

Some of Electrical and Detection properties of nano silver oxide

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Abstract. Micro and Nano Ag₂O₃ thin films have been deposited using the Reactive Pulse Laser Deposition (RPLD) method. N-type silicon wafer was used as substrates. The prepared films were annealed at (400 -600) °C to produce the oxide films. Spectral Responsivity had been sensed more optically for green (560nm) and near IR (840nm). Response time reveals an enhancement with annealing temperatures.

Keywords: Ag₂O; RPLD; hetero-structure; detector parameters

1. Introduction

As a p-type semiconductor material, Ag₂O thin film appear with an excellent energy gap from 1.2 to 3.4 eV which is related to the deviation in the stoichiometry [1-5]. Thin films of this material have unique physical properties that attracted much interest [6-9]. They have been used widely in the batteries electric pole and in the photography [10-12]. And in the SERS (surface-enhanced Raman spectroscopy) and in a surface-plasmon (SP) source. Many methods can be used to prepare and deposit the AgOx, such as the (CBD) chem.-bath dep. [13, 14], thermal evaporation and (RMS) reactive magnetron sputtering, exposing the films of silver to atomic oxygen environment, and Pulsed Laser Deposition techniques [15, 16].

The reactive Pulsed Laser Deposition using a pure silver targets while feeding it with oxygen gas as a catalyst to increase the interaction between pure silver atoms and gas to obtained and controlling to the oxygen composition ratio and to allowed to use a low energy of lasers for deposition [17]. The optical properties of AgOx have been studied previously [18], the correlation between the microstructural features and the process parameters during deposition has not yet been well established. In this work, we studied the optical properties of Deposited AgOx thin films on the glass substrate. The additional analysis by X-ray diffraction results [19, 20].

Different techniques were used to prepare oxide thin films, such as thermal oxidation of metal silver films, thermal evaporation, electron beam evaporation, and pulsed laser deposition.

This material have a promising applications such as optical and gas sensor, a catalyst for methanol and ethylene oxidation , chemical sensor for ammonia ,in solar cell application as photovoltaic



materials, Plasmon photonic devices, optical memories ,and as active cathode materials in silver oxide/zinc alkaline batteries and , Recently, they have been used as surface enhanced Raman scattering (SERS) substrates [20]. The use of silver oxide thin films in super-resolution near-field structure has been demonstrated to solve signals due to optical diffraction limit .

In this paper, we present the PLD as a technique to deposit Ag_2O over substrate of Si. The research continued to study and analyze the effect of annealing temperatures on the growth mechanism of the material and, thereafter, I-V results, R_{λ} , and R_t are presented and discussed deeply.

2. Experimental work

Undoped Ag_2O thin films were deposited on a cleaned N-Silicon as a substrate using a tattoo removal Nd: YAG laser. The pulse duration of the Q-switched Nd: YAG laser is 7 ns (FWHM) with wavelength= 1.064 nm, the laser beam was focused through a lens with a focal length=10 cm spotted on a silver target (99.999% provided from Fluka com.). The targets spin at a rate of one cycle per minute. The laser fluence at the target surface was 57 mJ/cm². Number of laser pulses was fixed at 50 laser pluses. The deposition process was done with the aid of halogen lamp to keep substrate temperature at (623 K) and at (90 sec) as an oxidation time. The calcinations process was done at 250 °C for 30 min in static air within oxygen atmosphere to remove any organics. (Lenton VTF/12/60/700) tube furnace was employed to anneal the prepared samples at 400, 500 and 600 °C, respectively.

The white light response of the photodiode was tested by using a (100W) tungsten filament lamp. The electrical properties represents by I-V characteristics were investigated using a DC power supply and Keithley electrometer. The spectral responsivity of the photodiode was measured at the spectral range (200-900nm).The minority carrier's lifetime was also measured.

3. Results and discussion

3.1 Electrical measurements of constructed device

3.1.1 Current-Voltage characteristics

Using n-type silicon substrate $\text{Ag}_2\text{O}_3/\text{Si}$ heterojunction device was deposited. The results of the I-V characteristics measurement in the dark could be shown in figure (1). The study of such properties is very important to describe the performance of the prepared heterojunction.

In the presented results, under reverse bias, it is obvious that there are two regions, the generation current region, where the reverse current is slowly increased as a function of applied voltage and this resulting in production of electron-hole pairs at low bias. The second region shows a significant increase in the reverse bias, which is resulted from the diffusion of minority carriers through the junction. A rapid incremental also could be noted in this figure, which is probably due to the leakage current arising from the surface layer. While the results in the forward bias, two regions are recognized; the first one represents recombination current while the second represents tunneling current. The ideality factor of ($\text{Ag}_2\text{O}_3/\text{Si}$) junction at optimum conditions of substrate temperature was estimated to be 1.3. These values refer to good rectification properties for the prepared junctions. C-V measurements are one of the most important measurements since it determines different parameters such as built-in potential, junction capacitance and junction type.

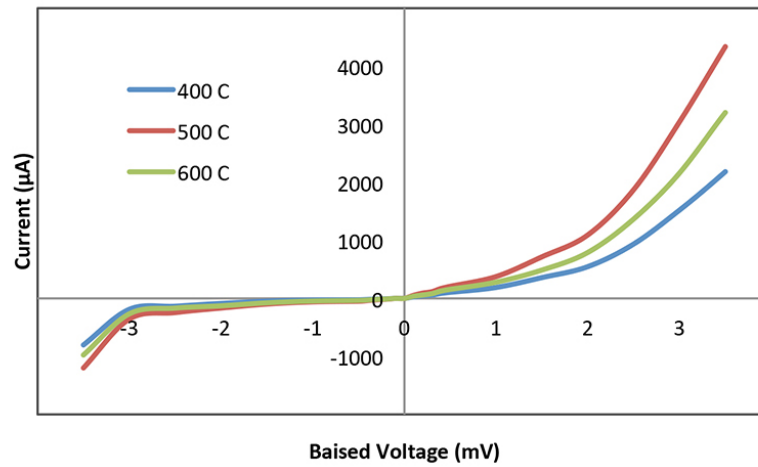


Figure 1. I-V characteristic under forward and reverse biased

Figure 2 present the $C-V$ plot and $C^{-2}-V$ for the optimum preparation condition (500 °C) of the nano and micro grown silver oxide heterostructure deposited on the Si substrate at 40 kHz, this fig present an (abrupt junction) as a linear relationship between the $1/C^2$ and the V at the optimum preparing condition to the x -axis (0.83 V) essentially equal to the diffusion potential within Ag_2O side.

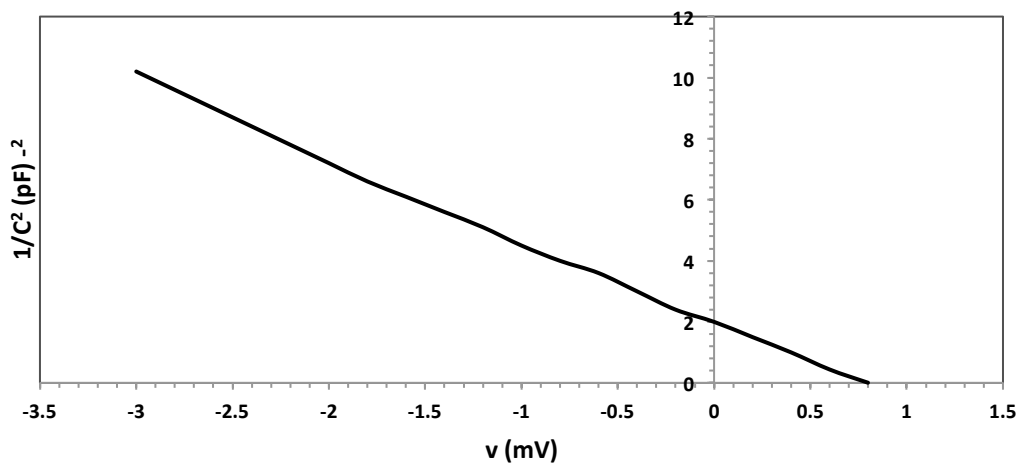


Figure 2. C-V and C-2-V plot of nano silver oxide heterojunction.

3.2 Measurements of device Parameters

3.2.1 Spectral Responsivity (R_λ)

The presented results of the spectral responsivity were performed using the double-beam UIR-210A spectrophotometer operating within the range (0.15-1.1) μm of the wavelengths while the current measurements were performed using the Fluke digital millimeter (8010 DMM). The values of the spectral responsivity were calculating using the following equation:

$$R_\lambda = \frac{I_{ph}}{P_i} \quad A/W \quad (2)$$

where I_{ph} is the measured photocurrent and P_i is the incident optical power

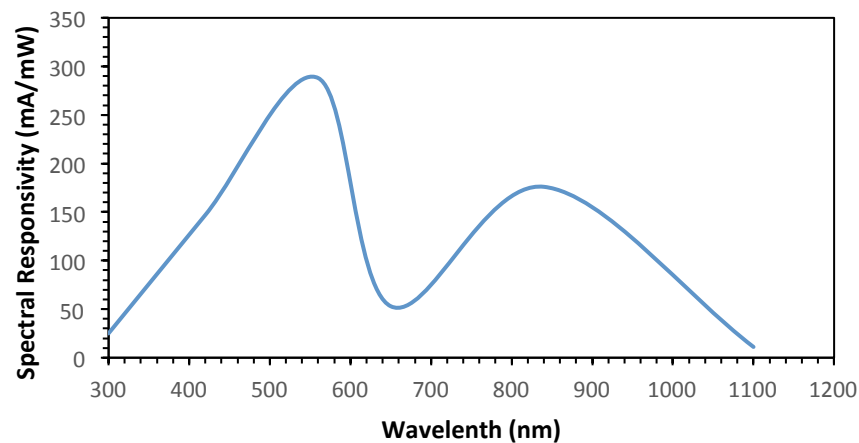


Figure 3. the responsivity characteristics at optimum annealing's

We have two peaks in this result as its responsive to the wavelength that used in the experiment these two curve:

One for the silver that responsive for green wavelength

One for the silicon and that is responsive for IR wavelength

Figure (4) present the open voltage decay pulse of the $\text{Ag}_2\text{O}/\text{Si}$ heterostructure and we could recognize the value of the carriers life time of about (211 μsec) which give rise in the enhancement of other device photocurrent and quantum efficiency.

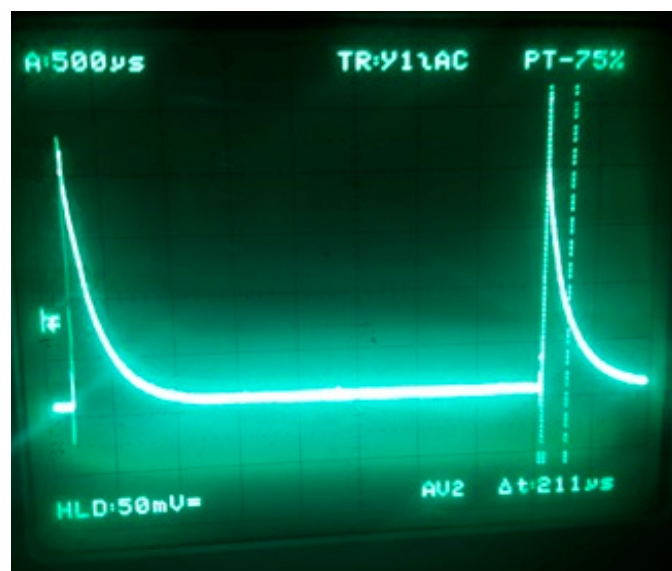


Figure 4. The rise time pulse of Ag_2O film

Figure (5) presents the obtain the response time pulse from fabricated detector device, which find to be (58.3 μs),



Figure 5. Device rise time

4. Conclusion

The encouraged optoelectronic properties of this heterojunction suggest that it candidate to be visible-enhanced photo detectors. The method of fabricating Ag_2O layer by RPLD method are, cheap, and it is hoped it can be improved either by doping or annealing. According to the obtained electrical properties a good enhancement in the device performance could be achieve and it could recognize clearly that device has three main peak of the Responsivity, at (650nm). The encouraged optoelectronic properties of this heterojunction suggest that it candidate to be visible- enhanced photo detectors. The photodiode exhibited good rectifying characteristics and the turn-on voltage was around I-V. The C-V measurements showed an abrupt type junction and a diffusion potential of I-V.

5. References

- [1] A. H. Hammad, M. S. Abdel-Wahab, A. Alshahrie 2016 *Digest Journal of Nanomaterials and Biostructures* **11**(4): 1245-1252.
- [2] Makram A. Fakhry 2016 *Int. J. Nanoelectronics and Materials* **9** 93-102.
- [3] W. Wu , C.C. Tseng , C. Li, C.K. Chang, J.H. Hsieh 2015 *Vacuum* **118** 147-151
- [4] Evan T. Salem 2013 *Surface Review and Letters* **20**(5):50046.
- [5] L.A.A. Pettersson , P.G. Snyder 1995 *Thin Solid Films* **270** 69-72
- [6] Ibrahim R. Agool, Evan T. Salem, Marwa Abdul muhsien 2011 *International Journal of Modern Physics B* **25**: 1081-6 pages.
- [7] T.C. Kaspar, T.C. Droubay, S.A. Chambers 2010 *Thin Solid Films* **519** 635–640
- [8] F. Hattab, M. Fakhry 2012 *Engineering Sciences (FNES)*, **2012** First National Conference (IEEE) 1-5.
- [9] Evan T Salim, Marwa S Al Wazny, Makram A Fakhry 2013 *Modern Physics Letters B* **27** 1350122-1 – 1350122-7.
- [10] C.C. Tseng, J.H. Hsieh, W. Wu 2011 *Thin Solid Films* **519** 5169–5173.
- [11] Esben Lund, AugustinasGaleckas, Alexander Azarov, Edouard V. Monakhov, Bengt G. Svensson, *Thin Solid Films* 536 (2013) 156–159.
- [12] Evan T. Salem, Makram A. Fakhry, Hala Hassen 2013 *Int. J. Nanoelectronics and Materials* **6**(2) 121-128.
- [13] Y. You, L. Wan, S. Zhang, D. Xu 2010 *Materials Research Bulletin* **45** 1850–1854
- [14] K.Lalitha, J. K.Reddy,M. V. P. Sharma, V. D.Kumari,M.Subrahmanyam 2010 *International Journal of hydrogen energy* **35**:3991-4001.

- [15] Jonathan Derouin, Rachael G. Farber, Stacy L. Heslop, Daniel R. Killelea 2015 *Surface Science* **641** L1–L4
- [16] Evan T. Salem 2012 *Int. J. Nanoelectronics and Materials* **5(2)** 95-100.
- [17] F.X. Bock, T.M. Christensen, S.B. Rivers, L.D. Doucette, R.J. Lada 2004 *Thin Solid Films* **468** 57– 64.
- [18] S.B. Rivers a, G. Bernhardt b, M.W. Wright c, D.J. Frankel b, M.M. Steeves c, R.J. Lad 2007 *Thin Solid Films* **515** 8684–8688.
- [19] G.Xiaoyong, Z.Mengke, Z.Zengyuan, C. Chao, M.Jiaomin, L.Jingxiao, 2011 *Thin Solid Films* **519** 6620–6623
- [20] Evan T. Salem, Ibrahim R. Agool, Marwa Abdul muhsien 2011 *International Journal of Modern Physics B* **25(29)**:3863-3869.