E-beam domain patterning in thin plates of MgO-doped $LiNbO_3$

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We have studied the formation of periodical domain structure (PPLN) induced by controllable electron beam (e-beam) irradiation in the single-crystalline plates of MgO-doped lithium niobate covered by artificial dielectric layer depending on electron energy, plate and layer thickness. The creation of the through periodic domain structures with vertical domain walls and a period down to 1.5 μm was demonstrated in 1-mm-thick plate [1].

The studied samples represented Z-cut optical grade plates of MgO-doped lithium niobate (MgOLN) of various thicknesses: (1) 1-mm-thick, (2) 100-μm-thick, (3) 7-μm-thick produced by polishing. The irradiated Z^--polar surface was covered by AZ nLOF 2020 (MicroChemicals) photoresist layer with thicknesses 1.5, 2, and 2.5 μm. The solid copper electrode was deposited on the opposite surface and grounded during irradiation. The Auriga Crossbeam Workstation (Carl Zeiss NTS) equipped with e-beam lithography system Elphy Multibeam (Raith GmbH) was used for the patterning. The static domain structures at the surface were imaged by piezoresponse force microscopy, scanning electron microscopy (SEM) in backscattered electron channeling mode in a nondestructive manner and secondary electron mode after selective chemical etching. The confocal Raman microscopy was used for domain imaging in the bulk.

The influence of the plate and resist layer thicknesses and the electron energy on the morphology of the produced domains has been studied. It was shown that there were no changes in the domain morphology with reduction of the plate thickness. The dependences of the switched domain area on the dose demonstrated the linear behavior in plates of various thicknesses. The fact was explained by the external screening of the depolarization field by the injected charge. The increase of the domain sizes with the plate thickness was attributed to a shorter stage of the forward domain growth. It was shown that the domain sizes decrease for the distances between the domain walls less than 2-μm for all crystal thicknesses. The fact was attributed to the interaction of charged domain walls. The effect of the suppression of the domain formation in arbitrary positions within the array in the thick plate was attributed to the domain interaction during the forward growth. The variation of the resist layer thickness and the electron energy led to decrease in the domain sizes due to the delocalization of the space charge.

The obtained results allowed revealing the optimal parameters for periodical poling with short periods, which have been used for the creation of through 1D and 2D periodical domain structures with the neutral walls and period down to 1.5 μm on thick and thin plates (Fig.1).

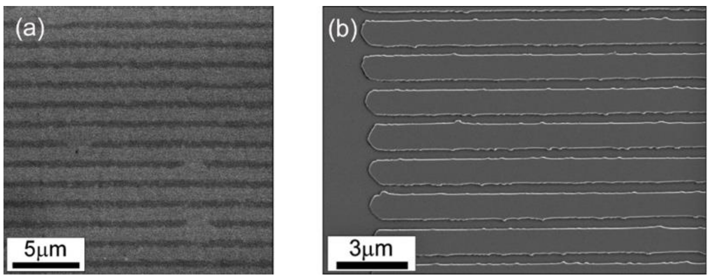

Figure 1. SEM images of PPLN with 1.5-μm-period in (a) 7-μm-thick, (b) 1-mm-thick plates.

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1. E.O. Vlasov, D.S. Chezganov, E.A. Pashnina et al., *Ferroelectrics* **542**, 85 (2019).