Electrophysical Properties, Morphology and Memristive Behavior of Completely Charged Domain Walls in Reduced Bidomain Lithium Niobate

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The influence of a charged domain wall (CDW) on the formation of the induced domain structures in congruent x-cut lithium niobate crystals ($LiNbO_3$, LN) was studied. By diffusion annealing in air ambient near Curie temperature, as well as infrared annealing in oxygen-free ambient bi- and multidomain ferroelectric structures containing CDWs head-to-head and tail-to-tail were formed. By Kelvin probe mode of atomic force microscopy (AFM) surface potential near the CDWs was investigated. We studied surface needle-shaped induced microdomains which were formed in a vicinity of the domain boundary and far from it by applying of voltage to the cantilever being in a contact with the surface of the sample. Dependence of morphology of the induced domain structure on the crystal's electric conductivity was demonstrated. Screening effect of charged head-to-head domain wall on a shape and size of the domain, that was induced near the boundary was shown. We described partition of the single needle-shaped domains formed by AFM cantilever to several microdomains having a shape of several beams based in a common nucleation point. We found an influence of the CDW on the topography of the samples, which consisted in the appearance of a long groove corresponding to the domain boundary after the reducing annealing.
It was revealed that the electrical conductivity of head-to-head CDWs in the reduced LN is accessible without super-bandgap photoexcitation, shows memristive behavior and can be tuned by external voltage while tail-to-tail CDWs are insulating. The activation energy of polaron mobility as well as electron localization energy was estimated based on I-V curve measurements. The data obtained for the head-to-head CDWs in bidomain crystals shows comparative or even higher local conductivity relatively to inclined CDWs in $LiNbO_3$:Mg as well as ion-sliced single-crystal LN films. Moreover, domain walls in bidomain crystals are highly reproducible, almost flat and possess maximum interface charge density which is promising for future mass production of CDW-based nano-electronic devices operating at the intersection of electronics, optics and mechanics.

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