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The role of humidity on the domain growth during local switching in RKTP single crystals

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The domain growth during local switching by conductive SPM tip at controlled humidity has been studied in thin Rb doped potassium titanyl phosphate $KTiOPO_4$ (RKTP) single crystal.

The 10-μm-thick plate was cut perpendicular to the polar axis and the bottom surface was covered by solid ITO electrode. The local switching was performed by rectangular pulses with duration from 10 ms to 200 s at the controlled relative humidity (RH) from 0 to 70%. The low plate thickness results in formation of the stable intergrown domains with neutral walls. The domains were imaged by piezoresponse force microscopy (PFM). It was shown that the shape of isolated domain changes from rounded nanodomain to the prolate hexagon. The linear voltage dependence of the domain length is typical for local switching in uniaxial ferroelectrics [1]. The pronounced increase of the domain length with RH was revealed. It was revealed that in dry atmosphere the domain size is independent on the pulse duration less than 1 s.

For explanation of the obtained effects we have considered the influence of the RH on the spatial distribution of the local switching field. The sample surface is free of water in dry atmosphere only. In typical ambient conditions (RH = 30%, T = 20 °C) and at higher RH values the surface is covered by thin layer of absorbed water leading to broadening of the field distribution caused by formation of the water meniscus at the conductive tip [2]. Moreover, the water layer acting as a solid high-resistant electrode allows to obtain the domains with several micron size because of long-time switching. The calculation of the switching field under the tip and at the domain wall was used for explanation of the obtained experimental data.

To explain the domain evolution, we use the kinetic approach considering the effect of screening retardation. Switching in dry atmosphere shows the independence of the domain size on pulse durations less than 1 s. It means that the nucleated domain reaches the size determined by the spatial distribution of the field produced by the conductive tip faster than 10 ms. Further slower domain growth at the switching times above 1 s is obtained after the essential screening of the depolarization field at the domain wall, since for dry atmosphere the external screening is negligible. The domain shape is determined by field distribution at the domain wall and the nucleation sites at the vertexes of hexagonal domains.

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