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Diffraction grating tuning of a high power, synchronously pumped PPLN OPO

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A diffraction grating is used for tuning a synchronously pumped periodically poled lithium niobate optical parametric oscillator, and its high-output-power performance investigated. Higher order signal modes, caused by pulse-front-tilt, are observed, but are readily suppressed.

The use of a diffraction grating as a tuning element in a synchronously pumped optical parametric oscillator (SPOPO) offers a number of advantages. It provides an agile tuning mechanism (compared with temperature tuning of the nonlinear crystal) and it can, as we confirm here, suppress the cavity-length-dependent tuning behaviour that is normally seen in SPOPOs. It can also allow very close approach to degeneracy while maintaining singly resonant operation, as recently reported [1].

Here we report on an examination of some unexplored aspects of the behaviour of a SPOPO equipped with a grating. In particular we examine the role of pulse-front-tilt induced by the grating. We show that its main effect is the introduction of an excess loss whose experimentally measured value agrees well with a simple analytical prediction. We confirm that, with appropriate placement of the grating, the output beam is not degraded by this tilt action (observed signal M^2 of ~1.1-1.2). We also confirm that use of the grating is compatible with high power operation (up to 1.6W of signal output demonstrated).

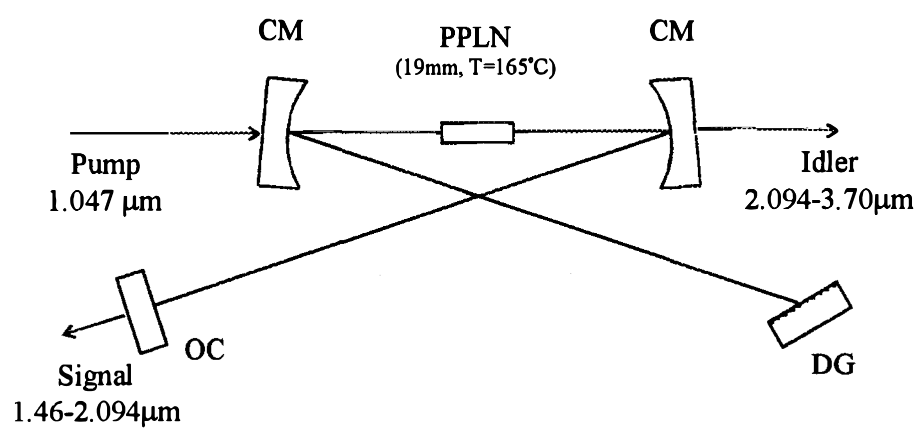

Fig. 1. OPO standing wave cavity setup. DG: diffraction grating; CM: curved mirrors, roc=200mm; OC: output coupler or high reflector.

The experimental set-up is shown in Fig. 1. The pump source consists of a commercial cw additive-pulse mode-locked Nd:YLF laser (λ=1.047μm) and amplifier, providing a train of 4ps pulses at 120MHz and delivering a maximum average power of ~6.5W. The oscillator is based on a 19mm-long periodically poled lithium niobate (PPLN) crystal, with periods chosen over two crystals to cover the signal range 1.46-2.094μm (implied idler output 2.094-3.70μm).

The diffraction grating, blazed for use at 1.85μm, with a groove frequency of 600 lines/mm, has an acceptance-bandwidth matched to the spectral width of our pump pulses. Grating efficiency remains high across the signal tuning range, 85-95%. The high gain of the SPOPO, and the high value of the near-optimum output coupling (T=58%), resulted in an acceptable threshold increase, from 530 to 900mW, i.e. 70% increase due to the insertion loss of the grating, allowing signal output power up to 1.6W. The use of the grating provides greater frequency stability overall, and a marked increase in cavity length mismatch tolerance (by a factor >2).

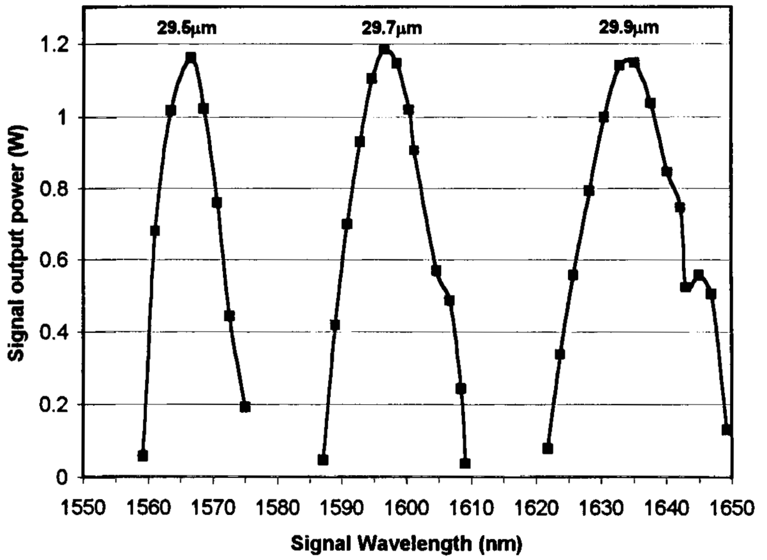

Fig. 2. Experimental tuning curves by grating rotation for three adjacent PPLN periods (noted above traces). Results obtained using a 58% transmission output coupler, ~3.5W pump power, with the signal beam incident on the centre of the grating's rotation axis.

Fig. 2 shows typical tuning curves related to several adjacent PPLN periods, obtained by rotation of the grating. The asymmetry, with extended tuning on the long-wavelength side, is not fully understood and is the subject of further investigations. It remained even with the grating's rotation axis positioned to compensate cavity-length-change caused by rotation. Another feature, seen only on the long-wavelength side, is the appearance of higher order transverse signal modes. The presence of these modes can be understood on the basis of higher order modes being created by pulse-front-tilt, and having extended temporal duration, so that they can dominate when the cavity-length is mismatched. However, this multimode behaviour was easily suppressed, and TEM_{00} operation restored, by insertion of a mode-selection aperture. Symmetric tuning curves then resulted.

This work confirms the practical utility of a grating for tuning a SPOPO. While these results were obtained with 4ps pulses, our analysis suggests that the same effective use of a grating in a SPOPO can be extended to the femtosecond regime.

[1] K. Puech, L. Lefort, and D. C. Hanna, "Broad tuning around degeneracy in a singly resonant synchronously pumped parametric oscillator by means of a diffraction grating", J. Opt. Soc. Am. B **16**, 1533-1538 (1999)