Design and Fabrication Sensors for Toxic Gases Using PLD

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Abstract

The surface morphology of the deposits, studied by scanning lepton (SEM) and atomic force (AFM) microscopes, has uniform distributions of grains within the films and grains area unit within the Nanocrystalline dimensions AFM analysis evidenced the presence of spherical silver particles on the catalyst surface and provided quantitative surface parameters as form dimension, surface roughness and mean particle diameter. In this work a new approach was manufactured sensors for poison gases (CO, H2) that effects on the quality of life. The sensitivity toward (CO, H2) poison gases has been measured under 10 ppm concentrations. SnO2 doped with 15 % Ag noble metal has a big sensitivity and increase in the sensing current for poison gases (CO, H2). The thermal annealing effect of the sensitivity thin films SnO2 doped with 15 % Ag to the poison gases has been studied.

Key Words: Fabrication Sensors, Toxic Gases, SnO2.

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Introduction

Transparent pure and conductor doped SnO2 skinny films were big by periodical optical maser deposition (PLD) technique (Nd : YAG (λ = 532 nm, τ = 7 ns, ν = ten Hz) on quartz substrates. X-ray diffraction shows that the films area unit crystalline and have the mineral structure. The scale and density of the nano particles determined at the surface depend upon the Temperature of substrate throughout growth

The smallest particles of regarding twenty nm diameter were obtained for the very best Temperature Ts=500 °C. we've got additionally investigated the photoluminescence(PL) emission of the simples made by PLD. The absorption of terribly intense PL emission for the films at temperature Ts= five hundred °C. Tin chemical compound (SnO2), wide used as a very important part for optoelectronic applications [1,2] and gas sensors [3,4] because of its giant gap band and optical transparency, has attracted a lot of attention among chemical science researchers. typically doped with conductor to extend its physical phenomenon [5–7] similarly as chemical science property [8,9], SnO2 displays a wonderful chemical science performance to most organic pollutants [8,10–11] compared with different oxides like RuO2 and IrO2. Typical SnO2-based conductor is ready by thermal depositionof a skinny layer of metal chemical compounds on a base metal or In-dopedtin oxide (ITO). Metal chemical compound gas sensors area unit the foremost commercial sort of gas sensors [1,2]. Notwithstanding these sensors still area unit studied intensively.

The studies tend chiefly to outline the mechanism of the resistance response to gas in metal oxides [12]. The analysis and development of theoretical models area unit expected to resolve the issues connected with sensible applications. First, models tried recover the fundamental limits of the solid-state gas sensors [13]. These limits area unit determined by the basic options of the gas sensing mechanism.

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It is tried by basic studies that universal metal chemical compound gas sensors couldn't be developed for any conditions of applications. On the opposite hand, thorough investigations of the sensing mechanism oftentimes reveal new potentialities to switch the metal chemical compound sensors. Consequently the parameters of the sensors might be improved for AN application in sure circumstances in essentially known close of gases [14,15]. periodic optical device deposition (PLD) is taken into account as a versatile technique for getting well outlined nanostructures and surface morphologies [16]. Doping is one among the foremost effective ways for AN improvement of sensitivity and property of metal chemical compound gas sensors [17–18]. numerous gold-bearing dopants were tried for these functions. Typically the doping technique relies on the choice of the foremost effective catalyst that modifies some specific chemical action on the surface of the solid state gas sensing element.

Experimental Work

The Ag-doped targets for PLD were ready by the standard solid state powders method. Fine powders of high purity (>99.9%).SnO2 ,Ag with completely different ratios square measure weighed and mixed. the powders were ground in Associate in Nursing calcedony ball shaping machine for thirty min to induce homogeneous mixtures. The deposition was distributed employing a letter switched Nd: YAG optical maser with a frequency second radiation at 532nm (pulse dimension 7nsec repetition rate one0HZ) and fluencies energy 1 J/cm.

The chamber was unbroken at vacuum pressure of 10-6 millimeter of mercury victimization the condensation pump. The SnO2 target was ablated from ten to one hundred pulses (10–20 min) to induce single layer skinny films. The studied films were ready by from pure SnO2 and I Chronicles , a pair of Associate in Nursingd 15 August 1945 Ag-doped SnO2 targets films were mature by periodic optical maser deposition on Associate in Nursing optically Flat quartz substrates unbroken an on-axis distance of 4cm from the SnO2 target. As shown in Fig. (1). throughout the deposition the substrate temperatures (Ts) were unbroken at five hundred °C. XRD measurements (Philips PW 1050, λ=1.54) measurements victimization conductor k Shows crystalline structure of the films. Optical absorption spectra of all the films were recorded employing a UV-ViS (Perkin Elemer Company) photometer, within the spectral vary of (200-900)nm. Transmission measurements were performed for a variety 400-900nm victimization UV-VIS-PV-8800 (Perkin Elemer Company) photometer.

The characterizations enclosed determination of the coefficient as a perform of incident gauge boson energy, determination the worth energy gap. The surface morphology was examined by scanning research|microscopy} (SEM–JEOL 7000) and by atomic force microscopy (AFM-Digital Instruments NanoScope) operating in sound mode. Typical film thickness was two hundred nm, as measured by Laser (He_Ne). Photoluminescence is that the optical emission obtained by gauge boson excitation (used laser) victimization the Luminescence LS fifty five device equipped with American state Win science lab software package. The measurements of gas sensing were distributed by activity the output current ensuing from exposing the film surface to the CO & H2 unhealthful gas. A Hewlett-EDUARD COMPANY Systems three hundred Series I RW was used as shown in figure(8). Finally, we have a tendency to tempering the 15 August 1945 Ag-doped SnO2 skinny films in air at completely different temperatures (400, 500) °C for thirty five minutes.

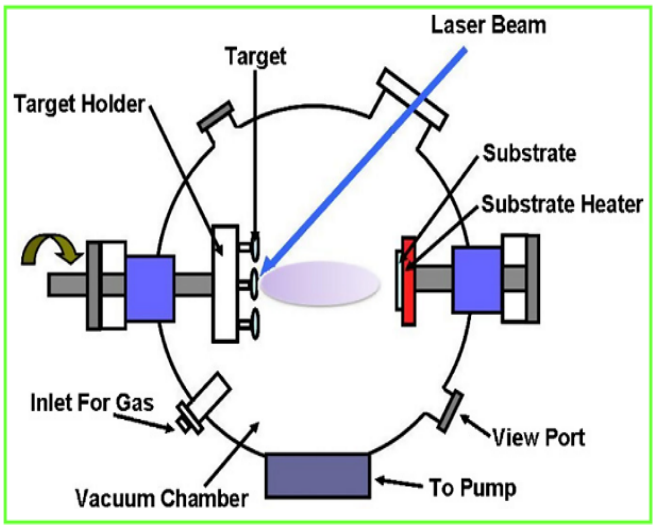


Fig. 1. Schematic diagram of pulsed laser deposition system

Result and Discussion

Fig (2. a, b) presents the XRD patterns of SnO2 pure and SnO2 doped 15 % Ag nano-particles thin

films, of 200 nm thickness. Three different peaks could be recognized in figure (2.a), these are (101), (110), (200) at 2θ (26.7°) and (34.3°) and (37.6°) respectively agreement with ref.[9] which related to the formation of SnO2 thin film Figure (2.b) present the main components of Ag could be identified by as labeled. However Ag dopant XRD peaks could be seen clearly in (2θ=25.8°).

In order to see the worth of energy gap still because the dominant absorption processes in such material, the relation of (αhν)2 with the incident gauge boson energy (hν) is explained in Fig. (3). The obtained price of energy gap is concerning three. 6 energy unit and it's terribly near to the worth obtained by previous works [9, 10].

The relation was linear, that indicates that the TiO2 of this work has direct energy gap. and therefore the direct allowed absorption processes ar the dominant. the energy gap decreases with will increase concentration of silver impurties. And some remains constant at silver dopant 15 August 1945. The energy gap reached at two. 5eV. The coefficient (α) of such processes is given by [11, 12]:

$$\alpha = A(h\nu - E_g)^n. \quad (1)$$

"where α is absorption coefficient and n =1/2 for direct transition where A is a parameter independent of hע and Eg is the optical band gap energy" the optical absorption coefficients (α) increase with increasing Ag dopant the value of absorption coefficient for SnO2 Pure (38 *10^3 cm^{-1}) at hע=4 eV while at SnO2 dopant 15% Ag absorption coefficient =(97 *10^3 cm^{-1}) at hע=4 eV as seen in fig (4) .fig.(5) depicted the gorse morphology of the nano-porous SnO2 layer before and after doped with Ag with laser irradiation with 300 shots.

There is a good result between the surface roughness values obtained by AFM for all the films surface roughness increase when we doped Ag.

The increasing from 26 nm to 38 nm Although the samples are very smooth with RMS values lower than 30nm (Fig. 5 a,b) they present a super-hydrophobicity. relaxation of anatase lattice and consequently by the increase of the crystallite's size of the SnO2 film when we doping with (15% Ag) from (20-45 nm). Pure SnO2 and Ag-doped 15% SnO2 films thermally treated at 500°C. The scanning electron (SEM) micrographs of the Ag 15 % doped SnO2 sample are presented in Fig. (6) It is seen in figures that the microstructure has the certain type grains and also the voids take place between the grains. It is also found that the Ag atoms are diffused into the SnO2 grains.

The s‖ize o‖f th‖e gro‖wth par‖ticles var‖y i‖n th‖e rang‖e o‖f 20-40 nm whe‖n fluencies o‖f 1J/cm^2 are used. Photoluminescence (PL) of Ag doped SnO2 thin film have been recorded at temperature (500°C) with an excitation wavelength of 330 nm. Higher energy (shorter wavelength) excitation photons cause more phonons to be emitted before.

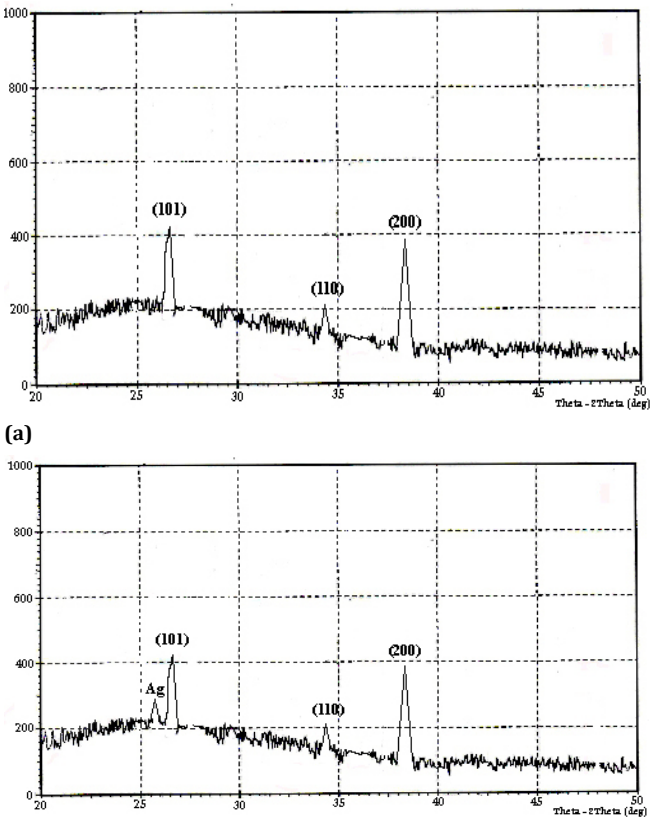


Fig. 2. XRD pattern (a) of SnO2 pure thin film deposited at vacuum =10^{-6}mbar (b) SnO_2: 15 % Ag thin film deposited at vacuum =10^{-6}mbar

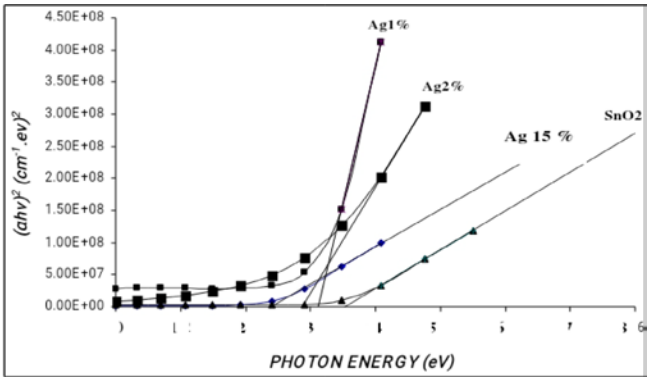
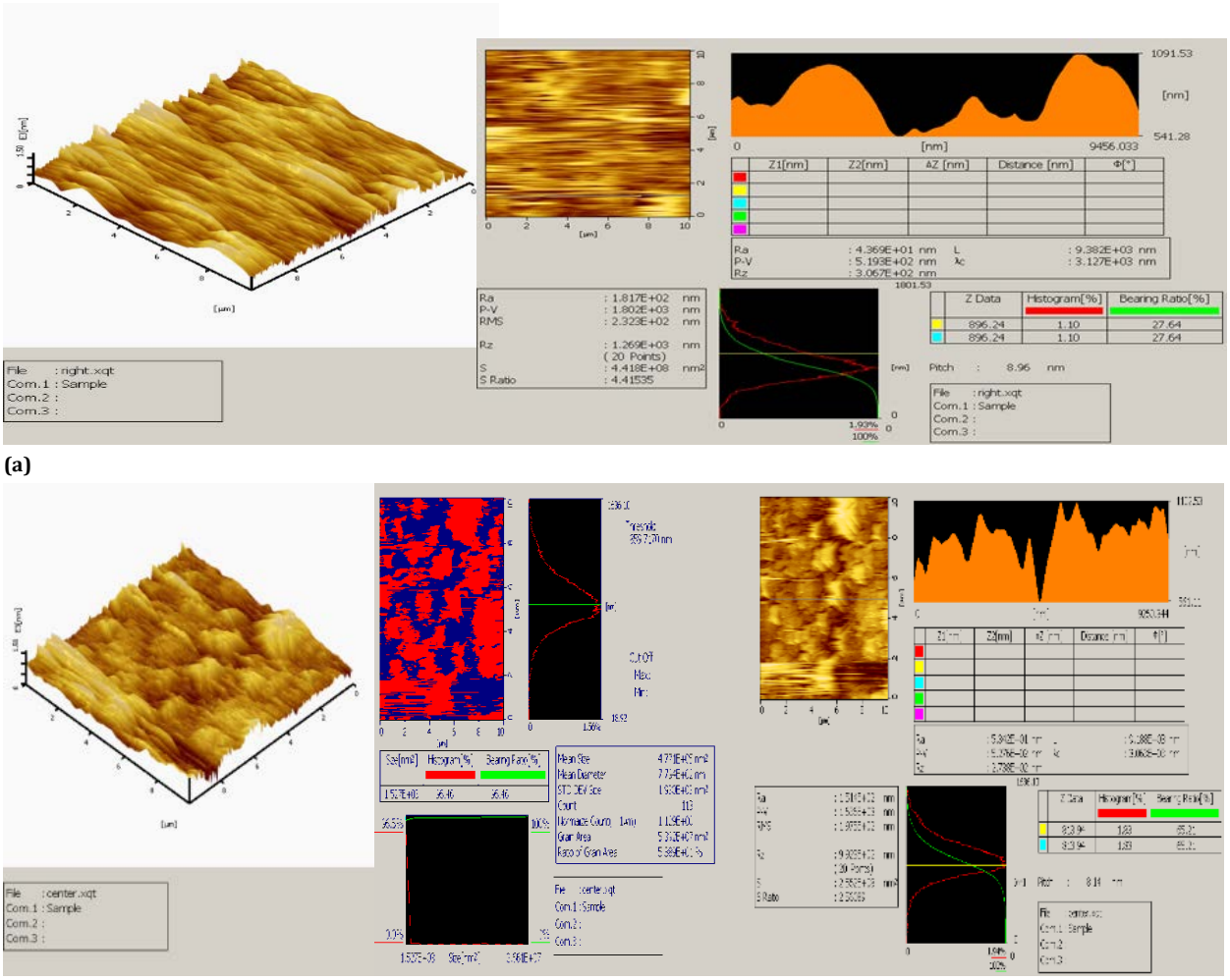


Fig. 3. Energy gap of the SnO_2 Pure and dopant with Ag impurities (1%), (2%), (15%) at Ts (500 °C).



(a)

(b)

Fig. 5. AFM images of(a) pure SnO2 and (b) Ag-doped SnO2 15% both films thermally treated at 50‖0 ˚C, measured over an 10_10 nm² area; root-mean-square (RMS) deviation: 1.18, 6.40 and 5.29 nm, respectively.

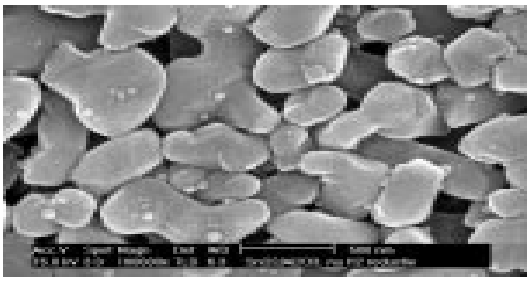


Fig. 6. SEM micrographs of the SnO2: Ag 15%

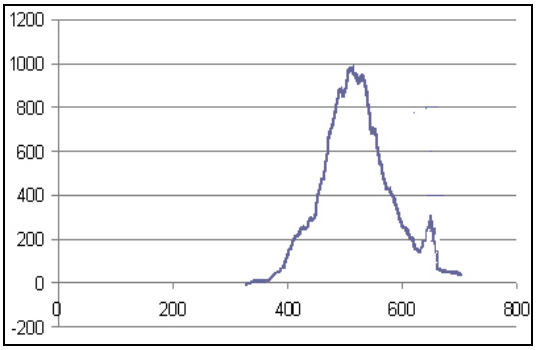


Fig. 7. Photoluminescence spectrum (PL) of SnO2 doping with 15% Ag thin film prepared at 50

Gases Sensitivity Measurements

The shown system in Figure (8) has been used to measure prepared SnO_2:15 % Ag thin films sensitivity for the (CO, H_2) measured under 10 ppm concentrations. After connecting the deposited aluminum electrodes on the SnO_2: 15 % Ag thin films with wires and the sample was fixed on a base inside a chamber. The working gases were pumped in to the chamber and recording the change in thin films resistance with time (per 10 seconds) and measure the current corresponding to the voltage in absence and presence of the gases to determine the impact of them on SnO_2: 15 % Ag thin films: We calculate the sensitivity(S) from as the following equation [2]:

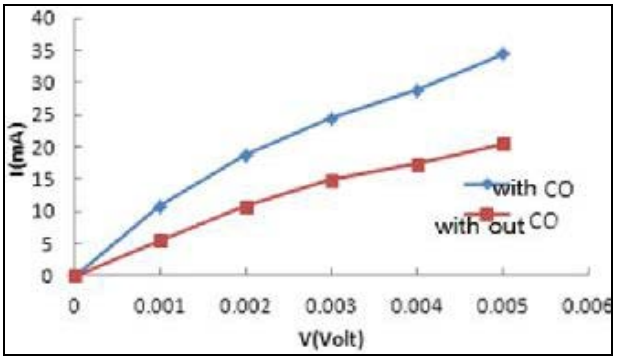
S = (Rg – Ra) / Ra× 100 %.....(2), where,

Rg: Electric resistance of the thin film in presence of gas

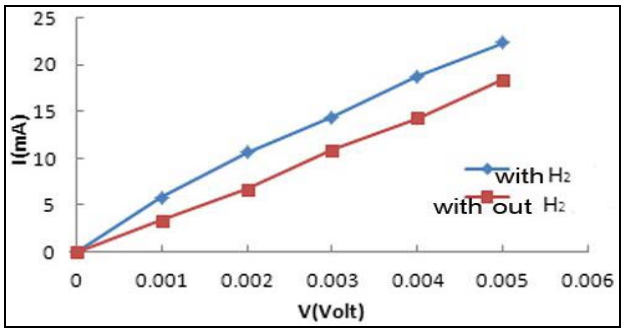
Ra: Electric resistance of the thin film in absence of gas

Fig. 8. Gas Sensing measurement 1- Rotary pump vacuum bellow 2- conductivity tubes 3- vacuum head 4-reader of pressure 5- system chamber a- electrical feed through and pump gas b- Glass window c- Lead throw 6- DC . Power supply 7- multi meter 8- metal base.

SnO_2:15 % Ag thin films suffer from the height of potential barrier in the reducer by using H_2 gas closed to 10 ppm; where ions (charge carriers) required a substantial amount of energy to cross that barrier, that means decrease conductivity, as well as a decrease in potential barrier in the oxidizing gas such as CO and CO_2 because of the adsorption of oxygen andthe formation of pair (hole - electron) that increase the conductivity. The voltage- current properties of the SnO_2: 15 % Ag thin films in absence and presence of CO gas, are show in Figure (9: a and b) where the curve is linear at room temperature. This manner depends on each of the gas and the used semiconductor type. If the gas was an oxidizing factor such as CO, the current value through the gas occurrence is greater than it in gas absence because the ions move from the material having a lower tendency to grab electrons, this material is called a reductive factor to the material having a higher tendency to CO and it's also called the oxidizing factor. The first gas effect is oxidized and the second is reduced, as shown in Fig (10: a and b). The resistance changes (increase or decrease) to change in gas atmosphere as shown in table (1).



(a)

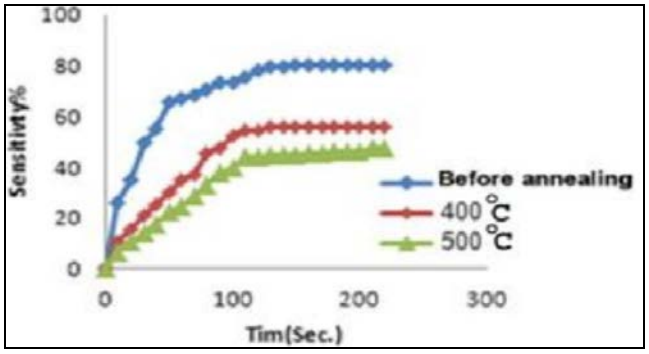


(b)

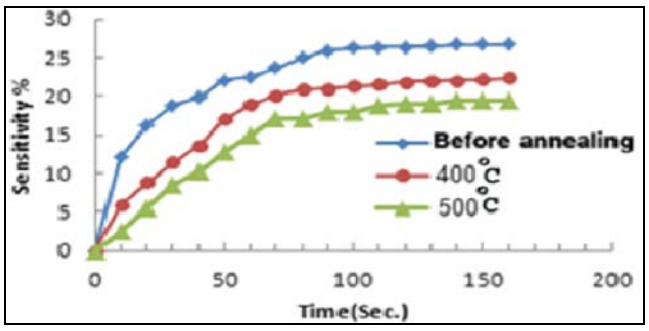
Fig. 9. The voltage current characterizes (a) characterties in the absence and presence of CO after and before annealing (b) in the absence and presence of H2 after and before annealing.

Table 1. The resistance changes (increase or decrease) to Change in gas atmosphere [6].

Classification	Oxidising Gases	Reducing Gases
p-type	Resistance decrease	Resistance increase
n-type	Resistance increase	Resistance decrease



(a)



(b)

Fig. 10. SnO_2 15%Ag thin film sensitivity (a) CO gas after and before an Annealing (b) H2 gas after and before annealing

Conclusion

"SnO2 skinny films as they're ready victimization the PLD methodology, the structural of the films were analysis shows the film has poly crystalline structure embrace mineral phases. The energy band gap was found three. 6 work unit for pure SnO2. The surfers' morphology of the fabric

deposited was ascertained by SEM and AFM. The films feature a extremely homogenised nonfunctional morphology with grain size of little as twenty nm. he prepared Ag 15 % doped SnO_2 thin films had used to detect low ppm of the gases in the atmosphere, which depend on the detection mechanism concept of the process of gases adsorption on the semiconductor oxide surface based on the defects size presence and a crystalline structure of a thin film, where oxygen atoms appear in the ions O_2 form on the thin film surface, that work to form the depletion layer and the barrier potential growth at the granular borders and it also represents a source of gas molecule shunting which are adsorbed on the surface."

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