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[1] It is indicated in [9] that preliminary measurements of the odd effect for the thermal conduction were also made, and their results will be published.

PHASE BOUNDARY IN FERROELECTRIC SbSI AS THE ANALOG OF AN ELECTRIC DOMAIN IN A SEMICONDUCTOR

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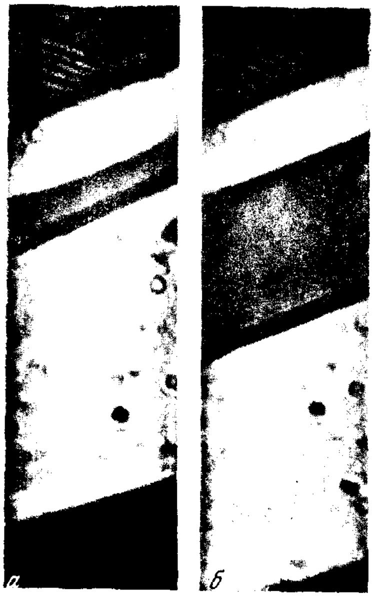
Submitted 9 September 1966
ZhETF Pis'ma 4, No. 11, 461-464, 1 December 1966

In an earlier paper [1] we reported a new optical method of observing the phase transition of single-crystal SbSI. This method is based on the fact that an anomalous shift of the intrinsic absorption edge of SbSI toward longer wavelengths occurs in the region of the first-order phase transition near 20°C [2].

The crystal was placed in a glass vacuum cryostat and observed and photographed with the aid of a microscope in transmitted monochromatic light of wavelength corresponding to the intrinsic absorption edge near the phase transition. Owing to the difference in the absorption, the paraelectric phase regions should appear to be dark and the ferroelectric regions light. Both phases coexist in a first-order phase transition within a finite temperature interval. Accordingly, we observed in [1] a structure of alternating strips, similar to that shown in the figure. Analogous results were obtained independently by Japanese workers [3,4]. The phase boundaries correspond to the (101) planes. The results described below were obtained by the optical method of [1] for SbSI crystals grown from the gas phase in the form of needles and with dimensions on the order of 1 x 0.1 x 7 mm. The axis of the needle (c axis of the crystal) coincides with the direction of the spontaneous polarization. The observation of the crystal in transmitted light was carried out through parallel pinacoid (100) faces in a direction perpendicular to the c axis of the crystal.



Motion of the boundary between phases in SbSI under the influence of a constant electric field (cathode on top, anode on bottom). a - With field, b - without field. Distance between electrodes 2.5 mm, applied voltage 75 V. The boundary moved 180 μ toward the cathode in 15 seconds.

1. A constant electric field applied to the crystal causes the interphase boundary to move toward the cathode. In sufficiently weak fields this motion is not accompanied by, and cannot be connected with, a shift of the Curie temperature, since the ratio of the areas corresponding to the two phases remains constant. This is also evidenced by the fact that the shift of the Curie temperature does not depend on the field direction. The rate of boundary displace-

ment in one of the investigated crystals was 10^{-3} cm/sec. The results for this crystal are shown in the figure. When the boundary makes contact with the cathode, another new boundary appears at the anode, and also moves toward the cathode.

2. Under certain experimental conditions undamped oscillations of the interphase boundary were observed, accompanied by electric oscillations in the external circuit of the crystal. The experimental conditions were as follows: A temperature gradient was produced along the c axis of the crystal in the absence of an external field. This was done by maintaining one end of the needle at a temperature t_1 and the other at t_2, with $t_1 > \theta > t_2$, where θ is the Curie temperature. During the course of establishment of the stationary temperature distribution along the c axis, the paraelectric phase grew and the interphase boundary moved accordingly toward the cold end of the needle. After the stationary temperature distribution had set in, oscillations of the interphase boundary were observed near the equilibrium position. The oscillations occurred only at a sufficiently large temperature gradient, thus, undamped oscillations with a frequency on the order of 1 cps and an amplitude $\sim 0.2 \times 10^{-1}$ cm were observed in the direction of the c axis at $t_1 = 33°C$ and $t_2 = 18.5°C$ and at a crystal length $\sim 2.5 \times 10^{-1}$ cm. The oscillations of the boundary were observed directly with a microscope and were also recorded with an electrometer incorporated in the external circuit of the crystal.

The boundary between the two phases can be represented by an electric double layer, one layer being the bound charge of the ferroelectric phases and the other the screening space charge of thickness d_s localized in the paraelectric phase.

The motion of the boundary in the external electric field can be explained within the framework of the mechanism of the Boer phenomenon [5,6] or instability phenomena in semiconductors [7,8]. As is well known, to realize this mechanism it is necessary to produce in the crystal regions with large field concentrations. In our case such a region is the screening layer. The external field applied to the crystal, on the one hand, polarizes the ferroelectric region and produces thereby the screening layer, and on the other it causes this layer to move. Thus, the motion of the ferroelectric region, shown in the figure, is equivalent to the motion of an electric domain in a semiconductor. This still does not determine the concrete mechanism or the direction of motion of the interphase boundary in the external field. In fact, in our case the motion of the boundary is made possible not only by the redistribution of the charge and the field in the volume of the semiconductor, but also by a mutual transformation of the phases. Thus, in the figure the motion of the boundaries is brought about by transformation of the paraelectric phase into the ferroelectric one at the first boundary (closer to the cathode), and by the inverse transformation at the other boundary. It is possible that this is due to a corresponding distribution of mechanical stresses that shift the point of the phase transition (tension in the crystal at the first boundary and a corresponding compression at the second).

Within the framework of the proposed model, we can readily explain also the second observed phenomenon - the oscillation of the interphase boundary in the presence of a temperature gradient in the absence of an external field. The strong field in the paraelectric region on the boundary between the phases shifts the Curie point toward higher temperatures, as a result of which the boundary moves toward the heated end of the crystal a distance on the order of the screening length. After the space charges are redistributed, the screening layer should contain near the new boundary a section of ferroelectric phase at a temperature higher than the phase-transition temperature. This shifts the boundary in the opposite direction, and the process is then repeated. It is clear from the foregoing that the period of the oscillations should be determined by the Maxwell time constant τ_p, and the oscillation amplitude by the screening length and by the temperature gradient. The estimated values for SbSI are $\tau_p \simeq 1$ sec and $d_e \simeq 3 \times 10^{-1}$ cm, and agree with the frequency and amplitude of the observed oscillations. Illumination of the crystal, which causes photoconductivity, should increase the oscillation frequency. The redistribution of the charges in the volume of the crystal, which accompanies the oscillations of the boundary, leads to oscillations of the current in the external circuit (pyrocurrent).

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QUASILINEAR TRANSFORMATION OF WAVES IN AN INHOMOGENEOUS PLASMA AND NONLINEAR EFFECTS

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Submitted 22 August 1966
ZhETF Pis'ma 4, No. 11, 464-468, 1 December 1966

It was shown earlier [1] that wave transformation in an inhomogeneous plasma may be caused not only by nonlinear effects, but also by quasilinear ones. In such effects, the plateau produced as a result of quasilinear interaction of one group of waves with the particles can be unstable for another group of waves. The possibility of quasilinear transformation of high-frequency waves ($\omega_\alpha \approx \alpha_p$) in the low-frequency part of the spectrum ($\omega_\beta << \omega_\alpha$) was demonstrated by using as an example potential electron oscillations of a cylinder of cold homogeneous plasma of radius R, Excited by a longitudinal electron beam of radius a, moving along a homogeneous magnetic field $\vec{B} \parallel z$. The ratio of the beam and plasma densities was