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SHG using different combination of modal and quasi-phase matching in PPLN waveguides.

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Theoretically, increasing the mode confinement is the way to go to improve the nonlinear efficiency, and we are actively working in this direction [1], but up to know there are still fabrications issues to solve to get low loss, highly confining waveguides with preserved nonlinearities in PPLN. Therefore, we are still intensively studying the SPE technique and despite our experience and the numerous devices we have been able to develop for Quantum Communications [2], precisely controlling the spectrum and the efficiency in SHG experiments is still an issue. Our devices are designed to be used at low CW power, but in order to characterise them more precisely, we add a characterisation step using a pulsed OPO NT242 from EKSPILA which emits 5ns pulses at 1kHz rep. rate and is tuneable from 210 to 2600 nm.

Using a 1.5 cm long sample in which the PPLN section obtained by e-beam writing [3] was 1.5mm long and the waveguides produced by the SPE process using a proton source composed of Benzoic Acid and 3.1% Lithium Benzoate melted at 300°C, we obtained the normalized spectra reported in fig.1a. In this picture, we can see that we obtained the same results with the OPO and with a tuneable monomode CW laser (Tunics T100S-HP).

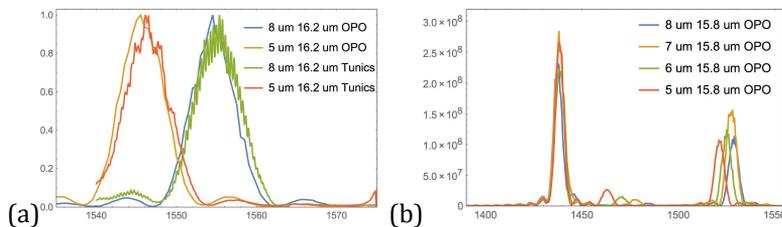


Fig. 1. (a) Comparison of the SHG normalized spectra obtained with the OPO and a CW monomode tuneable laser and (b) SHG spectra showing the harmonic signal obtained with different combinations of modal and quasi-phase matching.

Using an intense broadly tuneable source, we expected to find the different combinations of modal and quasi-phase matching which can be observed in fig. 1b. The signal observed for a pump wavelength of 1.55 μm correspond to the interaction

between fundamental modes at both frequencies (pump and harmonic). The other peaks correspond to interaction with the harmonic in a higher order mode. Fig. 2 shows the energy distribution of the harmonic corresponding to the peaks observed with a pump at 1.4 μm . What was not expected, was to find that the efficiency in this case is higher than in the case of interaction between fundamental modes.

Another surprising result is also to see that in this case, the phase-matching wavelength is nearly independent of the waveguide width, which can be an important point if one want to design a device insensitive to fabrication tolerances.

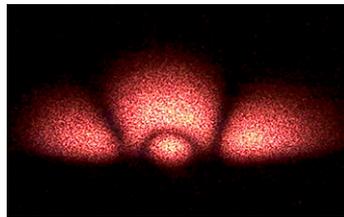


Fig. 2. The energy distribution of the harmonic corresponding to the peaks observed with a pump at 1.4 μm

This result is not specific to a particular sample and we obtained a very similar result using a 1.5 cm long sample with a 1.5 cm long PPLN section produced by E-field poling: fig. 3. Nevertheless, with this sample the harmonic mode is not the same and one can note that if the phase matching wavelength doesn't change with the width of the waveguide the efficiency varies quite significantly.

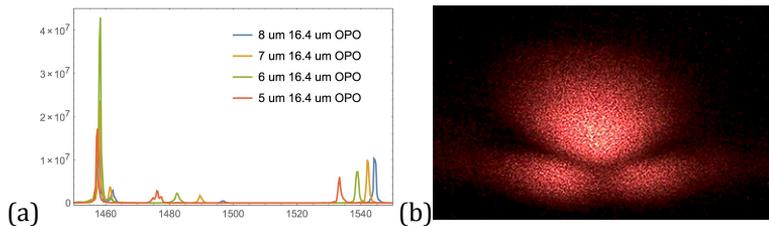


Fig. 3. SH spectra and energy distribution of the SH mode for the pump at 1460nm in the waveguide presenting a 1.5cm long PPLN section

Therefore in order to design efficient devices one has to know very precisely the index profile of the used channel waveguides in order to be able to calculate the overlap integrals.

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References

- [1] O. Stepanenko, et al. "Crystallographic and optical properties of Z-cut High Index Soft Proton Exchange (HISoPE) LiNbO₃ Waveguides", J. of Light. Tech. 34(9) 2206-2212, 2016
- [2] Olivier Alibert, et al., "Quantum photonics at telecom wavelengths based on lithium niobate waveguides", J. Opt. 18,p.104001, 2016
- [3] D. S. Chezganov, et al., "Periodic domain patterning by electron beam of proton exchanged waveguides in lithium niobate " Appl. Phys. Lett. 108, 192903, 2016