The observed singularities of the distribution of the potential are reflected in the current-voltage characteristics (CVC) (Fig. 2): in the initial sections of the CVC there is observed the current saturation characteristic of the barrier contact [3]; the vanishing of the depleted layer at large voltages is accompanied by a transition to a quadratic CVC, and when the field is concentrated on the cathode the CVC becomes more gently sloping.

We note in conclusion that all the potential distributions observed previously in SbSI by the probe method [3, 4] are contained, as particular cases, among the curves given above.

The authors are grateful to V.A. Lakhovitskaya for the SbSI single crystals.

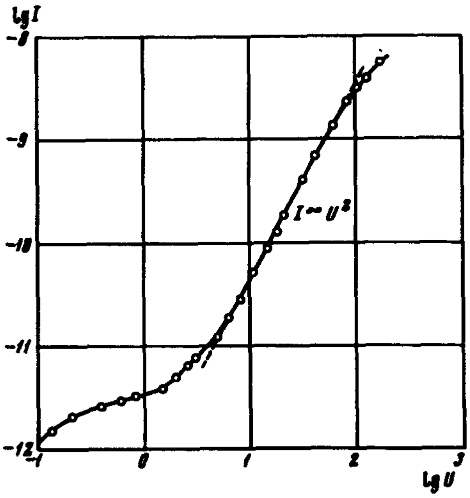

Fig. 2. Current-voltage characteristic of single-crystal SbSI: I - amperes, U - volts. The measurement conditions correspond to Fig. 1b.

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CURRENT INSTABILITY AND MICROWAVE RADIATION OF n-CdHgTe

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Submitted 21 June 1971
ZhETF Pis. Red. 14, No. 3, 164 - 168 (5 August 1971)

Although the results of investigations of coherent microwave radiation in InSb [1, 2] have not yet made it possible to establish the concrete mechanism whereby this radiation is excited, they do show that this mechanism is based apparently on an electron-hole plasma instability that is not connected directly with the singularities of the energy spectrum of the carriers and their interaction with the crystal-lattice vibrations. It was therefore natural to assume that analogous phenomena can be observed also in other semiconducting materials, in which moderate electric fields can produce a non-equilibrium plasma with high mobility and not too high a carrier density. Such materials include, in particular, the solid solution $Cd_xHg_{1-x}Te$, which at $x \leq 0.15$ is a semimetal, and at $x > 0.15$ is a semiconductor whose band structure is similar to the band structure of InSb, and the mobility of the electrons at $T = 77°K$ reaches $10^4 - 5 \times 10^5$ cm²/sec.

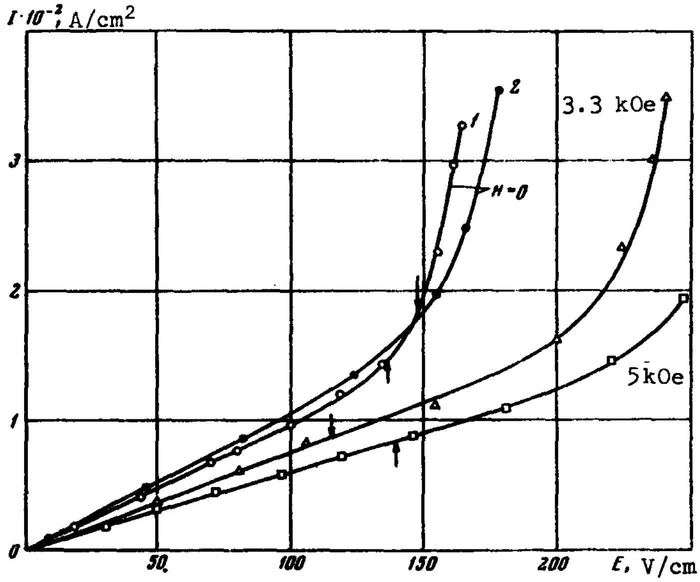

Fig. 1. Current-voltage characteristics of n-$Cd_{0.23}Hg_{0.77}Te$ crystal at T = 77°K. The arrow shows the threshold of the microwave radiation. Curves 1 and 2 correspond to opposite polarities of the supply pulses.

This assumption was confirmed by an investigation of single crystals (prepared at the L'vov State University) of n-$Cd_{0.23}Hg_{0.77}Te$, with approximate dimensions 2.5 × 2 × 0.1 mm and with electron density 10^{15} - 10^{16} cm^{-3} and mobility $\sim 3 \times 10^4$ cm^2/sec, carried out by a procedure described in [2]. The results revealed a high-frequency current instability and microwave radiation in the frequency band 1.5 - 5 GHz, characterized by the following features.

The current-voltage characteristic (CVC) of the samples, which is linear up to fields E < 100 V/cm, becomes superlinear with further increase of E, with a slope that increases sharply at E > 150 V/cm, corresponding apparently to the threshold of impact ionization. A transverse magnetic field $\vec{H}_\perp$ noticeably increases the resistance of the sample and shifts the threshold of the impact ionization towards larger E (Fig. 1).

On the superlinear section of the CVC there are observed regular oscillations of the current with frequency 1 - 20 MHz (Fig. 2). Application of a weak magnetic field $\vec{H}$ stimulates excitation of these oscillations, and their frequency increases smoothly with the increasing H. Thus, for example, for one of the samples at E = 160 V/cm and J $\sim$ 3.5 × 10^2 A/cm^2, a change of the transverse magnetic field from 1.1 kOe to 1.8 kOe was accompanied by an increase of the current oscillation frequency from 3 to 8 MHz. The phase of the current oscillations is characterized by high stability and reproducibility from pulse to pulse in a wide range of regimes. A longitudinal magnetic field $\vec{H}_\parallel$ has practically no effect on the excitation of the current oscillations.

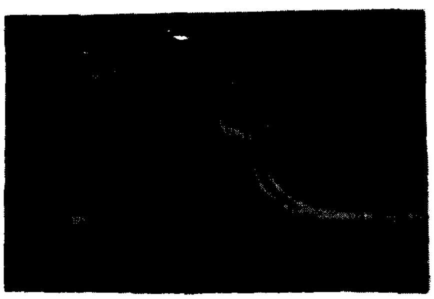

Fig. 2. Current oscillations (upper curve) and envelope of microwave radiation pulse of an n-CdHgTe sample at $H_\perp$ = 1 kOe. Horizontal scale 0.2 μsec/div. Vertical scale (upper curve) 0.2 A/div.

The microwave radiation occurs at E > E_{thr} ≈ 100 - 120 V/cm and J > J_{thr} ≈ (1 - 2) × 10^2 A/cm^2, both in magnetic fields of intensity up to 6 kOe, of arbitrary orientation, and without a magnetic field[1].

For one of the samples, having a lower resistivity, the microwave radiation at H = 0 was observed only in a narrow current interval and had a much lower intensity than at H > 0. For another sample, a magnetic field up to 1 kOe had little influence on either the threshold values E_{thr} and J_{thr} or on the radiation intensity, although in fields $\vec{E} \perp \vec{H} \simeq 3.5$ kOe and at certain crystal orientations small kinks were observed on the $E_{thr}(H)$ and $J_{thr}(H)$ curves, connected apparently with the change in the oscillation mode. Similarly, a change of the crystal orientation in a transverse magnetic field has practically no influence on the threshold values E_{thr} and H_{thr} at $H_{\perp} \gtrsim 1$ kOe, whereas at $H_{\perp} \gtrsim 3$ kOe these values change by a factor 1.3 - 1.5.

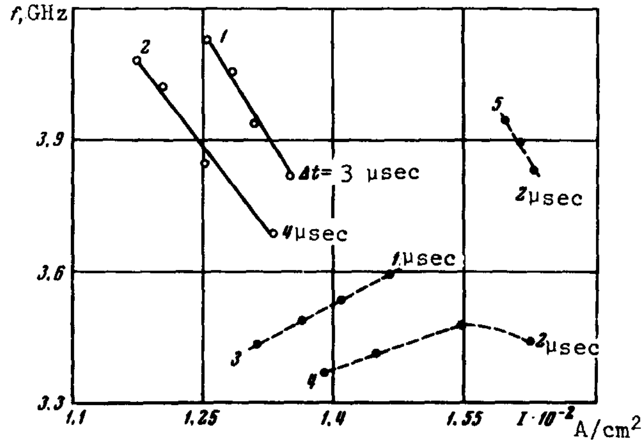

Fig. 3. Dependence of the frequency of the coherent radiation on the current and pulse duration at $H_{\perp}$ = 5 kOe and at different values of the angle α between the broad face of the sample and the direction of the magnetic field: 1, 2 - α = 7°; 3, 4, 5 - α = 21°.

In fields not greatly exceeding the threshold values, the microwave radiation is nearly coherent and has a characteristic "multimode" structure.

For small changes of $\vec{E}$ and $\vec{H}$ and of their mutual orientation, the envelope of the microwave pulse can assume most exotic configurations, each of which not only remains stable from pulse to pulse, but is reliably reproduced after numerous repetitions of the experiment. The sharpest spikes on the microwave-pulse envelope are frequently accompanied by the appearance of noticeable steps and projections on the shelf of the supply pulse. An impression is gained that different sets of values of E and H correspond to different modes of microwave oscillations in the volume of the crystal.

The frequency of the coherent radiation is a function of the current, of the magnitude and orientation of the magnetic field, of the sample orientation, of the interval Δt from the start of the supply pulse, etc. The variation of the frequency with current is shown in Fig. 3 for one of the samples in a transverse magnetic field $H_{\perp} \simeq 5$ kOe. Depending on the oscillation mode, the frequency can either increase or decrease with the current. An increase of the interval Δt is accompanied as a rule by a decrease of the radiation frequency. Simultaneous generation of oscillations with different frequencies is observed (curves 4 and 5 of Fig. 3).

The characteristics of the microwave radiation observed in CdHgTe are similar in many respects to the corresponding characteristics obtained for n-InSb [2]. The threshold values of the electric field are close; in both cases one observes excitation of coherent oscillations whose frequencies depend on the current density, magnetic field intensity, sample orientation, and pulse duration; the transformation of the coherent oscillations into noise with increasing current is analogous, etc. This makes it likely that in both cases the microwave instability is produced by the same effective mechanism connected

[1]In this respect the microwave radiation of CdHgTe differs from the radiation of InSb, which is observed as a rule when H ≠ 0.

with the electron-hole interaction. The different degree of influence of the magnetic field on the characteristics of the radiation in the two materials can be attributed to the lower mobility of the electrons in CdHgTe, and indicates that the magnetic field plays a secondary role in the instability mechanism. The fact that excitation of coherent radiation in CdHgTe is accompanied by a noticeable change of the sample resistance (which is manifest in distortion of the current and voltage pulse wave forms) indicates a high intensity of the microwave oscillations of the electron-hole plasma in the interior of the crystal, and the low power of the observed radiation, which is evidence of a low coefficient of conversion of the oscillations into electromagnetic ones, is apparently due to the potential character (small wavelength $k \gg \omega/c$) of the plasma oscillations.

Further investigations of the microwave radiation of CdHgTe crystals with different component ratios will probably make it possible to draw more definite conclusions concerning the nature of the described phenomena, including the most obscure question, that of the mechanism ensuring coherence of the microwave radiation.

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PRODUCTION OF $\pi^+2\pi^-$ SYSTEM OF NUCLEI AT SMALL MOMENTUM TRANSFERS

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Submitted 29 June 1971
ZhETF Pis. Red. 14, No. 3, 168 - 171 (5 August 1971)

The production of a charged system ($2\pi^-\pi^+$) by pions on complex nuclei was investigated at several values of the primary pion momentum [1 - 3]. It was established that coherent production of the indicated system occurs at small values of the 4-momentum transfer to the target nucleus. The cross section of the process decreases with decreasing primary energy. The interesting region below 6 GeV, where coherent generation should gradually attenuate, has hardly been investigated (one event was registered at an input momentum 3.85 GeV/c [4]).

We have observed coherent production of a triplet of pions ($2\pi^-\pi^+$) on light nuclei by negative pions with momentum 4 GeV/c. The work was performed with the aid of the 105-cm bubble chamber of our Institute, filled with a mixture of light freons (chemical composition $C_2F_5Cl_3$). The chamber was exposed to a beam of pions from the proton synchrotron of the Institute of Theoretical and Experimental Physics. The magnetic field in the volume of the chamber was 16 kOe.

We selected 3-prong interactions without a visible disintegration of the recoil nucleus, without evaporation products, and not accompanied by emission of γ quanta and neutral strange particles. A total of 922 events was measured.

A fitting procedure was used to separate the reaction. For the target mass we used the neutron mass, since fitting to a definite type of reaction at small values of the momentum transfer is insensitive to the target mass. At large momentum transfers the neutron mass apparently corresponds more closely to the character of the process [2, 5].

After additional selection by the χ^2 criterion and measurement accuracy, we were left with 281 cases of the reaction π^- + (neutral target) $\to \pi^+ + 2\pi^-$ +