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Measurement of Low Concentrations of Hydrogen in Oxygen By Using Sensors Based on MIS-structures

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Abstract

It is shown that the possibility of using MIS-sensors as sensitive elements of gas analyzers for monitoring the concentration of hydrogen in the range of $5–10^{-5}$... 1% in oxygen. The article reports on the possibility of measuring low concentrations of hydrogen (0.5... 10 ppm) in oxygen using a MIS-sensor (metal-insulator-semiconductor).

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1. Introduction

Currently, there are many sectors of the world industry that require the use of industrial gases to various industrial processes. The most popular gases are hydrogen and oxygen. The best method of getting both of these gases with high purity is electrolysis of water: if installation properly operating it enables the production of hydrogen by one step process with a purity level of 99.6–99.9% by volume [1].

The purity of gases (especially oxygen) must be continuously monitored by automatic gas analyzers during the electrolysis of water for ensuring labor safety and efficiency of production. This is equally necessary both for monitoring the formation of explosive mixtures of oxygen with hydrogen in apparatuses and for assessing the deterioration of electrolysis cells and deciding on their replacement or repair.

The article reports on the possibility of measuring low concentrations of hydrogen (0.5... 10 ppm) in oxygen using a MIS-sensor (metal-insulator-semiconductor), the device and description of operation of which are given in [2].

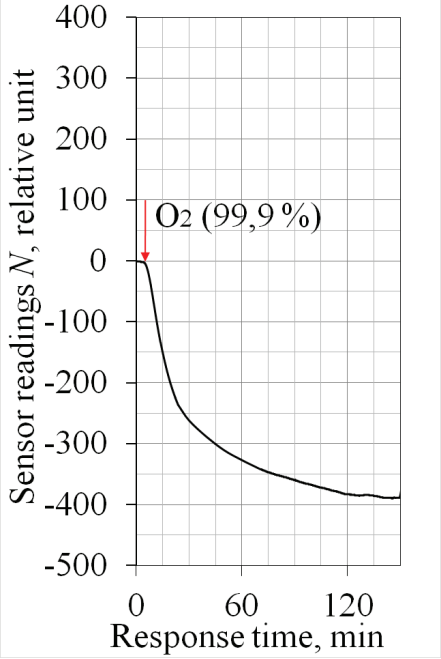

Figure 1: MIS-sensor response to oxygen.

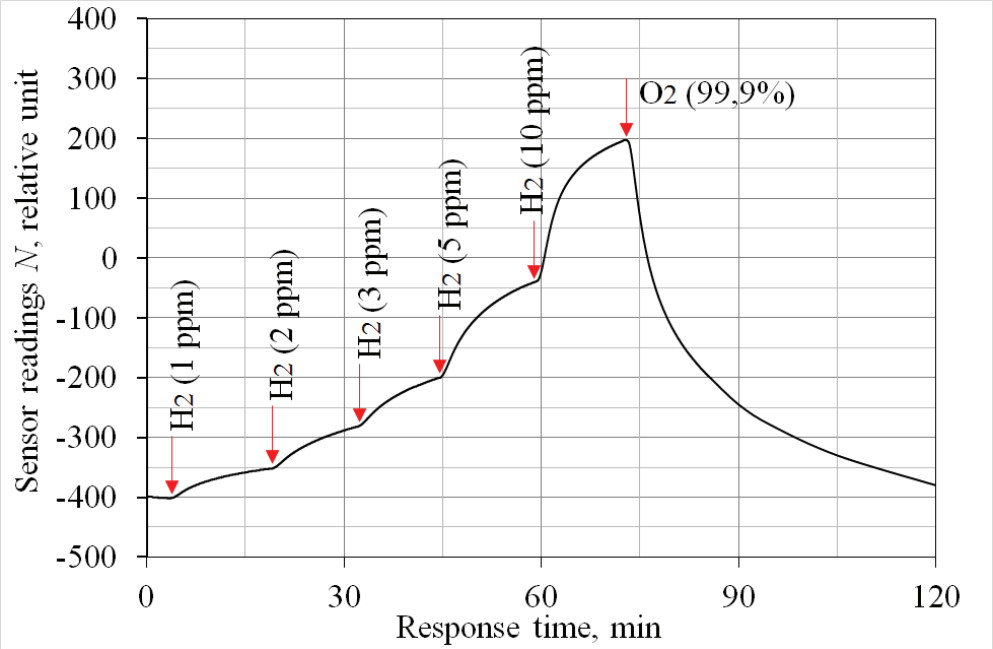

Figure 2: MIS-sensor response to hydrogen concentration of 1... 10 ppm in dried oxygen.

2. Materials and Methods

The experimental installation consisted of a sealed gas chamber with a volume of 1 liter and an oxygen cylinder of special purity. The MIS-sensor was installed in the gas chamber, which was pumped up by oxygen cylinder by using a pressure regulator with a flow of 1... 2 l/min. The sensor response to the replacement of air with dried oxygen

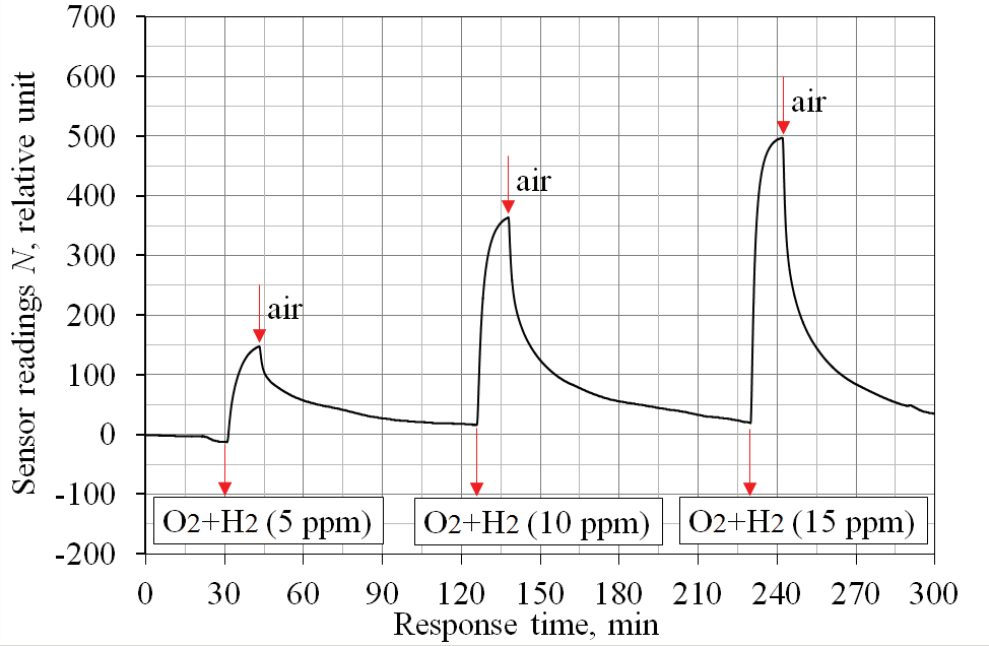

Figure 3: MIS-sensor response to oxygen with an admixture of 5... 15 ppm of hydrogen.

(the oxygen concentrations change was $\Delta K_{O2} \approx$ 80%, the relative humidity change – $\Delta K_{H2O} \approx$ 50%) is shown in Figure 1.

It is known that the MIS-sensor exhibits sensitivity to oxygen and water vapor, like all semiconductor sensors, based on the phenomenon of adsorption/desorption of gas molecules on the solid state surface [3]. However, it was shown in [4, 5] that the sensitivity of MIS-sensors to a variation of the concentration O_2 (especially in the range of 10% by volume and more), and also of H_2O (especially in the range 50... 100% under normal conditions) is negligibly low compared with the sensitivity to H_2.

3. Results

The gas supply from the cylinder was overlapped after stabilizing the readings of the MIS-sensor in dried oxygen. Then, certain volume of hydrogen with 0.5% vol. (from the cylinder of the calibration gas mixture) was injected into the sealed gas chamber every 15 minutes. Thus, the MIS-sensor was calibrated in a dried oxygen by concentrations of hydrogen from 1 to 10 ppm (Figure 2).

If to keep the MIS-sensor in the air under normal conditions and then to pump it a mixture of dried oxygen with addition of low concentration H_2, even in this case it will be possible to record a reliable signal level for hydrogen, although smaller in magnitude due to the superimposition of sensor reaction because of the lowering of humidity and growth of oxygen concentration (Figure 3).

4. Conclusions

It was shown that the possibility of using MIS-sensors for detecting hydrogen in oxygen with a limit of detection 0.5 ppm H_2, response time less than 15 min and recovery time 30 ... 60 min. The upper limit of detection can be 1... 4 % vol. H_2, and the reaction rate herewith is a few seconds [2].

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