

Current oscillations in crystals of the wide-band dielectrics BaF₂, CaF₂, NaCl, and KBr

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Current oscillations of frequencies 10^{-1} - 10^4 Hz were observed in crystals of the wide-band dielectrics BaF₂, CaF₂, NaCl, and KBr in constant electric fields on the order of 10^6 V/m. The periods and the amplitudes of the current oscillations depend nonlinearly on the electric-field intensity.

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An investigation of the properties of semiconductors in strong electric fields has revealed the presence in them of various instabilities of the electric current, due as a rule to domain formation.^[1] We know of no published report of

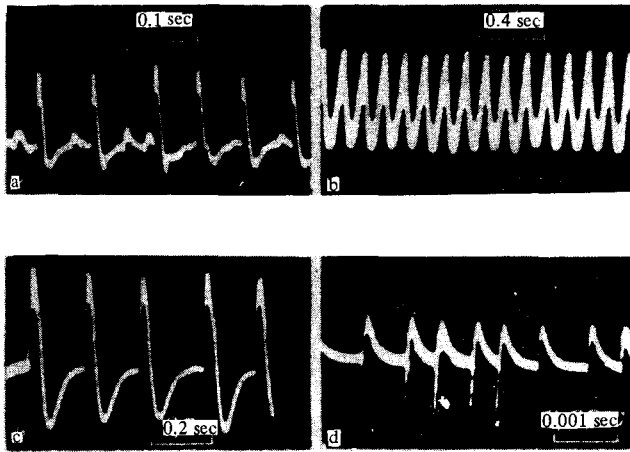


FIG. 1. Current oscillations in crystals: a) BaF_2 , $V=2000$ volt, $d=2.5 \times 10^{-3}$ m; b) CaF_2 , $V=2600$ volt, $d=2 \times 10^{-3}$ m; c) NaCl , $V=2200$ volt, $d=2.5 \times 10^{-3}$ m; d) KBr , $V=2200$ volt, $d=3 \times 10^{-3}$ m.

current oscillations in wide-band dielectrics. We report here observation of current oscillations in the dielectric crystals BaF_2 , CaF_2 , NaCl , and KBr , the widths of the forbidden bands in which range from 7 to 12 eV.^[2] DC voltages V from 0 to 4000 volt was applied to crystals of thickness (d) from 1×10^{-3} m to 5×10^{-3} m and area 2×10^{-4} m². The contacts were silver paste or clamp electrodes of copper or aluminum with area from 1×10^{-6} to 3×10^{-5} m². The measurements were made at 300°K. A guard ring of silver paste was deposited on the end face of the crystal to prevent the flow of surface currents. The current was registered with a U5-7 electrometric amplifier, the output signal of which was fed to an S1-70 or S8-2 oscilloscope.

Typical current oscillations in the crystals are shown in Fig. 1. In the fluorides, regular current oscillations of frequency 10^1 – 10^2 Hz were produced at effective electric field intensities $E = V/d$ on the order of 10^6 V/m and direct currents 10^{-10} – 10^{-9} A. With increasing E , the amplitude of the oscillations first increased while the period decreased, but subsequently these quantities became independent of E (Fig. 2).

In the NaCl and KBr crystals, current oscillations of frequency 1– 10^4 Hz were produced at $E > 10^6$ V/m and direct currents 10^{-10} – 10^{-6} A. With increasing

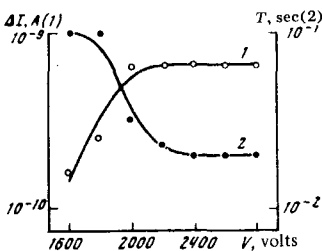


FIG. 2. Dependence of the amplitude (1) and period (2) of the current oscillations on the voltage for the BaF_2 crystal, $d=2.5 \times 10^{-3}$ m.

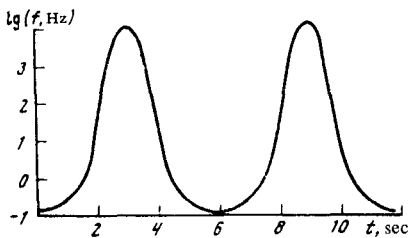


FIG. 3. Dependence of the repetition frequency of the current oscillations on the time for an NaCl crystal, $d = 2.5 \times 10^{-3}$ m, $V = 200$ volt.

E , as a rule, the amplitudes of the oscillations increased, and the periods decreased. In some NaCl crystals, at a fixed voltage, periodic variation of the repetition frequency of the oscillations was observed. An approximate plot is shown in Fig. 3.

The current oscillations, both in the fluorides and in the alkali-halide crystals, could be observed for at least several hours. The period of the oscillations increased with time. Grounding the guard ring did not change the waveform or the period of the oscillations, thus indicating that the current oscillations are of volume origin.

The character of the oscillations may be connected with injection and motion of the carriers in the dielectrics. In the voltage region where the oscillations appeared, the current-voltage characteristics of the crystals revealed singularities in the form of abrupt increases of the nonlinear dependence of the current on the voltage. Under our conditions, we observed no sections with negative differential conductivity, possibly because of polarization effects that impede the correct measurement of the current-voltage characteristics.

One cannot exclude the possibility that an investigation of the dependences of the amplitude, frequency, and waveform of the oscillations on different parameters can yield hard-to-get information on the drift of carriers in wide-band dielectrics.

¹V. L. Bonch-Bruevich, I. P. Zvyagin, and A. G. Mironov, *Domennaya élektricheskaya neustoičivost' v poluprovodnikakh* (Electric Domain Instability in Semiconductors), Nauka, 1972.

²W. Hayes, *Crystals with the Fluorite Structure*, Oxford, 1974.