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50. Internationales Wissenschaftliches Kolloquium
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Thermal simulation and optimization of micromachined gas sensor structure

ABSTRACT

This work is concerned on analysing of the thermal parameters of suspended micromachined structure based on GaAs for gas detection. The main attention was dedicated to minimazin of sensor power consumption. Electro-thermal simulation confirmed the achievement of required operating temperatures (200-320°C) with the heating power less than 25 mW. Avarage temperature gradient in the active area did not exceed 0.6 K/μm.

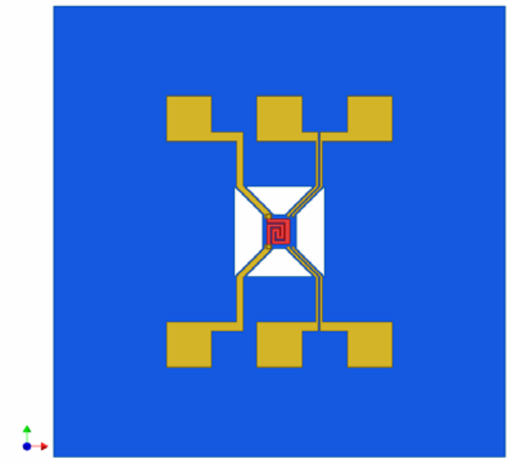
INTRODUCTION

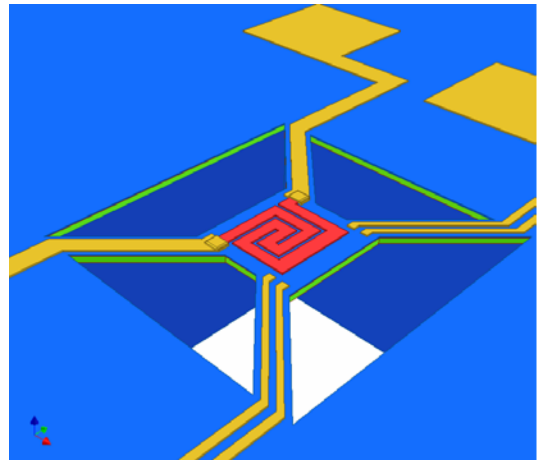
Modeling and simulation of microsystems and microsensors play an important role in developing of new designs [1]. Before fabricating the prototype, we can build a virtual device and predict its behaviour. This allows us to optimize various design parameters. Those can be changed much more quickly than redesigning the device and fabricating a new prototype. Thus we can reduce the cost to develop the commercial devices. Our work describes the optimization process of a micromachined gas sensor structure using commercial software for finite element analysis – ANSYS [2]. Gas sensors generally works, in high temperature mode, that is required by the chemical reactions between molecules of the specified gas and the surface of the sensing material. High temperature gradients between the active area and its colder surrounding cause heat losses as a result of three known effects – heat conduction, convection and radiation.

SIMULATION USING ANSYS SOFTWARE

We have designed a novel gas sensing microstructure in order to reduce the power consumption of the sensor element. GaAs was chosen to be the substrate material. In comparison with commonly used silicon, it has better thermal properties (thermal conductivity 46 W/m.K) and allows a better control of the micromachining process. Its usage allows to achieve higher accuracy of the etched shapes. The active area is placed on a thin (1μm) suspended membrane based on $Al_{0.5}Ga_{0.5}As$, that is used simultaneously as a stop layer for back side etching. The influence of the sensor element topology with three various dimensions on the heat losses and the power consumption was investigated. A platinum heater element situated under the active area was designed in two modifications – as a classical meander shape and a double spiral shape. Temperature dependences of the air thermal conductivity and metal resistivity were also taken into account. The optimization proces based on thermal and electro-thermal simulations was performed using the ANSYS programme.

The simulation results agreed with the prediction that the smallest active area produces the lowest heat losses. The structure with the suspended membrane of 150 x 150 μm reaches the operation temperature in the range of 220 to 320°C using a heating power between 14 mW and 22 mW. Typical thermal resistance of the microstructure in this case was about 15 K/mW. Increasing the membrane area size the required power consumption increased to about 40 mW. The average temperature gradient in the heated area was 0.6 K/μm.





a) b)
Fig. 1: View on simulated microstructure for gas microsensor using ANSYS programme (a), detail of suspended membrane with microheater (b).

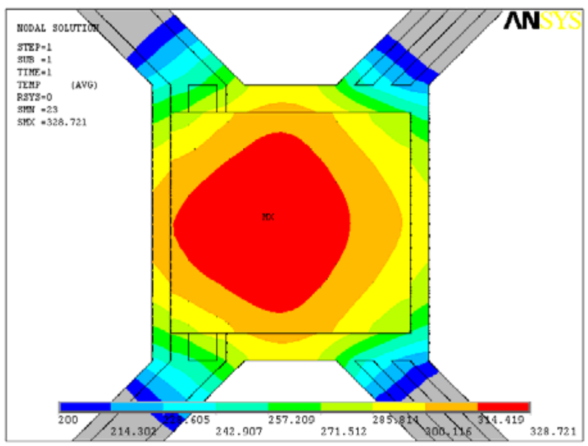


Fig. 2: Temperature distribution in simulated microstructure.

References:

[1] J. Piugcorbe, D. Vogel, B. Michel, A. Vila, I. Gracia, C. Cane, J.R. Morante, Journal of Micromechanics and Microengineering 13 (2003) 548-556.

[2] ANSYS Reference Manual, Swansom Analysis Inc., Houston, TX.

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