In situ AFM investigation of domain walls movement in triglicine sulfate crystals under influence of temperature and electric field

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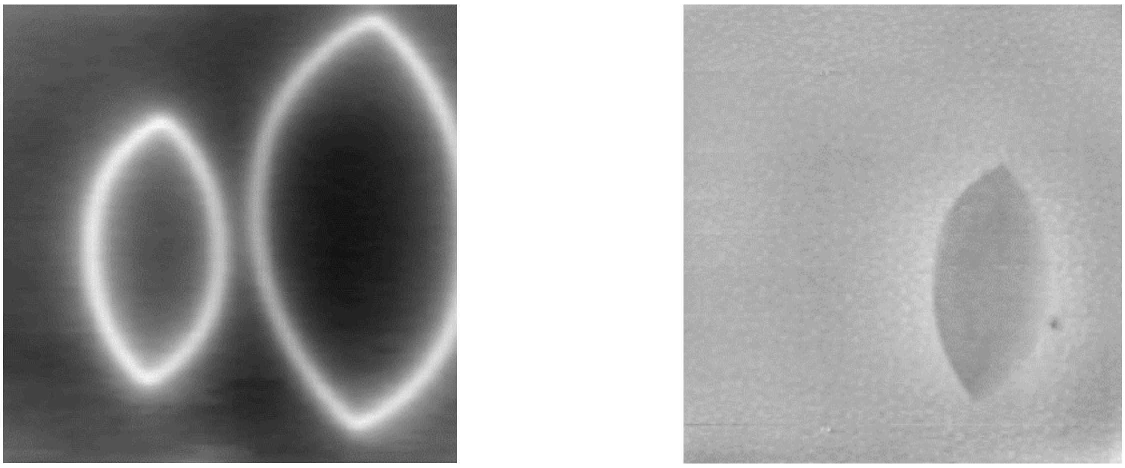
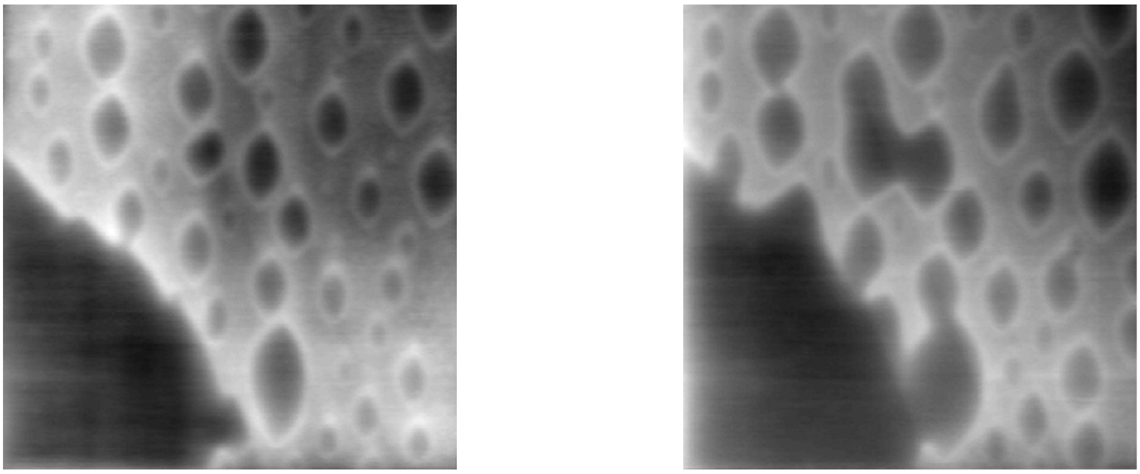
Recently atomic force microscopy (AFM) has been considered as a powerful method for research of ferroelectric domains with the high resolution and for their local modification. We have investigated generation and motion of domain walls on TGS crystal polar surface (010) under influence of temperature and DC field. The crystal of triglycine sulfate (TGS) $(N^+H_3CH_2COOH)_2(N^+H_3CH_2COO^-)SO_4^{2-}$ is one of the most convenient proper ferroelectric crystal for investigation due to low Curie temperature and perpendicularity of the spontaneous polarization vector to cleavage plane (010). The TGS crystals were grown in Institute of Crystallography by the method of isothermal evaporation at T> T_C. The samples prepared in different conditions were investigated. The series of samples comprised aging crystals of weak unipolarity with lens-like domains. Another series of samples were annealed in air at temperature of 115 ^{0}C for 2 hours with the subsequent cooling in the furnace. TGS crystals surface images were obtained in air in AFM contact and resonant (tapping) modes with the help of the microscope P47-SPM-MDT (Russia, NT-MDT). Si cantilevers NSC11 (Estonia, Mikromasch) were used in resonant mode. The important problem is certain identification (in different AFM modes) of domain on ferroelectrics surface having developed morphology. In fig. 1a one can see lens domains just generated in result of heating. Such domains can move under influence of temperature and light electrical field. On account of big contribution of electrostatic component into force interaction of atoms of tip and surface only lens domain boards are seen as a bright lines. Lens domains also may be occurred in aged crystals, but shape of such domain do not change under temperature and electrical field affection (fig. 1b). Probably it is socalled domain «memory". Image contrast of such «domain» have topographic nature on account of difference in heights of domains of different signs. The alteration of domain structure and microrelief of TGS crystal polar surface have been investigated with AFM method under room temperature, heating to Curie temperature higher and following cooling. In fig. 2 AFM images of the same part of crystal surface under heating to 48,8 $^\circ$C (fig. 2a) and 6 minutes exposition under this temperature (fig. 2b) are presented. Under heating of crystal beginning from 35-40 $^\circ$C intensive process of domain generation accrues as microrelief consisting by way of islands (holes) with the height (depth) about ½ b stays stable under heating to temperature higher T_C and cooling to room temperature. Application of DC field to TGS crystal also lead to domain boards motion which also fixed in AFM images (fig. 3). In fig. 3 one can see domain board having view of lighting line which overpasses cleavage steps. Application positive potential does not lead to motion of domain wall (fig. 3a). Change of potential sign leads to motion of domain wall (fig. 3b). In this work it is shown that topographic images carries information about micro relief and domain structure of ferroelectrics. The features of microrelief of TGS crystal polar surface are detected. This allows to dissociate them from image of ferroelectric domain structure. In situ AFM investigations of generation and motion of domain boards under affecting of temperature and outside electric field open big contemplation in research dynamics of domain motion that allows to adjust fundamental ferroelectric characteristics The authors would like to thank for research grant Russian fund of Fundamental Researches (project 00-02-17506).



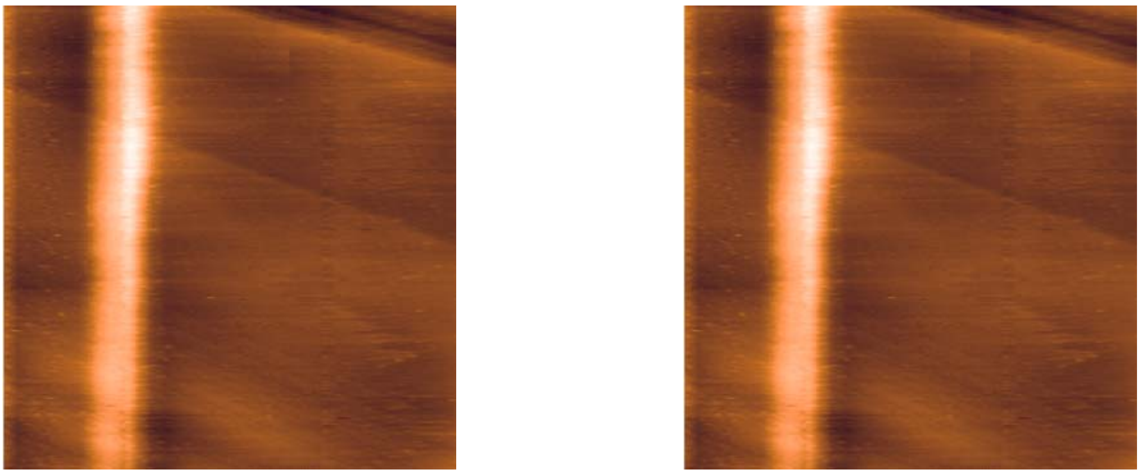
a **b**

Fig. 1. AFM images of lens domains on atomic smooth parts of the TGS crystal polar surface. In part **a** just generated domains are shown (scan size -15000×15000 nm). In part **b** – domain «memory» is presented (scan size 47000×47000 nm).



a **b**

Fig. 2. AFM images part of the TGS crystal polar surface under heating to48,8^0 C. (**a** – beginning of exposition, scan size -15000×15000 nm. **b** – after 6 minutes exposition, scan size 15000×15000 nm).



a **b**

Fig. 3 AFM images part of the TGS crystal polar surface under potential difference. (**a** – +4 V, scan size -15000×15000 nm. **b** – -6 V, scan size 15000×15000 nm).