VOL. 12, NO. 23, DECEMBER2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

LASER INDUCED FORWARD TRANSFER OF In_2O_3:ZnO: AU NANOCOMPOSITE THIN FILM FOR GAS SENSITIVITY APPLICATION

A. Kadhim[1], Farah T. M. Noori[2] and N. D. Hamza[1]
[1]Department of Laser and Optoelectronic Engineering., University of Technology, Baghdad, Iraq
[2]Department of Physics, College of Science, University of Baghdad, Baghdad, Iraq
E-Mail: abdulhadikadhim5@gmail.com

ABSTRACT

Indium Oxide(In_2O_3) and Zinc Oxide (ZnO) nanoparticles were mixed carefully with gold nanoparticles which was synthesis by turkevich method with particles size ranged of (73.74 nm).Different concentration from these chemical compounds were used to preformed nanocomposite thin films of thickness of (250-300) nm by using spray pyrolysis method. The morphlogical properties were studied for all nanocomposite thin film samples with different concentrations. SEM results showed that all characteristics of samples in the nano scale. This work has been extended to study the FTIR properties, which included the transmission spectrum for all samples, the result showed two main broad metal oxygen bands. Finally the measurements of the gas sensor showed that the sensitivity increased when the gold nanoparticles concentration increasing.

Keywords: laser induced forward , In_2O_3:ZnOnanocomposite , Gas sensitivity.

INTRODUCTION

Laser Induced Forward Transfer (LIFT) is a laser technique, capable of conveying different materials with different sizes to one or more than of substrates. LIFT used pulses of laser to transmit little amounts of material from a donor film to an acceptor substrate [1]. The receiving substrate is set parallel and front on to the donor material. The distance between the substrate and the donor film is ranging from near contact to a few micrometers[2].Pulses of the laser are absorbed by the giver film, above threshold energy of the laser that incident, the material is ejected from the film toward the acceptor substrate[3]. A pattern of the propagated material can be "written" on the substrate with multiple shots by separating the substrate and the thin film with respect to the laser beam [4]. In the present work an attempt was being made to synthesis LIFT technique on In_2O_3:ZnO: Au thin films with different concentrations.

MATERIALS AND METHODS

Raw materials

The raw materials include the following compounds:

Indium Oxide nanoparticles (In_2O_3) of purity of 99.999 and particle size ranged of (82.07nm), Zinc Oxide nanoparticle(ZnO)of purity of 99.999 and particle size ranged of (53.63nm), Gold nanoparticles of purity of 99.999 and particle size ranged of (73.74nm). All compounds were supplied from fluka company swiss product. Propanol solution ($CH_3.CH_2.CH_2OH$) of purity of 99.999 and double distilled deionized water.

EXPERIMENTAL DETAILS

Preparation of Au nanoparticles

Gold nanoparticle prepared by turkvich method [5,6]. 50ml from colloidal Chloroauric acid ($HAuCl_4$) was prepared. we added 0.15ml from of Chloroauric acid solution (stock solution) to the 49.85ml of distilled water. Then the solution was heated at 100°C on hot plate without stirring till the solution starts an evaporation, stir the solution by magnetic bar and then add 0.5ml from 1% Trisodium citrate dihydrate ($Na_3C_6H_5O_7$) solution (stock solution) at once and keep heating it until the color turned to wine red. The Gold nanoparticles solution cooled at room temperature and then wash the solution by centrifuge device for three times at 13000 rpm.

Sample preparation

($In_2O_3$and ZnO) nanoparticles was dissolved in propanol solution for one hour by using ultrasonic technique, the Au nanoparticle was prepared.

Thin film preparation

In_2O_3: ZnO: Au thin films with different concentrations a, b, c, d, e and f where (a=5:5:0, b=5:4:1,c=5:3:2,d=5:2:3,e=5:4:1andf=5:0:5) were prepared by spray pyrolysis and also the influence of substitution of ZnO and Au in In_2O_3 on structural and optical properties are investigated. The mixture of nanoparticles for different concentrations was placed in ultrasonic device for one hour. Thin films deposited by spray pyrolysis method on glass substrates placed on hot plate at 250 ^{0}C then all samples entered the furnace at 400 ^{0}C for one hour.

LIFT preparation

All samples applied to the LIFT technique, the pulses of laser is focused on the back side of the donor

film and propel a tiny part of the donor film forward, causing the deposition of the transferred material on the substrate.

RESULTS AND DISCUSSIONS

Scanning Electron Microscopy (SEM)

Figure-1(A, B and C) shows the SEM micrograph images for (In_2O_3:ZnO:Au) nanocomposite thin film with different concentrations (5:5:0,5:2:3,5:0:5) respectively. The SEM image show that the samples are not closely packed and consist of several grains. The gold additions showed no major effect on the surface morphology of the films.

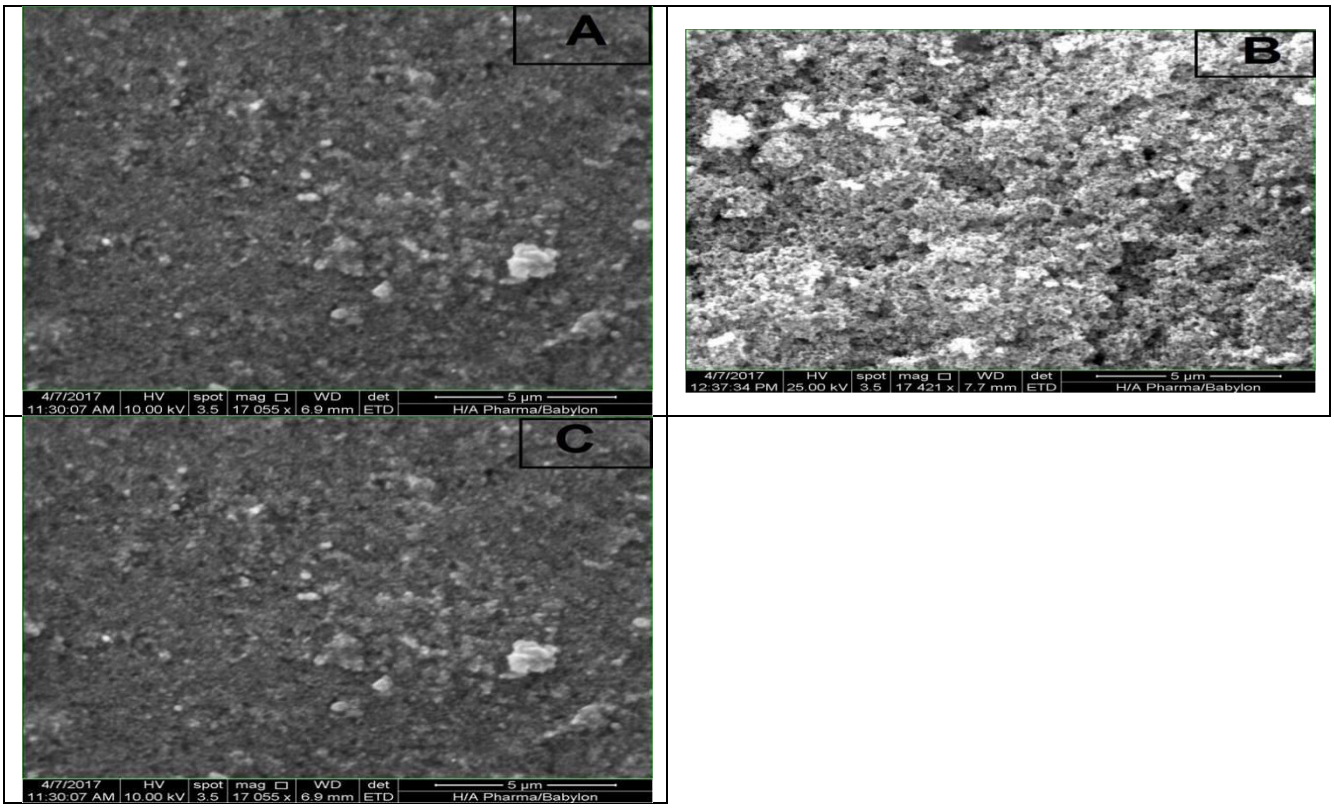

Figure-1. SEM images of (A) the concentration 5:5:0, (B) the concentration 5:2:3 and (C) the concentration 5:0:5.

Fourier Transform Infrared Radiation (FTIR)

Figure-2 show the FTIR spectra of (In_2O_3:ZnO:Au) nanocomposite thin film for the concentrations 5:5:0, 5:2:3 and 5:0:5 in 400 to 4000cm^{-1}range. The figures show that the bands around 3415 and 1621cm^{-1}are due to stretching vibration of the O-Hof the free or absorbed water. The (C=O) stretching vibration band of the C-O group was observed around 1390 cm^{-1} [7]. FTIR spectra showed two main broad metal oxygen bands. As can be seen in FTIR spectra a main absorption peak around υ1 was detected around500 cm^{-1},which corresponds to intrinsic stretching vibrations of the metal ion at the tetrahedral site, (M tetra−O; In-O) [8].While the weakest band, that observed aroundv2 was detected in the range of 507-545 cm^{-1}is allocated to octahedral metal stretching vibration (M octa−O; ZnO+↔O) [9].From the Figure-2 one can notice that a difference in the peak positions of ν1 and ν2 absorptions bands which may be due to change of bond length with increase in gold.

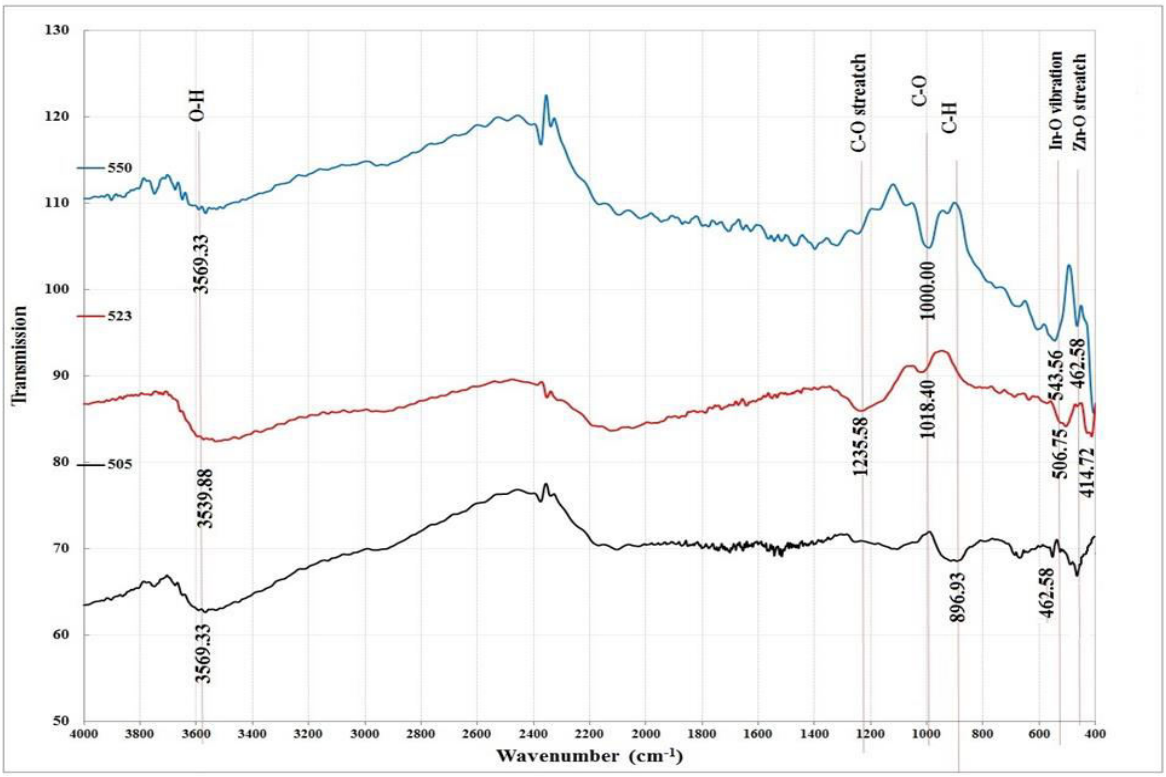

Figure-2. FTIR spectra of (In_2O_3:ZnO:Au)for the concentrations 5:5:0, 5:2:3 and 5:0:5.

Gas sensor

Figure-3 shows the sensitivity as a function of operating temperatures in the range of 30-200°C for (In_2O_3:ZnO:Au) thin film with different gold nanoparticls concentrations, The maximum sensitivity may be caused by the optimum surfaces roughness, large surface area and large rate of oxidation. The level of sensitivity increases as gold increases. In_2O_3: ZnO: Au nanocomposite thin film gas sensing material provides better sensitivity compared to In_2O_3, because of the distribution of Au_2O_3nanoparticles in the boundaries of grain of then anocrystalline($In_2O_3$and ZnO) and the formation of p–n heterojunction. The response time and recovery time variation with doping ratio of the gold at perfect working temperature are shown in Figure-3. The speed of response is studied at the temperature of sensor provided a maximum sensitivity. It is noticed that a (50%) nanoparticles of gold heavy impurities amount is the better doping rate to obtain fast response sensor. The fast response sensors for NO21 gas may be because quicker oxidation of the gas, these results agrees with references [10, 11].

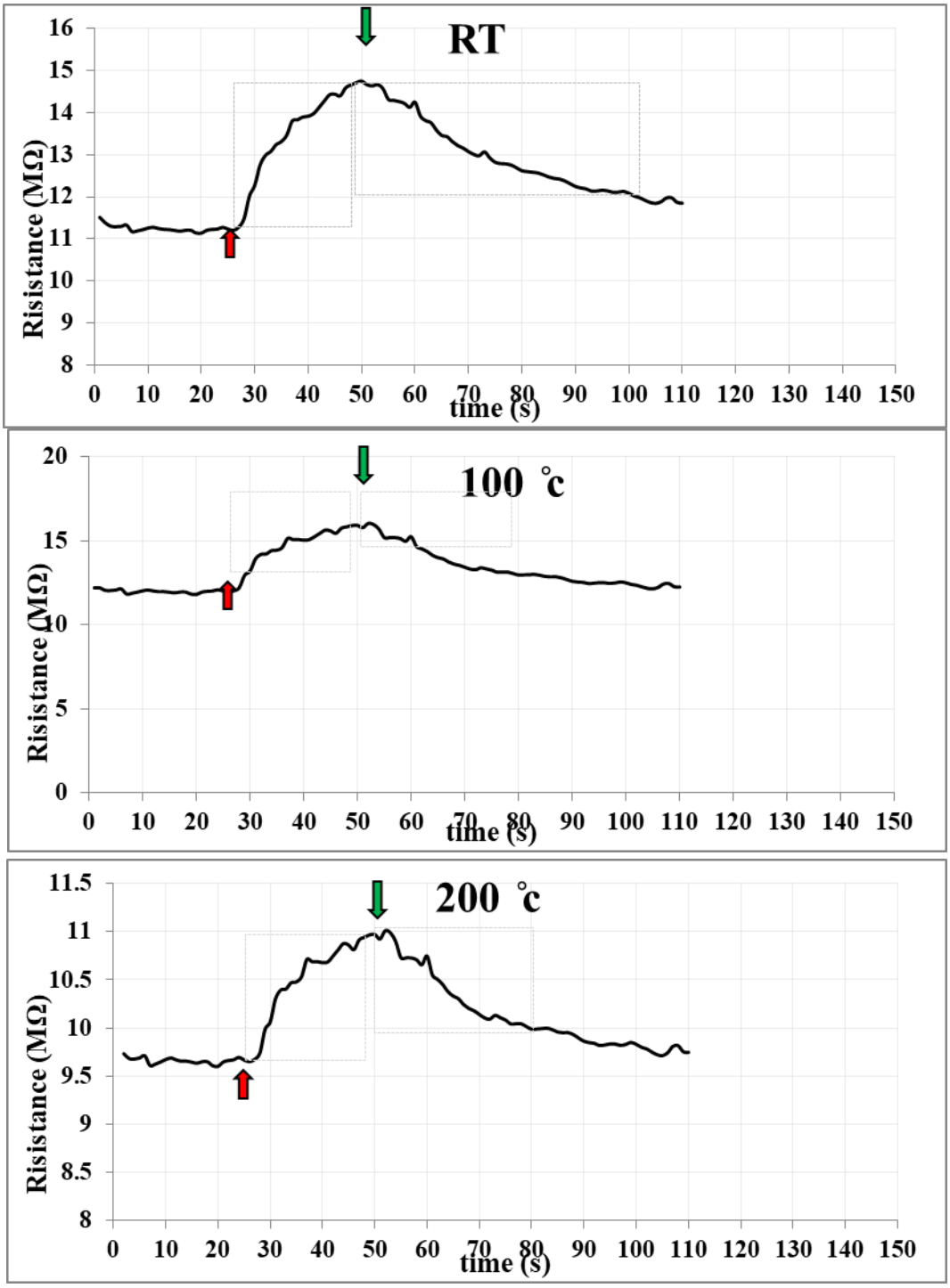

Figure-3. The change of sensitivity with the operating temperature, the variation of response time and recovery time for pure In_2O_3.

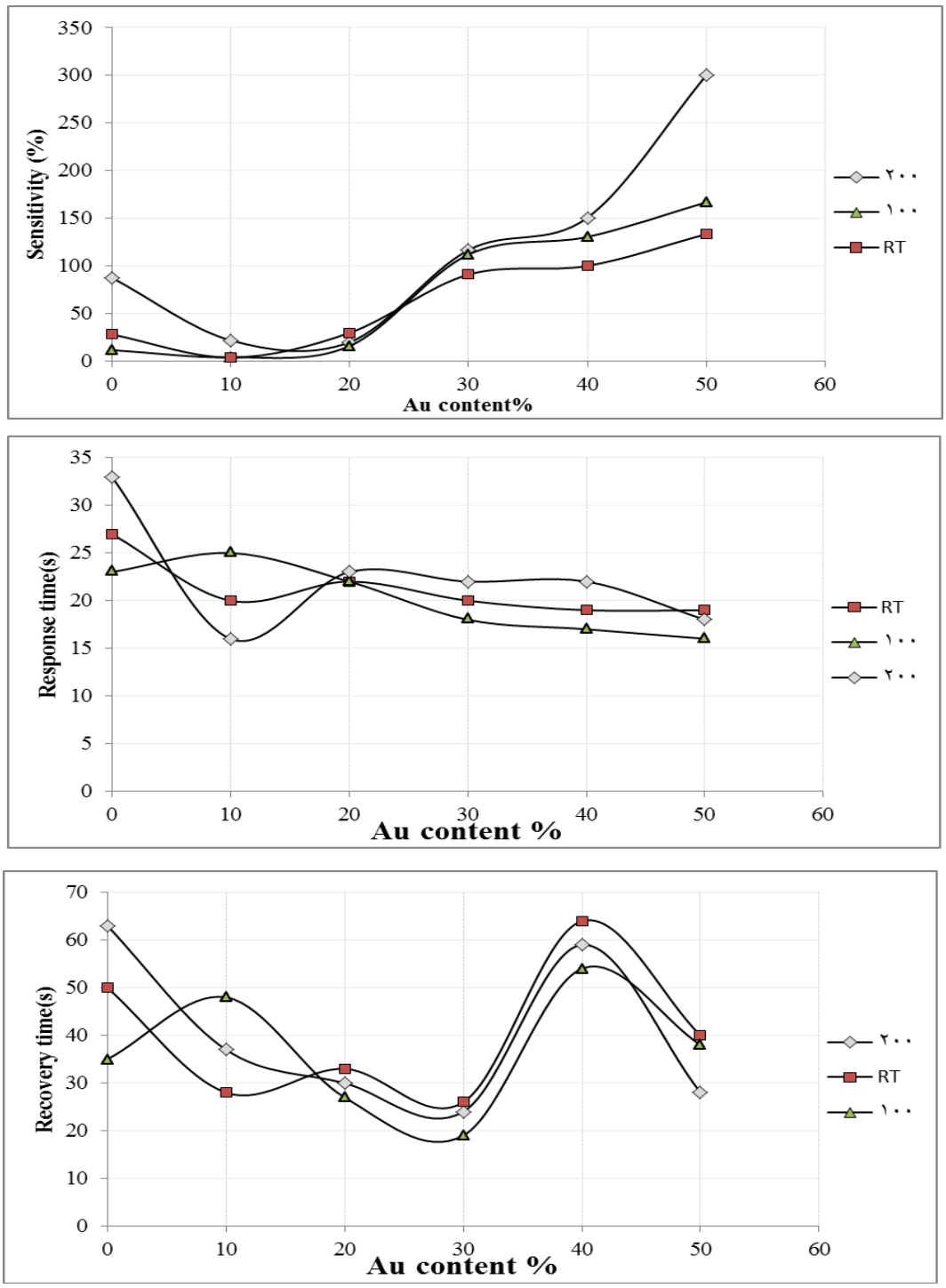

Figure-4. The change of sensitivity with the operating temperature, the response time change and recovery time change of different gold nanoparticles contents.

CONCLUSIONS

Polycrystalline composition (In_2O_3:ZnO:Au) has been successfully synthesized by spray pyrolysis method. The SEM image show that the samples are not closely packed and consist of several grains. Gold nanoparticles additions showed no major effect on the surface morphology of the film. FTIR spectra showed two major wide metal oxygen bands, the difference in the peak positions may be due to change of bond length with increasing of gold nanoparticles. Gas sensitivity increases as gold nanoparticles increases.In_2O_3: ZnO: Au nanocomposite thin film gas sensing material provides better sensitivity compared with In_2O_3.

REFERENCES

[1] D. Munoz-Martina, C.F. Braszb, Y. Chena, M. Moralesa, C.B. Arnoldb and C. Molpeceres.

2016.Laser-Induced Forward Transfer of High-Viscosity Silver Pastes. Applied Surface Science. 366: 389-396.

[2] M. Kandyla, S. Chatzandroulis and I. Zergioti. 2012. Laser Induced Forward Transfer of Conducting Polymers. Materials Science. pp. 12.

[3] A. Piqué and H. Kim. 2014. Laser-Induced Forward Transfer of Functional Materials: Advances and Future Directions. JLMN-Journal of Laser Micro/Nanoengineering. 9(3).

[4] A. Palla-Papavlu, V. Dinca, T. Lippert and M. Dinescu. 2011.Laser Induced Forward Transfer for Materials Patterning. Romanian Reports in Physics. Vol. 63, Supplement.pp. 1285-1301.

[5] Z.Yahia and R. M. S. Al-Haddad. 2017. The Effect of Slica Concentrations on the Absorbance of Gold Nanoparticles. 10(3): 448-455.

[6] H. NathVerma, P. Singh and R. M. Chavan. 2014. Gold Nanoparticle: Synthesis and Characterization. Veterinary World, EISSN: 2231-0916,7: 72-77.

[7] B. H. Rabee and B. Abdu AL-Kareem. 2016. Study of Optical Properties of (PMMA-Cu O) Nanocomposites. International Journal of Science and Research. 5(4).

[8] G.Liu,Synthesis. 2011. Characterization of In_2O_3 Nanocrystals and Their Photoluminescence Property. International Journal of Electrochemocal Science, Int. J. Electrochem. Sci. pp. 2162-2170.

[9] Z. R. Khan, M. S. Khan, M. Zulfequar and M. S. Khan. 2011. Materials Sciences and Applications. 2: 340-345.

[10] M. J. Abdulhussain. 2016. Preparation and Characterization of Cd - Ni Ferrite Complemented with Nd-YAG Laser as a Gas Sensor. University of technology.

[11] A. J. Haider, S. S. Shaker and A.H. Mohammed. 2013.A study of Morphological, Optical and Gas Sensing Properties for Pure and Ag Doped SnO_2 Prepared by Pulsed Laser Deposition (PLD). Energy Procedia. 36: 776-787.