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THE INFLUENCE OF MECHANICAL DEFORMATION ON THE PROPERTIES OF FILMS $(BI_{0.25}SB_{0.75})_2TE_3$

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Abstract:
The article presents discussions about the influence of cyclic deformations on the current-voltage characteristics of $(Bi_{0.25}Sb_{0.75})_2Te_3$ films and the use of strain gauges for measuring mechanical quantities.

Key words: semiconductor, cyclic deformation, voltage drop, strain gauge, strain sensitivity, current-voltage characteristic .

The use of automation elements in science and technology is associated, for the most part, with the measurement of non-electrical quantities and the transmission of measurement results over a distance. One of the many possibilities for using electrical methods to measure non-electrical quantities is the measurement of mechanical quantities. Currently, metal (wire, foil) and, especially, semiconductor strain gauges are widely used in measuring these quantities.

Currently, semiconductor strain gauges are made from monocrystalline and polycrystalline semiconductor material. Industry began to practice the use of semiconductor film strain gauges obtained by evaporation and condensation of a semiconductor in a vacuum.

From the point of view of the technical application of films as a strain-sensitive element, the current-voltage characteristic (VC) allows us to judge the energy capabilities of strain gauges, if by this we mean the maximum power that can be allocated to a strain gauge under given operating conditions. This is due to the fact that polycrystalline films of semiconductors are very sensitive to temperature changes, and when large currents are passed through film samples, their Joule heating can occur, which will correspondingly affect their operating

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parameters, in particular, lead to a nonlinear current-voltage characteristic and thereby to increasing errors in instrument readings.

We studied the influence of static deformation on the I-V characteristics of the film in the range of relative deformations up to $0.9 \cdot 10^{-3}$ rel. units, the corresponding curves are shown in Fig. 1. From them it is clear that the current-voltage characteristics of the samples are linear in the region of low voltages. With increasing voltage, the linearity of the dependence of current on voltage is violated, which occurs, for example, in the unstrained state at U = 5V (curve 4). This voltage, at which nonlinearity of the current-voltage characteristic occurs, significantly depends on the sign and level of deformation.

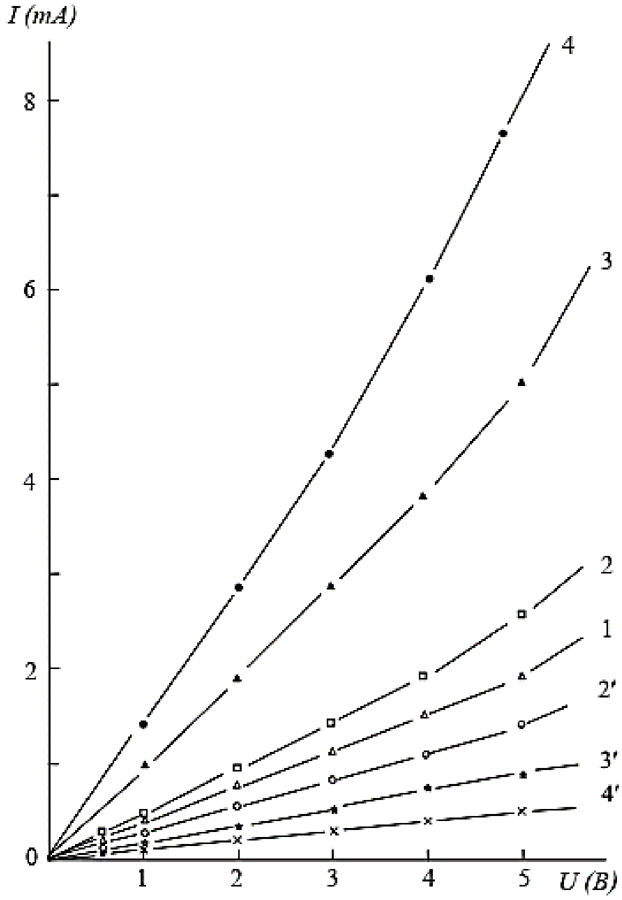

Figure 1. Current-voltage characteristic of the film $(Bi_{0.25}Sb_{0.75})_2Te_3$ on a PM-I polyimide substrate, under the influence of static deformation: ε=0 (curve 1). Curves 2-4 were taken under compression, and 2'-4' - under tension.

Studies of the current-voltage characteristics of $(Bi_{0.25}Sb_{0.75})_2Te_3$ films subjected to CCPD are shown in Fig. 2. The figure shows that the current-voltage characteristics of the film change significantly after exposure to cyclic deformations ($N=5 \cdot 10^5$). All curves taken at different values of relative

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deformation εclearly reflect the increase in film resistance. The action of N=5·10 ^{5} cycles of alternating deformations leads to an increase in the voltage drop across the films at a constant source to almost 10 V, i.e. twice.

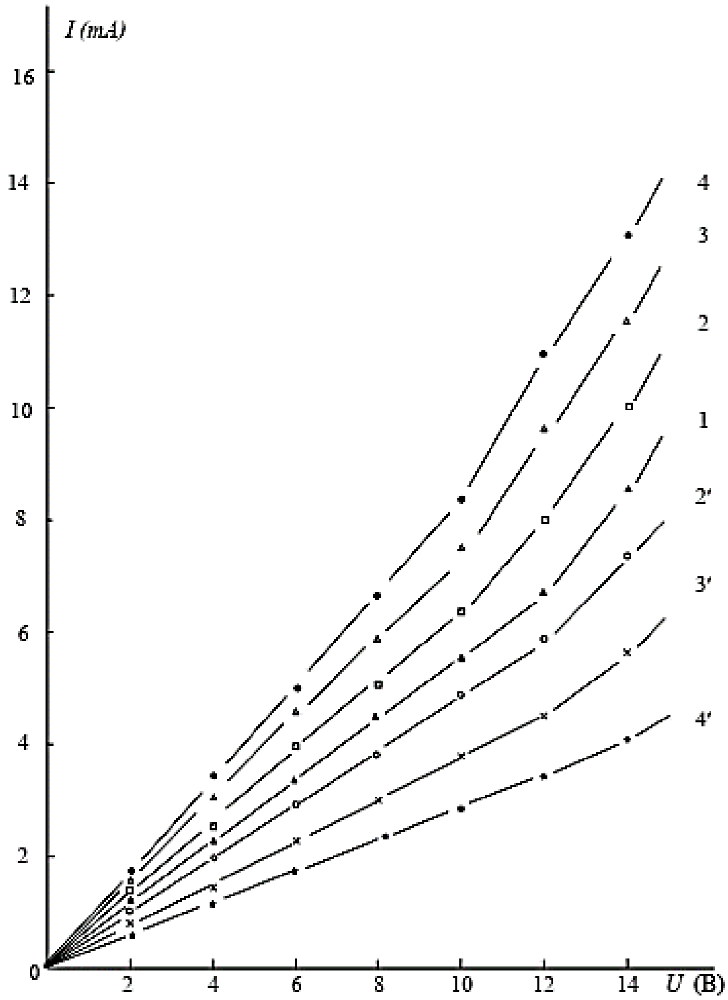

Figure 2. Current-voltage characteristics of the film $(Bi_{0.25}Sb_{0.75})_2Te_3$ after exposure to N=5·10 ^{5} cycles of alternating loads. Curves 1-4 and 2'-4' correspond to curves 1-4 and 2'-4' in Fig. 1.

Since under the action of cyclic deformations as a result of abrasion of the contacting surfaces of crystalline grains, the distances between them increase, this leads to an expansion of the linear section of the current-voltage characteristic of the film.

It is known that strain gauge measurements must be made in the linear region of the current-voltage characteristic. In this case, one should take into account the possibility of an error arising due to the fact that a rather large current can flow in the devices, which heats up the strain gauge and also causes the appearance of a section of nonlinear current-voltage characteristic. In this case, it is not the

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nominal resistance that is measured, but the static one corresponding to a certain point of the current-voltage characteristic. To reduce the current through the strain gauge, an additional resistance can be switched on, previously measured with sufficient accuracy.

The measuring current through the strain gauge must be an order of magnitude lower than the current that causes a change in the mechanism of electrical conductivity in the film or heating of the strain gauge body. The magnitude of this current can be roughly determined from the current-voltage characteristic. Typically this is the current value where the current-voltage characteristic begins to deviate from a linear relationship.

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