P-66

Domain kinetics during polarization reversal in 36º Y-cut CLN

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Modern market of technologies formed demand on low price middle-infrared (mid-IR) lasers [1]. The mid-IR is defined as 2-20 μm spectral range with a number of so-called "water windows", representing wavelength of light which can propagate through Earth's atmosphere without absorption by water vapor [2]. Moreover, most molecules have distinct absorption lines in the mid-IR, providing a fingerprint that makes it possible to identify them by optical spectroscopy [3].

To realize the optical frequency mixers adapted to the ultra-short pulses sources (<100 fs) and high average power (above 10 W) in mid-IR it is necessary to have non-linear components offering large aperture (about 1 cm^2). The periodically poled non-linear optical crystals lithium niobate (LN) and lithium tantalate are well suited to the optical parametric amplification in the mid-IR due to wide transparency range and high non-linearity, but the usual poling technique is not suitable for producing the components with required large aperture.

In order to overcome this technological barrier, the "slanted poling" (or axis-slant QPM) have been demonstrated [4]. The essence of the method is to produce periodical grating in plate with slanted polar axis, specifically in 25º X-cut MgO-doped LN (MgO:LN). In our work we investigated 36º Y-cut congruent LN (CLN) crystals, which are used for surface acoustic wave devices. The main advantages of these crystals are low price and great offer on the market.

The studied samples represent the 0.5-mm-thick double polished plates with 36º angle between Y-axis and normal to surface of the sample. The polarization reversal under application of pulses with increasing field and varied field rate was realized using liquid electrodes (aqueous solution of LiCl). The poling was performed in SF_6 to exclude electric arc discharge. The switching current and the set of instantaneous domain images visualized by optical microscopy have been recorded simultaneously.

It was demonstrated that the shape of micro-domains correlates with the crystal symmetry C_{3v} [5]. The static domain structure in the bulk was visualized by Cherenkov-type second harmonic generation [7]. Forward and sideways domain wall motions have been measured.

The dependence of threshold field on field rate (dE/dt) has been measured. The threshold fields E_{th} at constant field were estimated E_{th} = *32.8±0.3 kV/mm* along normal to the sample surface and E_{th} = *19.3±0.3 kV/mm* along Z-axis. Last value is close to the threshold field in Z-cut CLN, $E_{th} = 21$ kV/mm [6].

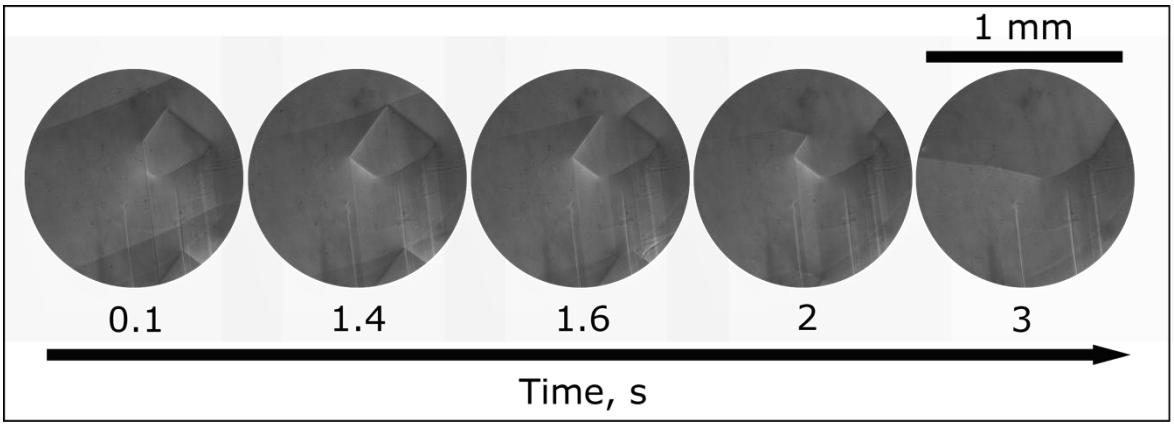

Figure 1. Time resolved coalescence of domains in 36º Y-cut CLN *in situ* visualized by optical microscopy during polarization reversal with liquid electrodes. E_{max} = 33 kV/mm.

The field dependence of domain wall velocity was studied by application of pulses with variation of $\Delta E_{ex} = E_s - E_{th}$ (excess of switching field above the threshold value). Complete switching by wall motion occurred for $\Delta E_{ex} > 2.4$ kV/mm.

Local polarization reversal has been studied by application *dc* voltage ranged from 100 to 250 V and duration from 0.1 s to 100 s to conductive tip of scanning probe microscope. Resulting static domain structure was visualized by piezoresponse force microscopy. Each pulse ended before withdrawing of the tip.

The dependences of domain diameter on pulse duration and amplitude have been measured. The obtained partial backswitching effect becomes more pronounced with pulse duration. Almost complete backswitching was obtained for U = 100 V and t_p = 100 s.

Self-organized nanodomain arrays were formed when grounded conductive tip was moved in vicinity of the freshly switched domains. The acceleration of backswitching effect has been observed when grounded tip was moved through freshly switched domain.

The equipment of the Ural Center for Shared Use “Modern nanotechnology” Ural Federal University was used.

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