P56

Direct laser writing of periodic structures in a Cu-doped near-surface layer on *z*-cut $LiNbO_3$ crystals

P.P. Basnin[1], I.M. Chirkova[1], O.G. Sevostyanov[1], S.M. Kostritskii[2]

[1]*Phys. Dept., Kemerovo State University, Russia*

[2]*RPC Optolink Ltd, Zelenograd, Moscow, Russia*
skostritskii@optolink.ru

In this work we demonstrate the possibility to form periodic homogeneously-altered refractive index structure in a Cu-doped near-surface region of lithium niobate crystals using direct laser writing technique. To increase photosensitivity the selective Cu-doping of a thin near-surface layer (0.25-0.5 μm) was applied, utilizing the ion exchange in the molten palmitic acid mixed with small amount of copper carbonate. A cw Ar^+-laser was used for fine controllable modification of the near-surface layer. This laser produces radiation at wavelengths of 488 and 514.5 nm. A laser beam was focused into the sample surface by a microscope objective (100×, NA= 0.9). To form the regular periodic structure (Fig. 1), the samples were translated by two linear stages with velocity 10-260 μm/s in X-Y plane.

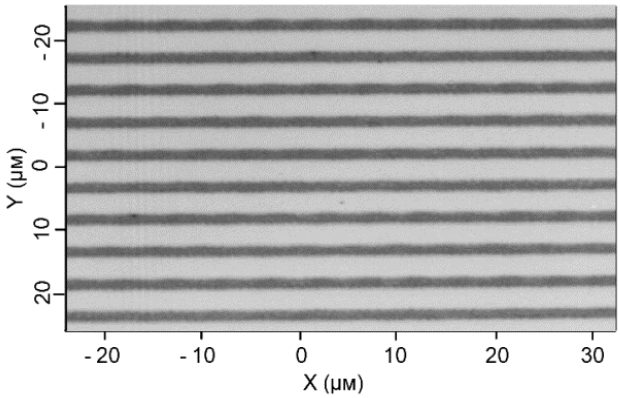

Figure 1. Microscopic image (reflection mode) of periodic structure written by focused laser beam in a near-surface layer of $LiNbO_3$ wafer doped by Cu with ion exchange technique.

The heavy Cu-doping and, hence, the strong absorption (optical density ≥ 1.5) of laser radiation within near-surface layer provide a marked heating (≥ 100 °C) of the illuminated area. It causes thermally-induced out-diffusion of H^+ ions from this area in a space-charge field, and, thus, formation of a self-fixed structure with spatially-modulated refractive index, Fig. 1. The bulk photovoltaic and pyroelectric effects [1] are assumed to be the main contributing factors to the space charge field, spatial modulation of the Cu^+/Cu^{2+} ratio and optical absorption. Note, that this self-fixed laser-induced refractive index change can be by one-two orders of magnitude higher than values reached with the standard holographic technique in a bulk of crystals doped with photorefractive ions. It allows for fabrication of highly effective Bragg gratings for the various integrated photonics applications.

Considering the significant temperature gradient within micro-regions with modified crystal stricture, very large fields may be generated under surface well in excess of the coercive field strength. This transient field has pyroelectric origin and its strength may be enough for local reversal of spontaneous polarization and for formation of a periodic domain structure [2]. Additionally, we show that with different ion exchange algorithms a sufficient control on topological charge separation can be achieved in micrometer scale that lets implement the well-controlled recording procedures in lithium niobate waveguides.

This work is funded by Volkswagen Foundation/Trilateral Project “Investigation of the domain wall conductivity in uniaxial ferroelectrics".

1. L.B. Schein, P.J. Cressman, L.E. Cross, *J. Appl. Phys.* **49**, 798 (1978).
2. J. Imbrock, H. Hanafi, M. Ayoub, C. Denz, *Appl. Phys. Lett.* **113**, 252901 (2018).