Discussions and conclusions

The replacement of thermionic cathodes by FEM, for example, as a two or is more with necessary radius r of conuse microelectrodes, that divided by microintervals d with an FE, which creates FE pinches, which raise a luminescence of a covering on screen, to the full releases from these lacks.

Really, at replacement of heated cathodes on “could”, disappears necessity in increased of additional power of heating to cathodes and accordingly in radiation from the heated up parts. It creates economy of the electric power, simplifies a design and warns indirect thermal action on an environment.

For its manufacturing any metal or semi-conductor materials can be used i.e. disappears necessity for scarce and precious refractory metals, is especial W and Mo or their alloys, and also, materials of a covering of oxide - Ba, Ir, Ca, Zr. Disappears necessity and at characteristic for the majority of light sources precious rare noble gases and mercury, as working environment of FE elements is the vacuum.

Could character of FE allows to create effective ERS. The efficiency of vacuum generators of light on FEM practically equal to efficiency of transformation of energy of an electronic flow to the optical radiation in cathode luminophores, which now achieves 10... 20 %. For comparison, for film and powder electro luminophores efficiency equal 0,1... 2,0 %, for radiated (light) diodes - 0,6 % and for discharge cells - 0,5 %.

The obtained results has shown, that decrease between electrode distance has allowed to reduce anode voltage in experimental FEM practically on the order. The application of modern technological achievement by development of a field emission microelements with low voltage and hight stability allows to create new and to improve, existing photo medical devices, for example, as ecological alternative of Hg discharged UV-radiators for hematology providing significant improvement of the characteristics.

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CREATION OF TEMPERATURE FIELD USING RESISTIVE THICK – FILM HEATER SYSTEMS

In a great number of electronic devices the operation temperature higher than room temperature is required. Sensors of the different physical and chemical quantities are very good example of such circuits. Additionally, the temperature field distribution is one from the main factor which determines proper exploitation parameters. Thick – film technology is often used for creation of heater systems in above-mentioned devices. The idea of heater systems construction (made in thick-film technology) has been included in the paper. The results of simulations (using ANSYS program) and IR measurements have been also presented.

Introduction

One of the most important features of thick-film technology is a big design flexibility of resistive elements. Additionally, very good heat conductivity of used substrates, low thermal capacity and possibility of resistive element geometry forming makes this technology an excellent solution for manufacturing of wide range of different heaters and heater systems with given temperature distribution.

In thick-film technology (characterised by layer structure of the circuit) heaters are generally made from resistive or conductive (PdAg, PtAg, PtAu, Au, Pt) pastes. It is placed – in most cases – on the opposite side of the substrate in relation to active part of microcircuit. The heaters made from typical resistive pastes are the simple (and the cheapest) solutions characterised by good dynamic parameters. The main disadvantage is the lack of good time stability but this problem can be solved by using special compensation circuit in supplying systems [1,2,3,4].

Resistive heater systems – simulation of temperature field

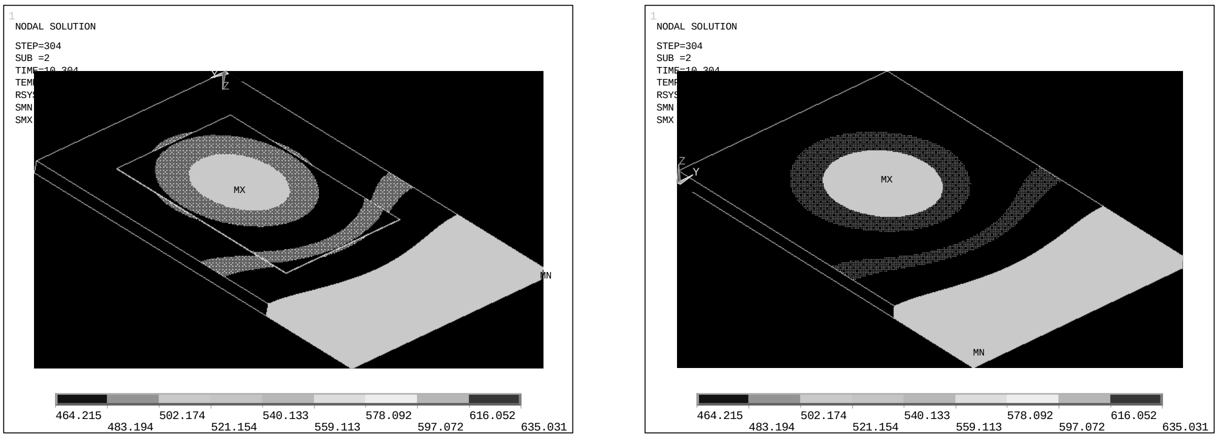
Resistive paste is a composition of the metals, metal oxides (in the most often – RuO_2)or their compounds (Ru, Ag, Au, Pd, Pt) and glass phase. Sheet resistance of the typical manufactured inks change per decade – from 10Ω do 10MΩ. The typical basic parameters of the resistive pastes (ITME Warszawa – R34x series) are presented in Table 1 [5].

Table 1

Typical basic parameters of the resistive pastes (ITME Warszawa – R34x series): TCR – temperature coefficient of resistance

Parameter	R-34x pastes
TCR; 10^{-6}/°K	± 100
Resistance stability (load: 1000h, 100V), %	± 1
Thickness of dry layer, μm	25 ± 3
Firing temperature, K	1123
viscosity, Pa·s	200 - 250

In the simplest case, resistive heater is manufactures as square printed on the alumina substrate. The example results of temperature field simulation of microcircuit with single resistive heater are presented in Fig.1 (test circuit – substrate dimensions: $15 \cdot 10^{-3}$ m $\times 10 \cdot 10^{-3}$ m, side of square heater: $7 \cdot 10^{-3}$ m, distance from the substrate edge: $2 \cdot 10^{-3}$ m).



a *b*

Fig. 1. Temperature field in structure with single heater (simulation in ANSYS program) with load P=2W (substrate thickness - $0,5 \cdot 10^{-3}$m): a) view from heater side, b) view from the opposite side

In many cases the flat temperature distribution is required (for example in gas sensors where temperature is the main factor which influences on sensitivity and selectivity of the such devices). As is presented in Fig.1, the creation of the flat temperature shape on the substrate surface is not possible using single resistive heater. From this reason the introducing of the additional heaters into microcircuit topology is required for correction of the temperature field.

The starting point for topology elaboration of the such heater systems were following assumptions:

– substrate dimensions: $25 \cdot 10^{-3}$ m × $15 \cdot 10^{-3}$ m (possibility of printing 4 test circuits on the standard alumina substrate $50 \cdot 10^{-3}$ m × $30 \cdot 10^{-3}$ m);

– supplying of the whole system from the one source;

– manufacturing of the particular system components from the same resistive paste (simplification of the technology process);

– all heaters placed on the same side of substrate.

Taking into account the above-mentioned aspects, the test circuits (with different resistive heaters topology) were designed and simulated using finite element method (ANSYS program). The example heater system configurations illustrate Fig.2.

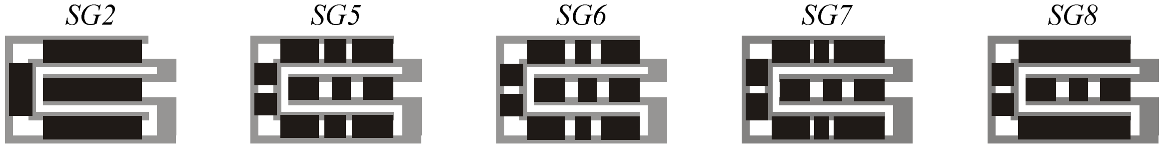
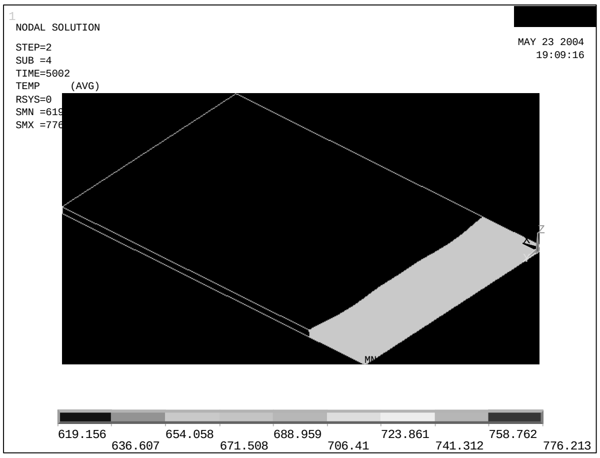


Fig.2. The example heater system configurations which were simulated

The best results were obtained for SG5 and SG7 systems. The temperature difference on the substrate surface was not exceeded than 20K. The examples of computer simulations of temperature field for SG5 system are presented in Fig.2.



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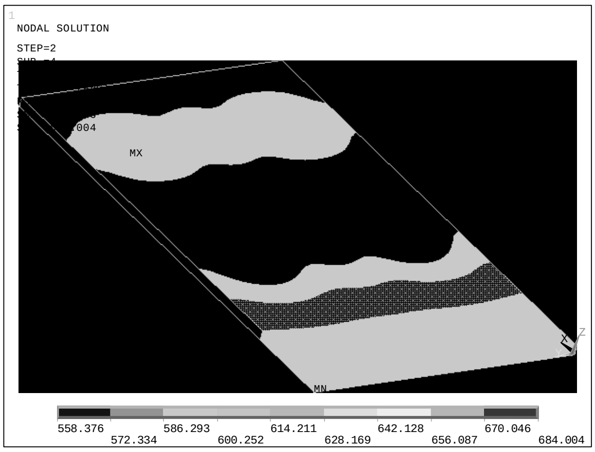


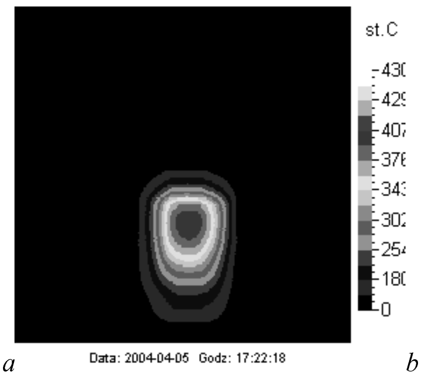
b

Fig. 2. Temperature distribution in SG5 structure (simulation in ANSYS program) for substrate thickness $0{,}5\cdot10^{-3}$ m and load: a) P=8W; b) P=9W

Temperature field simulations have been also made for pulse supplying.

Experimental investigations

The circuits with different heater systems (previously simulated in ANSYS program) were tested using IR camera V-20ER005-25 (VIGO Warszawa). Temperature distribution has been measured on the opposite side to the resistors (heaters). For error elimination the calibration course of IR-camera (for 96% Al_2O_3 substrate) has been elaborated. For pulse supplying the specialised power supplier (made in Department of Electronic and Communication Systems at Rzeszow University of Technology) was used.



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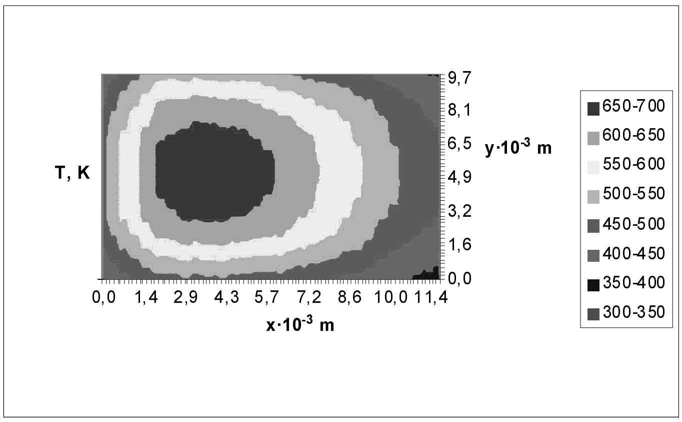
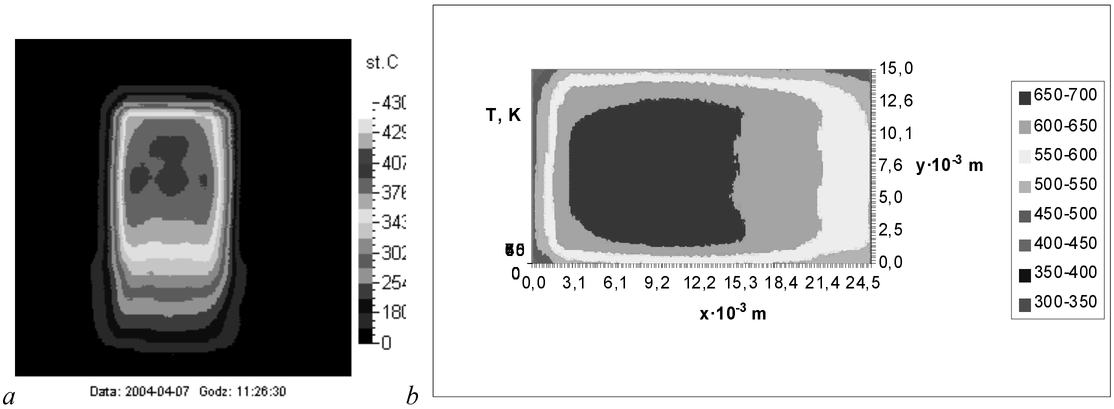


b

Fig. 3. Temperature distribution of the structure with single heater (P=4W): a) thermogram; b) view on the substrate surface

The example results of measurements (for the systems with single heater and SG5 structure) are presented in Fig.3 and Fig.4.



a b

Fig. 4. Temperature distribution of theSG5 structure (P=10W):
a) thermogram; b) view on the substrate surface

The above presented figures are the results of temperature field measurements for DC supplying.

Conclusions

The complexity of heat exchange mechanisms and difficulties in determination accurate coefficients make the thermal analysis of thick-film microcircuits a big problem. In reality, only numerical calculations and specialist simulation programs can solve the systems of differential equations with very complicated boundary and initial conditions.

The presented resistive heater systems can be used in different devices where flat temperature distribution is required. Created simulation models are very useful in the design process of heater systems. The laboratory measurements confirmed correctness of the calculation assumptions. sensitivity, etc.).

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