ANISOTROPY OF HOLE MOBILITY IN PLASTICALLY DEFORMED p-GERMANIUM

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We measured the electric conductivity and the Hall effect in p-germanium deformed by bending, in the temperature interval 300 - 4.2°K. A clearly pronounced minimum, whose depth increased with increasing dislocation density, was observed at T = 16°K in the temperature dependence of the mobility of the holes moving perpendicular to the dislocation lines.

Single crystals of p-type germanium with room-temperature resistivity 50 ohm-cm were deformed by bending in air at T = 430 - 450°C and annealed at T = 700°C to eliminate the influence of point defects [1]. From each deformed crystal, we prepared for the measurements two samples such that the current lines were perpendicular (orientation I) and parallel (orientation II) to the 60° dislocation lines [2]. We measured the electric conductivity and the Hall effect in direct current in the temperature interval 300 - 4.2°K with a helium cryostat. The magnetic field had an intensity 3200 Oe and was perpendicular to the dislocation lines. The Hall factor was assumed equal to unity. Ohmic contacts were produced with an indium-gallium alloy.

The measured temperature dependence of the hole mobility in samples with different dislocation densities are shown in Figs. 1 and 2 for orientations I and II, respectively. At high temperatures (T > 80°K) the hole mobility in all the deformed samples, both at orientation I ($\mu_\perp$) and at orientation II ($\mu_\parallel$), practically coincides with the mobility in the control sample. At low temperatures (T < 80°K), a strong difference between the temperature dependences of $\mu_\perp$ and $\mu_\parallel$ is observed, namely: 1) $\mu_\parallel$ is always larger than $\mu_\perp$ in all the deformed samples, $\mu_\parallel$ being smaller than the hole mobility in the control sample. 2) A clearly pronounced minimum is observed in the temperature dependence of $\mu_\perp$ at T = 16°K; the depth of the minimum increases with increasing dislocation density N_D, and in all the deformed samples the minimum is observed at one and the same temperature (16°K), while the decrease and the rise of $\mu_\perp$ in the vicinity of the minimum can be described by an exponential temperature dependence. 3) A distinct minimum in the temperature dependence of $\mu_\parallel$ is observed only for sample No. 4a, which has the maximal dislocation density ($N_D = 1\times10^7$ cm^{-2}). However, the absolute value of $\mu_\parallel$ at the minimum is

Fig. 1. Temperature dependence of hole mobility in the control (+) and deformed samples No. 1 (▲), 2 (■), 3 (o), and 4 (●) with dislocation densities 1×10^6, 4×10^6, 6×10^6, and 1×10^7 cm^{-2}, resepctively in orientation I.

Fig. 2. Temperature dependence of hole mobility in the control and deformed samples No. 1a (+), 2a (■), 3a (o), and 4a (●) with dislocation densities 1×10^6, 4×10^6, 6×10^6, and 1×10^7 cm^{-2}, respectively in orientation II.

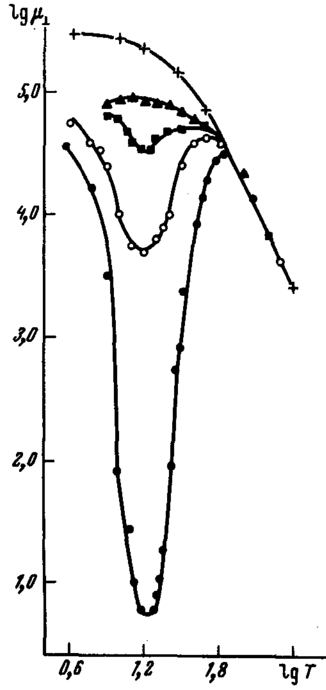

Fig. 1

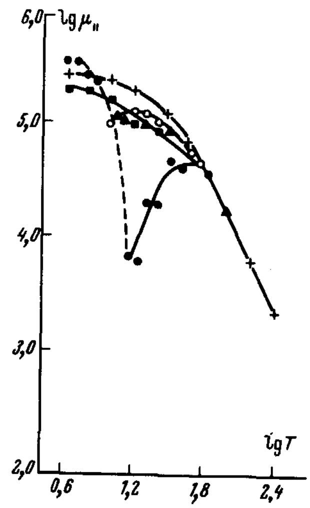

Fig. 2

larger by three orders of magnitude than $\mu_\perp$ for sample No. 4, which has the same dislocation density. In sample No. 3a, with $N_D = 4\times10^6$ cm^{-2}, the minimum at T = 16°K is barely noticeable.

It is important to note that in the entire interval of investigated temperatures all the deformed samples had p-type conductivity. The hole density in the deformed samples decreases with decreasing temperature, and remains lower than the density in the control sample practically everywhere, thus demonstrating the donor action of the dislocations [1].

The described singularities in the behavior of the mobility in deformed p-germanium cannot be explained qualitatively from the point of view of the known scattering mechanism, and are undoubtedly connected with the features of the effect of the dislocations on the energy spectrum and on the carrier-scattering processes in semiconductors.

Our future experiments will be aimed at investigating the mechanism of the observed effect.

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[2] V. I. Nikitenko and A. I. Polyanskii, Proceedings of All-union Conference on Structure Defects in Semiconductors (in Russian), Part I, Novosibirsk, 1970.

EFFECT OF LASER RADIATION ON THE TEMPERATURE OF THE SUPERCONDUCTING TRANSITION OF AN Nb-Sn ALLOY

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We investigated the temperature dependence of the electric resistance of $Nb_{0.8}$-$Sn_{0.2}$ samples in the region of T_c before and after application of pulsed-laser radiation. We show that the superconducting-transition temperature rises significantly after the irradiation, and that the new state of the alloy is stable.

We report here observation, for the first time, of an increase in the superconducting transition temperature of a niobium-tin alloy, resulting from irradiation with CO_2-laser pulses (λ = 10.6μ).

It is known by now that when giant laser pulses act on the surface of a solid crystal, an increased defect concentration is produced in the surface layers [1 - 4] and leads to a noticeable change in the physical properties of these layers.

The superconducting-transition temperature T_c is a characteristic that reflects electron interactions in real crystal structures. It is therefore of interest to investigate the residual changes of T_c following laser irradiation of superconducting materials. We note that destruction of superconductivity of lead films (type-I superconductor) was observed [5] at the instant of irradiation with laser pulses.

We have investigated the effect of laser pulses on the superconducting properties of a niobium-tin alloy (type-II superconductor). A pulsed CO_2 laser with helical excitation was used. We investigated samples of the alloy $Nb_{0.8}$-$Sn_{0.2}$, which has $T_c \approx 10$°K (T_c of $Nb_{0.75}Sn_{0.25}$ is ≈18.3°K), in the form of parallelepipeds measuring 10×3×2 mm. The composition of the initially cast samples was uneven. The tin concentration ranged from 21 to 11 at.% in different points. The irradiation by focused laser pulse was effected in air at room temperature and was accompanied by the appearance of plasma flares.

The transition to the superconducting state was fixed by measuring the electric resistance. The sample temperature was measured with a miniature resistance thermometer based on single-crystal germanium. The temperature of the superconducting transition was determined accurate to 0.05°K.

Owing to oscillations of the composition in the initial samples, a two-stage superconducting transition at 7.6 and 9.6°K was observed prior to the irradiation (see the figure). After the irradiation with the pulsed laser, the transition temperature increased appreciably. A much more abrupt but still two-stage superconducting transition was observed at T_c = 18.2°K, with $\Delta T_c < 0.05$°K, and at T_c = 17.85°K with $\Delta T_c \approx 0.15$°K (see the figure).