[2] R. I. Elliot, Phys. Rev. 124, 340 (1961).
[3] E. F. Gross and A. A. Kaplyanskii, Fiz. Tverd. Tela 2, 379 (1960) [Sov. Phys.-Solid State 2, 353 (1960).
[4] E. F. Gross and A. A. Kaplyanskii, Dokl. Akad. Nauk SSSR 139, 75 (1961) [Sov. Phys.-Dokl. 6, 592 (1962)].
[5] E. F. Gross and F. I. Kreingol'd, ZhETF Pis. Red. 7, 281 (1968) [JETP Lett. 7, 218 (1968)].
[6] E. F. Gross and F. I. Kreingol'd, Proc. IX Int. Conf. on the Physics of Semiconductors, Moscow, 1968, p. 456.

QUANTUM SIZE EFFECTS IN THIN InSb FILMS

O. N. Filatov and I. A. Karpovich
Gor'kii Physico-technical Research Institute
Submitted 14 July 1969
ZhETF Pis. Red. 10, No. 5, 224 - 226 (5 September 1969)

Effects of oscillations of the kinetic coefficients in size-quantized films, observed in semimetallic films [1, 2], can appear also in films of degenerate semiconductors. We have found in [3], from optical measurements, that the energy spectrum of electrons in thin InSb films has a quasi-discrete character. Owing to the small density of states in the conduction band, the electron gas in n-InSb films is degenerate at room temperature. In the present study we investigated the dependence of the resistivity ρ, the Hall constant R, the Hall mobility μ = R/ρ on the thickness L of n-InSb films. The investigation procedure was analogous to that given described in [2]. The samples were long narrow strips (2 x 90 mm) of various thicknesses, with probe leads every 2 mm. The thickness distribution along the thick-film samples was measured with the aid of a microinterferometer. The thickness of thin films was calculated from the weight of the evaporated substance, under the assumption that the distribution of the molecular beam remains the same in the condensation plane. The method of preparing the single-crystal n-InSb film on mica substrates, together with certain data on the structure and electric parameters of the films, is given in [3].

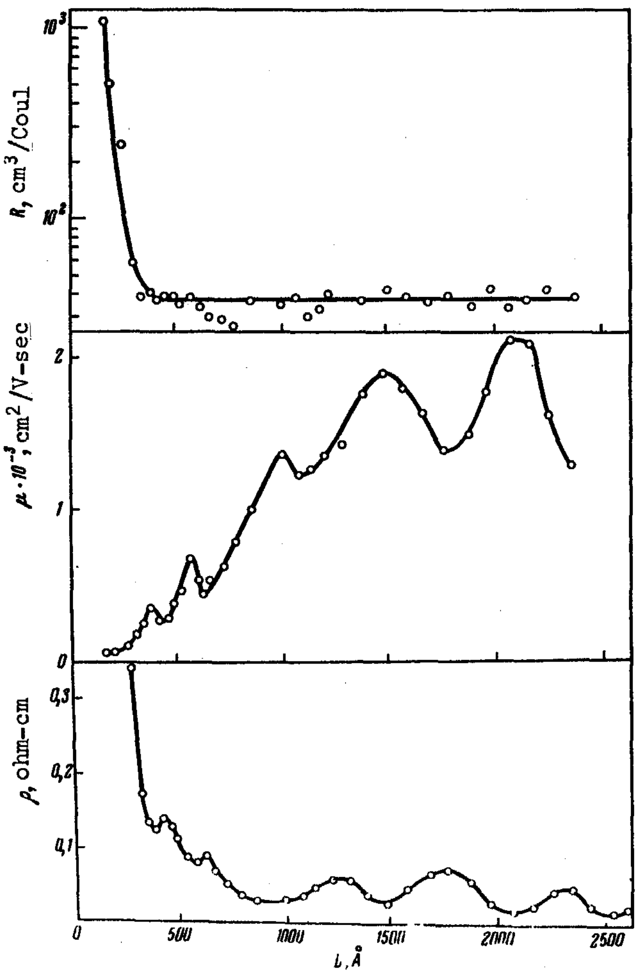

Fig. 1. Hall constant, mobility, and resistivity of InSb films vs. thickness.

The thickness dependences of ρ, R, and μ at room temperature are shown in Fig. 1. A characteristic feature of the dependences of ρ, R, and μ at room temperature are shown in Fig. 1. A characteristic feature of the dependences of ρ and μ on L is the presence of oscillations. The period of the oscillations on the thick end of the sample was $\Delta L \approx 500$ Å. An estimate of the effective carrier mass in accordance with [1]

$$\Delta L = \pi\hbar/\sqrt{2mE_F} \ ,$$

where E_F is the Fermi energy of the bulky sample, yields a value $m = 0.01m_0$, which is in satisfactory agreement with the data of the optical measurements [3]. Oscillations of the mobility appear against the background of a monotonic decrease of μ with decreasing thickness. The decrease of the monotonic component of the mobility was observed in Bi films [1] and recently in InSb films [4]. It should be noted that the authors of [4] observed no mobility oscillations, probably because of the large thickness steps used in the measurement of the thickness dependences.

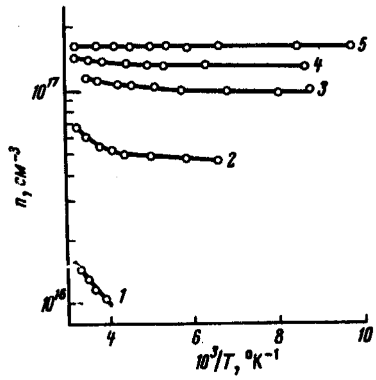

Fig. 2. Temperature dependences of carrier density for films of various thicknesses L (in Å): 1 - 240, 2 - 300, 3 - 360, 4 - 390, 5 - 410.

As seen from Fig. 1, a sharp increase of ρ is observed at $L \leq 300$ Å, due principally to the decrease of the carrier density. This phenomenon can be interpreted as the lifting of the degeneracy of the electron gas. Favoring this conclusion is the appearance of sections with an exponential temperature dependence of the concentration (Fig. 2, curves 1 and 2), the activation energy increasing with decreasing L. For films of minimum thickness (240 Å) the activation energy ΔE determined from the expression $n \sim \exp(-\Delta E/2kT)$ is equal to 0.24 eV.

We assume that the above-described singularities of the electric properties of thin InSb films are manifestations of quantum size effects.

In conclusion, the authors thank B. A. Tavger and V. Ya. Demikhovskii for a discussion of the results.

[1] Yu. F. Ogrin, V. N. Lutskii, and M. I. Elinson, ZhETF Pis. Red. 3, 114 (1966) [JETP Lett. 3, 71 (1966)].

[2] Yu. F. Komnik and E. I. Bukhshtab, Zh. Eksp. Teor. Fiz. 54, 63 (1968) [Sov. Phys.-JETP 27, 34 (1968)].

[3] O. N. Filatov and I. A. Karpovich, Fiz. Tverd. Tela 11, 1639 (1969); 10, 2886 (1968); 11, 805 (1969) [Sov. Phys.-Solid State 11, No. 4 (1969), 10, 2284 (1969); 11, 655 (1969)].

[4] K. Berchtold and D. Huber, Phys. stat. sol. 33, 425 (1969).

MICROWAVE RADIATION OF TELLURIUM

V. N. Kobyzev, A. S. Tager, and V. I. Shepshelei

Submitted 18 July 1969
ZhETF Pis. Red. 10, No. 5, 227 - 230 (5 September 1969)

We investigated the microwave radiation of tellurium single crystals in strong pulsed electric fields. The effect was initially observed in the 7.5 - 10 GHz range at a temperature T = 77°K in a crystal measuring 5 x 2 mm with a low hole density ($p \approx 2 \times 10^{14}$ cm^{-3}) and high mobility ($\mu_p \approx 800$ cm^2/V-sec), to which an electric field of intensity $E \geq 200$ V/cm was