Sensors and Actuators B 77 (2001) 525–528

SENSORS AND ACTUATORS B CHEMICAL

www.elsevier.nl/locate/sensorb

New semiconductor type gas sensor for air quality control in automobile cabin

K. Oto*, A. Shinobe, M. Manabe, H. Kakuuchi, Y. Yoshida, T. Nakahara

Figaro Engineering Inc., 1-5-11, Senbanishi, Mino, Osaka 562-8505, Japan

Abstract

A semiconductor type gas sensor for automobile ventilation control has been developed. A couple of tin dioxide based sensing materials, which were respectively sensitive to gasoline and diesel exhaust gases, were mounted on an alumina substrate with an integrated heater by using screen-printing technique. The sensor's sensing element for diesel exhaust, which was heated at about 300°C, showed high sensitivity to NO_2 (>0.5 ppm). The 63% response time to 1 ppm NO_2 was approximately 12 s so that the sensor could rapidly detect diesel exhaust. Moreover, the sensor was selective to NO_2 against coexisting gases such as CO or hydrocarbons. The sensor's sensing material for gasoline exhaust also showed excellent sensing characteristics to gases in gasoline exhaust. By mounting two materials on a 2.0 mm × 2.6 mm substrate, power consumption of the dual sensor could be reduced to about 360 mW also the sensor could be downsized. The sensor has high potential for air quality control in automobile cabins.

Keywords: Tin dioxide; Gas sensor; Air quality control; NO_x sensor; CO sensor

1. Introduction

There are some devices to keep the air in automobile cabins clean by reducing the amount of pollutants flowing into the cabin. The amount of pollutants flowing into the cabin can be reduced by a trap with a charcoal filter or by automatic control of the air intake flap in air conditioning systems. Gas sensors are used to measure the amount of pollutants outside the cabin and control the air intake flap.

The important pollutants are combustible gases such as CO and hydrocarbons emitted by gasoline-fueled engines and NO_2 emitted by diesel-fueled engines. The concentration range of CO detection is from 10–100 ppm and that of NO_2 detection is from 0.5–5 ppm. So, CO and NO_2 sensors need to have high sensitivity to low concentration gases together with high selectivity. Moreover, quick response to gases is needed in order to avoid the inflow of the pollutants into the cabin.

There are some reports concerned with CO and NO_2 sensors for the air quality control in automobile cabins [1–4].

In this paper, we describe a new type of gas sensor for air quality control in automobile cabins. The sensor bas a couple of sensing materials suitable for exhaust gas detection. The evaluation results on sensing characteristics of the sensor will be given and discussed.

2. Experimental

2.1. Sensing element

A schematic view of the sensing element is shown in Fig. 1. On the back of an alumina substrate (2 mm × 2.6 mm, $t = 0.254$ mm), Pt electrodes and a RuO_2 heater were formed by using screen printing technique. On the front, interdigitated electrodes and two sensing materials were screen-printed. SnO_2(I) was specially doped with Fe_2O_3 to increase sensitivity and selectivity to NO_2 gas. On the other hand, SnO_2(II) was doped with V_2O_5 and Pd to sensitize it to various combustible gases such as CO, hydrocarbons and so on. Two printed materials were coated with SiO_2 sol and calcined at 650°C.

2.2. Characteristics

Response time and sensitivity to various gases were obtained by the measurement of the sensor resistance in a test box maintained at 20°C, 65%RH. During the measurement the sensor was operated at about 300°C. The sensor

* Corresponding author.

0925-4005/01/$ – see front matter
PII: S0925-4005(01)00717-1

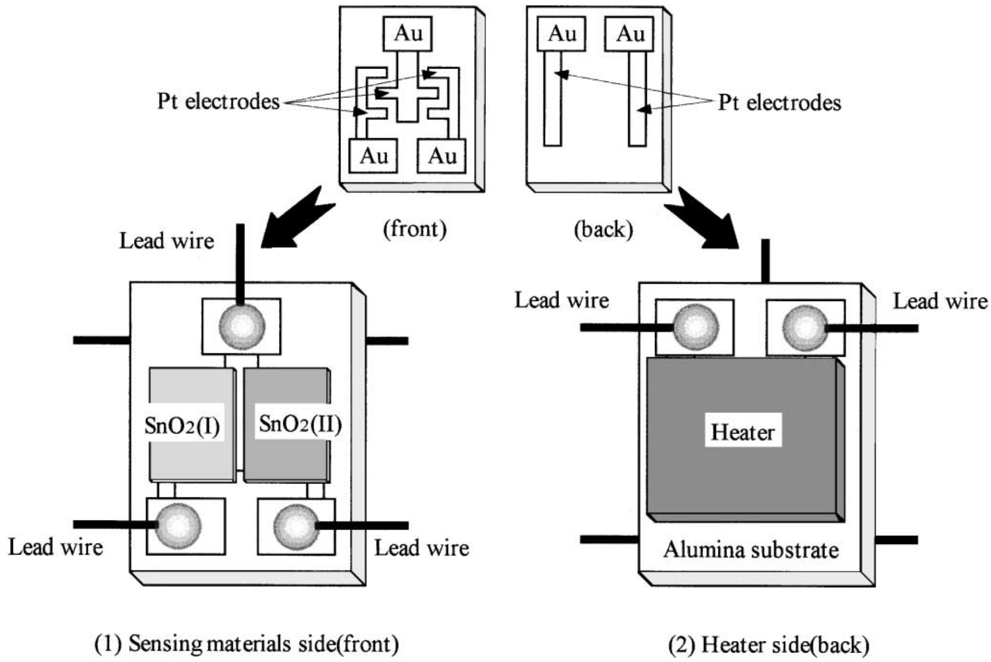

Fig. 1. Schematic view of sensor element. SnO_2(I): sensing material for the detection of NO_x emitted by diesel-fueled engines. SnO_2(II): sensing material for the detection of combustible gases emitted by gasoline-fueled engines. Heater: RuO_2 coated with glass. Lead wire: Pt.

resistance and sensitivities to CO and NO_2 were also measured in a range from 0°C, 60%RH to 40°C, 60%RH.

3. Results

3.1. Response time to NO_2 and CO

Two response curves for 1 ppm NO_2 gas on SnO_2(I) sensing material and for 30 ppm CO gas on SnO_2(II) sensing material are shown in Fig. 2. SnO_2(I) sensing material could rapidly response curve for NO_2 gas. The time for a 63% increase of the sensor resistance in the response curve for 1 ppm NO_2 gas was approximately 12 s. On the other hand, SnO_2(II) sensing material had a quick response to CO gas. The time for a 63% decrease of the sensor resistance in the response curve for 30 ppm CO gas was approximately 5 s.

3.2. Sensitivities to various gases

The sensitivities to various gases on two sensing materials are shown in Fig. 3. Sensitivity was defined by the ratio of the sensor resistance in air loaded with gas and that in clean air.

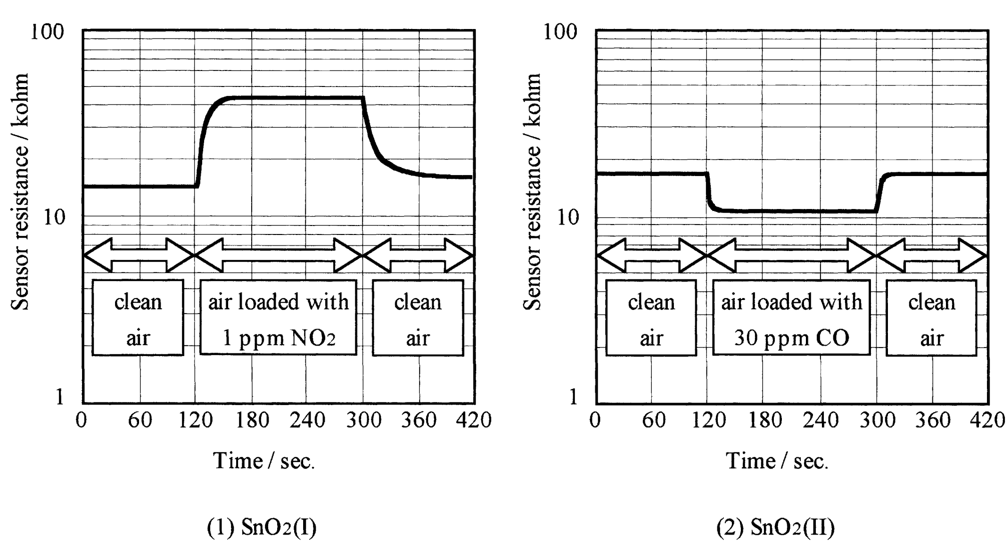

Fig. 2. Response curves.