OBSERVATION OF CURRENT INSTABILITIES IN ORIENTED n-GaAs

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Recently current instabilities in long samples of *n*-GaAs under applied high electric field have been studied in [1–3]. All authors have used samples orientated in the ⟨110⟩ direction with the length of about 1 cm and the electron concentration lower than 2.2×10^{16} cm^{-3}. Experiments discussed in [1] and [3] were made at 77 °K, those in paper [2] at room temperature. The origin of instabilities in long samples of GaAs is atributed to the acoustoelectric effect which is responsible for the appearence of the *high field domain* travelling in *n*-type material from the cathode to the anode at the velocity of sound. Phenomenological theories of this phenomena are given in [4, 5]. The effect, however, is not fully understood yet.

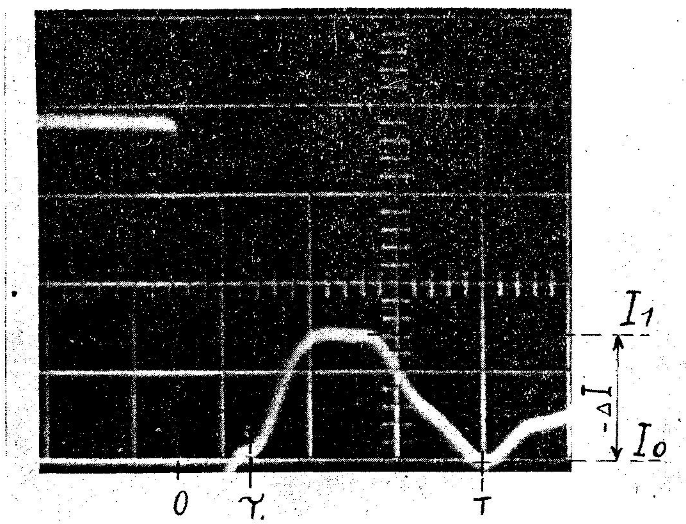

Fig. 1. The decrease of current $(-\Delta I)$ in the circuit with the sample. The applied pulse has been obtained by discharging the delay-line. Horizontal axis: .114 μs/div. Vertical: 4·6 A/div. The length of the sample was 6 mm.

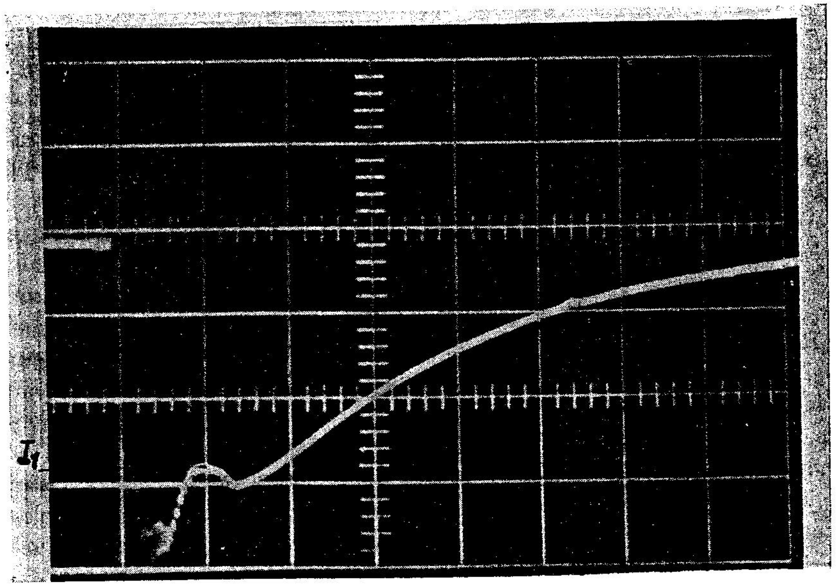

Fig. 2. The sample current. The applied pulse obtained by discharging the condenser.

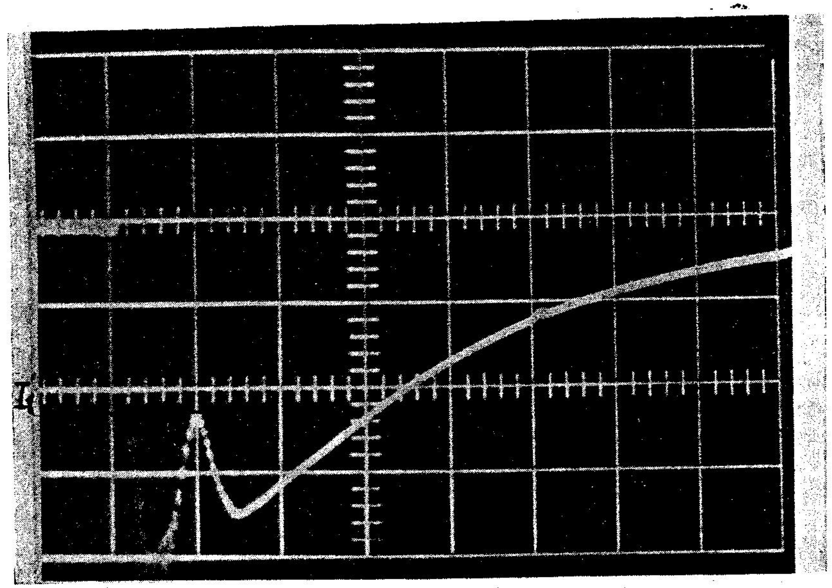

Fig. 3. The sample current. The applied pulse obtained by discharging the condenser.

We have investigated the samples of n-GaAs orientated in the $\langle 110 \rangle$ direction of a length in the rage of 3—6 mm, at 90 °K, in an electric field of about 1 kV/cm. The sample parameters were; $n = 5 \times 10^{16}$ cm^{-3}, $\mu = 3400$ cm^2/V . s at room temperature.

We have observed the decrease of the current at fields higher than a certain *threshold field* E_{th}. This decrease was detected on the calibrated resistor which was connected in series with the sample. The decrease of the current appears (see Fig. 1) after the time τ. (See I_1 also in Fig. 2 and Fig. 3.) We believe that this is the time necessary for the development of the domain. The current returns to the initial value I_0 after the time T. At this time T — in accordance with [3] for example — the domain disappears at the anode. The current instability increases with the increasing electric field while the change of the time T was not observed in our measurements. The decrease of current with the increasing field is apparent in Fig. 2 and Fig. 3. The plateau in Fig. 1 corresponds to the saturation of the current decrease.

We have calculated the velocity of the domain from the measured time T and the length of the sample. Results are in the range 2.98 × 10⁵—

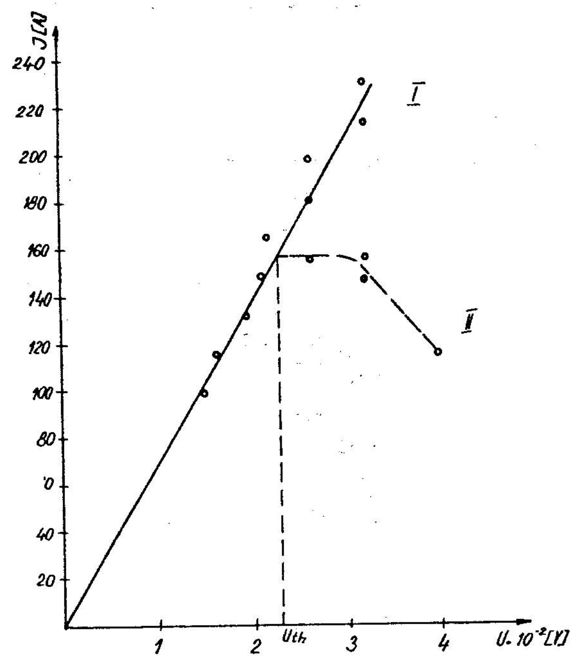

Fig. 4. The voltage — current characteristic of the sample with the length of 5 mm.

3.20×10^5 cm/s. The velocity of the shear $\langle 110 \rangle$ wave — after [6] — at 25 °C is 3.345×10^5 cm/s. It can be seen that the velocity of the domain is near to the velocity of the shear acoustic wave.

The voltage — current characteristic is on Fig. 4. Its linear part corresponds to the ohmic behaviour of the sample. The characteristic has two branches at $E > E_{th}$. The first branch (I) belongs to the behaviour of the sample before the formation of the domain in the time $t < \tau$. Branch II exhibits the region of the negative differential conductivity ($dI/dU < 0$) and corresponds to the non-ohmic behaviour of the sample in time $\tau < t < T$. (We have determined the current corresponding to the maximal decrease between the times τ and T. See I_1 in Figs 1—3.)

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