EXTINCTION OF FROZEN-IN CONDUCTIVITY BY AN ELECTRIC FIELD

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The phenomenon of frozen-in conductivity (FC) consists in a very long persistence of almost the entire initial photoconductivity of objects cooled to low temperatures (liquid nitrogen and helium) after the photoexcitation is turned off. The FC is usually destroyed when the temperature is increased. This phenomenon, which is potentially of interest from the point of view of developing "optical" memory devices, was observed in single crystals [1] and in polycrystalline films [2] and tablets [3] of CdS, in the CdS-SiO_x film systems [4], in polycrystalline layers of AgI and ZnO [5], and (at room temperatures) in thin layers of organic dyes [6]. The mechanism of the FC, in one form or another, is connected with the presence of a barrier to the photocarrier recombination [1-4]. If this is so, then the FC state should be strongly influenced by a strong electric field which, by lowering the "recombination barrier," say as a result of the Schottky effect or by carrier heating [7], should cause extinction of the FC. It follows therefore that the current-voltage characteristics of FC and of photoconductivity of the corresponding objects should reveal sublinear sections and regions of negative resistance, owing to the increased recombination rate in a strong electric field. The purpose of the present investigation was to verify experimentally these assumptions.

The investigations were made on single-crystal CdS films and on the CdS-SiO_x film system

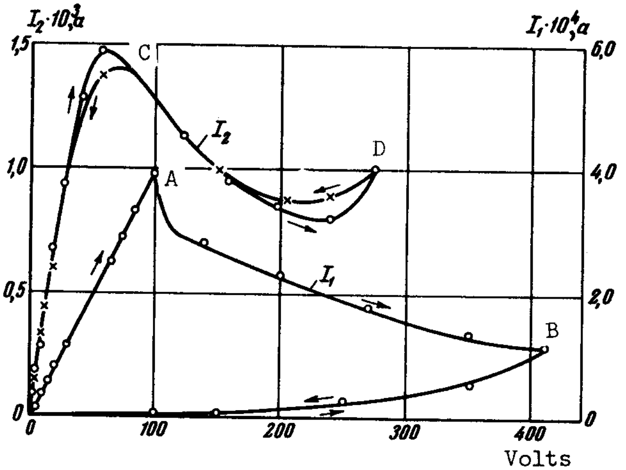

Fig. 1. Current-voltage characteristics of the CdS-SiO_x in the FC state (curve OAB) and in the photoconductivity state.

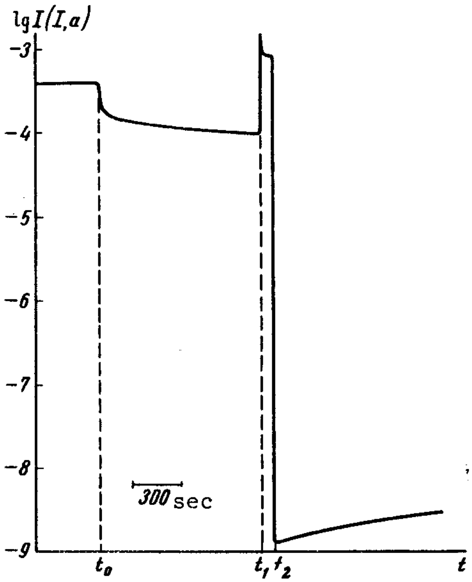

Fig. 2. Time variation of the FC quenching in the sample whose current-voltage characteristic is shown in Fig. 1: t_0 - time of turning off the photoexcitation (sample voltage U = 25 V), t_1 - time at which voltage is raised to U = 400 V, t_2 - time at which voltage is lowered to U = 25 V.

[4] at liquid-nitrogen temperatures. We measured the current-voltage characteristics along CdS films provided with indium contacts sputtered with a gap of 2 mm. The exposed CdS area between the electrodes was coated with an SiO_x film 0.15 μ thick by evaporation in vacuum. Figures 1 and 2 show the experimental data, which demonstrate clearly the effect of FC extinction by means of an electric field. The current-voltage characteristics corresponding to the FC state actual reveal regions of negative resistance (Fig. 1, curve AB). Application of a voltage ~400 V causes the conductivity of the sample to drop abruptly to almost its dark value; current-voltage characteristics similar to curve OB (Fig. 1) are observed in this state and can be consistently reproduced. The section OAB can be repeatedly observed by returning the sample to the FC state by photoexcitation at the experimental temperature (- 180°C). The effect of FC extinction by the electric field can be seen more clearly in Fig. 2, from which it follows that application of $E \approx 2 \times 10^3$ V/cm (average field) decreases

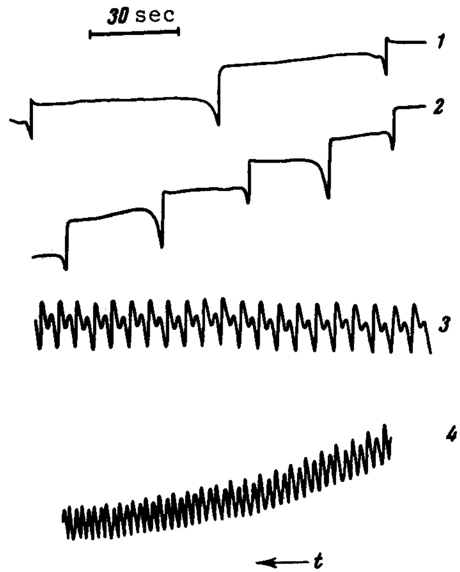

Fig. 3. Oscillations of current in single-crystal CdS film at different values of the voltage (U) and photoexcitation intensity (I): 1 - U_1 = 370 V, T_1 = - 180°C; 2 - U_2 = 400 V, T_2 = -180°C; 3 - U_3 = 370 V, T_3 = -180°C; 4 - U_4 = 370 V, T_4 = -130°C; $I_1 = I_2 < I_3 = I_4$. The courrent-voltage characteristic of the object in the FC state and under photoexcitation is similar to that shown in Fig. 1.

the FC by approximately five orders of magnitude. It is interesting to note that the current-voltage characteristic of the stationary photoconductivity of the same objects (excited by a 150-W incandescent lamp through a water filter 3 cm thick) also reveals a negative-resistance region (Fig. 1, curve OCD). In this state, low-frequency current oscillations are produced in the CdS-SiO_x system (as well as in "pure" CdS films), with amplitude ~1% of the stationary photocurrent); the parameters of these oscillations are functions of the intensity of the photoexcitation, the voltage, and the temperature (Fig. 3). The oscillation currents and the negative-resistance sections observed on the current-voltage characteristics apparently have a common nature.

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