주기적으로 분극반전된 $KNbO_3$에서 효율적인 광대역폭의 2차 조화파발생

Efficient broadband second harmonic generation using periodically-poled potassium niobate

유난이, S. Kurimura, K. Kitamura, S. Ashihara°, J. Hirohashi°°, 노정훈*, 전옥엽, 차명식****

National Institute for Materials Science, ° University of Tokyo, °° Mitsui Chemicals Inc.

* 부산대학교 의공학과, ** 부산대학교 유전체 물성연구소/물리학과

YU.Nanei@nims.go.jp

Recently, type-I second-harmonic generation (SHG) scheme with quasi-phase-matching (QPM) was developed for both group-velocity match (GVM) and high conversion efficiency.(1) Yu *et al.* demonstrated 95-fs-pulse doubling at the communication band with almost no temporal walk-off using d_{32} in 10 mm long periodically-poled MgO-doped lithium niobate (PPMgLN).(2) However there are still some restrictions on wavelength selection because the GVM depends on the material dispersion. Furthermore, in lithium niobate, d_{32} is almost 1/6 of d_{33}. In this work, we demonstrated more efficient broadband SHG in periodically-poled potassium niobate (PPKN) utilizing d_{31}, which is~ 2.6 times d_{32} of PPMgLN in our previous works.

Fig. 1 shows the calculated QPM period for the d_{31} (*aa->c*) interaction in $KNbO_3$(KN) at three different temperatures using the reported Sellmeier's formulas.(3) The expected center fundamental (FM) wavelength for a broadband SHG was around 1520 nm at T= 42 ℃ for a QPM period of 14.4 μm. The PPKN samples with dimensions of 9×10.5×0.5 mm^3 (a×b×c) were fabricated using the electric poling technique.(4) The QPM grating vector was parallel to the *b*-axis with a period of 14.4 μm. A ns-pulse optical parametric oscillator (OPO) was used for the QPM band-width measurement. The SH intensity with respect to the FM wavelength is shown in Fig. 2. The OPO beam was polarized along the *a*-axis and propagated along the *b*-axis for d_{31} interaction. At T=35 ℃, the most broad QPM band was obtained with the FM centered at 1520 nm as shown in Fig. 2. The FWHM bandwidth was ~38 nm, which is close to a predicted value of 40 nm. This ripple-less QPM bandwidth is useful for efficient doubling of 100 fs pulses at the S-band of telecommunication. A constant temperature shift between the results of experiment and calculation is possibly caused by the difference of the temperature dependent refractive index of our samples from that of Ref. 3.

We measured SHG conversion efficiency of 95-fs pulse input at the simultaneous GVM and QPM condition as shown in Fig. 3. A PPKN sample was measured with a FM wavelength of 1520 nm at T=35 ℃. For comparison, PPMgLN sample was measured at 1560 nm in two different configurations: type-0 (using d_{33}) at T=8 ℃ and type-I (using d_{32}) at T=16.6 ℃, respectively. The

SHG efficiency of the PPKN sample was ~3 times that of type-I SHG in PPMgLN, and ~14 times type-0 at the same input power of 10 μW. Estimated effective nonlinear coefficient was 3.8 pm/V for the PPKN sample which is about 53 % of the theoretical value, $d_{eff}=(2/\pi)d_{31}$. This discrepancy is attributed mainly to the existence of domains of different orientations such as 60°, 90° and 120°.[5] For future work we plan to improve the quality of periodically-poled structures.

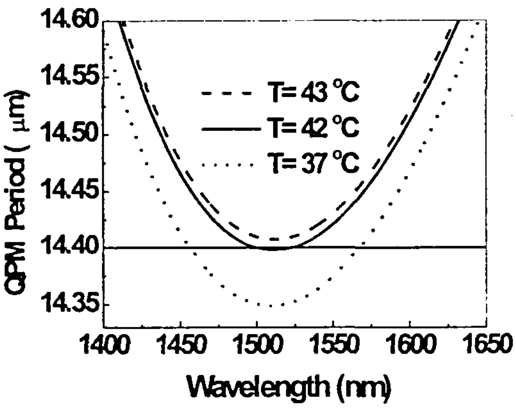

Fig. 1. Calculated QPM period depens on fundamental wavelength.

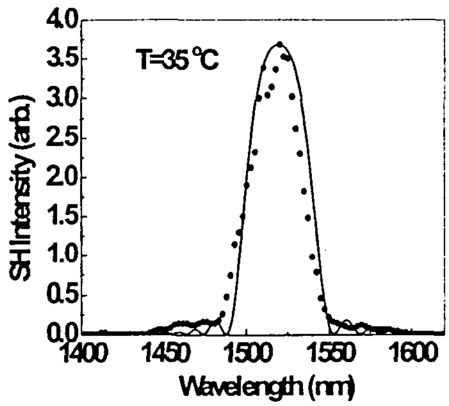

Fig. 2. Second harmonic intensity versus fundamental wavelengthwith.

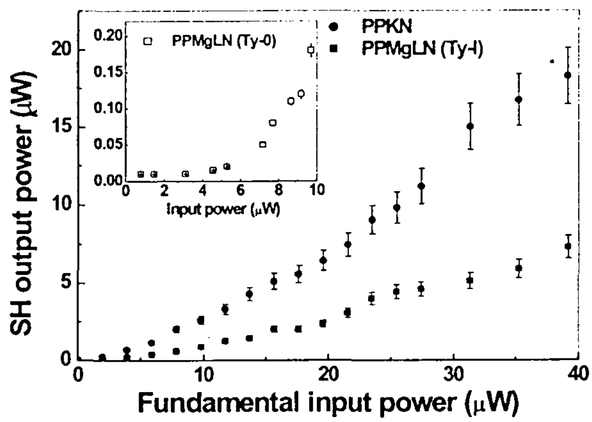

Fig. 3. Second harmonic conversion efficiency by simultaneous QPM and GVM at two samples.

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