Picosecond optical parametric oscillation in bulk quasi-phase-matched lithium niobate

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Abstract.

We report a synchronously pumped singly resonant, low threshold optical parametric oscillator pumped at 523.5nm. A sample of periodically poled lithium niobate ($d_{eff} \approx$ 15pm/V) has been used in the experiment.

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Summary

Periodically poled lithium niobate (PPLN) is an attractive nonlinear medium on account of its very large effective nonlinearity (d_{eff}) and the fact that, with suitable period it can provide noncritical phase-matching for generation of any wavelengths in its transmission range. Optical parametric oscillators (OPO), Q-switched [1,2] and quasi-cw pumped [3], in bulk PPLN have been recently reported. In the picosecond regime, the large dispersion of PPLN limits the effective crystal length (l_{eff}). Despite this, the product of d_{eff} l_{eff} for PPLN compares favourably with KTP and LBO. An indication of the effectiveness of PPLN for frequency conversion of picosecond pulses has recently been demonstrated with ~65% SH efficiency from 2.6psec pulses at a fundamental wavelength of 1.047μm [4]. Here we report the first (to the authors knowledge) operation of a PPLN synchronously pumped OPO .

The electric field poled PPLN [4] with period of domain reversal (Λ) of 6.4μm, has d_{eff}=15pm/V, length 3.2mm and thickness 300μm. The sample was AR coated with a single layer of MgF_2 for 930nm. A simple four mirror resonator provided a signal waist of 26μm. The pump light was focussed to a spot of ~18μm. The pump source used in these experiments is a frequency doubled diode-pumped APM Nd:YLF laser with optional amplifier [5]. This source can be operated in a quasi-cw mode to obtain greater pump power without the need for resonant frequency doubling. Initial results were obtained for a cw mode-locked doubly resonant OPO where the threshold was 5mW of average power incident on the crystal. Pump depletions up to 80% were observed at 10 times threshold. The average green power in the cw case was limited to < 100mW and so the quasi-cw pulses (10μsec at 2kHz) were used to pump the singly resonant OPO (SRO), allowing access up to 1.25W of envelope-averaged pump power. Using an output coupling of 3% we observed a pump power threshold of 5mW (envelope average 250mW). The temperature tuning of the SRO is shown in figure 1. The average output power and pump depletion are shown in figure 2. The temporal behaviour of the SRO is shown in figure 3 at twice threshold (500mW envelope average power). The power drop over the pulse is due to saturation effects in the amplifier stage. We have not observed any significant photorefractive damage in the PPLN at these levels of power in agreement with previous work [4].

In conclusion, we demonstrate the first PPLN synchronously pumped OPO and plan to further optimise and characterise this device by reducing the cavity losses and using other grating periods to access different wavelength regions.

References.

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2. V. Pruneri et al. Appl. Phys. Letts. **67**, p. 2126-2128 (1995)

3. W. R. Bosenberg et al. Postdeadline paper PD 1-8, ASSL 1995

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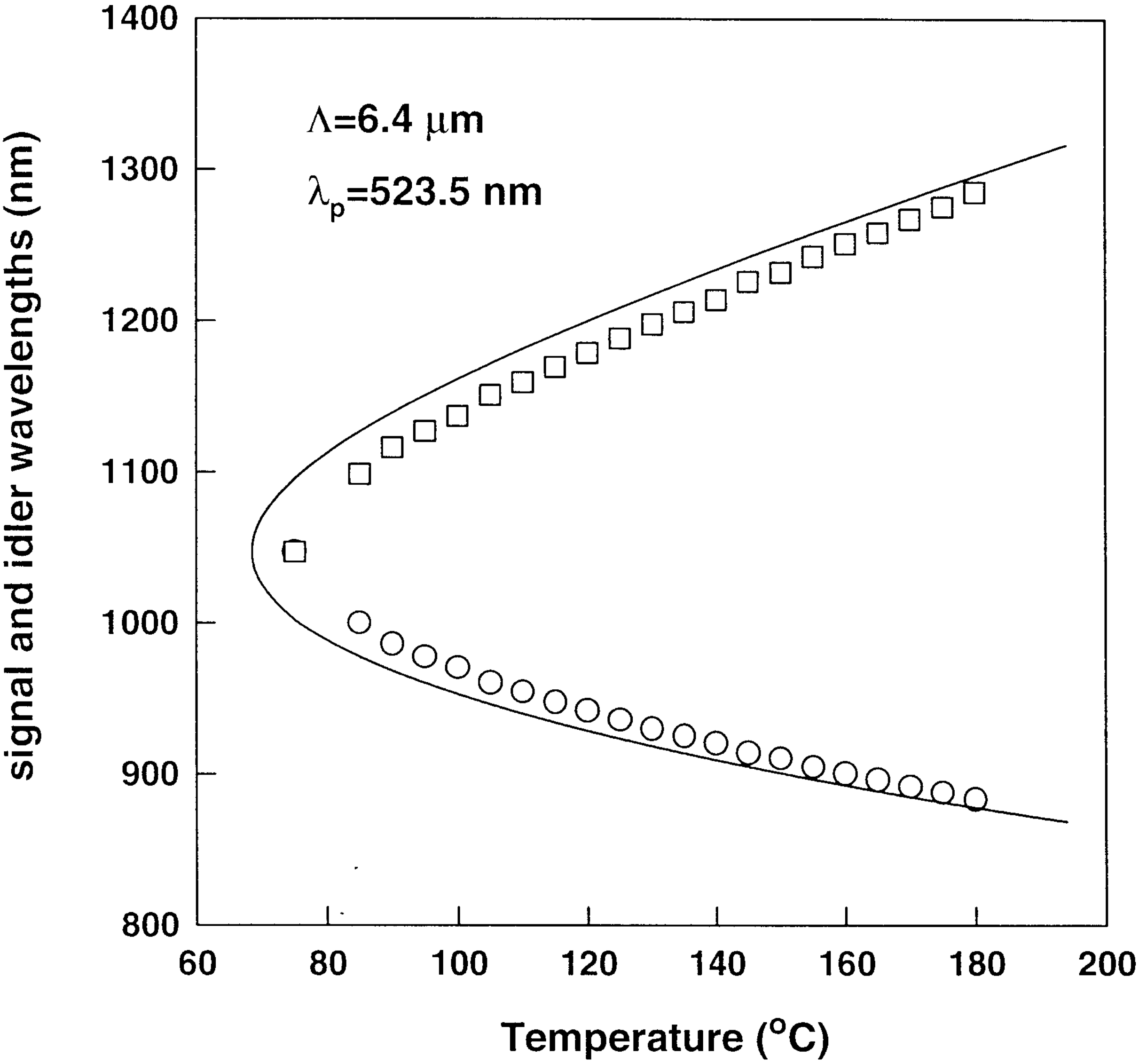
Figure Captions.

1. Tuning curves for the singly-resonant OPO. The degeneracy point corresponds to the quasi-phase-matching temperature for frequency doubling of ~75 °C. The solid curve is a theoretical trace for a grating of the same period.

2. Average output signal power and energy pump depletion as functions of the average pump power for quasi-CW mode-locked operation. The corresponding average powers within the ≤10 μs envelopes (2 kHz repetition rate) are ≥50 (=duty cycle) higher than the values shown in this figure.

3. Temporal behaviour of undepleted pump, depleted pump and output signal for a pump energy depletion of ~45 %. Pump power of 500mW (envelope average).



Λ=6.4 μm
λp=523.5 nm
signal and idler wavelengths (nm)
Temperature (°C)
1400
1300
1200
1100
1000
900
800
60
80
100
120
140
160
180
200

Fig.1

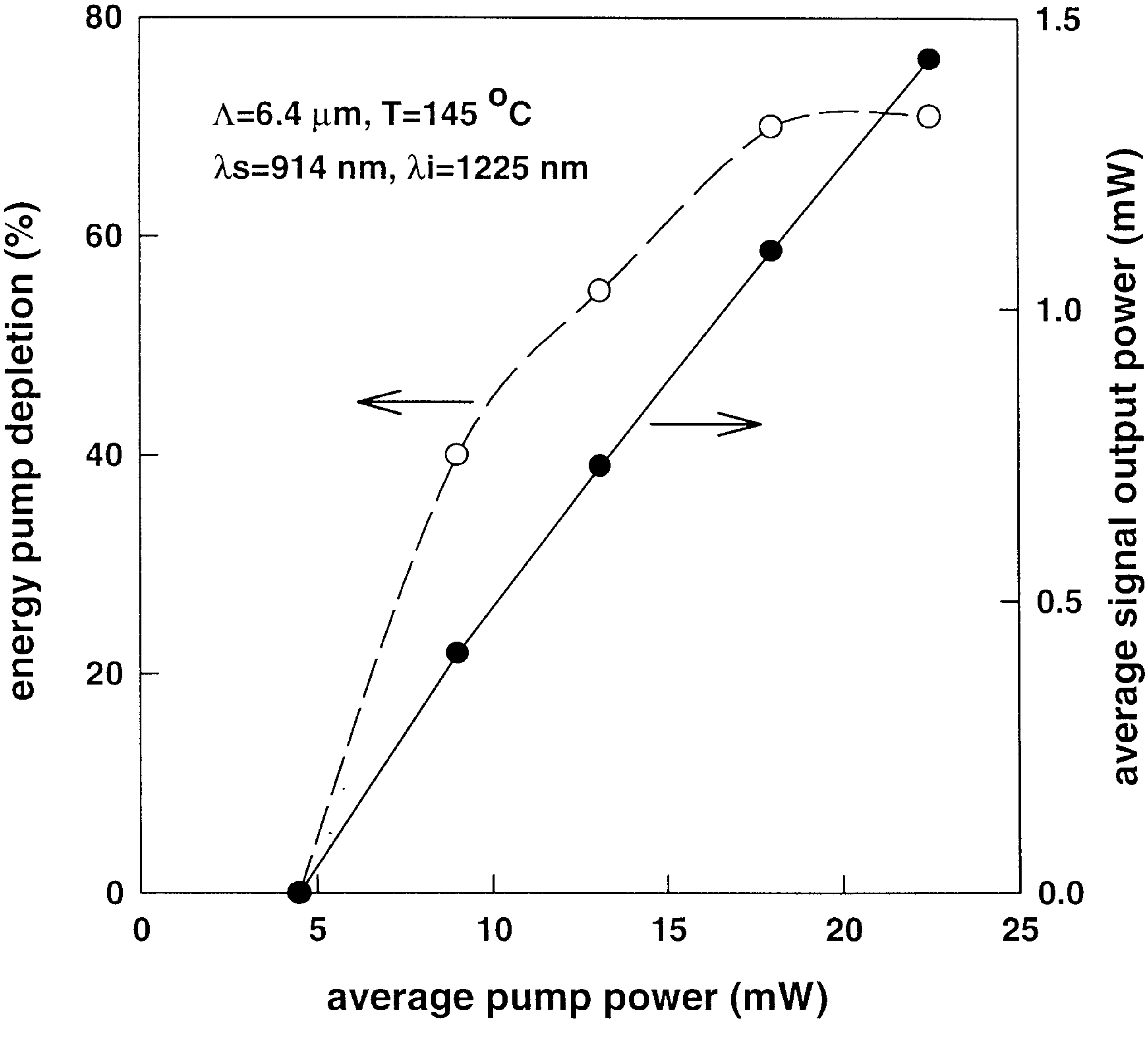

Λ=6.4 μm, T=145 °C
λs=914 nm, λi=1225 nm
energy pump depletion (%)
average signal output power (mW)
average pump power (mW)
0
20
40
60
80
0.0
0.5
1.0
1.5
0
5
10
15
20
25

Fig.2

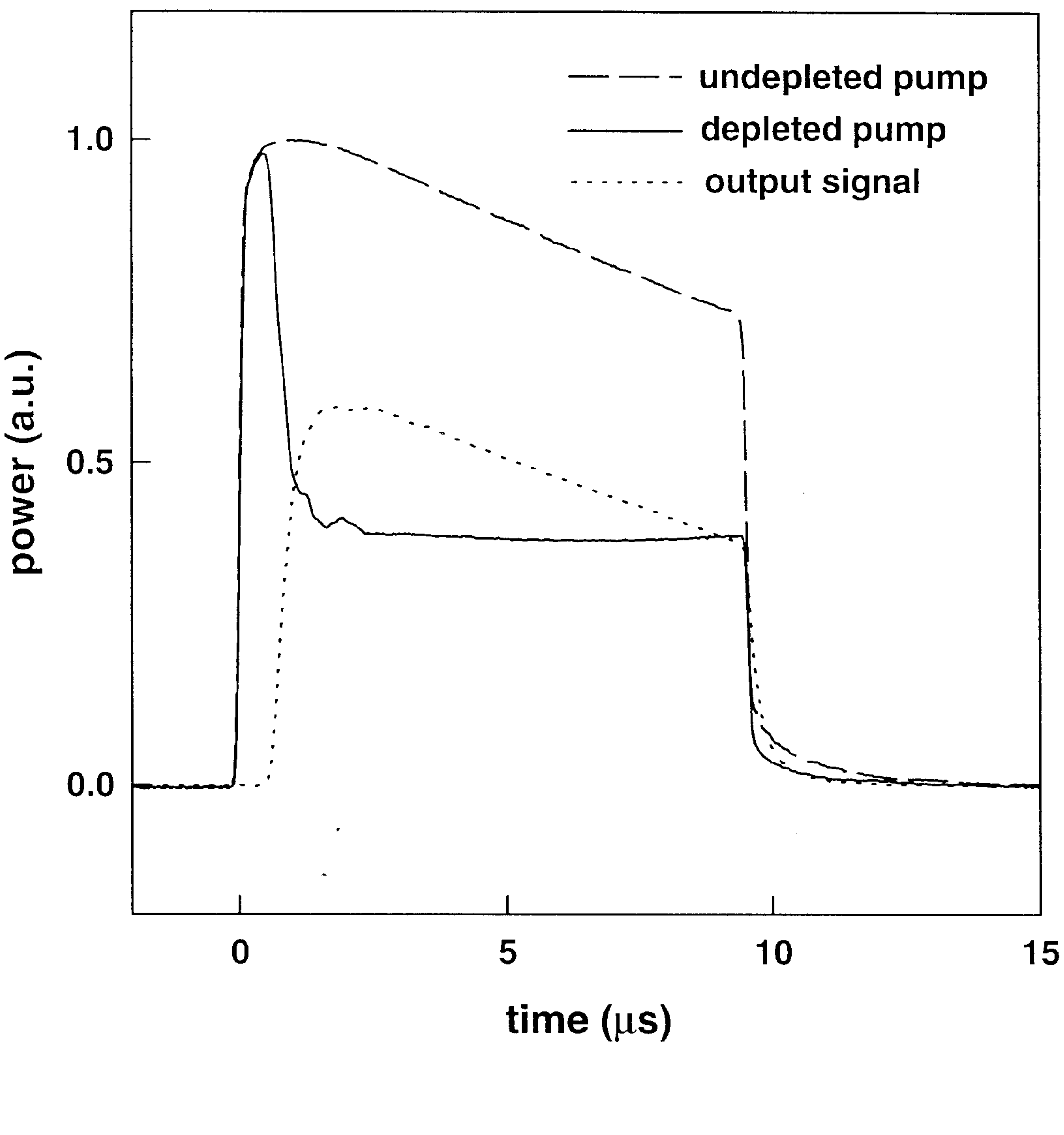

undepleted pump
depleted pump
output signal
1.0
0.5
0.0
power (a.u.)
0
5
10
15
time (μs)

Fig.3