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

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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^+-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 ΔT_H, presence of noise of the p-n junction ΔT_N and an influence of a base layer resistance of the diode structure ΔT_R. As the operation current decreases the magnitude of ΔT_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.:

$$\Delta T = \Delta T_N + \Delta T_R \qquad (1)$$

The value of ΔT is maximal at $T=T_M$, then:

$$\Delta T_R(T_M) = R_b I/|s(T_M)|,\ \Delta T_N(T_M) = U_N/|s(T_M)|, \qquad (2)$$

where R_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_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 ΔT_N rises and ΔT_R decreases. Thus there is an operation current I at which the total systematic error (1) is minimal. This value $I = I_{min}$ 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).