1358 Invited paper: I025 CLEO PACIFIC RIM CHIBA, JAPAN JULY 14-18 1997

Periodically-poled Lithium Niobate for Optical Parametric Oscillation

D C Hanna
Optoelectronics Research Centre
University of Southampton
Southampton SO17 1BJ
tel: +44 1703 592150
fax: +44 1703 593142
e-mail: dch@orc.soton.ac.uk

Abstract:

The use of periodically-poled Lithium Niobate for synchronously pumped optical parametric oscillation in the picsecond regime will be discussed, with results given for pumping with a 1.047μm Nd:YLF laser and with a tunable mode-locked Ti:sapphire laser.

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Summary:

Periodically-poled lithium niobate (PPLN) offers a number of major advantages for optical parametric oscillators (OPOs). These include the large nonlinearity (d ~20pm/V) and the ability to phase-match non-critically for any wavelengths in its broad transmission range. These features provide the possibility of single-resonant oscillation at threshold powers compatible with those available from cw pump lasers. In the case of synchronously-pumped optical parametric oscillation (SPOPO) threshold can be reached with a significantly lower average pump power, since the parametric gain is determined by the peak power. For example, a SPOPO based on LBO has shown a threshold pump power (average) of ~70mW.[1] Material dispersion becomes an important consideration in the context of short pulse operation (picoseconds or less) as involved in synchronously-pumped OPOs. Lithium niobate has a significantly larger dispersion than LBO, thus imposing a more stringent restriction on crystal length than is the case for LBO. Nevertheless the much larger nonlinearity of PPLN more than compensates this length restriction, so that in practice PPLN proves to be a very attractive material for a SPOPO. In this paper we describe the performance of SPOPOs based on PPLN pumped by a mode-locked Nd:YLF laser (1.047μm)[2] and by a tunable mode-locked Ti:sapphire laser, both operating in the picosecond regime.

The 1.047μm pumped PPLN device shows clear advantages over devices based on LBO. A notable advantage is the ability to achieve phase-matching for direct pumping with the fundamental wavelength of the Nd:YLF laser, whereas in the case of LBO phase-matching requirements made it necessary to pump with the second harmonic of the Nd:YLF laser, thus involving added complexity. Secondly, the PPLN device offers tunability to longer wavelengths, beyond 4μm, compared with LBO where the IR absorption edge limits operation to ~2.6μm in the case of LBO. Thirdly, very low thresholds of ~7.5mW average pump power have been achieved for a 20mm long PPLN device, around an order of magnitude lower than the best results obtained with LBO.

Similar low thresholds have also been obtained with a Ti:sapphire-pumped SPOPO, using a somewhat shorter PPLN crystal (mm) on account of the increased dispersion for the shorter (~0.8μm) pump wavelength. High slope efficiencies are achieved (>40%) with both devices.

A detailed discussion of the operating characteristics of these SPOPO devices will be given, with indications of how further improvements might be made.

References

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2. S.D. Butterworth, V. Pruneri and D.C. Hanna, "Optical parametric oscillation in periodically poled lithium niobate based on continuous-wave synchronous pumping at 1.047μm", Optics Letters, Vol. 21, No. 17, September 1, 1996.