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OPTICAL WAVEGUIDE STRUCTURES INDUCED IN A SURFACE-DOPED LITHIUM NIOBATE CRYSTAL FOR OPTOELECTRONIC DEVICES

ABSTRACT

The results of characteristics of optically induced waveguide structures are investigated. Waveguide structures were formed by point-by-point inducing the refractive index changes of the experimental sample via various exposure conditions of the surface layer by laser radiation with a wavelength of λ = 532 nm. The formed waveguide structures were studied by using the experimental setups containing the Mach-Zehnder interferometer scheme.

INTRODUCTION

Optical waveguides are fundamental elements in the construction of different optoelectronic devices and integrated optical circuits [1, 2]. Various materials with a wide range of physical and optical properties like a Lithium Niobate ($LiNbO_3$) are used as substrates for the same devices. [1, 3]. It is possible to change the refractive index of LiNbO3 crystals with a controlled periodicity by the local illumination of individual areas of material [4]. It makes possible to form waveguide structures with different characteristics and change their topology during the formation.

The purpose of this work is to study the characteristics of waveguide structures formed in a lithium niobate crystal by using various exposure conditions for the surface layer doped with copper ions.

SETUP SKETCHES FOR WAVEGUIDE FORMATION AND STUDY

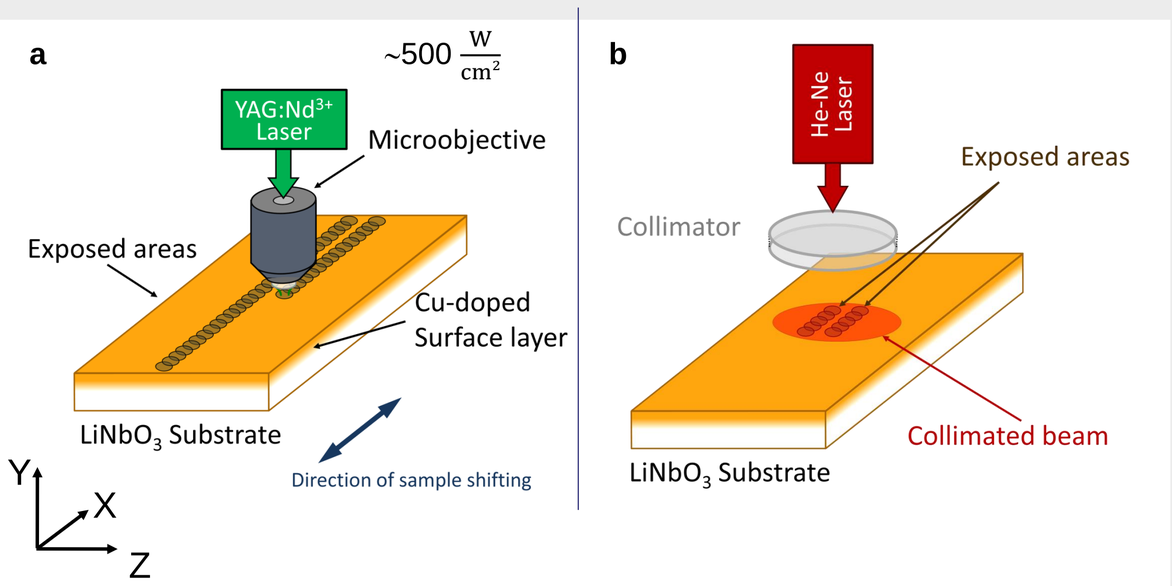

Fig. 1. Experimental setups for channel waveguide formation by point-by-point exposure (a), and for its study by optical probing (b).

EXPERIMENTAL RESULTS

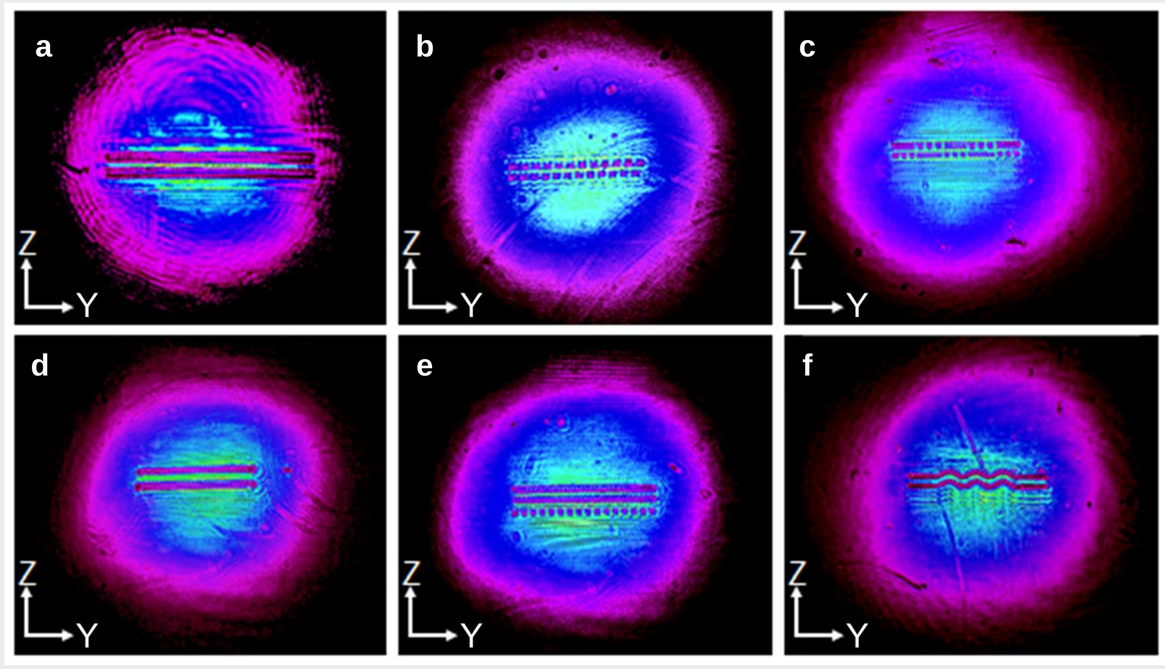

Fig. 2. Near field light patterns at optical probing of the induced waveguide structures with different topologies.

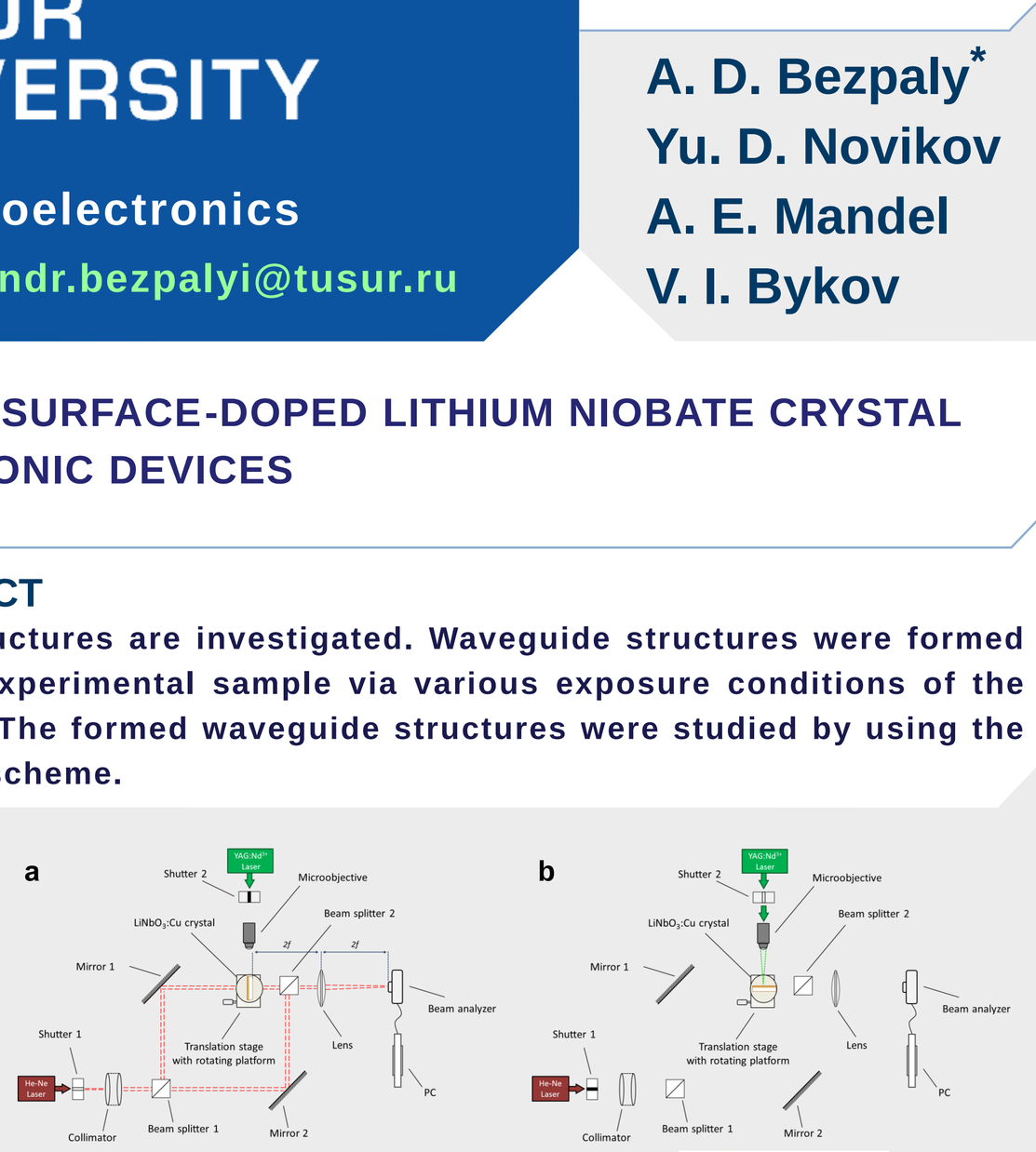

Fig. 3. Experimental setup containing the Mach-Zehnder interferometer for investigation of waveguide structures (a, b), and the «Wavefront visualizer» program interface (c).

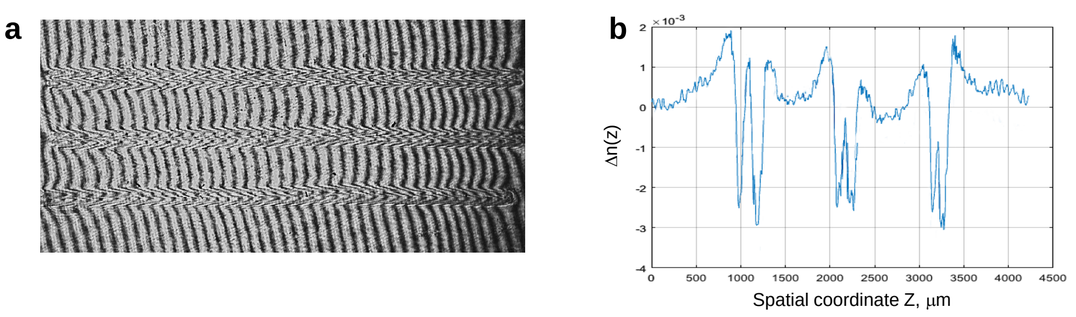

Fig. 4. Interference pattern in the region of induced structures(a), and spatial profile of the induced refractive index changes along the Z axis (b).

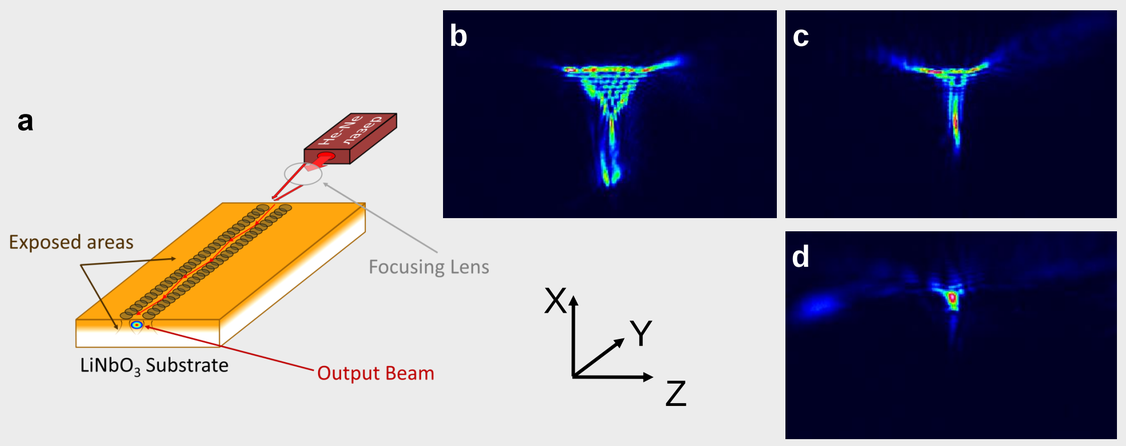

Fig. 5. Experimental setup for laser beam introducing into the formed waveguide structure (a); light fields images at the output end of the formed structures.

CONCLUSION

The characteristics of waveguide structures formed by point-by-point induced refractive index changes in a lithium niobate crystal with a surface doping are experimentally studied. It is shown that the magnitude of the induced changes in the refractive index can be controlled by changing the exposure time. The spatial profile of the induced changes in the locally illuminated area has an alternating character. The obtained results can be used in modeling and designing integrated optical circuits, hybrid and all-optical devices.

REFERENCES

[1] Bazzan M. and Sada C. Optical waveguides in lithium niobate: Recent developments and applications // Applied Physic Reviews. 2, 040603-1 – 040603-25 (2015).
[2] Liu Y. et. al. High-Speed Optical Transceivers. Integrated Circuits Designs and Optical Devices Techniques (World Scientific Publishing, Singapore, 2006).
[3] Petrov M.P., Stepanov S.I., Khomenko A.V. Photorefractive crystals in coherent optics (Nauka, St. Petersburg, 1992).
[4] Horn W. et. al. // Opt. Express. 20 (24), 26923-1 (2012). https://doi.org/10.1364/OE.20.026922
[5] Bezpaly A.D., Kapustin V.V., and Mandel A.E. Wavefront Visualizer: certif. 2021661646 RF. N2021660493/69 (2021).

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