TEST Engineering & Management

March - April 2020
ISSN: 0193-4120 Page No. 8984 - 8989

Design CuO-doped SnO_2 Thick film Gas Sensor for H_2S Using ANN Technique

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Article Info
Volume 83
Page Number: 8984 - 8989
Publication Issue:
March - April 2020

Abstract

Environment cause for concern stirred up a greater interest in the expansion of gas sensors for toxic gas detection The semiconductor materials and metal oxide material are found to be appropriate in the favors of untruth of thick film gas sensor. The suitability of these materials is because the cost was very low as compared to other materials. Nevertheless, different accessibility approach for vapors detection, solid-state gas sensor suggested a better choice due to their rugged monitoring construction and sufficiently low cost. Among the various micro-technologies used for fabrication of gas sensors thick film sensors offer benefit over other technologies in terms of cost, strength, less susceptibility to contamination, more sensitivity, high productivity and automation along with the running out of time appropriate transfer from paradigm model products. Some disadvantages associated with thick film sensors are their low selectivity and high-power consumption. The Internet of Things (IoT) is the current development in healthcare and domestic air grade supervision magnifies the business requirement on behalf of reducing the size of gas sensors. Metal Oxide Gas Sensors established on frequently utilized micro hotplates falsification over a Micro-Electro- Mechanical System (MEMS) field of technological advancement predominate the market appropriate performance and lower expense. Gas sensors have been mostly implementing in dissimilar domains, alike of agriculture, automotive industry, home automation system for inside air quality controlling and environmental supervision. The 1% CuO doped SnO2 based thick film fabricated sensors regression with H2S toxic gas (250 ppm- 1500 ppm) was demonstrated in the temperature wide ranges of 150 and 350˚C.

Article History
Article Received*: 24 July 2019*
Revised*: 12 September 2019*
Accepted*: 15 February 2020*
Publication*: 09 April 2020*

Keywords; *Artificial Neural Network (ANN), Thick film gas sensor, Sensitivity, Neural Network (NN)*

I. INTRODUCTION

An enormous advancement of the gas sensors market in the forthcoming years and the market worth appreciate will be furthermore $3 billion in 2028. Now a day' maximum development arrives from the IoT applications, slimier smart cities, smart homes, smartphones, and man-portable devices. For specimen, the smart city project demands the gas sensor to detect dissimilar gases concurrently with huge sensitivity and selectivity, whilst size and price are the key concerns for man-portable devices.

In recent times predominance, the Internet of Things (IoT) encourages the magnification of sensors with small sizes Also; miniaturization of the gas sensors gets excited the improvement of electronic noses (E-nose) in numerous domains, for instance of food quality monitor disease examination and domestic air impurities categorization. Micro-Electro-Mechanical Systems (MEMS) field of technology is significant to design and fabricate miniaturized gas sensors with extraordinary performance such as low power utilization [1,2]. Natural non-stoichiometry of SnO2- based thick film gas sensor makes it easy adsorption of oxygen at its superficial surface and

Published by: The Mattingley Publishing Co., Inc.

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ISSN: 0193-4120 Page No. 8984 - 8989

endows it with excellent physicochemical immoveable property similar high reactivity to reducing as well as oxidizing gases at relatively low operating temperatures. It is indicated that the microstructure of SnO_2 monitoring the sensitivity of gas sensors. The microstructure will moreover depend upon the temperature treatment, concentration of the dopant and the technological steps carried out for its preparation.

II. EXPERIMENTAL

The base substrate is 96% Al2O3. The dimension of the tile is 1" X 1" inch with a thickness of 0.8 mm in thick-film technology. They have associated with Pt or Au electrode of different classes on the front side for measuring the sensor resistance and Pt heater on the backside for keeping the sensor at the operating temperature. Thick film gas sensor operating temperature of (150°C-400°C). The electrical power supply is attached to ensure a constant voltage drop over the platinum on the rear side of the alumina substrate. Adhesion is effect by several factors should be noted that thickness, size, shape, surface chemistry, and surface roughness. The net result is increased conductor adhesion due to the extra area for mechanical and chemical bonding as well as the fact that adhesion test loading will not continuously perpendicular to the potential rupturing surface. The copper oxide (CuO) was worked on a p-type semiconductor over a narrow band-gap (1.2 eV) which demonstrates through provoking catalytic immovable. CuO doped SnO_2 thick film gas sensor was recognized extremely higher sensitiveness and selectiveness reaction of H2S gas. CuO neglected to react through SnO_2 and major susceptibility has been designed p-n intersection established separate n-type SnO_2 and p-type. CuOreparents destructors establishment of CuS on exhibition H2S gas. 1% CuO doped SnO_2 based thick film gas sensor powder was used to put together a thick film gas sensor through the used screen-printing technique. The implication of CuO doping, on the detecting performance of SnO_2 thick film gas sensor for H2S gas, has been taken into consideration in different operating temperature [3.4.5]. As a substitute for of Sn^{+4} by Cu^{+2} conduct to the genesis of oxygen vacancies. Oxygen deficiency increased was believed to be accountability for strengthened the resistance oxides and the destination gas[6]. Gas sensors typically accommodate a heating component and an externally or domestic temperature arrangement to achieve the excellent efficiency of the sensor. The reaction has to at close range involved gas centration impressive identification. At a stationary temperature, the think- film SnO2 based gas sensor response increases concerning the appropriate gas concentration to enhance carrier concentration and mobility [7,8,9].

In the current, work for the reorganization the sensitivity CuO-doped SnO_2 sensor feed-forward network has been used[10,11]. A Feed Forward network can be employed for the reorganization of the prototype system. Feed Forward network implements the Gaussian activation function [12]. The importance of such function indicates that it does not non

-negative all values of x that is one significate difference between BPNN & FEFN. 1% CuO-doped thick film gas sensor was manufactured used a thick film screen printing technique. Alumina substrate with size of 1″x1″inches thick film gas sensor fabricated .In addition to the heater element at the rear end of the underlayer to generate the desirable essential temperature for gas sensing. Alumina (96%) has been occupied as the substrate for sensor fabrication. The dissimilar elements of the sensor (sensing layer, electrodes, substrate) are intact influencing the gas detection.

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III RESULTS AND DISCUSSIONS

Temperature dependence of electrical resistance of 1% CuO doped sensors is shown in Figure 1.

Heater Elements SnO_2 Sensing Layer Alumina

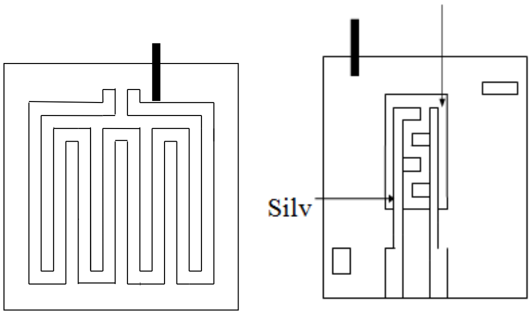

Fig 1: Fabricate Thick Film Gas Sensor

The sensors demonstrate an increase in sensitiveness as the concentration of H_2S was enhanced from 250 ppm to 1500 ppm in air.

ANN model may be an acceptable method for engineering assessments and predictions. For our paper, the two-layer Feed forward function is used. NN architecture was designed for one input at the input layer, hidden layer designed 10 neurons and one output at the output layer. The input of the FEFN NN model is the concentration H_2S at 150°C and 350°C. The output of the NN model is the sensitivity of the sensor for H_2S at 150°C. The ANN has mapped separate the input concentration of H_2S and the output of the sensitivity of H_2S at 200°C. The experimental data was first extrapolated by the MATLAB tool and 10 extrapolated data were obtained for the different concentrations of H_2S at 150°C and 350 °C. Out of these first six data were used for the training purpose and

rest four for the validation goal. The validation set was used to halt the instruction of the neural network, when the neural network begins to overfit the data. The test data set was not used during the instruction and authentication of the neural network model.

The experimental data was first extrapolated by the Matlab tool and 10 extrapolated data were obtained for the different concentrations of H_2S at 150°Cand 350°C. Out of these first six data were used for the training purpose and rest four for the validation purpose. The validation set was used to stop the training of the neural network when the neural network begins to overfit the data. The test data set was misused during the instruction and authentication of the neural network model.

The experimental data was first extrapolated by the Matlab tool and 10 extrapolated data were obtained for the different concentrations of methanol at 150°C and 350°C. Out of these first six data were used for the training purpose and rest four for the validation purpose. The validation set was used to stop the training of the neural network when the neural network begins to overfit the data. The test data set was in the course of the instruction and authentication of the neural network model.

Multilayer perception feed-forward ANN was designed for the testing and training purpose using Levenberg –Marquarth feed forward-propagation with adaptive learning rate algorithm offered forward propagation. LEARNGDM is used as its adaptation learning function and mean square error was utilized as an executive function. To estimate the effectiveness of the learning network, the mean square error was initiated as the training goal. The smaller the mean square error was the improved outcomes and correctness of the network in the genuine implements tansin, logsin and purelin were used as transfer function for all the neurons respectively one by one each set of input and output data. The standard approach of data preprocessing for ANN is to acquire the standard deviation and mean value from the training data, but not from the validation and testing data. Means and standard deviations were estimated for every attribute about the set of training data and utilized to scale each instance of the validation and testing data. The execution of the ANN will vary a large extent as the data was trained on several data representations.

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The Levenberg –Marquart feed forward-propagation with adaptive learning rate algorithm was used regression parameter of train data (0.9998) and output target train data (0.99913) in Figure 2.

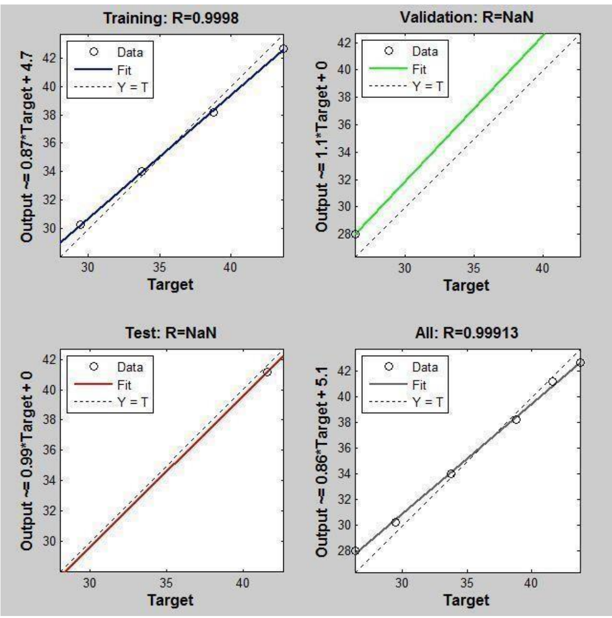

Figure 3 Results of regression Tansin transfer function

The Levenberg –Marquart feed forward-propagation with adaptive learning rate algorithm was used regression parameter of train data was (0.9652) and output target data (0.95683) are shown in Figure 4.

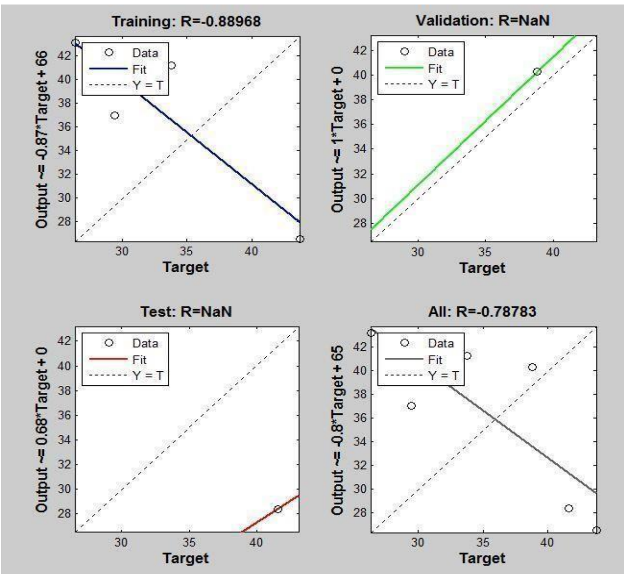

Figure 2 Results of regression Purelin transfer function

The Levenberg –Marquart feed forward-propagation with adaptive learning rate algorithm was used regression parameter of train data (0.88968) and output target train data (0.78783) as shown in Figure 3.

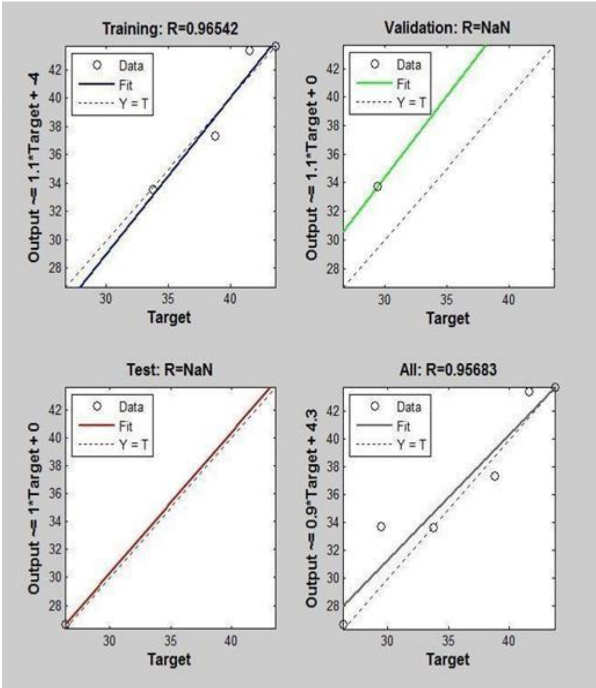

Figure 4 Results of regression Logsin transfer function

LEARNGDM is used as its adaptation learning function and means the square error is used as a performance function at 350°C. The Levenberg - Marquardt feed-forward propagation algorithm was used regression parameter of train data (0.95967) and output target data (0.95925) as shown in Figure 5.

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March - April 2020
ISSN: 0193-4120 Page No. 8984 - 8989

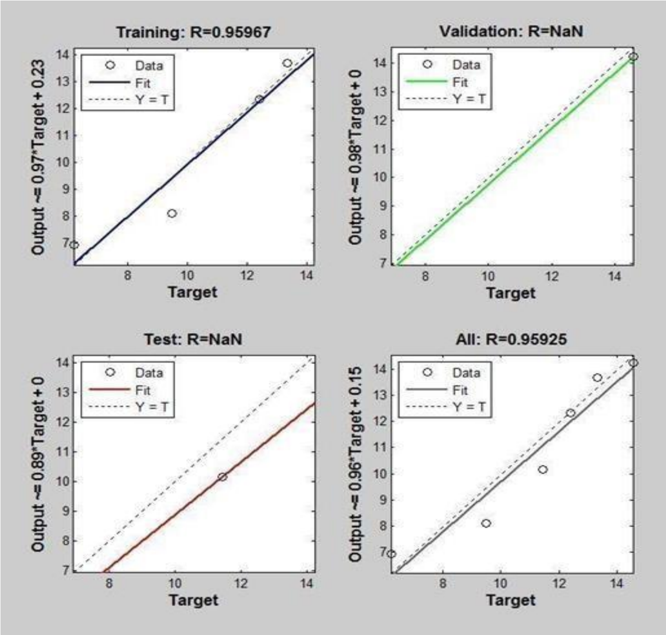

Figure 5 Results of regression Purelin transfer function

The above algorithm having a regression parameter of train data was (0.82369) and output target data (0.69584) are shown in Figure 6.

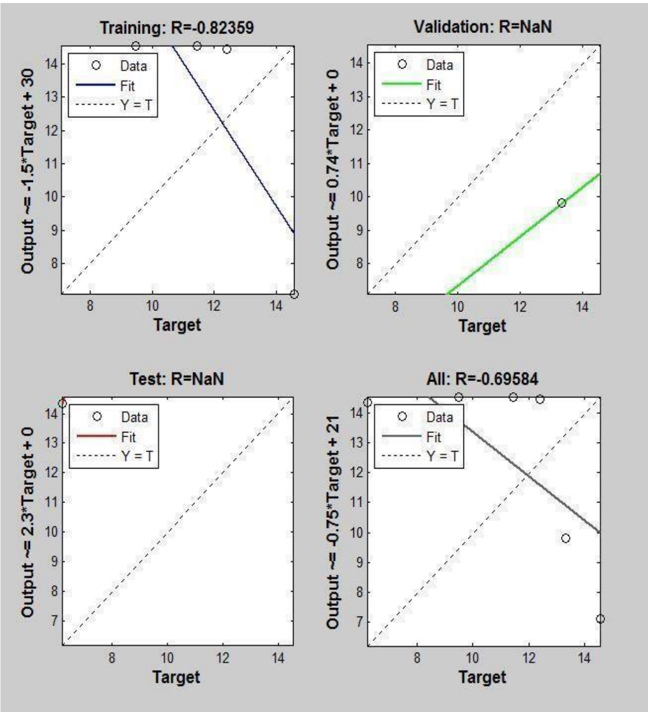

Figure 6 Results of regression Tansin transfer function

The Levenberg -Marquardt feed-forward propagation algorithm regression parameter of train data was (0.71513 and output target data (0.30378) are shown in Figure 7.

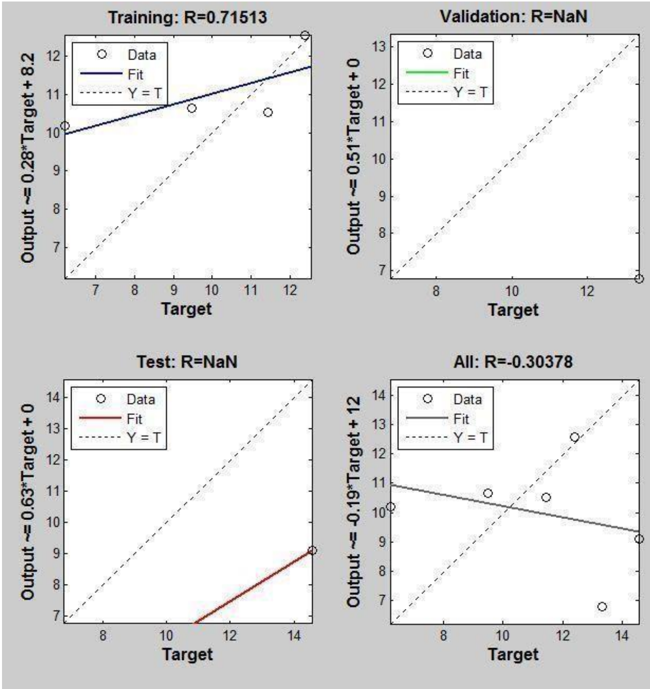

Figure 7 Results of regression Tansin transfer function

IV:CONCLUSION

The maximum sensitivity documented for 1% CuO doping SnO2 based thick film gas sensor was 33.26% at 150°C. The maximum sensitivity of H2S was also approved by matlab software neural network organization tool. In Levenberg –Marquarth feed forward-propagation with adaptive learning rate algorithm network function in purelin network transfer function it was found to be (0.99913) at 150°C in Figure 2. Throughout the three- transfer function network, purelin is the maximum convenient function as at zero epoch maximum validation performance was accomplished. The Levenberg – Marquarth feed forward-propagation with adaptive learning rate network function was establish to having least possible fault in purelin transfer function network.

The maximum sensitivity founded for 1% CuO doping SnO2 based thick film gas sensor was 79.33 at 350°C Amendment capability of 1 % CuO doped SnO2 based thick film gas sensor was checked by

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March - April 2020
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purelin transfer function for H2S at 350°C. The Levenberg -Marquardt feed forward propagation algorithm regression parameter of train data was (0.95967) and output target data (0.95925) are shown in Figure 5. Amongst the three- transfer function network, Purelin network transfer function was the most suitable function as at zero epochs maximum validation performance achieved. The Levenberg-Marquardt feed-forward propagation algorithm purelin network transfer function training data regression function at 350°C.

REFERENCE

1) Botter R., AsteT.andBeruto D., "Influence of microstructures on the functional properties of tin oxide-based gas sensors," Sensors and Actuators B, 22(1),27-36 (1994).

2) Butta N., Cinquegrani L., Mugno E., TaglieueteA. and Pizzini S., " A family of tin oxide based sensors with improved selectivity to methane," Sensors and Actuators B: Chemical, 6(1), 110-113 (1992).

3)ChowdhariA.,Gupta V. and Sreenivas K., "Enhanced catalytic activity of ultra thinCuO M islands On SnO 2 films for fast response H2S gassensors," IEEE sensors Journal, 3(6), 231- 235 (2003).

4) Chowdhari A., Gupta V., Sreenivas K., Kumar R., Mozumdar S. and Patanjali P. K., " Response speed of SnO2 based H2S gas sensors with CuOnano particles," Applied Physics Letters ,84(7), 1180-1182 (2004).

5) Katti V. R., Debnath A. K., Muthe K.P., Kaur M., A. K. Dua, Gadkari S. C., Gupta S. K. and Sahni V. C., "Mechanism of drifts in H2S sensing properties of SnO2: CuO composite thin film sensors prepared by thermal evaporation ," Sensors and Actuators B: Chemical , 96(1), 245-252 (2003)

6) Choudhary, Meenakshi, Mishra, V. N. and Dwivedi R., "Effect of temperature on palladium-doped tin oxide thick film gas sensor", Advanced Science, Engineering and Medicine, 5(1), 932-936 (2013).

7) Cominia E., Ferronib M., Guidib V., Fagliaa G., Martinellib G. and Sberveglieria G., "Nanostructured mixed oxides compound for gas sensing applications," Sensors and Actuators B: Chemical , 84(1) ,26-32 (2002)

8) Comini C. ,Faglia G. , Sberveglieri G., Calestani, D., Zanotti L. and Zha M., "Tin oxide nano belts electrical and sensing properties ," Sensors and Actuators B: Chemical , 112(1),2 –6(2006).

9) Fam D., Tok A. I., Palaniappan A., Nopphawan P., Anup L. and Mhaisalkar S. G. ,"Selective sensing of hydrogen sulphide using silver nanoparticle decorated carbon nanotubes ," Sensors and Actuators B: Chemical , 138(1) ,189–192 (2009)

10) Friestch M., Zudock F., Goschnick J. and Bruns M., "CuO catalytic membrane as selectivity trimmer for metal oxide gas sensors," Sensors and Actuators B: Chemical, 65(1), 379-381(2000)

11) Lee S. C., Kim Y. S., Hwang B. W. , Jung S. Y., Ragupathy D. , Duk, L. D. and Kim J. C. , " Improvement of H2S sensing properties of SnO2-based thick film gas sensors promoted with MoO3 and NiO," Sensors, 13(3), 3889–3901 (2013).

12) Dawson C. W., and R. Wilby ," An artificial neural network approach to rainfall-runoff modelling," Hydrological Sciences Journal, 43 (1), 47-66,(1998).

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