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Recognition Capability of ANN For The Analysis of PbO-Doped Sno_2 Sensor For Detection of Acetone

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Abstract— ***In the present work thick film SnO_2 sensor was fabricated on a 1″x1″ alumina substrate. It consists of a gas sensitive layer (SnO_2) doped with PbO, a pair of electrodes underneath the gas sensing layer serving as a contact pad for sensor. Also a heater element on the backside of the substrate was printed. The sensitivity of sensor has been studied at different temperatures (150^0C-350^0C) upon exposure to acetone. An approach is made to measure the sensitivity of PbO-doped SnO_2 by using ANN tool. Result presented in the paper shows the potential of ANN as a design tool in the area of thick film sensor.***

Keywords— Artificial Neural Network, Thick film sensor, sensitivity, Radial basis function

I. Introduction

Metal oxide semiconductor sensors based on electric conductivity measurement have been used extensively for gas detection. SnO_2 is most widely used material among semi conducting oxides for making gas sensors due to its low cost, long life and good reproducibility [1,2].Tin oxides can be fabricated mainly into three types of devices i.e. sintered block, thick film and thin film[3]. Among these, thick film SnO_2 devices are most studied and most suitable candidate due to their high level of sensitivity, simple design, low weight and cost effectiveness. SnO_2 is an n-type, wide-band gap (3.6 eV) semiconductor [4]. Its electrical conductivity is due to the non stoichiometric compositions as a result of oxygen deficiency [5]. The sensing properties of the thick film gas sensor are based on the adsorption of the gas molecules on it surface which produce changes in their conductivity [6]. Thick film of SnO_2 consists of large number of grains of slightly different sizes, interconnected by Schottky barriers of different heights [7]. The Schottky barrier height is dependent on the surface charge density, which get modulated due to adsorption of gas molecules [8, 9].

These gas sensors could achieve more improved sensitivity to organic compounds by the control of particle size and addition of promoter [10, 11]. Despite the high sensitivity, disadvantages such as lack of reproducibility, long term stability and selectivity for specific gases are frequently observed; moreover, the sensitivity to ambient moisture strongly interferes with the conduction mechanism. A better control of the number, distribution and size of the grains and of the intergranular boundaries, together with the addition of catalysts and other promoters during preparation, can contribute in limiting the effect of the previously mentioned disadvantages [7]. It is reported that the microstructure of the SnO_2 is one of the most important factor, which control the sensitivity of gas sensor [12, 13].

The concept of ANN analysis have been discovered nearly 50 years ago , but in handling the practical problems it is used only from last 2-decades[14].

ANNs are collections of small individually interconnected processing units. Information is passed between these units along interconnections. An incoming connection has two values associated with it, an input value and a weight. The output of the unit is a function of the summed value. Once an ANN is trained for a prescribed data it may be ready to be used then for the prediction or classification ANNs can automatically learn to recognize pattern in the data real systems or from physical models, or other sources. An ANN can also handle many inputs and produce answers that are in a form suitable for designers [15].

In the present work for the recognization of the sensitivity of the PbO-doped SnO_2 sensor Radial basis function algorithm has been used. A Radial basis function network (RBFN) can be used for the recognizing the pattern of the system. Radial basis function network uses the Gaussian activation function. The importance of such function is that it is non negative for all the values of x. This is one of the important differences between (BPNN) and RBFN [16]

III. RESULTS AND DISCUSSIONS

A. Experiment

The schematic of fabricated gas sensor is shown in fig.1. Tin oxide was available in the form of indium doped tin oxide paste, supplied by Electro Science Laboratories (ESL3050, USA). This indium doped tin oxide paste (SnO_2) has been taken as the base sensing material. The doped pastes were prepared by adding 1% PbO (by weight) in base SnO_2 paste with cellulose based thinner. The thermistor pattern is screen printed first (paste NTC 2413 ESL), dried at a temperature of 100^0C and fired at 950^0C. In the second step, finger electrode pattern is screen printed using silver conductor paste (No. PD 6176, DuPont) and dried at a temperature of 100^0C. Subsequently, a heater element is screen printed on the back side of the substrate using silver palladium conductor paste (No. C1214, Heraeus,Gmbh) which is dried at the same temperature. Now the dried screen printed films are fired at 850^0C. In the third step, PbO-doped tin oxide paste was screen printed over the electrode pattern and the print was allowed to dry at a temperature 100^0C for 20min. The dried film was then fired in a thick film furnace (DEK model 840) in a set temperature profile with peak temperature zone of 550^0C.

The fabricated sensor was then exposed to varying concentration of acetone in a locally developed test chamber of volume 2047 cm^3 having placed at the metal base. The change in resistance of sensor is measured using KEITHELY 195A

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multimeter.

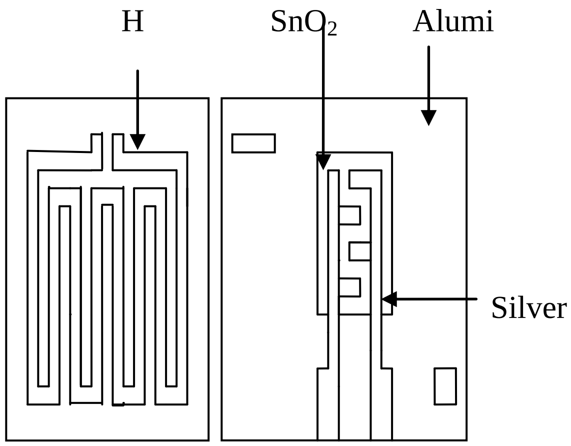

Fig.1 Schematic of fabricated sensors

ANN models may be used as alternative methods for the engineering analysis and predictions. For the purpose of our study, the two layer Radial basis function network (RBFN) is used. The architecture of this NN is one input at the input layer, 10 neurons in the hidden layer and one output at the output layer. The Input of the (RBFN) NN model is the concentration of the acetone vapor and the output of the NN model is sensitivity of the sensor for the acetone gas. The ANN is trained to generate a mapping between the input concentration of acetone and output of the sensitivity of acetone.

B. Testing and Result

The experimentally obtained data are first divided in two groups which is given in Table 1and 2. The first one is training data group by which we have to train the network and the next one is testing data group by which we have to test the network. Ten experimentally obtained data is used for the training and remaining three data sets at the concentrations at 1200 ppm, 1800 ppm and 2400 ppm were used for the testing. The test data set is not used during training. RBFN (exact fit) is used for this purpose. We have scaled the training target data (sensitivity) by the highest magnitude of the sensitivity and used these scaled values as training and testing of the network. The spread constant is changed during the experiment. Our goal is achieved at spread constant 0.1 and at 47 epochs. The output of the NN matches well with the experimental output.

C. Conclusion

Paper presents the recognization capability of the neural network. It describes the result for the best trained RBFN (exact fit) which has been used to model the realization between the experimentally obtained sensitivity of the PbO-doped SnO_2 gas sensor and output obtained sensitivity of the NN model. NN trained for the different spread constants. Best result is obtained at spread constant 0. 1 and the result obtained is given in Fig.2-3. Thus ANN may be used as design tool for the thick film sensors.

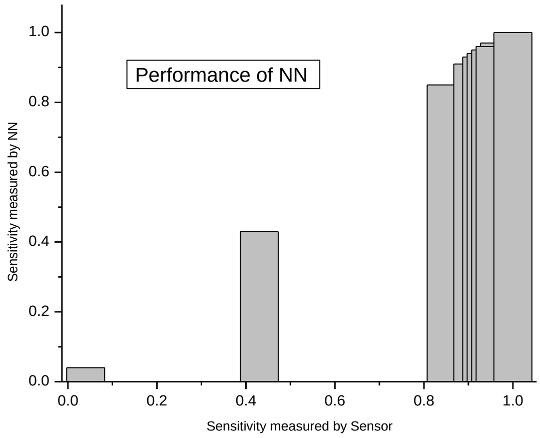

Fig.2 Performance of the Neural Network

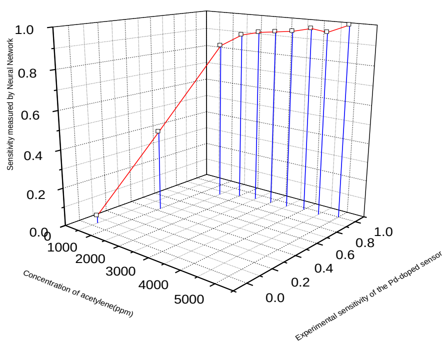

Fig.3 Comparison of Experimental and NN data output with acetone concentration

Table.1 Training Data Set

Concentration of (acetylene in(ppm**)**	Sensitivity of the Sensor	Scaled sensitivity of the sensor
500	10.14	0.04
1000	45.75	0.43
1500	62.27	0.85
2000	72.25	0.91
2500	81.52	0.93
3000	90.75	0.94
3500	92.25	0.95
4000	93.15	0.97
4500	93.45	0.96
5000	93.89	1.0

Table.2 Test Data Set

Concentration of (acetylene in(ppm)	Sensitivity of the Sensor	Scaled sensitivity of the sensor
1200	24.32	0.64
1800	33.82	0.89
2400	35.15	0.925

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