Synthesis Gas Sensor from $CuFe_2O_3$: Cu Films by Spin Coating

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Abstract: - Thin films from $CuFe_2O_3$: Cu were prepared with different weights and then the membranes were prepared using a spin coating method with the rotation speed are (2000,3000,4000,5000) rpm respectively and the rotation time is 7s.. The films were examined as gas sensor against NH_3gas at operating temperatures (200) ^oC, also sensitivity of films for gases increases with decreases temperature. The variation of the operating temperature of the films have led to a significant change in the sensitivity of the sensor. The gas sensor at the operating temperature increasing in recovery time and decreasing in response.

Key-Words: - Thin film, $CuFe_2O_3$: Cu, Operation Temperature, sensitivity, relatively, response, gas sensor, Spin coating.

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1. Introduction

Technological advancements have increased the demand for soft magnetic materials in devices. Among soft magnetic materials, polycrystalline ferrites have attracted special attention due to their good magnetic properties and high resistivity over a wide frequency range from hundreds of hertz to several gigahertz.[1]. Most of the materials of electronic device produced today contain some ferromagnetic spinel ferrite materials. Speaker, motors, electromagnetic interference suppressors, inductors, antenna rods, proximity sensors, broadband transformers, memory devices, recording heads, humidity sensors, filters, radar absorbers, etc. are frequently based on ferrites [2]. Such a seeing helps us to explain why ferrites have been used and studied for several years. The properties of ferrites are being improved because of the increasing way in ferrites technology. It is believed that there is a shiny future for ferrite technology [3]. Ferrites show dielectric properties, that dielectric property means that even though electromagnetic waves can pass during ferrites, they do not easily conduct electricity [4]. This gives them an advantage over iron, nickel and other transition metals that are magnetic in many applications because these metals conduct electricity. Another important factor that is quite important in ferrites and completely irrelevant in metals is porosity [5]. Such a seeing helps us to explain why ferrites have been used and studied for several years. The properties of ferrites are being improved because of the increasing way in ferrites technology. It is believed that there is a shiny future for ferrite technology [6].

2. Experimental

The thin film of $CuFe_2O_3$:Cu was prepared by using spin coating, the rotation speed is (2000,3000,4000,5000,) rpm respectively and the rotation time is 7s.(0.1) gm of, $CuFe_2O_3$ solve in 5 ml of Dimethyl sulfoxide (DMSO). then applied on a glass slide at room temperature. All substrates were washed thoroughly using Distilled water, and then left to Dry out. Interdigitated electrodes

(IDEs) substrate to study Gas Sensor Measurements are carried out by measuring the variation in resistivity resulting from exposing the thin film surface to the gas (NO2).The temperature is recorded by a k-type thermocouple (XB 9208B). The bias voltage was supplied by (FARNELL E350) power supply. The resistivity is recorded by (Fluke Digital Mustimeter 8845A / 8846 A). In this study, un-doped and Cu-doped $CuFe_2O_3$ thin films were coated on glass substrates using low cost and simple spin coating technique to studying the variation of the sensitivity with operating temperature of the films

3. Results and discussion

3.1. Determination of Operation Temperature of the Sensor

Resistive sensors have been used to measure a wide range of physical and chemical properties and can be considered the most familiar and low-cost sensors. The temperature at which the sensitivity of the sensor reaches a constant value is called the operating temperature. The change in resistance is only affected by the presence of certain gases of interest. Changes in resistance are only affected by the presence of certain gases of interest. The changing of resistance is just only influenced by the presence of amount of some gases of interest. Figure (1) Figure(2) shows that sensitivity as a function of operating temperature in the range (150-300)°C fo $CuFe_2O_3$:Cu thin films, which are deposited on FTO substrates at an air mixing ratio the bias voltage of (5) Volt are applied on all the samples[7]., Figure (1) is obvious that the sensitivity of all films increases with increasing of the operating temperature until (200) ºC. This is attributed to increase in the rate of surface reaction of the target gas. The optimal temperature that has maximum values of temperature is (200) ºC for all films. At this temperature the activation energy may be enough to complete the chemical reaction. Also we observed that increases and decrease in the sensitivity indicate the absorption and desorption phenomenon of the gases. These results are in a good agreement with studies conducted by [3].

For NO2,H_2S gas, the sensitivity is observed to increase at operating temperature (200) °C. After (200)°C temperature, the surface would be unable to oxidize the gas so intensively and the NO2 ,H_2Sgas may burn before reaching the surface of the film at higher temperature. Thus, the gas sensitivity decreases with increasing temperature [34], also the increase of the of $CuFe_2O_3$: Cu causes decreasing in the sensitivity of thin film [8]. The sensitivity of all films is shown Table (1) and Table (2).

3.2. Response Time and Recovery Time

It is the time interval over which the resistance of the sensor material attains a fixed percentage (usually 90 %) of final value when the sensor is exposed to the full-scale concentration of the gas. A small value of the response time is highly desirable in application such as detection of flammable or combustible gases to prevent fire [10].Recovery Time It is the time interval above which sensor resistance reduced to (10 %) of the saturation rate when the target gas is switched off and the sensor sited in artificial (or reference) air a sensor should have a small recovery time so that it can be ready for the next detection [10].Figures (3a) (3b) (4 a)(4b) show the relation between the response time and the recovery time with the operating temperature of the Sb2O3 , Sb2O3:In2O3thin films for H2S and NO2 gas and bias voltage 5V. From Table (3) note that the increasing Vol.% of Cu is due to increasing in response time and decreasing in recovery time at optimal temperature (200) ºC The large recovery time would be due to lower operating temperature. At lower temperature O2species is more prominently adsorbed on the surface and thus it is less reactive as compared to other species of oxygen, O- and O- .

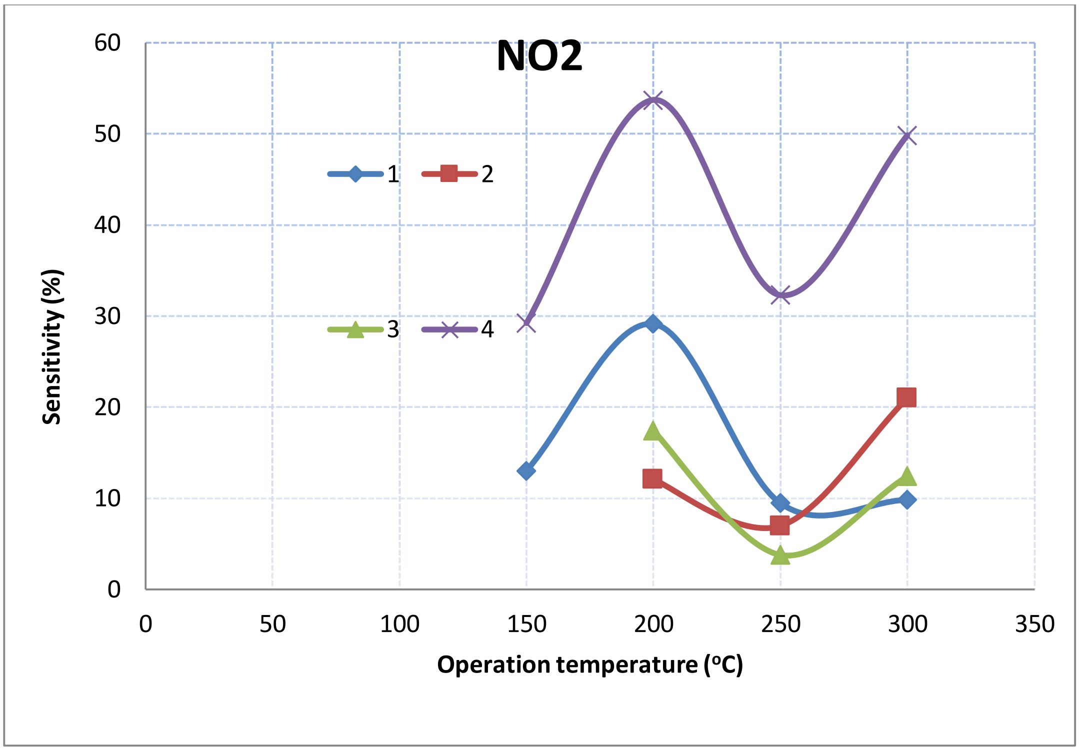

Fig (1): The variation of sensitivity with the operating temperature of the 1- pure $CuFe_2O_3$ 2- $CuFe_2O_{3\ 8\%}$,Cu2 $_{2\%\ wt}$ 3- $CuFe_2O_{3\ 6\%\ wt}$, Cu $_{4\%\ wt}$ 4 $CuFe_2O_{3\ 4\%\ wt}$, $Cu_{2\ 6\%\ wt}$

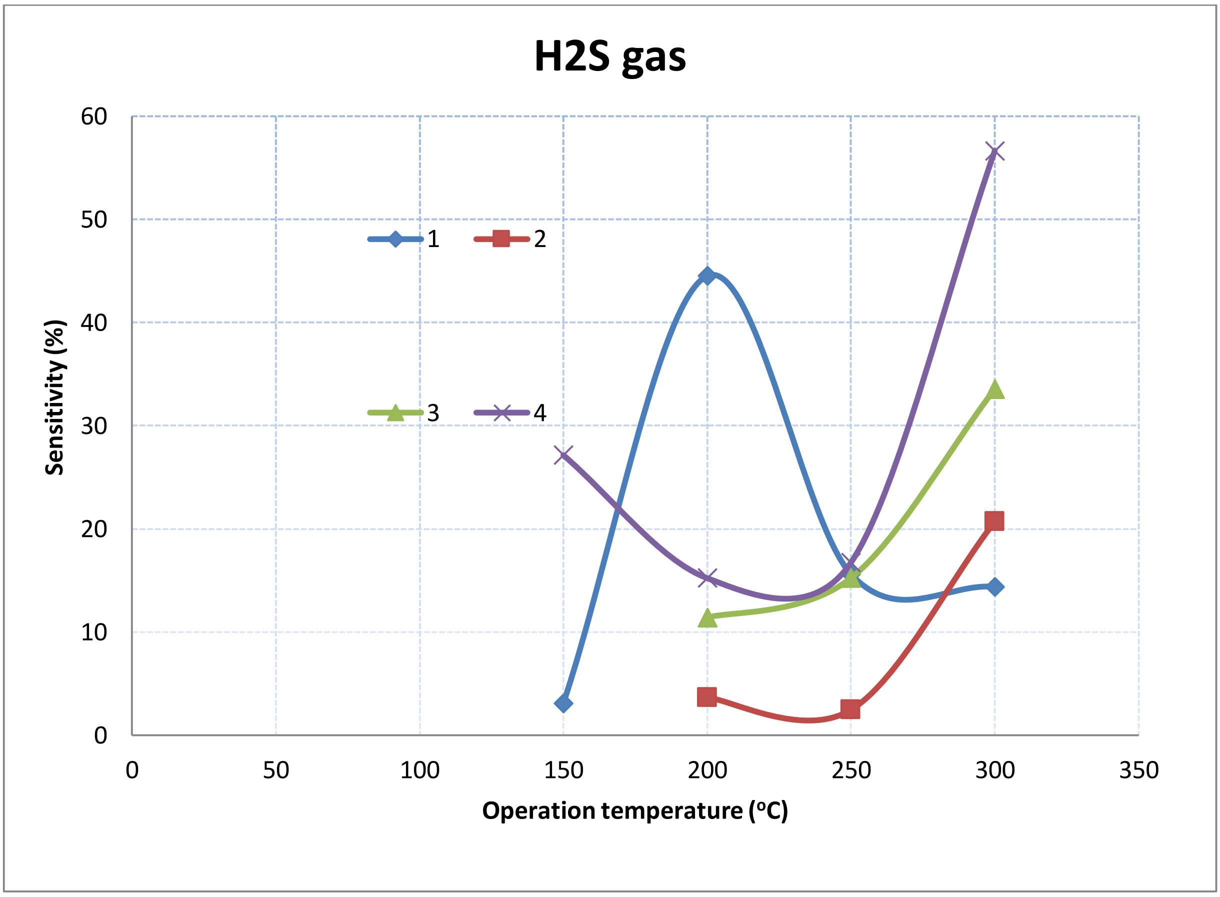

Fig (2): The variation of sensitivity with the operating temperature of the 1- pure $CuFe_2O_3$ 2 $CuFe_2O_3$ 3- $CuFe_2O_{3\ 6\%\ wt}$, Cu $_{4\%\ wt}$ 4 $CuFe_2O_{3\ 4\%\ wt}$, $Cu_{26\%\ wt}$

Table (1): Sensitivity of the $CuFe_2O_3$:Cu thin films with H_2Sgas.

Sample	Sensitivity% at the optimal temperature (200) ^oC
pure $CuFe_2O_3$	27.16049
$CuFe_2O_{38\%}$,Cu2 $_{2\%\ wt}$	15.24086
$CuFe_2O_3$ $_{6\%\ wt}$, Cu $_{4\%\ wt}$	16.75
$CuFe_2O_3$ $_{4\%\ wt}$, $Cu_{26\%\ wt}$	56.65025

Table (2): Sensitivity of the $CuFe_2O_3$:Cu thin films with NO_2gas

Sample	Sensitivity% at the optimal temperature (200) ^oC
pure $CuFe_2O_3$	29.21523
$CuFe_2O_{38\%}$,Cu2 $_{2\%\ wt}$	53.70748
$CuFe_2O_3$ $_{6\%\ wt}$, Cu $_{4\%\ wt}$	32.28261
$CuFe_2O_3$ $_{4\%\ wt}$, $Cu_{26\%\ wt}$	49.83607

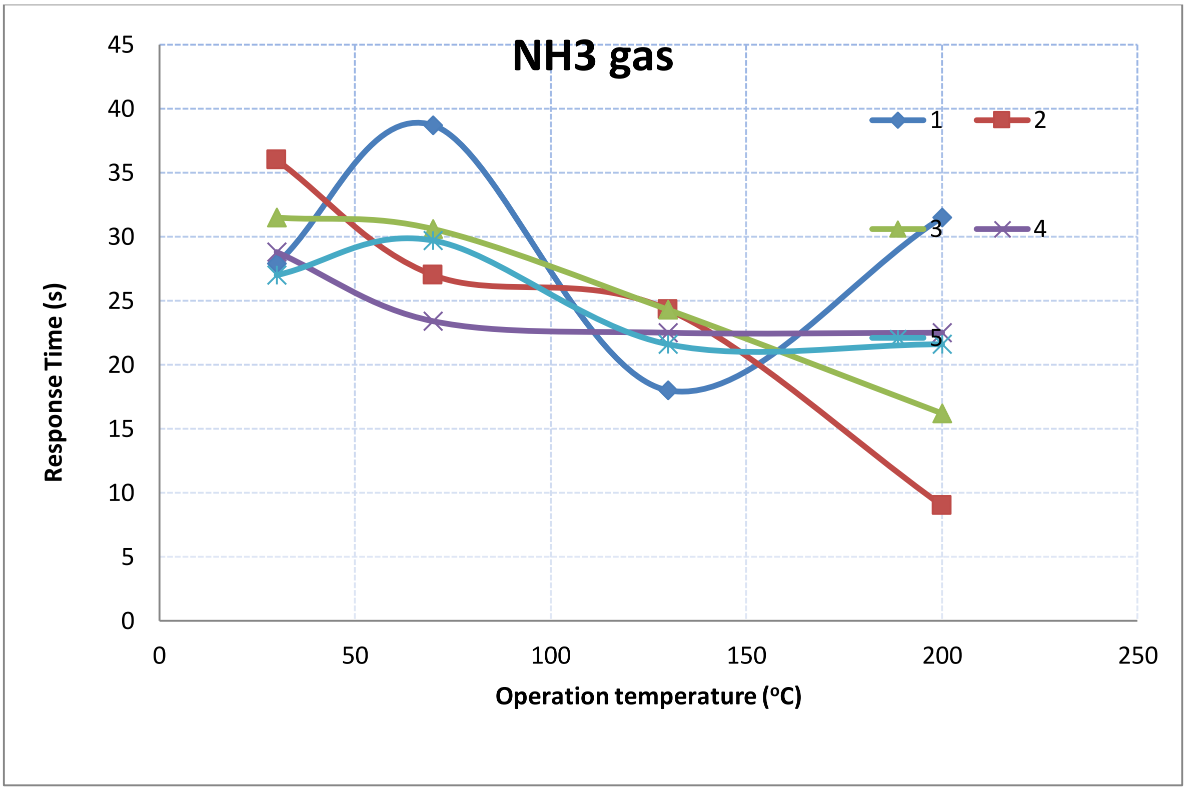

Fig (3a): The variation of response time with operating1- Pure 2- the 1- pure $CuFe_2O_3$ 2 $CuFe_2O_3$ 3- $CuFe_2O_3$ $_{6\%\ wt}$, Cu $_{4\%\ wt}$ 4 $CuFe_2O_3$ $_{4\%\ wt}$, Cu$_{26\%\ wt}$ NH_3gas

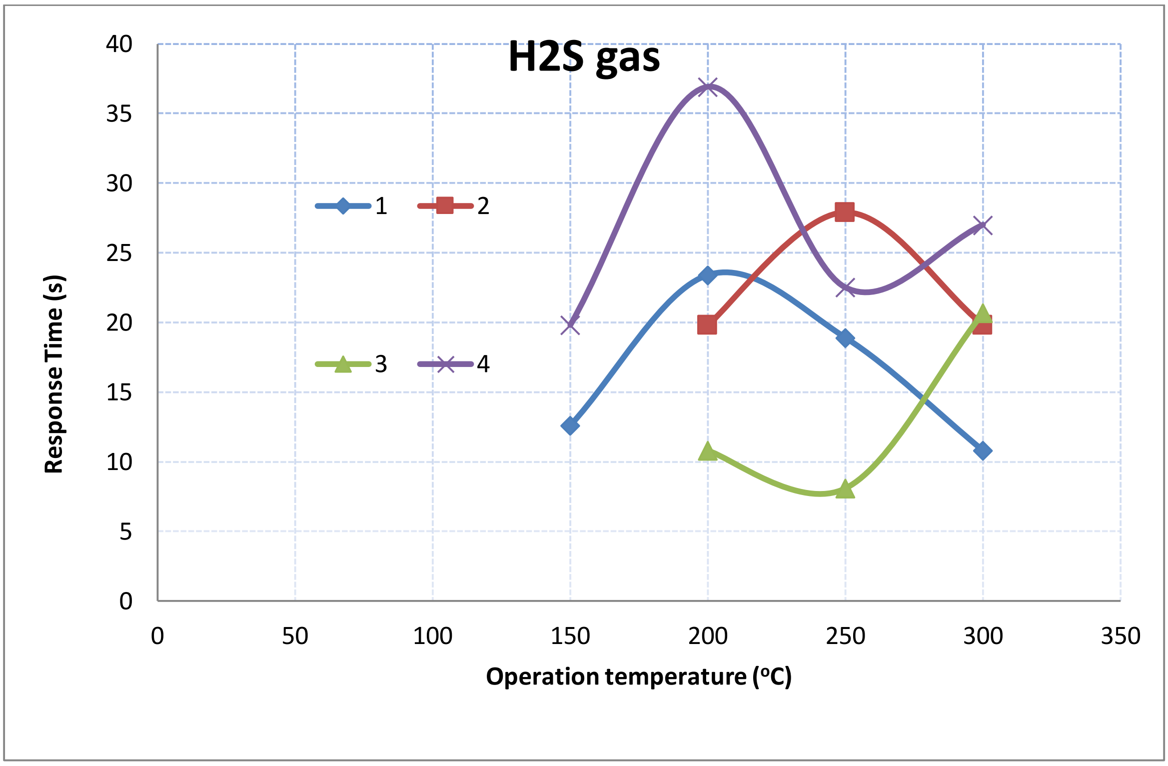

Fig (3b): The variation of response time with operating1- Pure 1- pure $CuFe_2O_3$ 2 $CuFe_2O_3$ 3- $CuFe_2O_3$ $_{6\%\ wt}$, Cu $_{4\%\ wt}$ 4 $CuFe_2O_3$ $_{4\%\ wt}$, Cu$_{26\%\ wt}$ H_2Sgas

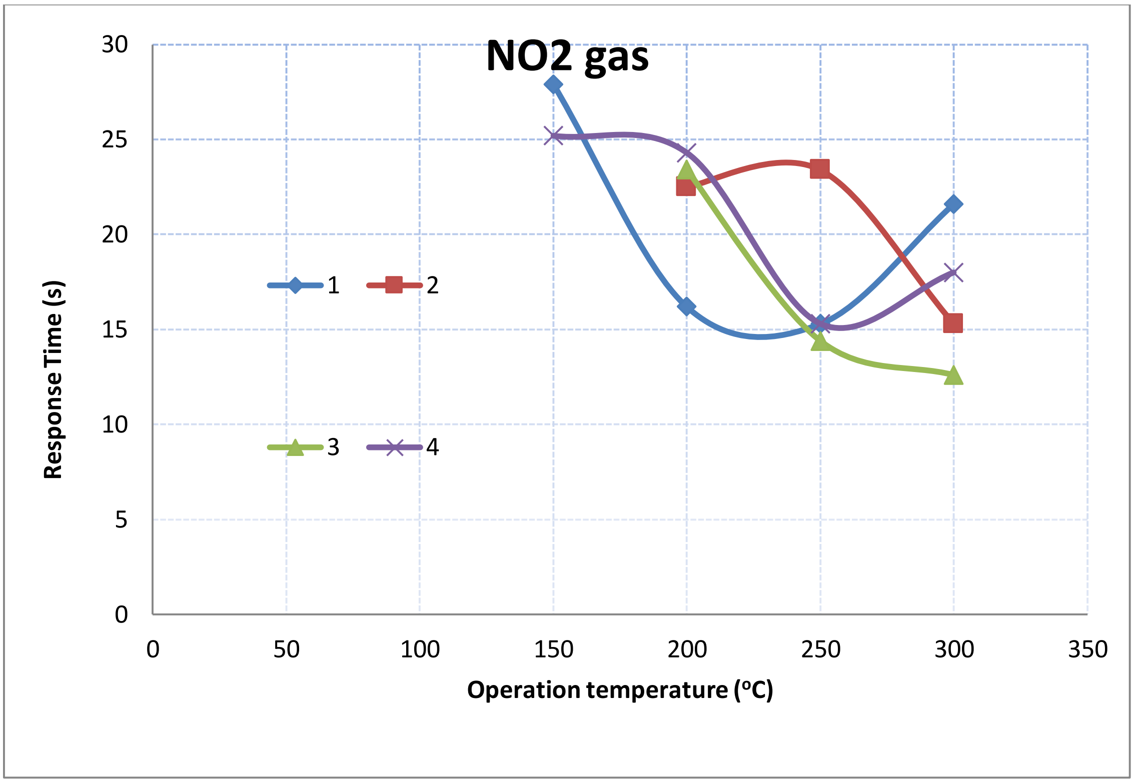

Fig (4a): The variation of Response time with operating1- Pure 1- pure $CuFe_2O_3$ 2 $CuFe_2O_3$ 3- $CuFe_2O_3$ $_{6\%\ wt}$, Cu $_{4\%\ wt}$ 4 $CuFe_2O_3$ $_{4\%\ wt}$, $Cu_{26\%}$ with NO_2gas

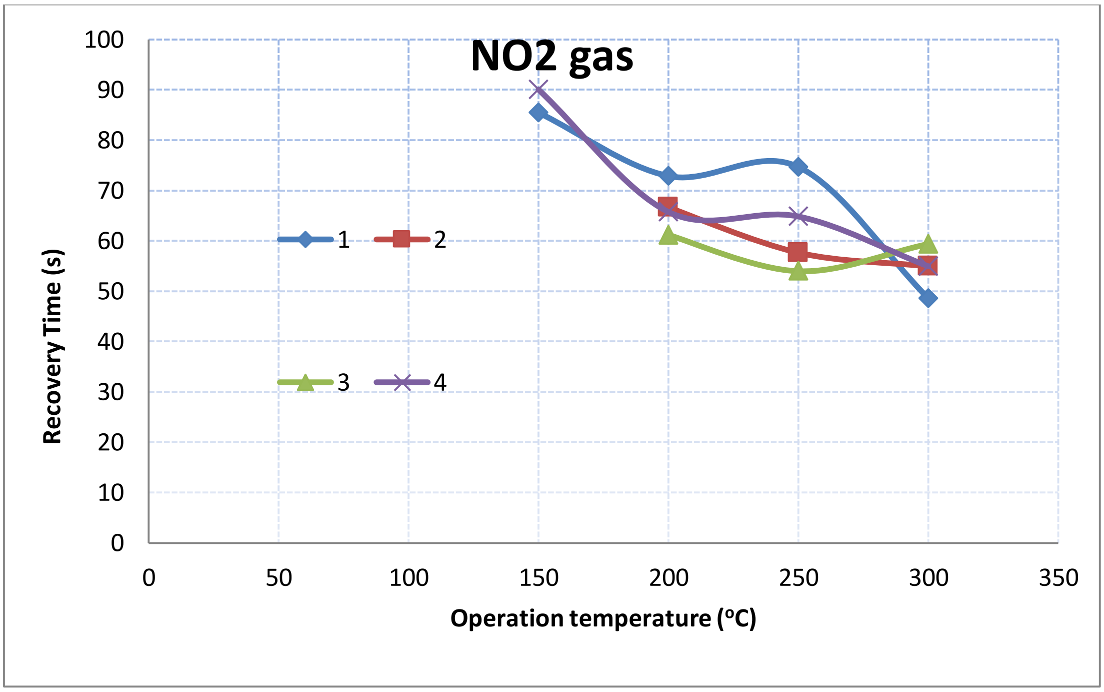

Fig (4b): The variation of response time with operating 1- pure $CuFe_2O_3$ 2- $CuFe_2O_3$ 3- $CuFe_2O_3$ $_{6\%\ wt}$, Cu $_{4\%\ wt}$ 4 $CuFe_2O_3$ $_{4\%\ wt}$, $Cu_{26\%}$ with NO_2gas

Table (3): The response time and the recovery time with the Temp.(ºC) temperature of CuFe2O3:Cu thin films for H2S and NO2 gas

Sample	Response Tim(s) at (200) ºC with H_2Sgas	Recovery Time (s) at (200) ºC with H_2Sgas	Response Tim(s) at (200) ºC NO_2gas	Recovery Time (s) at (2) ºC NO_2gas
pure Sb_2O_3	19.8	94.5	25.2	90
pure $CuFe_2O_3$	36.9	77.4	24.3	65.7
$CuFe_2O_{3\,8\%}$,Cu2 2% wt	22.5	61.2	15.3	64.8
$CuFe_2O_3$ 6% wt , Cu 4% wt	27	83.7	18	54.9

4. Conclusions

The samples is tested for gas NO_2 , H_2S at a temperature range of 150–300 °C. Sensitivity, response time, recovery time and selectivity of samples are studied. The results showed that the $CuFe_2O_3$:Cu thin films produced are a good candidate to be used as a sensor. The sensing measurements show that the films have high sensitivity to these gases and vapors. The best result recorded for sensitivity at 2% Cu Sensitivity reactions of films decrease with increasing of cu %. Increased recovery response time and decreased response time of gas sensor at operating temperature.

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