The sample was glued with a dielectric resin to the diode holder. The laser-illuminated strip on the sample was apparently 10-15 μ wide. The possibility of attaining generation depends in critical fashion on accurately setting the sample in such a way that this illuminated strip is strictly perpendicular to the mirrors.

The sample was cut from a large-block polycrystal of InP doped with tellurium with density 5×10^{17} cm^{-3} and electron mobility 2000 $cm^2V^{-1}sec^{-1}$. Generation set in at an approximate diode current 70 A in one case and at somewhat larger currents in others. A summary spectrum of the emission is shown in the figure. The band connected with GaAs appears as a result of scattering of the coherent emission.

Narrow InP generation lines are seen at 8880, 8900, and 8930 Å. From the average distance between the equidistant maxima we obtained for $(n - \lambda dn/d\lambda)$ a value 5.0 - 6 at 8900 Å, i.e., the same value as for diodes based on InP [6]. Diodes obtained by diffusion of zinc in InP from the same ingot gave generation at 9070 Å, i.e., with a photon energy approximately 30 MeV lower than the largest photon energy obtained by optically exciting an n-type sample. This difference corresponds to the depth of the acceptor level of zinc. We note that for the interband transition [7] at 77°K the wavelength should not exceed 8770 Å, giving grounds for assuming that the observed transitions in n-InP proceed from levels in the donor impurity band to the valence band.

The threshold value of the flux of exciting power was in our case about 0.2 MW/cm^2, which agrees with earlier experiments on optical excitation of semiconductors.

[1] N. G. Basov, A. Z. Grasyuk, and V. A. Katulin, DAN SSSR 161, 1306 (1965), Soviet Phys. Doklady 10, 343 (1965).

[2] N. G. Basov, A. Z. Grasyuk, I. T. Zubarev, V. A. Katulin, JETP Letters 1, No. 4, 29 (1965) transl. 1, 118 (1965); FTT 7, 3649 (1965), Soviet Phys. Solid State 7, 2942 (1966).

[3] R.J. Phelan Jr. and R. H. Rediker, Appl. Phys. Lett. 6, 70 (1965).

[4] I. Melngailis, IEEE J. Quantum Electronics, QE-1, 104 (1965).

[5] N. Holonyak, H. D. Sirkis, G. E. Stillman, and M. R. Johnson, Proc. IEEE 54, 1068 (1966).

[6] N. G. Basov, P. G. Eliseev, I. Ismailov, A. Ya. Nashel'skii, I. Z. Pinsker, and S. V. Yakobson, FTT 8, 2610 (1966), Soviet Phys. Solid State 8, 2087 (1967).

[7] W. J. Turner and W. R. Reese, Radiative Recombination in Semiconductors, Dunod, Paris, 1965, p. 59.

PHOTOSENSITIVE PHASE TRANSITION IN THE FERROELECTRIC SEMICONDUCTOR SbSI

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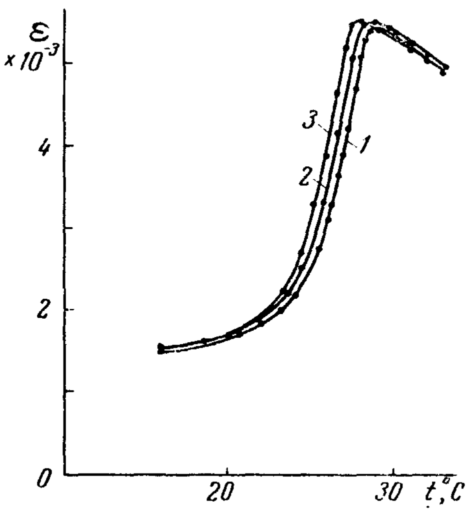
Submitted 24 April 1967
ZhETF Pis'ma 6, No. 1, 481-483 (1 July 1967)

One of us has previously predicted [1] on the basis of a simple thermodynamic calculation that the Curie temperature of a ferroelectric crystal should shift when the concentration of the nonequilibrium carriers changes. In the approximation of the Landau-Ginzburg theory for second-order phase transitions [2] the magnitude of this shift Δθ satisfies, according to [1], the relation

$$\Delta\theta = -\frac{\Delta E_g C}{\pi P_o^2} N, \qquad (1)$$

where P_0 is the jump of the spontaneous polarization, ΔE_g the jump in the width of the forbidden band at the Curie point, C the Curie-Weiss constant, and N the density of the excited carriers produced upon illumination. The direction of the shift of the Curie temperature, i. e., its sign, is determined in accord with (1) by the sign of ΔE_g.

Since SbSI is ferroelectric photoconductor, it became possible to observe in it, for the first time, the shift of the Curie temperature upon illumination. Since $\Delta E_g < 0$ for SbSI [3], illumination of the crystal should lead, according to (1), to a shift of the Curie point towards lower temperatures. It is easy to estimate the magnitude of the effect for SbSI by determining from (1) the minimum concentration of the excited carriers, N, needed to shift the Curie temperature one degree. Substituting in (1) $\Delta\theta = 1°$, $|\Delta E_g| \approx 6\times10^{-2}$ eV [3], $C \approx 6\times10^5$ °K, and $P_0 \approx 25\times10^{-6}$ Coul/cm^3 we get $N \approx 4\times10^{17}$ cm^{-3}. This value of N is realized as a rule in high-resistance semiconductors [5,6]. N must be taken to mean here the density of the carriers at the adhesion levels.



Temperature dependence of the dielectric constant of SbSI at a frequency $\nu = 10^8$ Hz in darkness (1) and upon illumination (2, 3). The respective free-carrier densities are 10^8, 2×10^9, and 10^{10} cm^{-3}.

The shift of the Curie temperature of SbSI upon illumination, predicted in [1], was first observed experimentally in [7] by measuring the peak of the dielectric constant in the microwave band. In the present work we carried out independent measurements for SbSI, which confirmed the existence of this effect. The measurements were made with SbSI single crystals grown from the gas phase and having a Curie temperature $\theta \approx +29°$C (in darkness). We measured the dielectric constant of the crystal at 10^8 Hz in darkness and at two values of light intensity. The figure shows the corresponding plots. It is seen from these data that when the free-carrier density is increased by two orders of magnitude the Curie temperature of the crystal drops approximately one degree. The shift of the Curie point upon illumination has been consistently repeated in numerous measurements in darkness and in light. The shift exhibits no lag relative to the application and removal of the light, thus excluding a possible influence of heating. Consequently our results confirm further the conclusions drawn earlier in [1], and point to the existence of a new photoelectric effect in SbSI, namely the change of its dielectric constant upon illumination, due to the shift of the Curie temperature.

[1] V. M. Fridkin, JETP Letters 3, 252 (1966), transl. p. 161.
[2] V. L. Ginzburg, UFN 38, 490 (1949).
[3] V. M. Fridkin, K. Gulyamov, V. A. Lyakhovitskaya, V. N. Nosov, and N. A. Tikhomirova, FTT 8, 1907 (1966), Soviet Phys. Solid State 8, 1510 (1966).
[4] E. Fatuzzo, G. Harbeke, R. Nitsche, H. Roetschi, and W. Ruppel, Phys. Rev. 127, 2036(1962).
[5] A. Rose, Fundamentals of Photoconductivity Theory (Russ. transl.) Mir, 1966.
[6] S. M. Ryvkin, Photoelectric Phenomena in Semiconductors, Fizmatgiz, 1963.
[7] B. P. Grigas, I. P. Grigas, and R. P. Belyankas, FTT, 9, No. 10 (1967) (in press).