algorithms, but when moving through the game tree, the number of positions increases exponentially, so it is impossible to search more than 5 to 10 positions ahead. In practice, some approximation is applied to evaluate the leaves, and then some version of the negamax procedure is used to evaluate the possible next moves.

An example of the simplest evaluation function is a function based on the value of the pieces: each pawn – 1 point, each knight – 3 points, etc. We will use the function we have trained to evaluate the leaves of the game tree.

To summarize: to solve the problem, it is necessary to train the function $f(p)$, and then integrate it into the search algorithm.

Findings and their discussion. As it turned out, the function that I trained can really play chess. She beat me in all games. I organized a competition for my program and the Sunfish program, sponsored by Thomas Dybdahl Ahle. Did my program win? Sometimes.

I think the written algorithm could play much better with the following optimization:

1. More efficient search algorithm. For example, Sunfish used MTD-f, while I used negamax with alpha-beta pruning. I will not say that MTD-f is better, it is a fundamentally different algorithm and one could test it.
2. More efficient evaluation function. If we use more “complex” examples for training, for example, the results of the game of grandmasters, the result should be a more effective model of the evaluation function.
3. Speed up evaluation function. You could speed up the process if you train a smaller version of the same neural network.
4. Speed up evaluation function. In this work, the GPU for the game was not used - it was used only for training.

Conclusion. It is worth remembering that the written algorithm is still far from perfect and did not compete with any advanced chess program. However, it has some positive aspects: There is the opportunity to train the evaluation function directly on the "raw" data without pre-processing; relatively slow evaluation function.

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SCANNING CAPACITANCE MICROSCOPY OF TGS–TGS+Cr FERROELECTRIC CRYSTALS

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The method of Scanning Capacitance Microscopy (SCM) has rarely been applied to ferroelectrics and the observed contrast of capacitive images in the limited number of publications on this issue is interpreted in the literature in different ways. Although the nature of observed contrast was not completely established by the authors, the observed result indicated the possibility of visualization of ferroelectric domain structures by the SCM method [1].

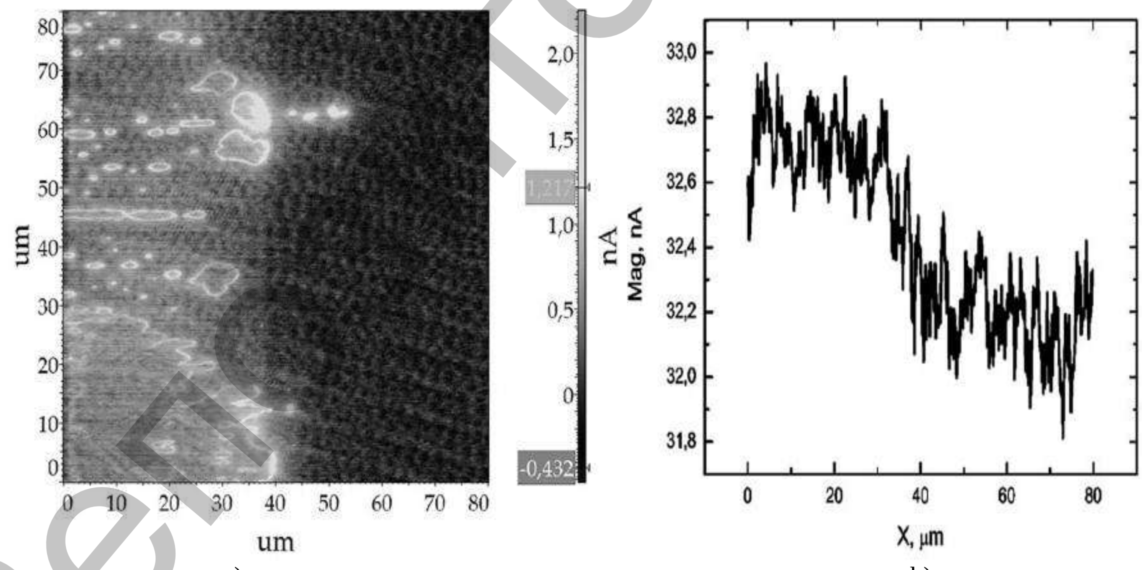
The purpose of this work is to study of the capabilities SCM as a method of local nanodiagnostics of heterogeneous ferroelectric surfaces. The question of the applicability of the SCM method for the composite mapping of ferroelectric crystals with the growth periodic impurity structure is considered.

Material and methods. The material of the study was single ferroelectric crystals of triglycine sulfate (TGS) with a periodic growth impurity structure. The TGS–TGS+Cr^{3+} crystals with a profile impurity distribution of chromium ions (Cr^{3+}) were obtained in Institute of Technical Acoustics NASB. The crystals were grown by a velocity method with a constant growth temperature of 31.4 °C (Curie temperature of TGS is 49.15 °C). The supersaturation of the pure solution was 0.1°C, and for the solution with an admixture it was 0.5 °C. A periodic change in the composition was achieved by growing the seed in solutions of a different compositions (nominally pure and containing an admixture of Cr^{3+} 5–6% by weight). In this way, the periodic growth structure of alternating stripe was obtained. The spatial modulation of the composition of obtained crystals was confirmed by X-ray fluorescence analysis. Difference in Cr^{3+} concentration between nominally pure and containing an impurity stripes turns out ~ 0.08% by weight.

All experiments on the preparation and precision surface samples study were carried out under strictly controlled conditions of the TRACKPORE ROOM-05 measuring complex (class of purity of 5 ISO (100), humidity of 35 rel. % ± 1%, and temperature of 24 _C ± 0.05 _C) in Federal Research Center "Crystallography and Fhotonics" of RAS. The crystals were studied with NTEGRA Prima scanning probe microscope (NTMDT SI).

To measure the surface variation of the capacitance, a two-pass non-contact technique was used. At the first pass, relief is recorded in the process of scanning. The second pass scanning is carried out at a constant distance of cantilever from the surface and under variable voltage $U = U_0 + U_1 \sin(\omega t)$ applied to it. The cantilever oscillations amplitude on the second harmonic (2ω) is measured. In these experiments, the capacitance measurements were performed by applying a voltage Uac with an amplitude of 3–4 V and a frequency of 29 kHz. In principle, the measured capacitance characterizes the probe-sample system as a whole, but the contribution to the capacitance from different parts of surface decreases inversely proportional to the distance from the probe (and the differential capacitance dC/dz, respectively, even faster), so this technique still belongs to the local ones.

Findings and their discussion. Using the SCM method, contrast images of surface area (1) were obtained. Figure 1a shows a typical image with a boundary between containing an impurity (left) and nominally pure (right) stripes.



a) b)

Figure 1. Image SCM of the same surface area (1) of TGS – TGS+Cr with containing an impurity of Cr^{3+} stripe (left) and nominally pure TGS (right) (a), relief, (b) section profiles parallel to the X axis for the capacitive image.

The fine-dispersed domains presence on one side of the boundary and in the stripe itself indicates an impurity area in the SCM image (Figure 1a). In this case, three contrasts are observed: light (corresponding to domain boundaries), dark (corresponding to the stripe of nominally pure TGS), and medium (corresponding to the stripe with impurity). Medium contrast in our case is due to the presence of an impurity. The SCM method proves to be informative in the respect to the impurity composition of TGS. The method are capable of visualizing an impurity stripe in the absence of domain structure.

The profile of capacitive image section is shown in Figure 1b. One can see the step corresponding to the impurity stripe. The difference in the absolute value of SCM signal between the nominally pure stripe and the one containing an impurity is 1.6% at the given measurement conditions (Figure 1a). It can be related to the difference in the permittivity of corresponding layers.

The topographic image of the crystal surface (Figure 2) contains islands (rounded ridges) 0.63nm high (1/2 b, b is an elementary cell parameter) covering both nominally pure and impurity stripes. This characteristic nanorelief of natural TGS crystal cleavage surface (010) does not depend on the composition. Although the boundaries of the layers are decorated by a set of larger islands, the topography mode does not reveal features related to the layer composition in our case.

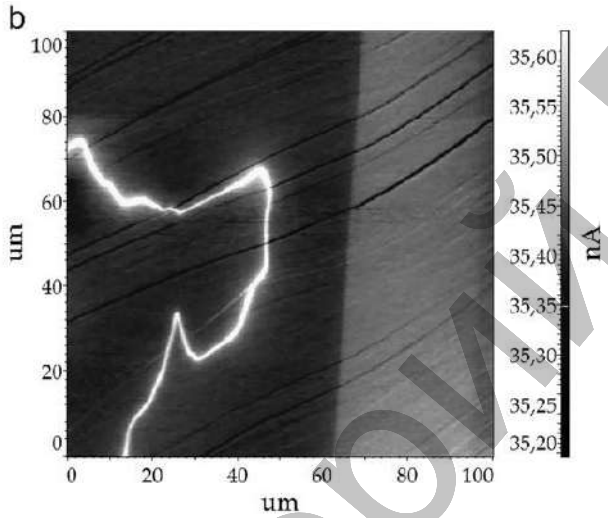


Figure 2. Image of the same surface area (2) of TGS–TGSюCr with containing an impurity of Cr^{3+} stripe (left) and nominally pure TGS (right). Size 100x100 μm^2.

Figure 2 shows the SCM image obtained for another surface area (2) of the same crystal, with an interface between pure and impurity strips. one can see a big domain of positive sign, which is characteristic for the pure crystal. There is no fine domain structure that could be an indicator of the impurity stripe. One can see that, along with domain walls, there is an impurity stripe with intermediate medium contrast, caused by the spatial capacitance variation.

Conclusion. The SCM method was applied to the study of ferroelectric crystals of triglycine sulfate with a profile distribution of chromium impurity. It was shown that the contrast of capacitive image was observed in the regions with an impurity gradient, at domain boundaries, and on individual relief elements. The difference in the chromium concentration of the nominally pure and impurity stripes was~ 0.08 wt%, which gave a perceptible difference (1–2%) in the signal forming the capacitive image. The observed capacitive contrast correlated with changes in the permittivity and conductivity.

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