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Efficient cw synchronously-pumped optical parametric oscillation out to 4.8μm in periodically-poled lithium niobate

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Abstract

A cw synchronously-pumped optical parametric oscillator, using periodically-poled lithium niobate has operated efficiently out to 4.81μm (signal 1.33μm). Available idler power at 4.81μm was 40mW average (100W peak), for ~1W of 1047nm pump.

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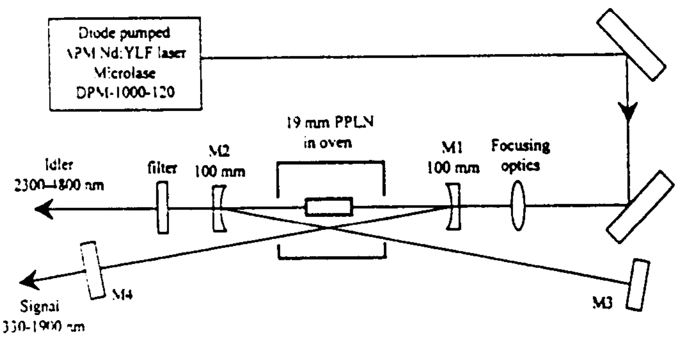
Periodically-poled lithium niobate (PPLN) offers many attractive features for optical parametric oscillation (OPO). These include high nonlinearity and non-critical quasi-phase-matching over its entire transmission range 0.35μm - 5μm. It is well-suited to synchronously-pumped operation. Using a mode-locked 1047nm pump, tuning of a singly-resonant oscillator over the range 1.67μm - 2.8μm was demonstrated[1], with low-threshold (now reduced to ~10mW average pump power). Here we report a major extension of synchronously pumped OPO tuning range in PPLN to cover the range 1.33μm - 4.81μm, thus encompassing much of the important infrared range 3 - 5μm, while still retaining low threshold and high efficiency. .The efficient performance at the long wavelength limit is particularly noteworthy. PPLN allows extension to longer wavelengths than bulk lithium niobate, since the infrared absorption edge for the extraordinary polarisation (as used in PPLN) is at a longer wavelength than for the ordinary polarisation[2]. While the infrared absorption at 4.8μm ($0.75cm^{-1}$, [2]) is already significant in our 19mm long PPLN crystal, the wavelength limit was in fact set by the shortest period (25.5μm) available on the PPLN sample used, rather than by the idler absorption.

It is the high-gain available from PPLN that allows this significant extension into the region of infrared absorption. Thus, pumping with a mode-locked 1047nm Nd:YLF laser (4ps pulses at 120MHz repetition rate, see Fig.1), an incident threshold (average) power of only 80mW (160Wpeak) was achieved for 4.8μm generation. This was obtained with 3 mirrors of high signal reflectivity and one of 95% signal reflectivity. The idler output was taken through a mirror having a CaF_2 substrate. An available output (average) power of 40mW (80W peak) was measured at 4.8μm for 800mW of incident pump. The observed pump depletion was ~75%, a level maintained or exceeded across the entire tuning range, implying that over 100mW of 4.8μm idler was generated. Of this some 60% was lost via absorption in the crystal and by reflection at the PPLN AR coating and idler output mirror.

Three 19mm long PPLN samples, each having 8 different grating periods (fabricated at Crystal Technology) were used to cover the full tuning range, accessed by a simple transverse displacement of lthe sample. In Figure 2 each circle on the signal branch (<2.1μm) represents the measured signal wavelength with the crystal held at 160°C. Corresponding idler wavelengths have also been directly measured. For each grating, fine tuning of wavelength is achieved by changing the crystal temperature.



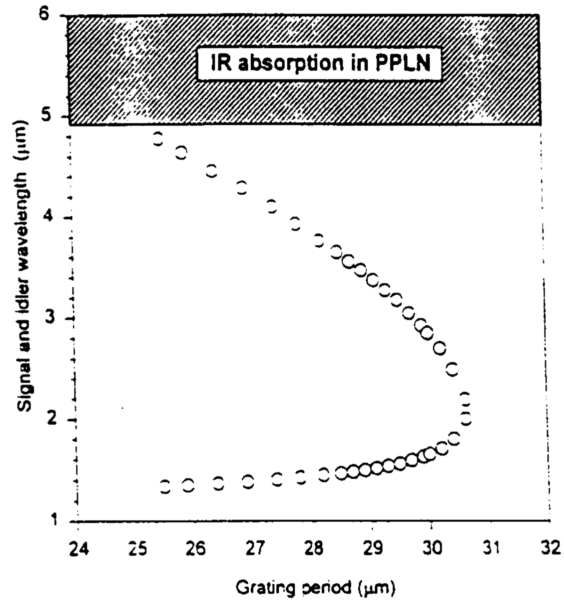


Fig. 1 **Fig.2**

Based on these performance figures we calculate that, allowing for the increased infrared absorption, this cw mode-locked operation in PPLN could be usefully extended even beyond 5μm.

References

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