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Electrocatalytic gas sensor with reference layer

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Abstract

This paper presents studies of gas sensors prepared in ceramic technology with Nasicon as a solid electrolyte. Sensors work in the voltammetric mode thus based on the excitation of a sensor with a periodic potential signal while current response is recorded. The main aim is to investigate a $Bi_8Nb_2O_{17}$ reference layer influence on sensor properties. Sensors I-V characteristics in different concentration of nitrogen dioxide have been measured. Three different constructions of the sensor are compared.

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Keywords: electrocatalytic sensor; gas sensor, nitrogen dioxide; solid state electrolyte

1. Introduction

In recent years electrochemical gas sensors based on solid state electrolytes have been intensively developed. They are easy to obtain, use and relative durable [1]. Nasicon is one of the most promising materials, which have been used in construction of gas sensors based on solid electrolytes. Most of these devices work in potentiometric or amperometric mode. However, some works are dedicated to sensors working in electrocatalytic mode [2, 3]. Reported results indicate that such sensors have enhanced selectivity [3]. Principle of operation of such sensors is based on the galvanic cell excitation with a periodic potential signal, while current response is recorded. When a voltage is applied to sensors electrodes an oxidation or a reduction of chemical species occurs. This results in a unique current-voltage (I-V) characteristic for each type and concentration of measured gas mixture. As a consequence gas concentration determination is possible.

Electrocatalytic sensors usually employs simple structure of a solid electrolyte and two metal electrodes [3, 4]. In this study electrocatalytic sensor with additional, reference layer is proposed. Our main goal was to check if presence

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of $Bi_8Nb_2O_{17}$ reference layer has any beneficial effect on sensor properties in case of electrocatalytic nitrogen dioxide sensor. In case of potentiometric gas sensor with such layer an improvement of sensor properties have been reported [5]. Properties of the sensors with and without this layer are compared.

2. Experimental

2.1. Sensor preparation

Nasicon pellets were prepared using the sol-gel method [6]. As a substrates $NH_4H_2PO_4$, $Na_2SiO_3{\cdot}9H_2O$ and $ZrO(NO_3)_2{\cdot}xH_2O$ were used. Aqueous solution of $ZrO(NO_3)_2$ was mixed with aqueous solutions of $NH_4H_2PO_4$ and $Na_2SiO_3{\cdot}9H_2O$ (molar ratio of components was 2:1:2) to form a sol. In order to obtain a gel, sol was heated at 100ºC for 12 hours and continuously dried at 100ºC to form xerogel. First calcination at 750ºC for 2 hours and afterwards sintering at 1000ºC for 12 hours were performed. Reference electrode material ($Bi_8Nb_2O_{17}$) was prepared from Bi_2O_3 and Nb_2O_5. These oxides were mixed at the molar ratio 4:1 (Bi_2O_3:Nb_2O_5). Calcination of oxides powders at 750ºC for 5 hours and sintering at 950ºC for 10 hours were performed.

One side of a Nasicon pellets was painted with Pt paste and then sintered at 900ºC. On the opposite side of pellet a layer of $Bi_8Nb_2O_{17}$ and Pt mixture was obtained in similar manner. Two kinds of sensor with reference layer were investigated, one with both electrodes exposed to the test gas mixture and other with Pt+$Bi_8Nb_2O_{17}$ electrode coated with dielectric sealing. Properties of these two sensors were compared with results obtained for the symmetrical sensor without the reference electrode. Investigated sensors structures are presented in Fig. 1 and referred later as a sensor 1, sensor 2 and sensor 3.

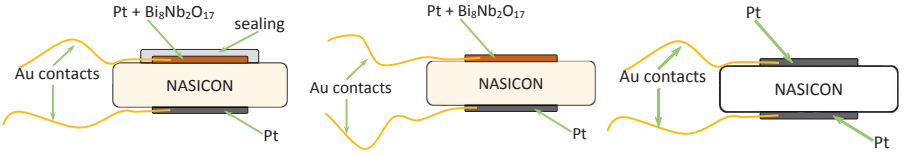

Fig. 1. Sensor 1 with additional layer sealed (a), sensor 2 with additional layer unsealed (b) and sensor 3 with symmetrical structure (c)

2.2. Sensor properties measurements

Measurement stand is presented in the Fig. 2. The measurements were performed using the electrochemical interface SI 1287 and a PC with suitable software for system control and data acquisition. Linearly changing voltage of symmetrical triangular shape (range from 5 V to –5 V) was used. Temperature was fixed to 300ºC.

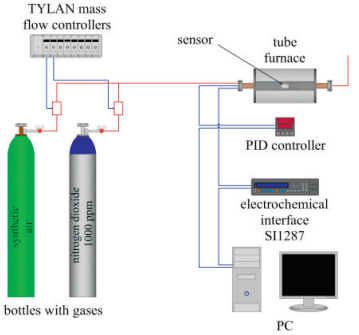

Fig. 2. Measurement stand