GREEN-LIGHT GENERATION OF PICOSECOND PULSES IN FIRST-ORDER QUASI-PHASE-MATCHED LITHIUM NIOBATE

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Abstract

Bulk periodically poled lithium niobate has been used for efficient first-order quasi-phase matched second harmonic generation of green light in the picosecond regime. We measured an effective nonlinear coefficient of ~14 pm/V.

Green-light generation of picosecond pulses in first-order quasi-phase-matched lithium niobate

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Recently periodically poled lithium niobate (PPLN) has become a very attractive material for efficient second order nonlinear interactions such as second-harmonic generation (SHG) [1] and optical parametric amplification/oscillation [2,3]. Compared to birefringence phase-matching, QPM can give access to higher nonlinear coefficients and new wavelengths, in particular where the birefringence cannot compensate the dispersion, by simply choosing the appropriate period of the domain grating. It also avoids spatial walk-off problems since fundamental and generated waves have the same polarization. In the case of pulsed applications, the dispersion of lithium niobate limits the effective interaction length (l_{eff}) in PPLN. However PPLN can offer a very high effective nonlinear coefficient, d_{eff} up to ~21 pm/V, maintaining a large product of $d_{eff}*l_{eff}$ which is very interesting for processes involving pulses of duration $\geq$ 1ps.

We report on efficient SHG of green light in the picosecond regime performed in PPLN. A sample of lithium niobate with 0.2 mm thickness was periodically inverted using high-voltage applied via liquid electrodes [1,3]. The sample, 3 mm long, had a pitch of 6.4 μm. It was Brewster-Brewster cut at an angle of ~65°. Initially, CW second harmonic measurements were carried out using a Nd:YLF laser at 1.047 μm. The measured nonlinear coefficient of ~14 pm/V is close to the theoretical limit of ~21 pm/V. Fig.1 shows the SH intensity as a function of the temperature of the crystal. The bandwidth agrees well with the theoretical prediction indicating that the whole length of the sample is involved in the interaction. The SH power was proportional to the square of the fundamental power up to 900 mW, confirming the absence of any significant photorefractive damage under CW conditions.

The same laser when additive pulse mode-locked gave transform-limited pulses of ~2.2 ps duration, at a repetition rate of 105 MHz. These pulses were frequency doubled in the PPLN sample. Fig.2 shows the dependence of the SH power on the fundamental power at the QPM temperature of ~76 °C. For an average fundamental power of ~450 mW (peak intensity of ~95 MW/cm^2), the average SH power was ~155 mW, giving an average conversion efficiency of ~35% (peak conversion ~70%). Fig.3 shows the intensity autocorrelation of the SH pulses. Assuming a sech^2 shape, the pulse duration was estimated to be ~2.4 ps while the bandwidth of the corresponding frequency spectrum was ~175 GHz. The time-bandwidth product was thus ~0.42, indicating the presence of only a weak chirp. These numbers are consistent with the group-velocity mismatch of ~1 ps/mm which limits the interaction length and gives rise to spreading of the SH pulses. Above 450 mW of average fundamental power the SH power instantaneously increased and then dropped, in a few seconds, to the values indicated in fig.2. Above 450 mW of average power we also observed a beam-spreading along the z-axis, typical of the photorefractive effect.

We remark that photorefractive damage in CW and Q-switched regimes was basically absent in our previous samples of PPLN while strongly evident in 'single domain' lithium niobate [4,5]. Its presence in the PPLN sample used in this experiment is probably related to a combination of high peak and average power in

the green. We plan to investigate the possibility of removing this limitation by fabricating shorter periods which have higher QPM temperature. In this way, based on the performance shown by this sample up to 450 mW of average fundamental power, we would hope to achieve ~60 % average conversion at ~1 W of average fundamental power.

References

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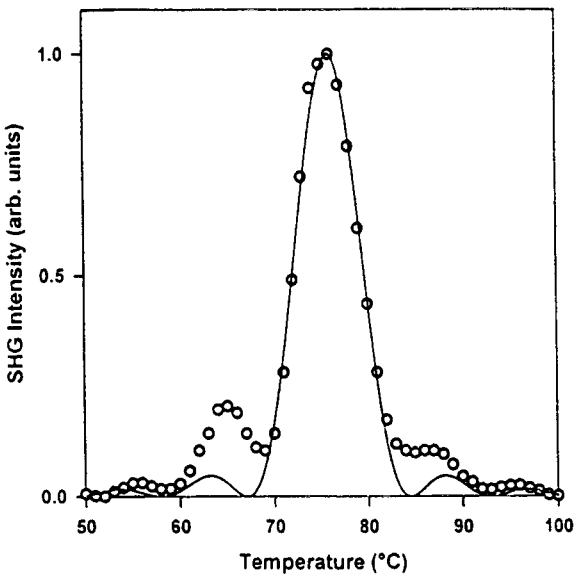

Fig.1 SH power as a function of the temperature of the crystal. The line is a calculated trace for a sample of the same length.

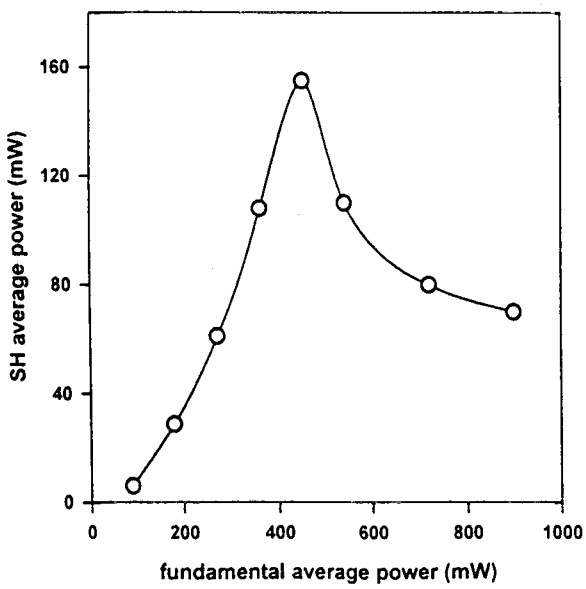

Fig.2 Average SH power as a function of the average fundamental power.

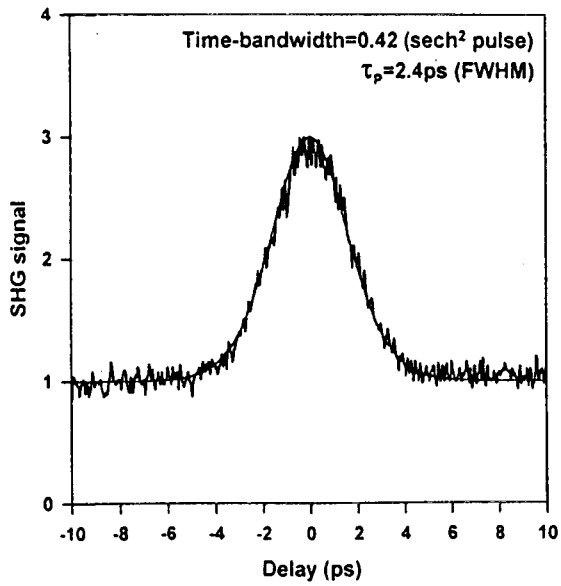

Fig.3 Autocorrelation of the SH pulses. The fit has been done assuming a sech^2 shape for the pulses.