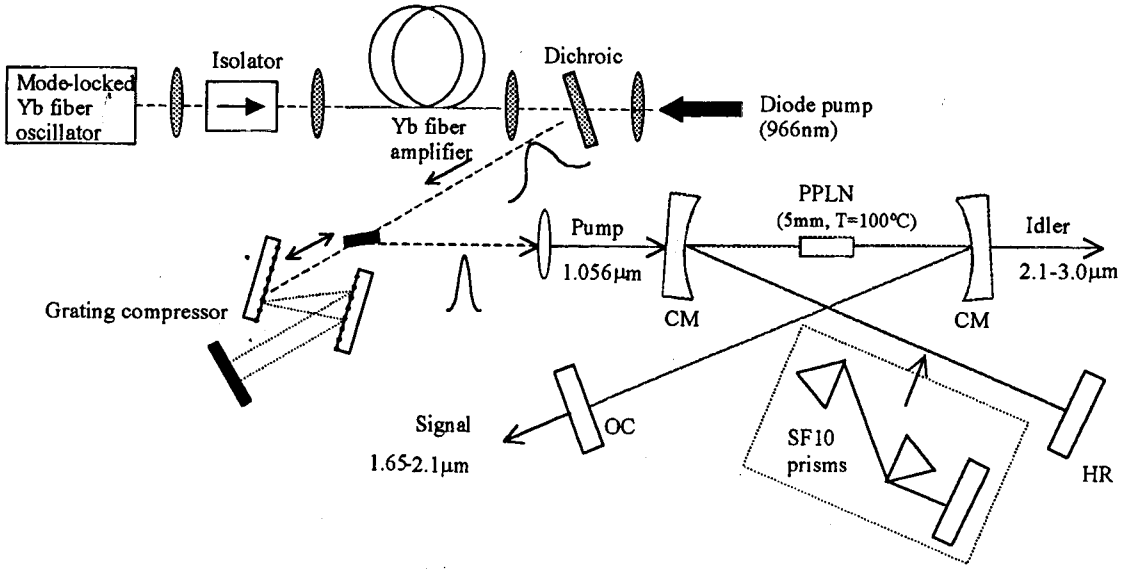

Figure 1:Schematic of OPO set-up. HR: high reflector; OC: output coupler; CM: curved mirrors.

An oscillation threshold of 21mW was achieved for a signal wavelength of 1.7μm in the case of a high reflector cavity. Using an output coupling reflectivity of 67%, with an average pump power of 188mW incident on the PPLN crystal, a maximum signal output of 40mW at 1.7μm was measured, corresponding to a signal conversion efficiency of 21%. The slope efficiency for the signal beam was 35% (see Figure 2).

The pulsewidth measured using a two-photon absorption intensity autocorrelation method was found to be 330fs (FWHM). A typical intensity autocorrelation and corresponding spectrum are shown in Figure 3. The time-bandwidth product was calculated to be 0.75.

Temperature tuning of the PPLN crystal for each grating period provided broadly tunable signal output over the range 1.65-2.1μm (implied idler tuning range 2.1-3.0μm). Increasing the tuning range below 1.65μm and beyond 3μm was limited only by the PPLN grating periods available. Agile wavelength control was achieved using cavity length detuning. With the wavelength set at 1.7μm, 35nm of continuous tuning was obtained from a cavity length change of 150μm.

The performance characteristics presented confirms the practicality of combining fibre laser systems with synchronously pumped PPLN OPOs. The low threshold and associated high gain suggest that the recently demonstrated use of a diffraction grating, in a picosecond OPO [2], to provide agile tuning, should be compatible with this femtosecond system. Ongoing work is aimed at demonstrating this.

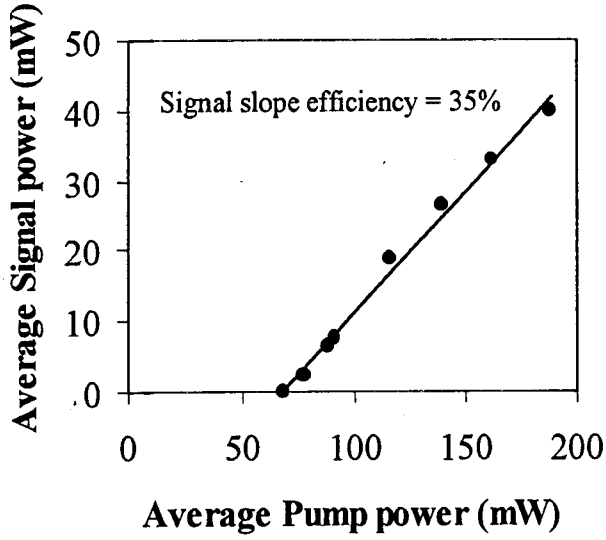

Figure 2: Signal slope efficiency, (output coupling reflectivity = 67%).

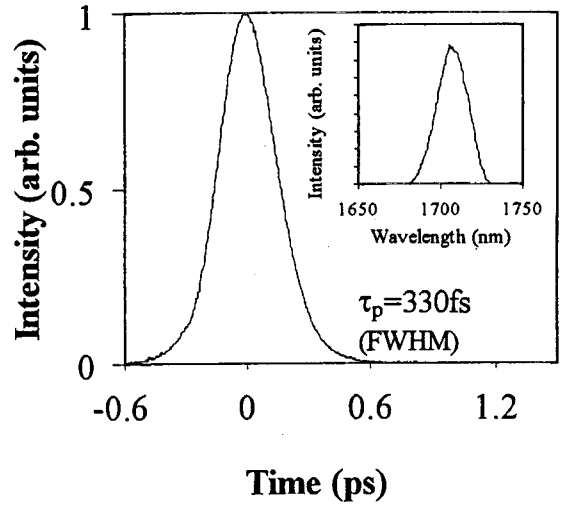

Figure 3: Intensity autocorrelation (two-photon absorption), associated spectrum (insert) λ=1706nm, Δλ =22nm (FWHM).

References:

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2. D.C.Hanna, M.V.O'Connor, M.A.Watson, and D.P.Shepherd, 'Synchronously pumped optical parametric oscillator with diffraction-grating tuning', J. Phys. D, (special issue), Sept (2001).