ature of the sensor at the times τ and τ_0; q, heat flux per unit length; r_1, radius of the probe wire; and ρ, density. The indices are as follows: m, molecular, refers to values of the international standard, and cr, critical parameter.

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STUDY OF THE STRAIN-RESISTANCE PROPERTIES OF MASSIVE SAMPLES OF $Bi_2Te_3-Sb_2Te_3$ AND $Bi_2Te_3-Bi_2Se_3$

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The coefficients of strain sensitivity of polycrystalline samples of ternary alloys based on bismuth and antimony chalcogenides were measured and the strain sensitivity of Peltier thermocouples of low height under real working conditions were evaluated.

The semiconductor materials Bi_2Te_3 [1, 2], Sb_2Te_3 [3], and their solid solutions [4] with a complicated multiellipsoidal band structure exhibit a significant sensitivity to strain. Under anisotropic strain in these semiconductors, like in Ge, Si, and PbTe, the energy extrema become nonequivalent, the current carriers are redistributed between states near different extrema, and, as a consequence, a large reversible change in the electric resistance occurs.

The strain sensitivity of polycrystalline films prepared using a special method from the compounds $Bi_2Te_3-Sb_2Te_3$ is significantly higher (by two to three orders of magnitude) than that of the bulk samples of these solid solutions, so that most measurements of the strain sensitivity have been performed on films [5, 6]. Nonetheless it is useful to compare the coefficients of strain sensitivity of films and bulk samples in order to determine the mechanism of the strain-sensitivity in films. Bulk samples of the solid solutions $(Bi_{0.25}Sb_{0.75})_2Te_3$ and $Bi_2(Te_{0.9}Se_{0.1})_3$ are employed to fabricate the positive and negative branches of thermocouples, respectively. The coefficient of strain sensitivity of a thermocouple must be known in order to use the method of strain measurement to predict the behavior of thermocouples under conditions of high temperature gradients [7].

In this work we measured the coefficients of strain sensitivity in bulk, large-crystalline samples of p-type $(Bi_{0.25}Sb_{0.75})_2Te_3$ and n-type $(Te_{0.9}Se_{0.1})_3$, prepared by growing by the method of zone melting. Samples 12 mm long, 2 mm wide, and from 0.3 to 0.8 mm thick were cut out on an electric-spark stand, after which they were subjected to chemical etching. The samples so obtained were glued to an elastic steel plate, and after drying at 100°C for 6 h copper wires for feeding current were soldered to them. The strain-sensitive elements were strained by the method illustrated in Fig. 1.

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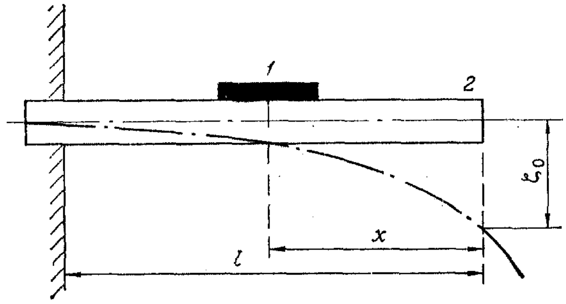

Fig. 1. Diagram of uniaxial strain-sensitive semiconductor element: 1) semiconductor sample; 2) elastic steel plate.

The average relative tensile and compressive strain of the semiconductor sample ε was determined from the bending of a steel plate using the formula

$$\varepsilon = \frac{c}{\rho}. \tag{1}$$

The calculation of the deflection ζ of a thin elastic plate with a clamped end by a force concentrated at the other end gives the relation [8]

$$\zeta(x) = \zeta_0 \frac{(l-x)^2(2l+x)}{2l^3}. \tag{2}$$

Calculating the second derivative of (2) with respect to x we find the radius of curvature and from the formula (1) the average relative strain of the sample

$$\varepsilon = \frac{3\zeta_0 cx}{l^3}. \tag{3}$$

The reversible relative compressive and tensile strains of the samples were observed up to $\varepsilon = 4.5 \cdot 10^{-4}$.

The relative changes in the resistance of the samples ΔR/R were proportional to ε. The coefficient of strain sensitivity ΔR/εR ranged from 100 to 200 in different samples (the average value equalled 150).

The value obtained for the coefficient of strain sensitivity is significantly higher than that used in [7] to determine the change in the resistance of a thermocouple induced by thermoelastic strain. Using the coefficient of strain sensitivity determined in this work, equal to 150, we arrive at the conclusion that the change in the resistance of the thermocouple with a branch 0.5 mm high and having a cross section of 3 × 3 mm with a temperature drop of 50 K can equal 30%, which substantially increases the possibility of the method employed in [7] (as compared with the estimates made there).

Thus we have obtained further evidence supporting the concept of determining the strain coefficients of the materials employed in the arms of thermocouples and then calculating the strain-resistance of the thermocouples as a method for predicting their behavior under conditions with large temperature gradients.

NOTATION

ε, relative strain of the semiconductor sample; x, distance from the center of the sample to the point of application of the force; ρ, radius of curvature at the point x; ℓ, length of the steel plate; c, distance from the center of the sample to the neutral axis of the plate; ζ, deflection of the plate at the point x; ζ_0, deflection of the tip of the plate; R, electric resistance of the sample; and ΔR, strain-induced change in the resistance.

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PHOTOTHERMAL DETERMINATION OF THE THERMOPHYSICAL CHARACTERISTICS OF SOLID-STATE OBJECTS

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The possibilities of determining the heat conduction, thermal diffusivity, and specific heat of thin solid-state layers by a photothermal method are investigated theoretically and experimentally.

Photothermal heating methods based on the optical generation of thermal and acoustic waves in condensed media have been developed intensively and are extensively utilized in scientific investigations and applications [1]. These methods are highly informative, local, contact-free, possess high fast-response, and in principle, permit the determination of the thermal properties of substances in a broad range of state parameters [2].

The development of photothermal diagnostic methods for solids with spatially inhomogeneous thermal parameter distribution draws great interest. The physical principles of such measurements have been developed sufficiently weakly even for the simplest kinds of thermal inhomogeneities. In this paper the problem of the simultaneous determination of the thermal diffusivity, thermal conductivity, and specific heat coefficients is examined for a layer located on a substrate with known thermophysical characteristics.

For definiteness we will examine the gas microphone method of recording [2]. The structure being investigated (layer + substrate) is here placed in a photoacoustic cell (Fig. 1) and exposed to light with the modulated intensity $I = I_0/2(1 + \cos \omega t)$. Pressure fluctuations Δp associated with the thermal expansion of the gas layer heated from the specimen u_t and the mechanical displacement of the specimen surface being exposed u_m [3] occur in the cell

$$\Delta p \sim \frac{P_0}{l_0}\ (u_t(0) + u_m(0)) = \frac{P_0}{l_0}\left(\eta_g^{-1}\ \frac{\Delta T(0)}{T_0} + u_m(0)\right), \tag{1}$$

where $\eta_g = (1 + j)(\omega/2\chi_g)^{1/2}$.

Formula (1) is valid when the thickness of the gas layer is large as compared with the thermal length and small as compared with the corresponding sound wavelength $\ell_0 \gg \ell_g$, $\ell_0 \ll \lambda_g$, $\ell_g = (2\chi_g/\omega)^{1/2}$. The quantities $\Delta T(0)$, $u_m(0)$ depend in a complex manner on the thermal, acoustic, optical properties and the geometric dimensions of the layer and substrate, the heat transfer and clamping conditions on the interfacial boundaries, which makes analysis of the dependence of the photoacoustic response $\Delta p \sim u_t(0) + u_m(0)$ on the thermal parameters of interest to us difficult in the general case.

Let us examine the case, which is of practical interest, of surface ($x = 0$) generation of heat and long sound waves in a layer and substrate $\ell \ll \lambda$, $\ell_1 \ll \lambda_1$. Let us neglect heat transfer to the specimen outer boundaries, and we consider the temperature and heat flux continuous on the interfacial boundary $x = \ell$. Let the surface $x = 0$ be free of mechanical stresses and $x = \ell + \ell_1$ clamped stiffly. In this case the mechanical vibrations of the specimen surface are not important and the pressure in the gas is determined by just the temperature of the surface being exposed

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