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HEAT MODE ELECTRONIC DEVICES AT ELEVATED EXTERNAL TEMPERATURES

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Abstract. In this article we consider the numerical study of the effect increasing the ambient temperature of electronic device under external microwave heating.

1 Introduction

The problem of forecasting thermal conditions of technical equipment is the development of two promising methodologies related to development (PDfR - Probabilistic Design for Reliability [1]) and operation (DRM - Dynamic Reliability Management [2]) of modern electronic devices. The essence of these concepts is to identify the most significant factors affecting the service life of heat-loaded elements, followed by the development of mathematical models to predict the reliability of indicators based on the physics of bounce. As is known, the temperature is one of the key parameters. At the same time the thermal regime of technical facilities affects both the internal heat transfer and higher ambient temperature.

2 Methods of analysis of temperature fields in the presence of local heat sources

By modern methods of analysis of thermal simulation modes include devices with different software systems (eg, Flow Vision) [3]. There are also other approaches: a simplified mathematical model [4], the method of heating circuits (thermal resistance) [5], thermal monitoring [6], the finite element method [7], the finite difference methods [8], taking into account natural convection [9] radiation, together with the heat sink in the stationary and the cyclic operating conditions [10, 11].

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3 Formulation of mathematical solving

Simulation of temperature field for the effects of microwave heating on the thermal regime of the system “polymer-semiconductor-composite” carried out in the range of operating temperatures in two dimensional axes.

In the two-dimensional formulation of the problem of heat transfer is reduced to the solution of non-stationary heat equation:

$$C(x,y)\rho(x,y)\frac{\partial T}{\partial t}=\frac{\partial}{\partial x}\left(\lambda(x,y)\frac{\partial T}{\partial x}\right)+\frac{\partial}{\partial y}\left(\lambda(x,y)\frac{\partial T}{\partial y}\right)+Q_{\text{heat}}\left(t,x,y\right)+Q_{\text{microwave}}\left(t,x,y\right),\quad(1)$$

where: C - specific heat; - The density; T - temperature; t - time; - coefficient of thermal conductivity; Q_{heat} - heat source; $Q_{\text{microwave}}$ - heat by microwave heating; x, y, z - coordinate.

When setting the initial conditions it was believed that at the initial time the temperature is evenly distributed:

$$T\big|_{t=0}=T_0(x,y),\quad(2)$$

where: T_0- the initial temperature.

The boundary conditions taken into account convective and radiative heat transfer:

$$x=0, y\in[0;L_y]:\quad -\lambda\frac{\partial T}{\partial x}=\alpha(T)\left(T_{\text{B}}-T\right)+\varepsilon_{pr}\sigma\left(T_{\text{B}}^4-T^4\right),\quad(3)$$

$$x=L_x, y\in[0;L_y]:\ \lambda\frac{\partial T}{\partial x}=\alpha(T)\left(T_{\text{B}}-T\right)+\varepsilon_{pr}\sigma\left(T_{\text{B}}^4-T^4\right),\quad(4)$$

$$y=0, x\in[0;L_x]:\quad -\lambda\frac{\partial T}{\partial y}=\alpha(T)\left(T_{\text{B}}-T\right)+\varepsilon_{pr}\sigma\left(T_{\text{B}}^4-T^4\right),\quad(5)$$

$$y=L_y, x\in[0;L_x]:\quad \lambda\frac{\partial T}{\partial y}=\alpha(T)\left(T_{\text{B}}-T\right)+\varepsilon_{pr}\sigma\left(T_{\text{B}}^4-T^4\right)\cdot\quad(6)$$

wherein: α - the surface convective heat transfer coefficient of the EA member with the external environment; $T_{\text{в}}$- ambient temperature; - Stefan-Boltzmann constant; ε_{pr} - Reduced coefficient of the surface and the surrounding black environment.

Convective heat transfer coefficient depends on temperature and is determined for each point of the surface [9].

$$\alpha(T)=\left(1.42-1.4\cdot10^{-3}Taver\right)N\left(\frac{T-T_{\text{B}}}{L}\right)^{\frac{1}{4}},\quad(7)$$

Powered emissivity products and the surrounding surface of the medium is given by [9].

$$\varepsilon_{\text{pr}}=\left(\frac{1}{\varepsilon}+\frac{1}{\varepsilon_{\text{aver}}}-1\right)^{-1},\quad(8)$$

The intensity of the heat (W) with exposure to microwave [9]:

$$Q_{\text{microwave}}\left(t,x,y\right)=2\cdot\pi\cdot\varepsilon_0\cdot\varepsilon\cdot\text{tg}(\delta)\cdot\text{f}\cdot\text{E}^2\cdot\quad(9)$$

4 The results of mathematical modelling

Temperature dependence of the maximum (curve 2, figure 1) and medium-temperature volume (curve 4, figure 1) without microwave heating at T_B = 320 K and under the influence of electromagnetic waves are presented in figure 1. Analysis of the results of numerical studies show that in the initial time interval (up to 40), there are significant differences in the absolute values of T_M and T_{aver}. However, at t = 100 s. to the differences in temperature estimates are not as large and ranges from 2 (3.4 curves in figure 1) to 5 K (curves 1.2 in figure 1).

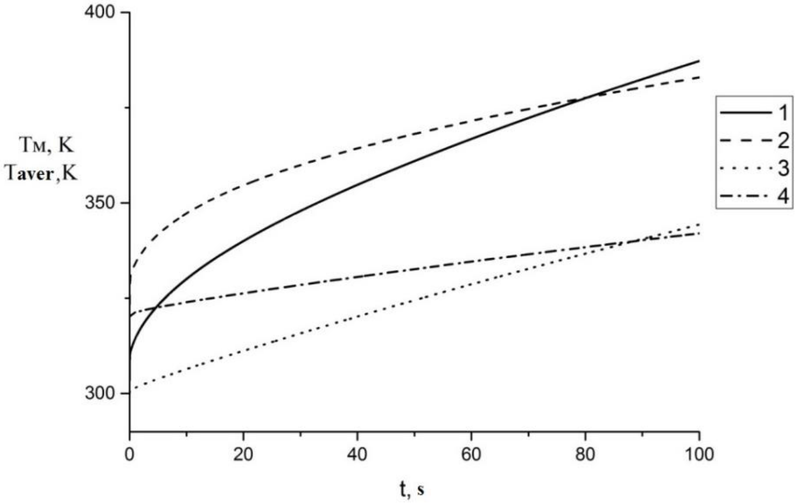

Fig. 1. Changes in the temperature characteristic of the system "polymer-semiconductor-composite' with time (1.3-T_M and T_{aver} at E = 1900 V/m, f = 7 GHz, T_B = 300 K; 2.4-T_M, at T_B = 320 K and without microwave heating).

5 Conclusion

It was found that at E = 1900 V/m in the frequency range of 3 - 7 GHz, the temperature increases from 10 to 25 K. The numerical study of the thermal regime of "polymer-semiconductor-composite" system has shown that the effect of microwave waves comparable to the increase in ambient temperature 20 K or increased local heat over 30 %.

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