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Modification of the domain kinetics in congruent lithium niobate by proton exchanged surface layers

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We have studied the domain kinetics in congruent lithium niobate (CLN) single crystals with different types of the proton exchanged surface layers. The influence of the artificial dielectric layers and the surface gradient of the spontaneous polarization on the domain structure geometry, the shape of the individual domains, and the switching parameters were demonstrated.

The surface layers in single crystalline CLN wafers cut perpendicular to the polar axis have been modified by several methods of direct and reversed proton exchange thus achieving both step-like and gradual profiles with controlled spatial distribution of the spontaneous polarization.

The domain kinetics under application of the uniform electric field using liquid and solid transparent electrodes has been studied by local and integral methods including *in situ* visualization of the momentary domain patterns by optical microscopy, and instantaneous recording of the switching current data during cyclic poling.

The domain shapes were studied mostly after usual revealing of the domain structure by chemical etching. Optical microscopy and scanning probe microscopy have been used for these needs. Moreover the domains have been visualized without etching by piezoresponse force microscopy and optical microscopy in phase contrast mode.

Original analysis of the switching current and simultaneously recorded set of the instantaneous domain images allowed to classify the domain kinetics in terms of nucleation density, wall motion velocity and statistics of the domain wall jumps. It was demonstrated that each current peak corresponds to jump-like growth of the switched area induced by domain merging or restarting of the temporary pinned domain wall. The strong dependence of the domain kinetics on the parameters of the proton exchanged layer has been revealed. This effect has been attributed to the existence of the artificial dielectric layer (dead layer) and gradient of the spontaneous polarization.

The analysis of the observed domain images allows us to show that existence of the proton exchanged layer leads to a loss of the domain shape regularity. The observed behavior is attributed to increasing of the residual depolarization field due to appearance of the layer with decreased spontaneous polarization. It was shown by computer simulation that formation of all existing domain shapes can be explained as a result of predetermined generation and subsequent growth of the steps at the domain walls in the case of incomplete screening of residual depolarization field.

It was shown that after several cycles of polarization reversal the domain kinetics changes drastically. As a result the domain geometry is defined by spatial distribution of the residual domains existing in the area of domain merging during the previous switching. The role of residual domains increases with the cycle number.

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