Magnetic Field Control of Local Domain Growth in Manganites

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The materials include, first of all, complex oxide compounds where due to the strong electronic correlations unique spin and transport properties, pronounced smearing of the dielectric transition, charge and magnetic order (low-doped lanthanum strontium manganite) are observed. The search for the materials with the magnetocapacitive properties is mainly focused on the weakly conducting multiferroics [1, 2]. Possibility exists to achieve analogous results by means of acting on the charge inhomogeneities possessing the magnetic properties. The distinct contrast of the electric field induced polar states was observed in $La_{0.89}Sr_{0.11}MnO_3$ single crystals [3]. Here we report the results of the dynamic of the induced states in the different condition of writing and relaxation and influence of magnetic field on this behavior. Local charged states have been induced at the surface of lanthanum strontium manganite single crystals as result of the local bias application by a conducting scanning force microscope tip. Charge and size of the created structures increase significantly if the induction occurs in a magnetic field. It indicates the tendency of manganites toward charge segregation stimulated by the magnetic ordering. The polar nanoscale areas are formed at room temperature by applying electric field via the tip of scanning probe microscope to the surface of the $La_{1-x}Sr_xMnO_3$ (x=0.1, 0.11) single crystals. Local properties of the induced states are verified with techniques of the piezoresponse force microscopy (PFM) and of the Kelvin probe force microscopy (KFM). The piezoelectric contrast is observed in these states pointing to the existence of a local polar state. It is amazing that the induced charged states relax with characteristic time constant of about 50-100 hours at room temperature. These results are complemented by the measurements of surface potential hysteresis loops in standard pulse *dc* mode. The electric-field-induced contrast is observed in Kelvin mode confirming local modification of the surface electric properties of manganites. We investigate the dynamic of induced states and determine the sizes of induced areas. These results show the dependence of the surface potential of induced area on the writing time a similar as for ferroelectrics. The influence of the external magnetic field on the writing process of electric-field-induced polar states is found out.

Acknowledgements. The reported study was partially supported by RFBR, research project No. 14-02-01154 a.

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