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STUDYING THE SENSING PROPERTIES OF THIN FILMS TUNGSTEN OXIDE TOWARDS AMMONIA GAS

Annotation: *Three thin films were prepared by thermal deposition technic starting from WO_3 powder with thicknesses (998.7, 1620, 2240nm) respectively on glass substrates under limited thermal and pressure conditions, studied their I-V characteristics and calculated the sensitivity for adsorption NH_3 (full of jar) (The temperature of the films have been changed from 50°C to 350°C). A comparison among them was achieved at 300 ℃ as an operating degree and found that the film which its thickness 1620nm has more sensitivity and has more power to adsorb for NH_3 on it. The comparison between the films which prepared as thin films and those prepared as thick films is reported.*

Keywords: *Tungsten Oxide WO_3, Sensing properties, thin films.*

Аннотация: *Три тонких пленки были получены методом термического осаждения, исходя из порошка WO3 с толщиной (998,7, 1620, 2240 нм) соответственно на стеклянных подложках при ограниченных условиях термического воздействия и давления, изучили их характеристики IV и вычислили чувствительность к адсорбции NH3 (полный сосуд) (Температура пленок была изменена с 50 ° C до 350 ° C). Сравнение между ними было достигнуто при 300 ° C в качестве рабочей степени и обнаружило, что пленка, толщина которой 1620 нм, обладает большей чувствительностью и обладает большей способностью адсорбировать на ней NH 3. Представлено сравнение между пленками, полученными в виде тонких пленок, и пленками, изготовленными как толстые пленки.*

Ключевые слова: *Оксид вольфрама WO3, Сенсорные свойства, тонкие пленки.*

1. Introduction:

Thin film considers the most important invention in twenty century cause we use this technique to prepare and study the materials in micro or even in nano dimensions. By the time thin film get more attention specially in semiconductor in several technical and industrial application like as: solar cells, anti-scratched layer, and sensors.

2. Nano-Technology:

Nanotechnology studies the molecules and compounds with dimensions not more than 100 nanometer as a grain size, nanotechnology gets a huge antecedence as the most cleaned produced technology [1,c. 325].

Gas sensors considers as one of the best output of nanotechnology specially that made from metal oxide [2,c.326] for their properties like: sensitivity, low cost, small size, low limit detection (a few of ppm), stability, in addition that we can make it to detect more than one gas at the same time[3,c.24], so, we find that it is important to study sensors and their sensitive properties for organic vapors which that is very important in many industrial fields[4,c.484].

3. Principal of sensors working:

The principal of sensors working depends on a variation of resistance or electrical conductivity for metal oxide when some of pollutant gas particles affection on it [5,c.2088].

The aim of my research is to prepare thin films of WO_3 by thermal deposition method , and study of its I-V characteristics in air and in present of NH_3 by using KEITHLEY 237, then find which thickness has the best sensitivity to NH_3 for comparison between the thin film which has high sensitivity with the thick film as size particle 72.19nm which has high sensitivity towards NH_3 vapor.

4. Experimental Procedure:

4.1. preparation of thin film by PVD:

Three types of thin films are prepared by PVD (Elltroava, Italy). Table .1 shows the thicknesses and preparation conditions:

Table .1 preparation conditions of thin films (998.7, 1620, 2240 nm)

Substance of the film	Method of deposition	The temperature during process	The pressure in the chamber	The rate of evaporation
WO_3 (powder)	PVD	400°C	5×10^{-4} mbar	32 A°/sec

5. Results and Dissection:

5.1. I-V Characteristics for prepared films:

The I-V characteristics for each prepared film is studied in air and in 100 ppm of NH_3 at different temperature (50-350 °C).

From figures we can calculate the resistance in air and in NH_3 as follows:

Table .2 Resistance for 998.7 nm WO_3 in air and in NH_3 full of jar

T[°C]	50	100	150	200	250	300	350
R_{air}[Ω]	2.71E+05	9.94E+04	3.66E+04	4.32E+04	6.09E+04	5.49E+04	3.29E+04
R_{gas}[Ω]	5.24E+06	7.98E+05	2.62E+05	4.81E+04	4.48E+04	3.59E+04	9.25E+03

Table .3 Resistance for 1620 nm WO_3 in air and in NH_3 full of jar

T[°C]	50	100	150	200	250	300	350
R_{air}[Ω]	5.78E+04	2.77E+04	2.12E+04	4.10E+04	5.89E+04	6.06E+04	3.82E+03
R_{gas}[Ω]	1.41E+05	1.73E+04	8.03E+03	4.61E+03	3.41E+03	3.14E+03	6.20E+02

Table .4 Resistance for 2240 nm WO_3 in air and in NH_3 full of jar

T [°C]	50	100	150	200	250	300	350
R_{air}[Ω]	7.02E+05	7.48E+04	3.04E+04	2.04E+04	2.06E+04	3.38E+04	2.33E+04
R_{gas}[Ω]	2.62E+06	9.67E+04	1.54E+04	3.11E+03	2.40E+03	2.02E+03	2.98E+03

We calculate the Sensitivity for WO_3 thin film towards NH3 from the equation

$$S = \frac{R_{air}}{R_{gas}} \times 100 \qquad [6,c.12]$$

so: R_{air}: Resistance for thin film in air (Ω)

R_{gas}: Resistance for thin film in NH_3 full of jar (Ω)

S: Sensitivity % .

Table .5 Sensitivity for WO_3 thin films by change of temperature

T[°C]	S[%]WO_3(998.7nm)	S[%]WO_3(1620nm)	S[%]WO_3(2240nm)
50	5.17	40.98	26.74
100	12.46	160.25	77.41
150	13.97	264.06	197.04
200	89.88	890.66	653.42
250	136.00	1725.35	860.24
300	152.93	1932.34	1672.03
350	355.69	615.84	781.86

We draw the sensitivity as a function of temperature for three thin films:

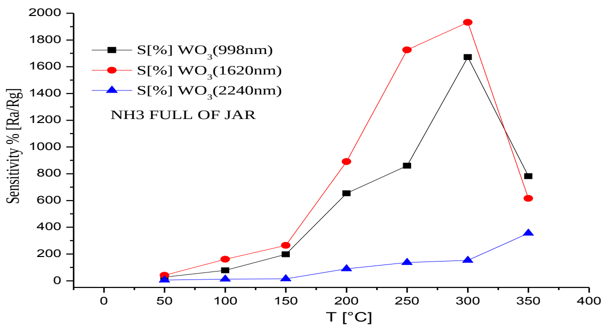

Figure 1. sensitivity as a function of temperature for three thin films of WO_3.

We found that WO_3 thin film with thickness 1620nm has a high sensitivity where the thickness, and the defects play a big role in sensitivity, so we get more defects on the surface at 1620nm and these defects decrease by increasing the thickness to 2240nm [7,c.1326].

5.2. Comparison of the sensitivity of the WO_3 film thickness 1620nm with WO_3 film particle size (72.19nm):

In a previous study [8,c.159] we have prepared thick films of WO_3 nano powders with method chemical painting, the Sensitivity Properties were studied towards NH_3 The results showed that the film with a smaller particle size (72.19nm) is the one who has the greater sensitivity towards NH_3 vapor so it was this compared to the sensitivity of this film with a thin film thickness (1620nm) and the results are shown in Figure 2.

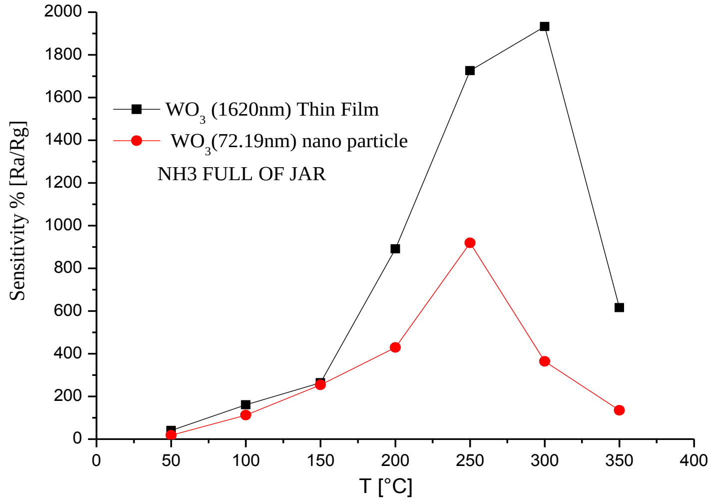

Figure 2. Comparison of the sensitivity between WO_3 thin film 1620nm with WO_3 thick films (72.19nm) as a function of applied degrees of heat.

We note that the sensitivity film WO_3(1620nm) Is the higher sensitivity than film WO_3(72.19nm) This is due to the quality of adhesion between the crystals to each other In the case of a film thickness (1620nm) as well as good adhesion between the film and the substrate, while there is no good adhesion between the crystals In the case of the film of a granular size (72.19nm) as well as there is no good adhesion between the film and the substrate, however, we find that sensitivity of thick film it considered very good after comparing it with the cost of preparation Therefore we can say The primary benefit of chemical painting coating process is the possibility of producing films used in gas sensors with the lowest possible cost and less materialism requirements with the possibility of coating large surfaces of the substrate with relatively easy control process.

6. CONCLUSION:

Three thin films were prepared by thermal deposition method starting from WO_3 powder (998.7, 1620, 2240nm), studied the I-V characteristic and calculated the sensitivity towards NH_3 and in comparison among them at 300 °C as an operating degree we found that film WO_3 (1620nm) has more sensitivity and power to adsorb an NH_3 on it. As well as when we comparison the thin film which thickness 1620nm with thick film which size particle 72.19nm we found that the thin film more sensitivity towards NH_3 from thick film.

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