11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25
ICAM2009

Application of semiconductor sensors for noninvasive diagnostics

M. V. Chuprin(1), O. M. Ivanova(1)*, S. A. Krutovertsev(1), A. V. Pislyakov(1), A. V. Shevchenko(1), V. V. Kalinovsky(2), V. V. Konovalov(2)

(1) JSC "Practic-NC", Zelenograd, Moscow, p/b 13, 124460, Russia, e-mail: pnc@pnc.ru
(2) Russian Federal Nuclear Centre, VNIIEF, Sarov, Russia
* Corresponding author.

Abstract – Health control for illness detection on the early stages is acquired important meaning. Now there are no any express methods of monitoring states of allergic inflammation in the upper respiratory tracks of patients suffering from bronchial asthma that can be widely used in medical practice. This work is development of problem solution of early noninvasive diagnostics. This task can be solving by using of methods based on semiconductor films for gas control. The characteristics of the new sensors, developed on the basis of ZnO, WO_3 and SnO_2 and intended for NO as inflammation marker defining in breath, have been investigated.

The recent year investigations proved that the nitric oxide is one of the most important biological mediators as it takes part in many physiological processes in a human organism. This fact enables to perform quick diagnostics and monitor development of many serious diseases such as bronchial asthma [1]. One of express and reliable noninvasive methods can be based on defining concentrations of NO in the exhaled air. We continued new sensors investigations, based on semiconductor films for this purpose [2]. The comparative characteristics of sensors, developed on the basis of ZnO, WO_3 and SnO_2 doped with RuO_2 and intended for defining nitric oxide micro concentrations in the breath have been investigated. The sensitive element consists of an alumina substrate measured 2 x 0.5 x 0.2 mm. One side of the substrate is covered with a gas sensitive film using thick-film technology; the other side of the substrate bears a film heater made of platinum paste. The film heater is, at the same time, a thermal resistor in the sensor.

The sensor's properties were examined on sample gas mixtures using a dynamic blender "Environics-4000" (Environics, USA). The Dräger test ampoules (Dräger, Germany) were employed. The investigations were carried out under the sensor thermal stabilization conditions in the range 50 - 450 ^{0}C. As the semiconductor sensors operate at optimal elevated temperatures, a heating and heater temperature stabilization circuit was used in the measuring unit; the circuit ensured the stability of about 1.5 V/^{0}C.

Developed sensors showed the best sensitivity to NO at temperature equal 150 ^{0}C. A temperature impulse mode effect on a sensitive layer was used for the model gas mixtures and breath analysis. Sensors based on ZnO had high repeatability of gas sensitivity and resistance's stability. Sensors showed high sensitivity to presence of NO micro concentrations at 10 ppb level in air, response time of sensors does not exceed 10 seconds. The influence of other gases present in exhaled air at 150 ^{0}C is minimal and can be estimated when the signals of sensors are mathematically processed. For this purpose the Generalized Regression based on the Radial Basis Networks was used. A device based on ZnO sensors for measuring NO concentration has been made.

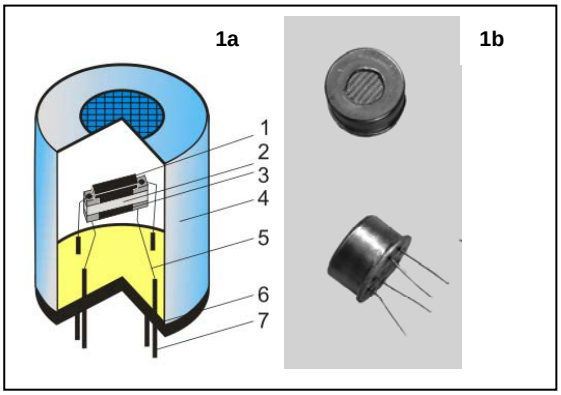

Figure 1: a) The construction of a semiconductor sensor: 1- gas sensitive film; 2 –substrate; 3 – heater; 4 - metal porous casing; 5 - platinum wire;6 - frame; 7 – leads. **b)** The sensor's photograph.

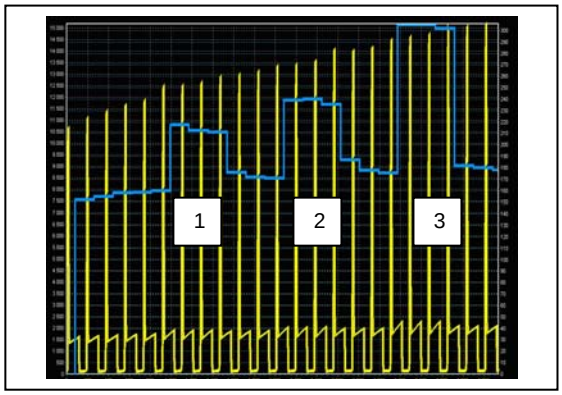

Figure 2: Results of measurements - window of the device (ZnO; working temperature – 150 ^{0}C): 1- 10 ppb NO, 2 – 25 ppb NO, 3 – 50 ppb NO. Yellow line – measured resistance;blue line – calculated results.

References

[1] Alving K., Weitzberg E., Lundberg J.M., Eur.Respir.J. 6 (1993), pp.1268-1270.
[2] O.M. Ivanova, S.A. Krutovertsev, A.V. Pislyakov, S.V. Vdovichev, M.V. Chuprin, High sensitivity NO sensors based on metal oxides, The 7-th East Asian Conference on Chemical Sensors, 2007, 3-5 December, Singapore, Book of Abstracts, p. 64.