CThM6 **3:45 pm**

Mobility effects in polarization switching of lithium niobates

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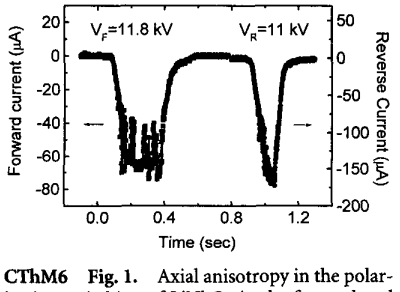
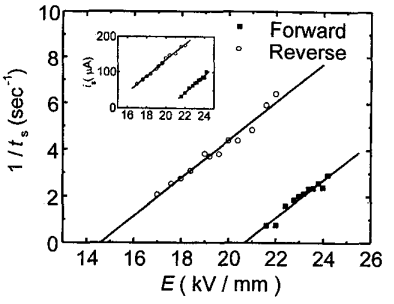
Quasi-phase-matching (QPM) of ferroelectric crystals with periodically 180° inverted domain structures has emerged as an important technology for nonlinear frequency generation.[1] A plethora of research activities on optical parametric and harmonic generation using periodically poled lithium niobate (PPLN) represent one such exciting achievement in nonlinear optics. Great challenge, however, remains in resolving the kinetics of polarization switching such that QPM at a given wavelength can be achieved with an optimum conversion efficiency. In this work, we report a use of transient current analysis to investigate the kinetics of polarization switching in congruent grown Z-cut lithium niobate ($LiNbO_3$) at various field strength and poling direction. Our study indicates the axial anisotropy and the linear dependence of switching current and 1/switching time on E are due to a field-driven sidewise 180° domain motion. The corresponding equation of motion is characterized by $v_s = \mu_s[E - (E_c \pm E_{int})]$, where E_c and E_{int} measure a threshold and internal field strength of 17.64 and 3.04 kV/mm, respectively, and μ_s a lateral mobility of 1.56 ± 0.05 mm^2/kV-sec.

The Z-cut, 500 μm-thick $LiNbO_3$ substrates used in this study were diced into 1 cm × 1 cm squares and had a patterned area of 10 mm^2 contacted to the lithium chloride (LiCl) liquid electrodes. In order to eliminate the RC charging current and block the charge backflow at the beginning and ending of the poling process, we typically delivered pulses with a baseline field strength greater than 12 kV/mm. By doing so we can ensure a stabilized polarization switching process in $LiNbO_3$.

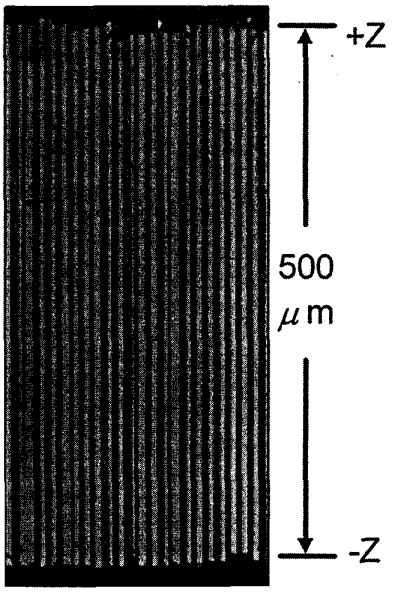
In Fig. 1 we illustrate a typical measurement of the switching current during a forward (23.6 kV/mm) and a reverse (22 kV/mm) poling process, respectively. It is found that polarization switching in reverse poling can take place at a smaller field strength (E), exhibit a larger switching current (i_s), and substantiate a faster switching time (t_s) compared with the forward poling case. Data shown in Fig. 2 exhibit a linear dependence of $1/t_s$ and i_s on E



CThM6 Fig. 1. Axial anisotropy in the polarization switching of $LiNbO_3$ in the forward and reverse poling direction.



CThM6 Fig. 2. Dependence of the switching time (t_s) and switching current (i_s) in the high-field forward and reverse poling.



CThM6 Fig. 3. Cross-sectional view of the etched +y face of a PPLN forward poled at 23 kV/mm.

which are independent of the poling direction. These observations represent an apparent sidewise motion of the 180° domain in the high field regime.[2] A mobility model analysis of $v_s = \mu_s[E - (E_c \pm E_{int})]$, reveals a threshold E_c and internal E_{int} field of 17.64 and 3.04 kV/mm, respectively, and a lateral mobility μ_s of 1.56 ± 0.05 mm^2/kV-sec. The origin of such a giant internal field has been recently identified as resultant from the non-stoichiometric point defects in congruent grown $LiNbO_3$ crystals.[3]

From the mobility model analysis, the vector sum of E ± E_{int} increases (decreases) the effective field strength in the + reverse (− forward) poling direction, respectively. It in turn enhances (reduces) the corresponding sidewise velocity v_s, and results in the axial anisotropy of sweeping rate ($1/t_s$) and switching current (i_s). In applying this method to control the periodical poling process of $LiNbO_3$, we illustrate in the Fig. 3 an etched y-face of PPLN whose periodicity was designed to be 10 μm. Albeit it is forward poled at a much higher field strength of 23 kV/mm, a good control of the aspect ratio is preserved over the 3 mm sample length and across the 500 μm-thick substrate.

In summary, we report a high field analysis on the kinetics of polarization switching in congruent grown Z-cut $LiNbO_3$ crystals. The non-stoichiometric point defects introduce an internal field E_{int}, modify the sidewise 180° domain motion according to $v_s = \mu_s[E - (E_c \pm E_{int})]$, and result in an axial anisotropy in the switching current and switching time.

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Rooms 318/320

Laser Displays and Diagnostics

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CThN1 **2:30 pm**

External cancellation of laser FM dither

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External laser phase modulation comes with costs, notably Residual Amplitude Modulation (RAM), coherent angle and spatial modulation normally associated with Electro-Optic Modulators. These cause errors in the DC lock point and thus precision limitations. Dither modulation is attractive, being free of these problems. However, a serious signal processing problem arises when characterizing the frequency of highly stable lasers with large dither modulations. With modern random-sampling frequency counters, a completely misleading picture emerges as it reports the large systematic frequency excursions faithfully in its output of the average instantaneous frequency. Older counters may count for a fixed period, 1, 3, or 10 s and so largely suppress these variations. However, the deadtime between counts being not completely stable, a small but similar aliasing problem is still visible over long counting periods, due to shifts between the frequencies of the dither generation and the counter timebase. One can synchronize the various crystal oscillators used in the system, but this gives an unknown frequency shift associated with the start phase. Thus many papers reporting new spectroscopic techniques point out that avoiding Dither locking is preferable. Here we report a demonstrable alternative.

A simple cure for this problem resulting from the laser dither is found by using an