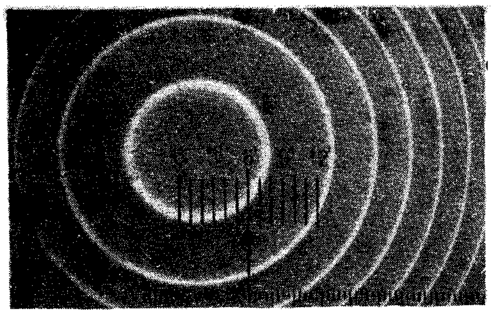
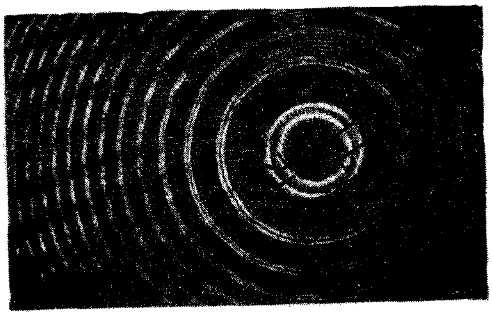


Fig. 2



From the point of view of the applications, the described interferometer differs from two-beam interferometers in that it produces a sharper interference pattern, and differs from ordinary Fabry-Perot interferometers in that the measurements can be made on the side of the light source. By varying the parameters of the coatings it is possible to make the interference fringes highly asymmetrical, and thus determine in principle the direction of the change of the phase difference. Under certain conditions, it is possible to replace the absorbing films in the described interferometer by light-scattering coatings prepared in accordance with [2].

The author is grateful to V.P. Koronkevich for a discussion of the work and to N.D. Goldina for preparing the optical coatings.

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INVESTIGATION OF RESISTIVE INSTABILITY EXCITED BY AN ELECTRON BEAM IN A SOLID-STATE PLASMA

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Submitted 2 February 1970
ZhETF Pis. Red. 11, No. 6, 284 - 287 (20 March 1970).

Collective interactions of beams of charged particles in a gas-discharge plasma have by not been thoroughly investigated both theoretically and experimentally. As to the interaction between beams of charged particles and a solid-state plasma, particularly a semiconductor plasma, experimental work in this field has just only started, in spite of the appreciable number of theoretical investigations. In [1] they observed experimentally the effect of excitation of helicons by an electron beam in a semiconductor plasma. Excitation of helicons by external fields was observed in [2]. The purpose of the present study was the experimental observation and investigation of the resistive high-frequency instability that should occur when beams of charged particles interact with a solid-state plasma. Such a study, besides being of purely physical interest, is essential for assessment of the feasibility of using plasma-beam interaction to excite microwave oscillations. The use of semiconductors makes it possible to obtain a "quiescent" -ense plasma (up to 10^{14} - 10^{18} cm^{-3}), and smooth variations of the density can be easily obtained. The dispersion equation describing the high-frequency branch of the oscillations excited by interaction of the beam with the plasma [3] is given by:

$$1 - \frac{\omega_o^2}{2\omega(\omega + i\nu)} - \frac{\omega_b^2}{(\omega - kV_b)^2} = 0 , \qquad (1)$$

where ω_b and V_b are the electron-plasma frequency and the velocity of the beam electrons. For most semiconductors the collision frequency ν is much larger than the Langmuir plasma oscillation frequency ω_0, and

$$\omega = (kV_b + \omega_b R) + I\omega_b ; \quad R = \mathrm{Re}\frac{1}{\sqrt{1 + \frac{\omega_o^2}{2\nu\omega} i}} ; \quad I = \mathrm{Im}\frac{1}{\sqrt{1 + \frac{\omega_o^2}{2\nu\omega} i}} . \qquad (2)$$

The oscillation growth increment is

$$\gamma = \mathrm{Im}\,\omega = I\omega_b . \qquad (3)$$

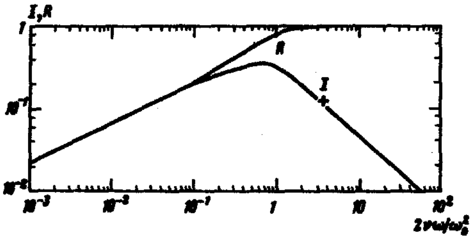

Fig. 1. Dependence of the coefficients I and R on the parameter $2\nu\omega/\omega_0^2$ (ω is the oscillation frequency).

As soon from Fig. 1, in this case the growth increment does not have a sharply pronounced resonance as a function of ω.

The experiments were performed with a setup whose diagram is shown in Fig. 2. An electron beam with energy 1 - 5 keV and a current 20 - 150 mA in a pulse of duration 200 - 300 µsec was passed through a channel of 3 mm diameter, cut

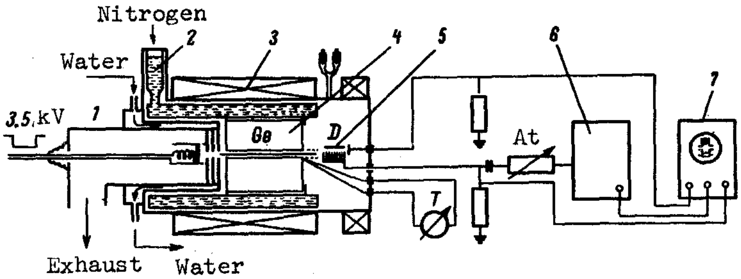

Fig. 2. Experimental setup: 1 - electron gun, 2 - Dewar, 3 - magnetic-field solenoid, 4 - crystal, 5 - "ridge" oscillation pickup, 6 - superheterodyne receiver, 7 - oscilloscope; At - attenuator, T - thermocouple, D - diaphragm.

along the [111] axis in single-crystal Ge having the following parameters: resistivity ρ = 47 Ohm-cm, impurity density n = (2 - 5) × 10^{12} cm^{-3}, number of dislocations K = 10 cm^{-3}, length 3.5 cm, diameter 3.5 cm. The crystal was placed in a special container inside a Dewar filled with liquid nitrogen. The entire beam channel and crystal system was rigidly adjusted and placed on the axis of a weak homogeneous magnetic field of intensity 300 - 400 Oe. The oscillations in the beam were picked up with a ridge-type periodic structure matched to the waveguide channel. The proper gain of the ridge was 3 dB. The oscillations were registered with a superheterodyne receiver of ~10^{-13}W sensitivity, operating at a fixed frequency 36.74 × 10^9 Hz with a bandwidth of 5 MHz.

In the experiment, the current in the crystal channel ranged from 20 to 150 mA, and the current over the ridge was maintained constant at 0.33 mA (smaller by a factor of 10 than the self-excitation current of the beam-ridge system). The measurements have shown (Fig. 3) that when a beam of electrons passes through the crystal channel, high-frequency oscillations are excited at the frequency 36.74×10^{9} Hz. In the temperature range 350 - 300°K (in the density range $2.6 \times 10^{14} - 2.3 \times 10^{13}$ cm^{-3}), these oscillations have the same frequency as the resistive oscillations determined by Eqs. (1) - (3). The temperature dependence of the growth increment of the oscillations agrees well with the resistive mechanism of oscillation excitation. The plot of the logarithm of the power of the excited oscillations against the square root of the beam current is linear in this region (as expected from (3)). The growth increments determined from this plot agree well with the theoretical ones. The cross in Fig. 1 designates the value of I determined experimentally at a sample temperature 310°K (the parameter $2\nu\omega/\omega_0^2$ equals 3.5 in this case). Besides the indicated region of oscillations, there exists a second region (300 - 240°K, $n = 2.3 \times 10^{13} + (2 - 4) \times 10^{12}$ cm^{-3}), in which the temperature dependence of the excited oscillations on T has a resonant character. The frequency of the excited oscillations at resonance coincides with the Langmuir frequency. It can be assumed that Langmuir oscillations are excited in this region as the result of two-stream instability (of the non-resistive type), but in our experiments the frequency of the collisions was several times larger than the Langmuir frequency. Under these conditions, it is possible to excite oscillations if they are due to effects of stimulated emission. The experimentally observed narrowing of the temperature resonance with increasing beam power and with increasing level of the excited oscillations is a confirmation of this fact. However, further verification is necessary to ascertain the feasibility of exciting in our experiment non-resistive instabilities.

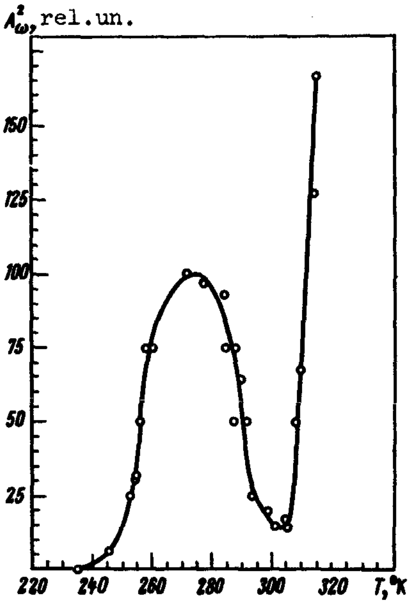

Fig. 3. Power of the oscillations excited at the frequency f = 36.74 GHz vs. the temperature of the Ge crystal.

The authors are grateful to I.Yu. Adamov for developing and providing the high-sensitivity superheterodyne receiver for the experiment, to L.I. Bolotin for continuous interest and help in the work, to V.I. Kurilko, V.D. Shapiro, and V.I. Shevchenko for a discussion of the experimental results, and to S.S. Pushkarev for help with the measurements.

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INFLUENCE OF THE SUPERCONDUCTING STATE ON THE CREEP OF METALS

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Submitted 19 January 1970; resubmitted 9 February 1970
ZhETF Pis. Red. 11, No. 6, 288 - 290 (20 March 1970).

In mechanical tests of metals near absolute zero, when thermally activated processes are suppressed to a considerable degree, the conduction electrons may play an important role in interactions with moving dislocations. The clarification of the influence of normal electrons on the mechanical properties has been recently the subject of a number of experimental [1 - 5] and theoretical [6 - 7] investigations.

Since it is difficult to separate experimentally in pure form the electronic component dislocation deceleration, the most suitable objects for this purpose are superconducting metals in which it is possible to vary extensively the density of the normal electrons. It was shown [1, 3 - 5] that niobium or lead loses strength on going over from the normal to the superconducting state, owing to the increase of the energy scattered by the moving dislocations.

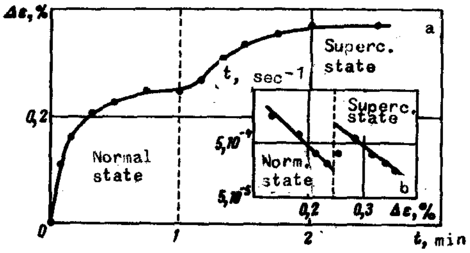

Fig. 1. Change of thallium deformation Δε vs. time (a) and of deformation rate vs. degree of deformation (b) in the transition creep state during the change from the normal to the superconducting state (T = 1.8°K, σ = 3.2 kg/mm².

The present paper is devoted to a verification of the presence of this phenomenon in a number of superconductors under creep conditions at temperatures 1.80 - 4.2°K.

The investigations were performed on metals with different types of crystal lattice: In (99.9999%), Tl (> 99.999%), Hg (> 99.999%), and Sn (99.9995%). The Hg samples were plane-parallel plates thickened on the ends, with working-section dimensions 20 × 4 × 3 mm. They were obtained by slow-cooling crystallization in a dismountable steel mold. The samples of the other metals had the form of plates measuring 40 × 4 × 1.5 mm. The In and Tl were annealed at room temperature for a day; the Sn samples were annealed at 100°C in vacuum 1 × 10^{-5} mm Hg for one hour. The average grain dimension in all metals was 1.5 - 3 mm.

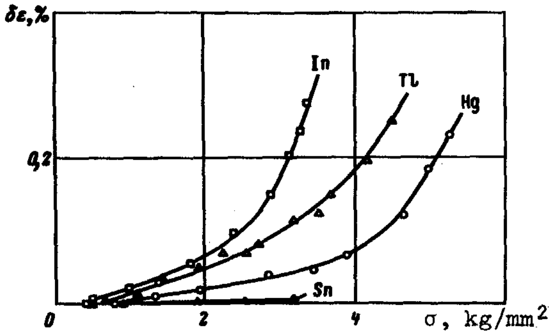

Fig. 2. Loss of strength δε vs. stress for In (T = 2.3°K), Te (T = 1.8°K), Hg (T = 3.5°K), and Hg (T = 1.8°K).

The creep tests were performed under stepwise loading conditions with gradual increase of the load up to failure, using apparatus [8] with a modified