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## Minimal operation current estimation for the temperature sensors based on $p^+$ -n GaP diode structures

<u>Yerochin S.Yu.</u>, Researcher, Demenskiy A.N., Junior Researcher; Krasnov V.A., Senior Researcher; Shutov S.V., Senior Researcher; Shwarts Yu.M., Leader Researcher

V. Lashkaryov Institute of Semiconductor Physics NASU, Lab.N23, Kherson, Ukraine

A decrease of the operation current of diode temperature sensors (DTS) allows to considerably reduce the systematic measurement error of the sensors [1]. In this connection we have made an estimation of the minimum operation current magnitude for p<sup>+</sup>-n GaP DTS [2].

According to the data of work [1] the temperature measurement error of the DTS caused by the current flowing consists of three principal components: Joule heating of the device chip  $\Delta T_{\rm H}$ , presence of noise of the p-n junction  $\Delta T_{\rm N}$  and an influence of a base layer resistance of the diode structure  $\Delta T_{\rm R}$ . As the operation current decreases the magnitude of  $\Delta T_{\rm H}$  component becomes less than the resolution of the temperature scale in the defined points, thus only the last two components have been taken into account in our estimations, i.e.:

$$\Delta T = \Delta T_{\rm N} + \Delta T_{\rm R} \tag{1}$$

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The value of  $\Delta T$  is maximal at  $T=T_{\rm M}$ , then:

$$\Delta T_{\rm R}(T_{\rm M}) = R_{\rm b}I/|s(T_{\rm M})|, \ \Delta T_{\rm N}(T_{\rm M}) = U_{\rm N}/|s(T_{\rm M})|, \tag{2}$$

where  $R_{\rm b}$  is the base layer resistance of the DTS,  $U_N \equiv \sqrt{\langle U_N^2 \rangle}$  is the root-mean-square noise voltage determined by thermal and shot noise, s is the thermal sensitivity of the DTS,  $T_{\rm M}$  is the maximum temperature measured by DTS.

According to the relations (2) and the dependence of thermal sensitivity on the current, when the current is reduced  $\Delta T_{\rm N}$  rises and  $\Delta T_{\rm R}$  decreases. Thus there is an operation current I at which the total systematic error (1) is minimal. This value  $I = I_{\rm min}$  is taken as the desired current value [1]. According to our calculations the value of minimal forward operation current of the sensors considered is in the range  $1.5 \cdot 10^{-9} - 5 \cdot 10^{-10}$  A.

- 1. Yu. M. Shwarts, et al., Sensor Actuat. A-Phys. **86**(3), 197 (2000).
- 2. V.Krasnov, S. Shutov et al., Rev. Sci. Instrum. 82(8), 086109 (2011).