Submitted to CLEO, June 3-5, 2003, Baltimore, USA.

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Efficient blue light generation from surface periodically poled Ti-indiffused channel waveguides

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We report first-order quasi-phase matched blue light generation at 413.17 nm, in a surface-poled Ti-indiffused channel waveguide in lithium niobate. For 70mW of incident c.w. pump, 3.46 mW (uncorrected for reflection losses) was generated at the second harmonic.

Because of the potential applications in high-density optical data storage, blue light generation has continued to generate a great deal of interest over the past few years. Non- linear frequency conversion in ferroelectrics, achieved by quasi-phase-matched interaction, remains an attractive route for achieving compact near-ultraviolet or visible blue light sources. Domain engineering for generating periodically inverted domain gratings is essential to realise such quasi-phase-matched non-linear optical devices. Lithium niobate with attributes such as high non-linear coefficient, wide transparency range covering the visible and extending into the mid-IR and the availability of large homogeneous optical-grade crystals remains one of the much-preferred material for such non-linear applications.

Fabrication of the uniform short-period inverted domain structures required for phase-matched ultraviolet and blue light generation still poses a challenge however, as the high coercive fields required for domain inversion, together with the inherent non-uniformities and defects present in commercially available materials, restrict the routine applicability of the poling technique to periods of order 2-4 μm in $LiNbO_3$ samples with thickness of ~500 μm. We have previously reported [1], a technique which induces domain inversion to a depth of a few microns only below the sample surface, involving an intentional over-poling step to achieve short period domains for first order non-linear processes. We have investigated the usefulness and quality of this superficial E-field poling process by implementing it to achieve domain inversion in a predefined waveguiding region just below the sample surface.

Surface poling was achieved with a periodicity of 2.47 μm, in a sample with Ti-indiffused waveguides of widths 1.5-8 μm. Subsequent quasi-phase matched second harmonic generation experiments for generation of blue light was carried out at an elevated temperature of 205^0C, to reduce the incidence of photorefactive damage. The maximum measured second harmonic power was 3.46 mW for a coupled value of fundamental power of 70 mW, which corresponds to an effective-length normalised efficiency of 117.2 % / W cm^2. The phase-matching curve shown in figure 1 indicates a conversion from the TM_{00} mode of the fundamental to the TM_{00} and TM_{01} modes of the second harmonic. Efficient conversion from the TM_{00} to the TM_{00} of the second harmonic was attained at a wavelength of 826.35 nm. The lower value of the efficiency reiterates the fact that the mark-to-space ratio of the periodically poled structure used was not the ideal 50-50, which therefore leads to reduced efficiency. We are attempting to optimise the superficial poling conditions which would yield the ideal mark-to-space ratio of unity, by varying the corresponding mark-to-space ratio of the mask used to pattern the periodic structure and also by modifying the E-field overpoling procedure used during poling, and we will report our most recent results.

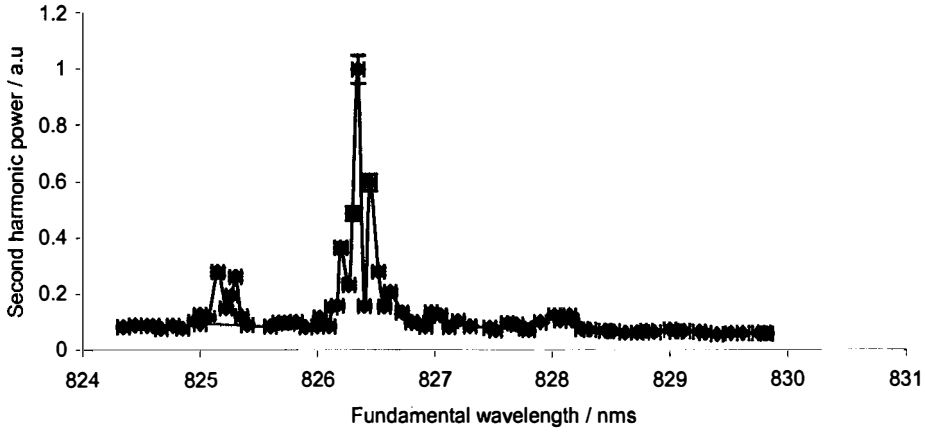

Figure 1. SHG Tuning curve

1) Busacca A.C, Sones C.L, Eason R.W, Mailis S, "Surface domain engineering in congruent lithium niobate single crystals: a route to sub-micron periodic poling" Appl.Phys.Letts. Accepted for publication.