Oriental Renaissance: Innovative, educational, natural and social sciences
SJIF 2023 = 6.131 / ASI Factor = 1.7
(E)ISSN:2181-1784
www.oriens.uz
3(10), October, 2023

SPATIAL DISTRIBUTION OF TEMPERATURE IN THERMOCOUPLES

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ABSTRACT

It is shown that, depending on the spatial distribution of temperature in semiconductor thermocouples, temperature instability can occur at "negative" temperature differences and "positive" temperature instability can occur.

Key words: *Pelte effect, Seebeck effect, Thomson effect, "negative" temperature, "positive" temperature, thermocouple*

ANNOTATSIYA

Yarimo'tkazgichli termoelementlarda haroratning fazoviy taqsimlanishiga qarab, "salbiy" harorat farqlarida haroratning beqarorligi paydo bo'lishi va "ijobiy" haroratning beqarorligi yuzaga kelishi mumkinligi ko'rsatilgan.

Kalit so'zlar: *Pelte effekti, Zeebek effekti, Tomson effekti, salbiy" harorat, "ijobiy" harorat, termopara*

АННОТАЦИЯ

Показано, что в зависимости от пространственного распределения температуры в полупроводниковых термопарах может возникать температурная нестабильность при «отрицательных» перепадах температур и «положительная» температурная нестабильность.

Ключевые слова: *эффект Пельте, эффект Зеебека, эффект Томсона, «отрицательная» температура, «положительная» температура, термопара.*

As is well known [1,2] Pelte thermocouples are also used as transducers of thermal or electrical signals. It is easy to check that the change in the temperature of the working compound that we want to use, that is, the change in the hot signal, leads to a change in the values that describe the thermoelectric properties of the semiconductor. Therefore, in our article, the spatial dependence of temperature and the calculation of temperature instability of thermocouples. In calculating this, we take into account the Thomson thermoelectric phenomenon, as well as the Peltier, Joule and Seebeck effects. Then it is not difficult to obtain a heat equation of the hydrodynamic type that describes the time-space dependence of temperature.

$$\frac{\partial \mathrm{T}}{\partial x^2} + \frac{\partial \ell nS}{\partial x} \cdot \frac{\partial \mathrm{T}}{\partial x} + \frac{j}{x^\sigma} = \frac{1}{a}\frac{\partial \mathrm{T}}{\partial t} \tag{1}$$

where $\chi = \chi_0 T^m$ the thermal conductivity of the $\sigma = \sigma_0 T^1$ grid, the electrical conductivity of the semiconductor, the numbers m and 1 (power), $j = \tau / S$ - the values of which are the current density depending on the propagation mechanism of current carriers, is the cross-sectional area of $S(x) = S_0(1+\beta x)S_0$. "cold" is a parameter describing the spatial relationship of the contact ($T_{хол}$ with temperature) and the cross-sectional area of the thermocouple; The x-axis is chosen in the direction of increasing temperature difference - $T_{гор}$ the temperature of the "hot" contact,) $T(x=0) = T_{хол}$, $T(x=1) = T_{гор}$,), 1 - the distance between the temperature and the contacts $T_{хол}$ $и$ $T_{гор}$

We immediately note that the equation in the form (1) can be solved only with the help of a computer. Because, at present, we do not have experimental results that allow us to compare them with numerical (computer) calculations and solutions. To do this, we change equations (1) taking into account the dependence.

Then the heat equations of the hydrodynamic type for the stationary mode of the thermocouple take the form

$$y^2 T'' + 2yT' + \gamma T^n = 0 \qquad (2)$$

Here $T' = \frac{\partial T}{\partial x}$, $T'' = \frac{\partial^2 T}{\partial y^2}$, $y = 1+\beta x$, $\gamma = \tau/(S_0\,\sigma_0\,\chi_0)$

The number n of experimentally realized temperature range (200÷) n=3. In this case $T^3 \approx \beta_T + \alpha_T \cdot T = \theta$,, with less than 17% error, we can guess that $\beta_T = -3{,}09 \cdot 10^{+7} K^3$, where . Then we write (2) as

$$y^2\theta'' + 2y\theta' + \gamma\theta = 0 \qquad (3)$$

$$\theta = C_1 y^{\upsilon} - C_2 y^{-\upsilon} \qquad (4)$$

Where $\tilde{\gamma} = \gamma\alpha_T$. Calculations show that for single crystals of lead chalcogenides $\tilde{\gamma} < 0{,}25$. In this case, the solution (3) is in the form of Case (4).

Where $\upsilon = \frac{1}{2}\sqrt{1-4\tilde{\gamma}}$. The unknown coefficients C_1 $и$ C_2 are determined using the boundary conditions:

$$\begin{aligned} \theta(x=0) &\equiv \theta_{хол} = \alpha_T T_{хол} + \beta_T \\ \theta(x=1) &\equiv \theta_{гор} = \alpha_T T_{гор} + \beta_T \end{aligned} \qquad (5)$$

Peltier coefficient in the working junction, where $T = T_{хол}$ r is the electrical resistance of the field between the contacts. Then the solution of equation (3) is written as follows

$$\theta = \frac{\sqrt{y}}{4\upsilon}\left[2\left(\theta_{хол} - \theta_{хол}\right)\left(y^{\upsilon} - y^{-\upsilon}\right) + 2\upsilon\theta_{хол}\left(y^{\upsilon} + y^{-\upsilon}\right)\right] \quad (6)$$

From expression (6), $\rightarrow y_0 = 1 + \beta t$ is determined instead of $\theta(x=1) \equiv \theta_{гор}$.

As can be seen from the expression under the ice, if $\upsilon(\upsilon << 1)$ u is at small values, the change in the temperature of the working compound $2\theta'_{хол} < \theta_{хол}$ can be negative, so if $\sigma T < 0$ σT is also negative, then there is a further decrease in temperature. the working compound leads to an increase in the amount of absorbed heat, as a result of which the instability of the space temperature is possible.

Thus, depending on T(x), it can turn out to be "negative" when the temperature drops to a certain value with a voltage increase (U) in certain value ranges Holtzman B.M. values take negative values $U = U_0$ - and $U > U_0$ positive (in the case we considered), and "positive" instability when the opposite situation occurs.

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