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FABRICATING A HYDREGON (H_2) GAS SENSOR USING n-TYPE CUPEROUS OXIDE (Cu_2O)

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ABSTRACT

Gas sensors fabricated using metal oxides are widely used in present. Adsorption of gas molecules on the surface of a metal oxide semiconductor causes a significant change in the electrical conductivity of the material. n - Cu_2O thin film was obtained by immersing copper plate in a 10^{-3} M $CuSO_4$ solution[1]. A small, cheap, portable and simple four point probe system has been designed to measure the sheet resistivity of Cu_2O thin film. Using the above home made four point probe system variations in the sheet resistivity of Cu_2O thin film was measured while exposing it to H_2 gas. Significant change in the resistivity was shown in n- Cu_2O sample which was boiled to 40min.

Keyword: H_2 Sensor, n-type Cu_2O, Four point probe technique

1. INTRODUCTION

Last few years, research and development of gas-sensing devices is in the focus of activity of scientists and engineers. Such detectors can be used for; monitoring of the concentration of gases in the environment, detection of toxic dangerous gases, drugs, smoke and fire, health, control of automotive and industrial emissions as well as precious technological processes in industry, energy saving, anti-terrorist defence. Gas sensors can be manufactured using different materials and technologies. However many gas sensing micro-systems have not yet reached commercial viability due to high price, consumed electric power and working temperatures, inaccuracies and inherent characteristics of the sensors themselves. So, suitable semiconductor materials with the required surface and bulk having higher sensitivity, stability and selectivity are demanding today.

There are hydrogen sensors with different operating principles and type, based on different materials. Some of them are, optical fiber type, piezoelectric type, thermoelectric sensor, wire coated by Pd, Schottky and MIS diodes, solid electrolyte, polymers, amperometric and potentiometric sensors, carbon nanotube and fullerene sensors, graphite oxide, different metal oxides etc.

At present, commercial hydrogen detectors are not suitable for widespread use, particularly in transportation, because they are mainly too bulky, expensive, and some are dangerous. It is necessary today to develop new hydrogen gas sensors working at/or near room temperature without any power source. In addition, they should be small, cheap and easy to be implanted into microelectronic integrated circuits.

This study explores the potential of n-type Cu_2O thin films in sensing H_2 gas. The study revealed that there was a clear change in resistivity in Cu_2O thin film with the presence of H_2 gas.

2. EXPERIMENTAL

2.1 n-Cu_2O preparation

A 20mm x 10mm Cu plate was well cleaned using sand paper, detergent and distilled water to remove oxide layer and dust particles. Furthermore the copper plates were polished until a mirror like surface was obtained. Cleaned Cu plate was immersed in a 100ml of 10^{-3} M Cu_2SO_4 (aq) solution ($CuSO_4.5H_2O$ molar mass=249.68gmol^{-1}) and boiled to 10 minutes in order to obtain Cu_2O layers on the surface of copper plate. A fixed volume (100ml) of Cu_2SO_4 was maintained during the boiling by adding distilled water until the volume reaches 100ml.[1] Sample was taken out when the boiling time is right and washed using distilled water and dried using a dryer. Diffuse reflectance spectrum of the sample was studied using Shimadzu UV-visible 1800 spectrophotometer.

Same procedure was carried out for samples boiled for 20 min, 30 min, 40 min, 50 min, and 60 min to grow n-Cu_2O on top of Cu substrate. Above mentioned procedure was done under room temperature.

2.2 Sensing measurements

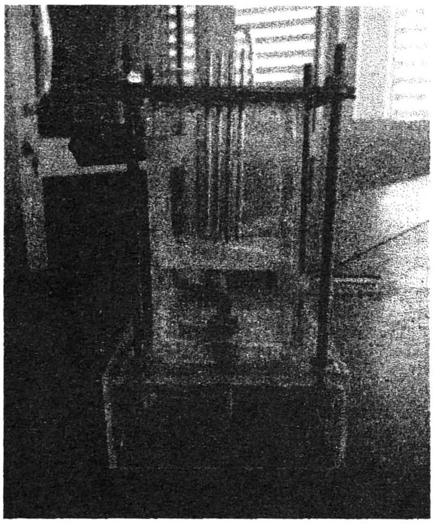

Figure 1: Four Point Probe System

The voltage was measured using inner probes while giving a constant current (100 mA) to outer probes[3]. Prepared sample is put into the system and taken the voltage measurement with the use of inner probes. After exposing the sample to H_2 gas the readings were taken from 1 min time intervals till 10 min. Readings were taken while irradiating the sample.

Resistivity was measured using the following equation.

$$\rho = \frac{\pi}{\ln(2)}\frac{V}{I} \qquad [1]$$

3. RESULTS AND DISCUSSION

3.1 UV-visible absorption analysis

Diffuse curves of samples prepared were taken. Diffuse spectrum of the samples which were prepared displayed most likely characteristics of n-Cu_2O.

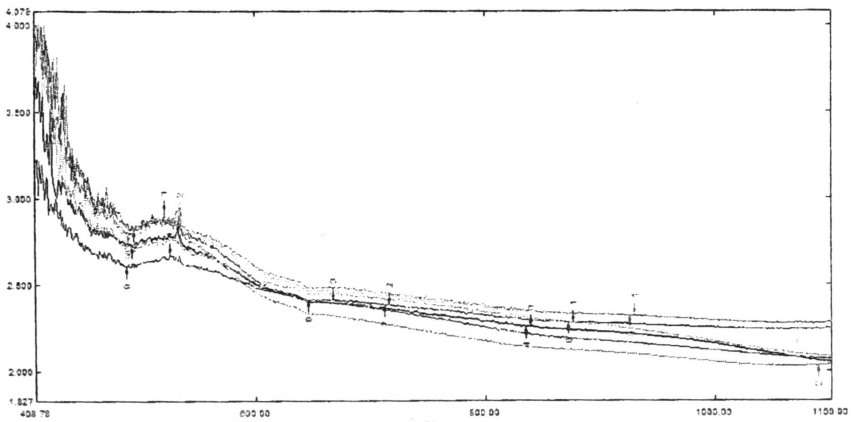

Figure 2: Diffuse curves

3.2 Resistivity

Resistivity is simply the voltage reading in mV because of the constant amount of current (0.1 A) kept throughout the measuring time.

Table 1: Measured voltages

Boiling time of n-Cu_2O (min)	Voltage after exposing to H_2 gas (mV)	Voltage after irradiation (mV)
10	1.1	1.7
20	1.4	1.9
30	1.8	2.1
40	3.4	2.1
50	0.5	0.4
60	1.7	0.9

Below graph shows the measured voltage values while keeping the current constant. Considerably higher response was shown by 40 min sample

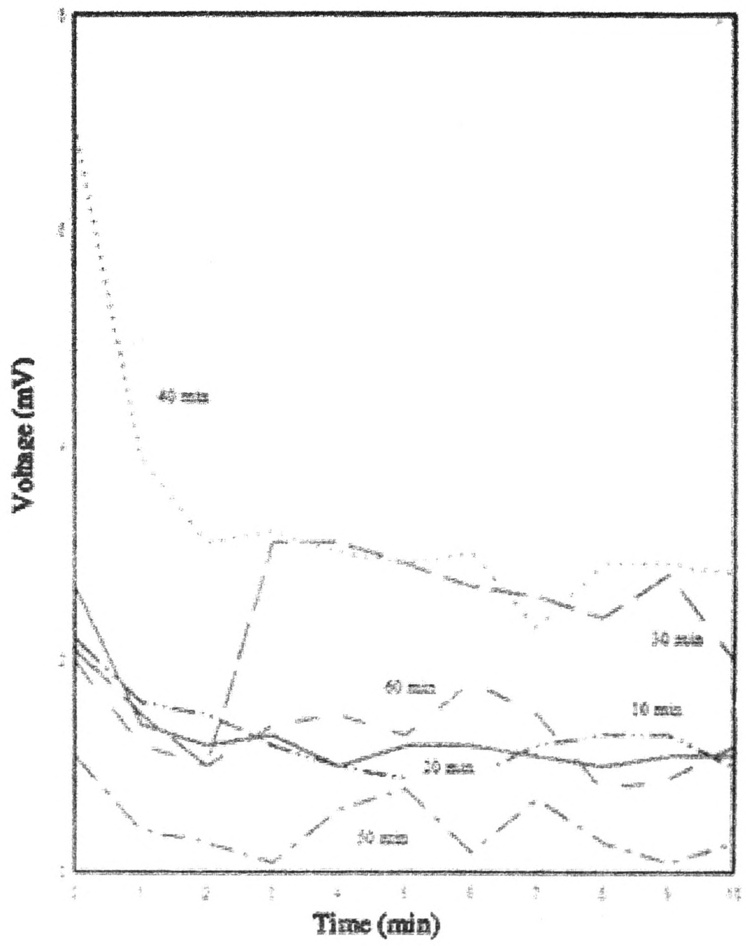

Figure 3: Time (min) vs Voltage (mV)

4. CONCLUSION

The sensitivity of n-type Cu_2O thin films was tested for hydrogen gas in this study. With the results obtained it was found that Cu_2O was sensitive to hydrogen gas. The gas sensitivity is dependent on the grain size, the use of nanocrystalline films, are likely to improve the sensitivity further. The measurements taken using four-point probe system are not 100% accurate because the probe spacing cannot be infinitely reduced due to many factors such as charge transfer and strength of probe material etc. And also there is probe lifetime and sample surface damage. The instability and the nature of the electric connections also imposed limitations in this experiment. By evaporating gold on to the thin film in the form of mesh we can improve connections further in order to increase the sensitivity. Also Most of the gas sensors only work at high temperatures, but n-type Cu_2O thin films were found to be gas sensitive even at the room temperature.

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REFERENCES

[1]. Fernando, C. A. N., De Silva, P. H. C., Wethasinha, S. K., Dharmadasa, I. M., Delsol, T., & Simmonds, M. C. (2002). Investigation of n-type Cu 2 O layers prepared by a low cost chemical method for use in photo-voltaic thin film solar cells. Renewable energy, 26(4), 521-529.

[2]. Ihokura, K., & Watson, J. (1994). *The Stannic Oxide Gas SensorPrinciples and Applications*. CRC press.

[3]. Smits, F. M. (1958). Measurement of sheet resistivities with the four-point probe. Bell System Technical Journal, 37(3), 711-718.